Transactions of the Wisconsin Academy of Sciences, Arts and Letters. volume XXVIII 1933

Madison, Wis.: Wisconsin Academy of Sciences, Arts and Letters, 1933

https://digital.library.wisc.edu/1711.dl/B44YAM2CN6YXH8B

TRANSACTIONS

OF THE

WISCONSIN ACADEMY

OF

SCIENCES, ARTS AND LETTERS

VOL. XXVIII

NATURAE SPECIES RATIOQUE

MADISON, WISCONSIN

1933

OFFICERS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

PRESIDENT
Charles E. Allen, *University of Wisconsin*

VICE-PRESIDENTS
IN SCIENCE: Rufus M. Bagg, *Lawrence College*
IN THE ARTS: Otto L. Kowalke, *University of Wisconsin*
IN LETTERS: William E. Alderman, *Beloit College*

SECRETARY-TREASURER
Lowell E. Noland, *University of Wisconsin*

LIBRARIAN
Walter M. Smith, *University of Wisconsin*

CURATOR
Charles E. Brown, *State Historical Museum*

COUNCIL
The president, *ex officio*
The vice-presidents, *ex officio*
The secretary-treasurer, *ex officio*
The librarian, *ex officio*
E. A. Birge, *past president*
Charles S. Slichter, *past president*
John J. Davis, *past president*
Louis Kahlenberg, *past president*
L. J. Cole, *past president*
S. A. Barrett, *past president*

COMMITTEE ON PUBLICATION
The president, *ex officio*
The secretary, *ex officio*
Arthur Beatty, *University of Wisconsin*

COMMITTEE ON LIBRARY
The librarian, *ex officio*
Howard Greene, *Milwaukee*
Mrs. Angie K. Main, *Fort Atkinson*
Rollin C. Mullenix, *Lawrence College*
George Van Biesbroeck, *Yerkes Observatory*

COMMITTEE ON MEMBERSHIP
The secretary, *ex officio*
E. F. Bean, *State Geological Survey*
Ralph N. Buckstaff, *Oshkosh*
Anselm M. Keefe, *St. Norbert College*
William N. Steil, *Marquette University*

Correspondence relating to publication in the Transactions or to other Academy business should be directed to the secretary, Lowell E. Noland, Biology Building, University of Wisconsin, Madison, Wis. Publications intended for the Library of the Academy should be sent directly to the Librarian, Walter M. Smith, University of Wisconsin Library, Madison, Wis.

CONTENTS

ERRATA FOR VOL. 27

By an unfortunate oversight the illustrations in Prof. Eric R. Miller's paper on "Cloudiness in Wisconsin", published in the last issue of these Transactions, were interchanged. The following corrections should be made:

Page 61, for "Fig. 2" read "Fig. 5", and for "March-April" read "September-October".

Page 63, for "Fig. 3" read "Fig. 6", and for "May-June" read November-December".

Page 64, for "Fig. 4" read "Fig. 2", and for "July-August" read "March-April".

Page 65, for "Fig. 5" read "Fig. 3", and for "September-October" read "May-June".

Page 66, for "Fig. 6" read "Fig. 4", and for "November-December" read "July-August".

THE WINTERING OF THE WISCONSIN BOBWHITE

PAUL L. ERRINGTON

The results presented in this paper were obtained from three seasons' field research (1929 to 1932), the purpose of which was to ascertain just how bobwhite coveys normally winter. The work was done in connection with the Wisconsin Quail Investigation, established at the University by the Sporting Arms and Ammunition Manufacturer's Institute and the U. S. Biological Survey.

Quail selected for observation were in coveys or groups of coveys for the most part within 50 miles of Madison, Wisconsin, in Dane, Sauk, and Columbia counties. While these counties perhaps do not constitute a representative portion of the bobwhite's northern range, they include almost all of the environmental types which might be called representative of southwestern Wisconsin farming communities, wild lands, and suburban properties.

The quail were studied from the standpoint of food habits, cover preferences and requirements, behavior, and mortality. To insure a minimum of interference with the natural order of events, the observational coveys were not banded, baited, fed, assisted, or disturbed in any way except when visited and flushed or when circumstances necessitated the collection of specimens. Specimens were usually taken from coveys not under regular observation but similarly situated to those that were. Banding and retrapping operations (for the Quail Investigation and the Zoology Department, cooperatively), conducted by Mr. H. G. Anderson and others on the University Marsh Farm area, Madison, Wisconsin, checked the reliability of the field census methods.

Food habits of the bobwhite were studied mainly through the "reading of sign" in the snow, by direct observation, and by crop and gizzard examination of specimens. The crop and gizzard analyses were run by the U. S. Biological Survey. In addition, continuous experimenting—concerned chiefly with values of emergency foods (Errington, 1931b)—was done with captives to clear up sundry points not fully adapted to study by field methods. The cover studies were mostly observational, supplemented by some experimentation, as can be said of the work on behavior (Errington, 1931c). Figures pertaining to quail mortality were compiled from successive counts of the number of birds in each covey under observation in the wild, and from the reading of "sign" pertaining to mortality causes.

Covey groups were visited about once every week or two when everything was going well with them, oftener when developments demanded more rigid surveillance. Sometimes coveys were visited every day for the duration of periods of crisis.

Observational covey groups were chosen from those separated from other quail, either by distance or by more or less effective natural barriers. It was taken for granted that the more widely separated were the coveys, the less would be the error due to birds wandering to and from neighboring coveys. The heavier the quail population the more difficult it was to obtain satisfactory censuses. Indeed, some important coveys were dropped from observation simply because their chaotic censuses were not to be straightened out. Birds well within the boundaries of an observational area were also chosen for the more intensive study, to reduce further the possibilities of interchange of birds with unknown outside coveys.

During snow periods the various covey territories could be rather definitely traced. The cruising radii for coveys living under good cover and food conditions were short, and the birds could usually be flushed within a quarter mile of the same place at each visit. Coveys were wont to develop habits which, if safe, they clung to indefinitely. Certain strips of fencerow brush, certain hill slopes, etc., were preferred for resting, certain other places for dusting or replenishing gizzard grit. There were certain bushes under which some birds liked to scratch for fallen fruits. Others entered corn fields from a particular end or displayed similar idiosyncrasies. I found that it did not take long as a rule to learn about where to look for given coveys, though once I followed the trail of 11 undisturbed birds 1.2 miles out of their regular territory. They had for no apparent reason left an ideally balanced environment to range elsewhere, but they returned later to remain, to the best of my knowledge, practically stationary all winter.

Cruising radii grew longer where the coveys were compelled to forage widely for food. If the food failure was sudden and complete, as was often the case where deep snow covered and kept covered the staple weed seeds on the ground, hungry quail, driven by desperation, were known to leave their old territories entirely. If the food failure was gradual, the birds sometimes left, sometimes remained. Remaining, they merely spent more time foraging or starved slowly and passively. I have tracked a starving covey in a circle a mile and three-quarters in circumference, the birds roosting in the evening a short distance from where they had begun their journey in the morning. Uninterrupted journeys of a half mile are common for moderately hungry coveys, usually within their regular territory.

Apart from the "fall shuffle" (Leopold, 1931), which appears but the abandonment of food-and-cover-impoverished summer territories and the re-orientation of coveys in more promising winter quarters, there is likely to be shifting on a considerable scale as a response to necessity. Shooting, attacks by much-feared predators such as Cooper's hawks (Errington, 1931c) may be responsible for pronounced modifications in covey habits, but seldom drive the quail out of their territories altogether; the quail are more likely to station themselves in the side of the woodlot opposite from that in which they had unpleasant experiences, or in another brush patch, or in some other place where they feel themselves in less danger. Hunger is the great force behind winter covey movements. But although birds finding a new source of food may not return to their former haunts—as when hard-pressed coveys locate near grain-rich farm yards—even a superior and available supply of food, of the whereabouts of which they are aware, is often insufficient to draw them out of their habitual territory. When living conditions are tolerable, the quail are prone to stay where they are.

A covey's attachment for a territory may perhaps be explainable in terms of habit, but I suspect that the proximity of other coveys in the neighborhood governs cruising radii more than I am able at present to prove. Quail in sparsely populated areas seem to exhibit a greater freedom in their peregrinations than birds of more populous surroundings. Some of this wandering may be due to necessity on account of the poor quality of the environment, but this explanation does not fit all cases.

While there may be only a single covey in a half township of country as a whole wretched for quail, yet the environment may be locally excellent where those few birds happen to be.

The bobwhite appears intolerant of its own species past a certain density level. My observational birds, gregarious enough to combine as coveys, have often displayed antipathies toward higher concentrations. Frequently they have gone to the extreme of exposing themselves to the perils associated with poorer environmental types to avoid too intimate contact with better situated adjoining coveys (see group XXXII). Coveys radiating away from good environment to poor are especially subject to winter mortality, but, despite this, are loth to return to more congested, though safer, habitats. Is this voluntary (?)—and possibly lethal—exodus from good territory to poor the mechanism maintaining the bobwhite's "saturation point" for a given area? I have no reason to believe that antipathies, should they exist, are violent, for coveys are occasionally seen together in amity; the tendency is for them to separate sooner or later and to drift in different directions.

That the bobwhite's intolerance of concentrations is not alone intraspecific is suggested by a few recent observations on the co-occupancy by quail and ringnecked pheasants of the University Hill Farm experimental area at Madison. In all three winters of the investigation, the favorite resort for gallinaceous game has been a long woodlot of about 5 acres convenient to an excellent food supply.

The winter of 1929-30, 12 to 18 quail and about a dozen pheasants frequented the woodlot. In 1930-31 about 25 pheasants and an average of 25 quail used the woodlot. In 1931-32 the pheasants came in from the environs until about 40 were concentrated in the woodlot and vicinity; the quail, after using the woodlot in late fall, left the pheasants in possession and established themselves elsewhere on the farm. Food and cover were so well distributed over the area that the quail had ample choice as to where they could station themselves.

The evidence is that the bobwhite's withdrawal from the woodlot in 1931-32 was not due primarily to antipathy toward the pheasant as a species. I have from concealment witnessed small numbers of pheasants feeding in the very midst of quail coveys with no friction whatever. The antipathy seems to be toward *too many* pheasants. As I see it, the situation is analogous to those in which quail spread out from areas over-populated with their own species.

Available data prove that much quail behavior appearing instinctive at first glance has its inception in experience. Individual birds must learn, for example, to open corn husks and various seed pods. They learn, where often night-flushed, to roost in the open, not in dense brush upon which they might injure themselves flying in the dark. The indications are also that coveys feeding during the winter about farmers' corn cribs when natural food becomes difficult to procure, are first led into the yards each season by old birds which have been there before.[1]

The bobwhite covey, which as Stoddard (1931) mentions is but a unit of convenience and of no fixed number or composition, nevertheless has shown with some exceptions a distinct winter constancy in my Wisconsin observational areas. Certain birds may consistently bunch up in the same covey for resting or roosting; others combine more or less promiscuously, within limits. Several hundreds of personal covey counts in the field, plus Anderson's banding data, give me the basis for a statement that a winter covey in lightly to moderately populated areas is usually made up of the same individual birds for weeks at a time.

The degree to which coveys preserve their identity is partially dependent upon the nearness of other coveys with which thev come in frequent contact. Less interchange is apt to take place between coveys having cruising radii that overlap only occasionally than among coveys living under conditions more conducive to intimacy. Some coveys even under crowded conditions keep their identity in a remarkable manner. As an extreme, one covey of 4 was noted to keep strictly to itself for some weeks, though it shared a territory with another covey of 12. Commonly, small groups like this are soon absorbed by larger units. Coveys of 6 to 8 are often found separate, however, where they have plenty of opportunity to combine with other birds. One would hardly expect these small coveys of

---

[1] One of my 1930–31 observational coveys at Prairie du Sac was pressed for food on account of a March snow. Two of the birds went readily into a farm yard (where quail have fed nearly every year) to feed with the chickens, the balance of the covey hanging back.

distinctive sizes and exhibiting distinctive behavior for protracted periods to be composed of any save the same birds.

It is a common occurrence, too, for small coveys to unite with larger ones (such as one of 8 with another of 12 to form a covey of 20). A recently combined covey is usually weakest at about its point of junction; the above would probably split now and then into its component parts (8 + 12), but not invariably (it may split as 7 + 13 or 9 + 11). Sometimes more than two coveys combine, as in a fairly well isolated area at Prairie du Sac, Wisconsin, in 1930-31, where coveys of 9, 15, and 24 coalesced—2 birds lost, 1 gained—to give at different times 30 + 17, 29 + 18, 28 + 19, 27 + 20; the converse may be likewise illustrated by another Prairie du Sac area in which coveys of 15, 16, and 31 split up and recombined as 10 + 12 + 16 + 24 and in other ways. In these latter instances the exact composition of the coveys could not have been determined except by banding or marking, but the total of associated covey groups was remote enough from those of bordering areas to reduce the chance of interchange with outside birds.

Splitting and recombining is almost inevitable when a remnant of a decimated covey joins with one already becoming top heavy numerically. If, let us say, a little group of 5 joins a covey of 30, thereby raising the total to 35 which the quail seem to sense as a dangerous or unwieldy concentration, the 35 may split into more desirable units of 15 + 20, 16 + 19, etc. Coveys of more than 30 birds are rare in my experience, despite prevalent reports among the populace of coveys mounting in numbers up to 100 or so. The largest permanent covey of which I have personal record is 33, but I have encountered ephemeral associations slightly in excess of this figure.

My censuses are made by flush counts, track counts, counts of running birds, and, under unusually favorable conditions, by counting fresh impressions of roosting birds in snow or grass.

A flush count is quite reliable for use with small coveys (5 to 10) and with those of moderate size (up to 20) where the quail fly well spread out and are not continually shifting places. A covey leaving a patch of thick cover such as a mat of creeping juniper in a steady succession of singles, twos, and threes can often be readily counted. Where a large flock bursts into flight as a compact mass, it is virtually impossible to obtain an accurate count, although an investigator, through increasing familiarity with coveys, learns to estimate size within a bird or two by general appearance in the air.

Flush counts are of scant utility if the birds have been disturbed and scattered a short time previous. Premature attempts to reflush for count a covey previously flushed and marked down are also unprofitable. Immediate reflushes are invaluable, however, in detecting weak individuals in the covey, for under-par birds may have the strength for a vigorous first flight but little more.

Censuses of an area were planned in such a way that flushed coveys were encouraged to alight in territory already covered, so as to obviate the chances of their being counted twice or confused with other birds. In actuality, things do not work out as smoothly as planned, but the quail, through the proper approach of their favorite rendezvous, may often be guided into flying about where desired.

Track counts are of the greatest usefulness, especially if checked by flush counts. Usually they are to be obtained from snow, but under exceptional circumstances from sand or mud. On the whole, the efficacy of the method in Wisconsin is conditioned by the distribution and the state of the snow. It is obvious that a crusted or a drifting snow or one bespattered by falling icicles and water drops may not be the best for tracking purposes. The difficulty of obtaining track counts may be further increased by absence of snow at strategic places or by daily accumulation of tracks in an indecipherable maze.

Erratic behavior of the quail themselves may add to the difficulties; not infrequently well-fed coveys lay up without moving the first day of a fresh snow, or do not venture forth until late. Deep fluffy snows cause the quail to fly instead of run from one place to another, or leave a trail that is a bewildering series of short flights and shorter runs. The tendency of coveys to run along in single file is also a very common source of trouble.

Broadly speaking, the best track counts can be made at points intermediate between a covey's roosting or resting spot and its feeding grounds. At some point enroute, the covey trail usually widens out to permit separation and tally of the individual trails. Where the covey trail is partially massed and partially open, judicious search sometimes makes possible accurate counts of a portion of the covey at one place and of the remainder at another. It is imperative to watch the trail carefully, for a lagging or an impatient bird may take wing and so leave no tracks over some of the route. Repeated counts along the covey trail are a necessity to minimize error.

I have found chances best for making good track counts on the margins of roadsides, on frozen creeks and sloughs, at the edges of fields, etc., where birds cross smooth stretches of snow in spreadout formation. Counts on feeding grounds are suitable if the coveys progress in some particular direction without too much back tracking or zigzagging.

Running counts may or may not be reliable, according to whether all the birds pass directly in the investigator's vision. I am not overly trustful of the method, for one may not notice the covey until some birds have disappeared from view. Then again, two or three more may dash past abreast, run back and forth, or similarly confuse the count.

The fourth method, i. e., counts of body impressions on roosts, is least dependable. It should be used sparingly and only under conditions most adapted to it and where even an undependable method is better than none at all. It has been most useful to me in the checking up of coveys of approximately known size when track counts were impossible and the birds could not be found. When a covey flushes from a roost after having been partly snowed over during the night, clear imprints of individual quail breasts may sometimes be made out. The same may also be true where quail roost frosty nights in soft, thick grass. The great drawback to the method, aside from the indistinctness of body outlines, lies in the possibility of roosting covey groups rearranging themselves in the night. Relative quantities of droppings corresponding to imprints may give a clue as to whether rearrangement has taken place. I have never been able to use the quantity of droppings on a roost as an index to the number of birds.

It has been found a good policy to locate the coveys of a prospective observational area quite early in the fall, in order that the fullest advantage can be taken of the first snows. Roosting and resting spots, scattered droppings on feeding grounds, dust baths, feathers, and quail "talking" may betray the whereabouts of coveys long before censuses can be made. Specially trained bird dogs (Wight, 1931) are said to have much utility in upland game census work, but I cannot speak on this topic from experience.

It is plain that the more nearly absolute a census, the greater will be its value in determining whether coveys are suffering losses. If an isolated covey, regularly visited without discovery of mortality evidence, shows no numerical fluctuations (when the birds are assembled) and finishes the winter with the same number with which it started, the investigator is entitled to conclude that it came through without loss. If a bird is missing, the watcher has grounds to suspect that something has happened. His next move is to search the territory for explanatory "sign."

In perhaps half of the instances in which birds were known to drop from observational coveys, I have been able to piece together fairly good evidence as to the cause of mortality, though my fortunes in this respect have vacillated from one extreme to the other. Practically all birds missing from some coveys have been accounted for, whereas in others the majority of disappearances could not be solved.

A prompt discovery of a dead bird, before scavengers or weather have blotted out the "sign," is a substantial step toward diagnosis of the mortality cause. Profitable places to inspect upon disappearances of birds are recent roost sites, fencerows, the borders of brushy cover, and the likeliest retreats of predator species under suspicion. Starving bobwhites found dead on roosts in cold weather leave a story that can be read, as do also fresh predator kills. If a predator kill is not distinctive enough, it may conceivably be checked up by means other than "sign reading," especially where remains may be retrieved later, as from raptor nests or pellets (Errington, 1932). The normal shedding of feathers on roosts and rests should not be mistaken for mortality evidence. Flight feathers and small feathers attached to particles of skin signify much more.

While evidence of mortality usually can be unearthed—though the "sign" may be so poor as to do nothing but confirm the loss of a bird—a notable exception must be taken into account where human poachers have been active. Often there is little to point to shooting except the vanishing of birds, or maybe a cripple or a kill overlooked by the hunters. A few times I have found just where quail had been shot, but the work of the human predator is exceedingly hard to trace down. Two or three or a half dozen birds are suddenly gone from a covey; maybe the covey split and part are living somewhere else; maybe they aren't; months later, perhaps, somebody may talk.

It may assist in illustrating how the technique of winter quail study works out by submitting as examples some observational area data condensed from general notes to bare outlines, but presented in more detail than as reviewed later on in this paper.

Group XIX. Area Two Miles east of Pine Bluff, Wis. Hilly, partly wooded farming country; cover excellent; food poor; predator population on the whole light.

Jan. 23, 1930—Track counts unobtainable but 17 birds were flushed, of which 2 weak ones (starving) were caught by hand for specimens. Another weak one escaped by hiding. One starved bird dead on last night's roost.

Jan. 25, 1930—The 15 survivors of the above covey were flushed, also 7 within 150 yards of them.

Feb. 3, 1930—Fresh evidence of only 13 birds (track count), of which about 6 had ranged a short distance by themselves. There were 5 starved birds dead on roosts (1 with carcass intact; 4 partly eaten by scavengers). Remains of another bird scattered by predators or scavengers. This leaves 3 of the last tally of 22 unaccounted for.

Feb. 11, 1930—Only 11 birds tracked and flushed today and they do not appear strong. No dead ones found.

Mar. 3, 1930—Birds gone from area, but it is more likely that they moved rather than all died. No evidence of recent mortality.

Group II. Wingra Wild Life Refuge, Madison, Wis. Mostly uncultivated with considerable open, natural woods and jungle-like marshy growths; woods cover poor; marsh cover good; food good; predator population heavy; 3 distinct quail coveys, A, B, and C.

Nov. 24, 1930—Coveys A, B, and C located through poor tracking snow, but no counts possible.

Dec. 14, 1930—Track count of 29 for covey A; flush and track count of 15 for B. No data on covey C.

Dec. 20, 1930—Flush count of about the same number (29) in A. Flush and track count of 16 for B. Covey C attended and scattered by a Cooper's Hawk which had made one kill today and another yesterday. An unsatisfactory track count of 17 previous to the raptor attack was obtained. The birds were also seen but not counted.

Dec. 21, 1930—Covey C situation kept under observation today by Dr. A. W. Schorger. Birds in hiding.

Dec. 24, 1930—Cooper's hawk had killed a bird out of A, and there are 26 left (tracked and flushed). Others may have been shot as there has been much illegal hunting on the refuge the past few days. Very careful search disclosed no additional loss to C since Dec. 20, and as there are today 22 birds (good flush count) in the fully assembled covey, this figure may be taken as the number surviving the Cooper's hawk. December 20 may then be accepted as the earliest date for a complete census of the area's quail population. Track and flush count of 16 for B.

Jan. 1, 1931—Covey C, 20 birds (track count); B, 16 (track count). Unsatisfactory track count of 23 for A, but all 26 may have been there.

Jan, 6, 1931—Covey B, 16 birds (track and flush count).

Jan. 7, 1931—Covey C, 20 birds (track count); B, 16 (track count); A, 26 (track and flush count).

Jan. 22, 1931—Covey A, about 26 (flushed); B, about 15 (unsatisfactory track count). A cripple from C, caught by hand, had a partly healed shot-shattered humerus. This may hint the fate of the two birds which disappeared without trace from the covey in late December.

Note: Subsequent evidence divulged that a horned owl had got one from B about this time.

Feb. 7, 1931—Covey B, 15 (tracked and flushed).

Feb. 8, 1931—Covey A, 26 (tracked and flushed).

Feb. 14, 1931—Covey B, 15 (track count); C, at least 19 (track count).

Feb. 26, 1931—Covey B, 15 (flush count).

Mar. 8, 1931—Unsatisfactory track count of 25 for A.

Mar. 14, 1931—Covey C, 19 (good flush count).

Mar. 17, 1931—Covey B, (track count); only part of A found.

Mar. 29, 1931—Covey A, 26; C, 18; and B, 14. All track counts. Today's was the last good census of the season. Covey A lost a bird possibly from impalement on a sharp twig, so there must have been 27 some time before. This extra bird might be the one recently missing from C, as the cruising radii of the two coveys have been overlapping of late. The bird missing from B was likely taken by a horned owl, as this covey has ranged all winter in the exact heart of a horned owl's favorite territory. Quail tracks at almost every visit were found under the very roost trees of the owl. With such habits it would not be surprising if the covey happened to lose two of their number in the course of three and a half months.

My field observational methods are not represented as being beyond criticism. They are weak in that they do not demonstrate with unquestionable certainty the identities of covey groups. This error, however, I think is negligible where sparse and isolated populations are worked with. Moreover, all major assumptions made as to covey composition and cruising radii are substantiated, so far as they have gone, by contemporaneous banding data. The important advantage claimed for the track-and-flush-count technique is that it approaches the optimum combination of accuracy and practicality for purposes of the winter field work.

Approximately 2650 quail in 155 coveys were located for study during the three winters of the research. Of these birds about 1600 were kept under regular observation, roughly: 400

from October 1929 to March 1930; 500 from December 1930 to March 1931; 700 from December 1931 to March 1932. Particular attention was paid to the influence of food, cover, and predators upon winter mortality. Miscellaneous factors bearing upon the problem were given the consideration warranted by their apparent importance.

The first winter was of ordinary southern Wisconsin severity, with occasional heavy snows and cold snaps; the second was exceptionally mild and open; the third was likewise mild and open except for a belated period of snow and cold weather in March. From the biotic standpoint the winters differed considerably. In 1929–1930 the quail populations were quite low, as their numbers had been depleted by the hard winter of 1928–1929. Quail food was plentiful but much was rendered unavailable by snow or eaten by competing forms, such as seed-eating boreal birds and the meadow mice which were so abundant as to constitute nearly a plague. Strong but not excessive predator populations were noted in many areas. In 1930–31 the quail were conspicuously more numerous than the year before. Food resources were excellent. Cooper's hawks stayed over, and gray foxes were strongly on the increase. In 1931–32 the quail were said to be the most numerous that they had ever been within the memory of most of the farmers and sportsmen with whom I talked. Food resources were intrinsically wretched —due largely to the summer's drought—but the openness of the winter held off the crisis until March. Grey foxes showed a pronounced ascendency.

With the salient characteristics of each winter in mind, let us examine the data. The data pertaining to covey groups will be evaluated as to accuracy: excellent, good, fair, or poor. Covey group data are evaluated upon the basis of degree of isolation and the resultant probability of covey gains or losses through straying birds, the liability to confused censuses attendant upon extraordinary covey shifting, and the frequency and estimated adequacy of the visits. Track and flush counts were both made in a single census, wherever possible. The examples which follow are not in any way hand-picked; they deal with most of the coveys upon which data reliable enough for publication were secured.

Area A—Wingra Wild Life Refuge, Madison

Most of the studies were conducted on an uncultivated tract of around 200 acres in area. Three environmental types were prominent: (1) marshy lowlands grown up to willows, alders, dog-woods, sedges, etc.; (2) unpastured open oak woods, and (3) hazel-brush pasture and fallow reverting to the wild. Adjoining the observational area were a golf course, a lake, a real estate development, and a number of truck farms.

1929-1930

Group I—Data excellent. Two coveys aggregating 37 birds lived under what might be compared to nearly primal conditions. That part of the area frequented by the quail had not been pastured for years, and as a result the forest floor was covered by a stand of tick trefoil (*Desmodium grandiflorum*), a splendid game food plant but one unable to tolerate grazing. The birds had no access to cultivated grain and relied almost entirely upon the trefoil seeds for subsistence. The woods cover was quite inadequate save for some briar patches, and the coveys ordinarily sought refuge in the marsh.

These coveys lost but one bird from the first of December to the middle of February, though one could always see fresh mink and weasel sign in their feeding and roosting territory. Dogs, an alleged grey fox, a horned owl, and redtailed hawks were seen or reported from time to time hunting in the area. Abundant buffer species were meadow-mice and cottontail rabbits. As long as the food held out the quail lived lives of security, despite cold and predators.

However, in the early spring when the trefoil became scarce, due in part to the foraging of ring-necked pheasants, the quail of the combined coveys dropped in numbers from 36 to 23 in a couple of weeks (March 3). As this date, long after the severest weather was over, pronounced weakness was detected in the flushed birds. The surviving 23 then left the refuge, found food and welcome in an adjoining farmyard, and had suffered no additional loss at the final spring census on March 28th.

1930-31

Group II—Data excellent. First complete census of 67 birds (3 coveys numbering 29, 22, and 16) on December 20. The covey of 29 had grapevine, plum, and hazelbrush covers, and fed to a limited extent about a farmer's corn crib. The other two subsisted upon tick trefoil beans in the oak woods, also upon some squirrel-opened acorns and the seeds of hog peanut *(Amphicarpa monoica)* and jewelweed *(Impatiens biflora)*.

Minks and weasels were more numerous than in any other locality studied in southern Wisconsin; their tracks as well as those of dogs were invariably to be found throughout the area under observation. A great horned owl headquartered in the heart of the quail territory (and, incidentally, did something to the weasels); redtailed hawks, marsh hawks, and Cooper's hawks were occasional visitors; infrequent house cat and badger sign was noted. The sanctity of the refuge was commonly violated by human poachers, most of whom centered their attention upon the abundant rabbits.

March 29, 1931, the final census showed 58 quail (26 + 18 + 14), a loss of 9 in 99 days. One was killed by a Cooper's hawk, one by the horned owl, another probably by the horned owl, one very likely by impalement in flight upon a sharp twig (crows had messed up the sign so that absolute diagnosis could not be made), and one was winged by a pot-hunter. Four left no discovered trace, but their disappearance is not necessarily to be attributed wholly to horned owls or Cooper's hawks—not considering the quail with the shot-broken wing.

1931-32

Predators resident: a pair of horned owls, a grey fox, a mink, a few weasels and housecats. Redtails and marsh hawks were seen now and then. In general, the mustelines were below ordinary numbers for the area, probably as a joint result of illegal trapping and the horned owl pressure. Cottontails as usual were very abundant, as were fox squirrels. Hunters continued to disregard refuge boundaries throughout the rabbit season (Nov. 1 to Jan. 1) and were not particular as to what they shot. Indeed, on my first census attempt, Dec. 9, I found where a pheasant had been shot on the fresh snow and some of the quail coveys so badly scattered that a count was impossible.

Group III—Data fair. First passable census of 37 (9 + 18 + 10) on Dec. 9; gain of 3 (9 + 20 + 11) by Jan. 3, probably from a covey known to be on the edge of the area but not kept under regular observation; about 37 again (8 + 18? + 11) Jan. 27; 37 (8 + 19 + 10) Feb. 3; same (6 + 20 + 11) Mar. 1. From here on the history of this group is baffling in the extreme.

On the eve of the cold wave, Mar. 5, the coveys were visited about 4:30 P. M. and found partially scattered. Thirty-three birds (16 +3 + 1+ 13) were searched out and flushed, to scatter still more, most of them alighting in plum thicket and fencerow brush. The snow was drifting a couple of feet deep in places. The birds were apparently strong, having been feeding on sweet corn all winter.

This group was not revisited until March 16, when only about 25 living birds were found, but quail remains were everywhere in the brush. There were feather piles corresponding to at least 7 dead birds. The evidence did not indicate death by violence; neither did it indicate death by either cold or starvation (these birds were all well fed and two had died with crops full of sweet corn). Did these birds, scattered shortly before dark, become individually drifted over to smother? It is not known whether the mortality had occurred all at once or had been dragged out over several days. The last censuses (Mar. 19 and 22) showed but 17 birds, in the most excellent condition.

Group IV—Data good. Good census Jan. 4 of 33 birds (11 + 13 + 9). These were the birds corresponding in location to those that relied upon trefoil in 1929-30 and 1930-31. This season, however, the pheasants made short work of a rather scanty trefoil crop, and the quail soon deserted the woods in favor of the marsh, except for occasional forays after hog peanut and squirrel-opened acorns. Smartweed and jewel weed in the marsh seemed the staple quail foods for the main part of the winter. By Mar. 5, the count was 31 (23 + 8); on Mar. 11 when the cold had moderated there were 29 (21 + 8). Mortality traced: one bird retrieved from a horned owl pellet.

AREA B—UNIVERSITY HILL FARM, MADISON

This was a food and cover experimental area. The studies were restricted to about a quarter section of land mostly under cultivation or in pasture, with the exception of three medium-sized woodlots and a couple of patches of brushy waste ground. In general, the cover was of fairly good quality and well distributed with respect to food sources.

1929-30

Group V—Data poor. The quail population on this area vacillated a great deal from October to March, due to constant ingress and egress of outside coveys. Only one covey (12 birds on most visits) could be termed truly resident all winter, but temporary concentrations up to 50 were noted, undoubtedly attracted from the edges of the area by the excellent supply of corn, wheat, and sorghum always available. Regardless of disappointing censuses and the confusing activities of most of the coveys, it is thought that the mortality was negligible except in one instance. Six birds of a covey of 7 were flushed one cold morning (18 below zero F.) from their warm roost on a steaming manure pile; the seventh, in the finest of flesh, was picked up frozen to death, the insulating value of its feathers ruined by moisture. This is the sole record I have of a well-conditioned bobwhite freezing. The six flushed birds disappeared at this time from their regular territory, presumably to chill and succumb also.

Important predators commonly on the area included several weasels, dogs, and housecats, a large mink, and a redtailed hawk. Meadow mice were very abundant, cottontails fairly so.

1930-31

Group VI—Data excellent. There were 47 quail in 2 coveys (22 + 25) on January 6; likewise 47 (19 + 28) on March 17, a perfect survival over a period of 70 days. The birds chose to feed regularly upon ragweed in the small grain stubble, but with promptness headed for the corn shocks (erected as feeding stations) whenever snow accumulated to any appreciable depth.

Short-eared owls and a redtailed hawk stayed in the midst of the experimental area all winter, the redtail sometimes perching a hundred yards or less from the quail. Roughlegged hawks and marsh hawks went through from time to time. The area was incessantly overrun with dogs, which, while they did no discernible damage, kept wild life in a state bordering upon turmoil. Some evidence of badger, housecat, weasel, and barn rat (in the corn shocks) in early winter. No buffer species were present in unusual abundance.

1931-32

Group VII—Data excellent. There was in early December an estimated population of between 35 and 40 quail in a woodlot on the experimental area, but a heavy influx of pheasants apparently caused them to leave their territory and establish themselves elsewhere. The Hill Farm was also shot over by hunters not especially law-abiding as the discovery (according to Mr. Zerbel, the foreman) of 4 pheasants killed or wounded by them betrayed; it is very probable that the quail were not spared either.

First satisfactory census Jan. 9, of 26 quail (16 +5 +5). The larger covey lived on corn picked out of a huge manure pile; the two smaller ones upon pigeon grass seed and locust beans. No change in numbers up to Jan. 26, but shortly afterwards one of the small coveys left the area. When the March snow cut off its usual food (locust beans), the resident covey of 5 was forced to corn shocks placed as feeding stations 3 months before, but the pheasants had exhausted the corn available from the outside of the bundles. Thus the 5 found themselves in serious straits. On Mar. 10 one bird was dead on the roost and the remaining 4 were plainly weak. The cold snap broke, and the snow began to melt just in time to save the others. The 16 feeding on corn from the manure pile retained their splendid condition. The corn-fed covey was still 16 and the other 4 on the last census, March 19.

Predators: one and sometimes two redtailed hawks almost always on the area; weasel, skunk, dog, and housecat sign common; mink sign frequent.

Area C—North of MacFarland

This area was about two square miles of low, flat farming country, in which the quail seem to be kept down more by pot-shooting rabbit hunters in the fall than by environmental deficiencies. The cover was of marsh, fencerow brush, and part-pastured woodlot types, not particularly well distributed. Corn shocks were commonly left out, though not always where they would be of much utility to bobwhites.

1929-30

Group VIII—Data fair. Thirty-two quail in 3 coveys (5 + 10 + 17) on Dec. 7; 23 (9 + 14) on Feb. 4. The covey of 5, attempting to live upon a failing source of ragweed seed, apparently died of hunger (remains of one bird found). The others sooner or later established themselves in a field of standing corn and thus averted starvation losses, though 3 were known to have been killed in a two day snow storm by a wintering marsh hawk. There was some evidence that the marsh hawk may have gotten 2 or 3 more birds in the spring, but the late censuses were too unreliable to count for much. Predators in the area besides the marsh hawk included a pair of long-eared owls, and numerous short-eared owls, redtailed hawks, and weasels.

1930-31

Group IX—Data good. Twenty-one quail on Dec. 27; 20 on Feb. 19. Food was seeds of ragweed and smartweed. The birds almost ignored a field of standing corn, easily available to them. The predator population was quite low except for redtails, dogs, and cats, with infrequent weasel and horned owl sign to be seen.

Area D—West of Pine Bluff

Save for a roughly outlined square mile where the studies were carried on, the general environs were almost quail-less. In this area, which typifies much of the non-glaciated south-west quarter of the state, a scarcity of winter food may be considered an ordinary environmental phenomenon. The cover was of highest quality, i. e., grapevine, haw, and plumbrush and tangled masses of vegetation, both in woodlots and along fencerows.

1929-30

Group X—Data good. Two neighboring coveys of 18 each (A and B) living about three-quarters of a mile apart were located in late January. Their earlier history is unknown. These, to the best of my knowledge, were the only bobwhites in the area.

The first covey (A) managed to glean enough grain from manure, hauled into the fields from a barn, to come through. The second (B) attempted to live on black locust beans and dried wild grapes. The grapes did not last long, and soon the birds had nothing to eat except locust. On a virtually straight—and scanty—locust diet the covey (B) dropped from 18 (January 25) to 11 (February 3), then to 7 (February 12). These 7 birds were so plainly weak that their ultimate demise was considered just a question of days. The cover available to both coveys was convenient and of good quality.

On March 3, 23 quail, in the rough proportion of 20 strong to 3 weak, were counted and flushed at the locusts. It so happened that the first-mentioned covey of 18 (A) disappeared from its former habitat coincident with the sudden heavy influx of birds into the locust territory. Inasmuch as no other birds had ever been seen in proximity to the two coveys, the inference is that the strong birds represented the first covey (A) and that the weak ones represented the remnant of the locust-eating covey of the same original number (B). At the last census, March 27, 22 quail, none of which were weak, still were found in the vicinity of the locusts, all getting along nicely on foods made available by the melting of the snow.

Snowfalls at inopportune times made it hard to determine the exact fate of the birds lost from the locust covey. Crow-picked remains of two were found in roosts, while one was taken by a horned owl. A weasel jumped on a roosting covey, but apparently succeeded in getting nothing save feathers. Other predators, the sign and presence of which were noted in the territory, were grey and red foxes, screech and saw-whet owls, and red-tailed hawks.

The favorite perching tree of a red-tail was situated in the open and about 200 yards from the very spot where the good-conditioned covey of 18 had been in the habit of picking grain out of spread manure.

1930-31

This winter the mammalian predator population was one of the heaviest yet noted—weasels, foxes (mostly grey, a few reds), and hunting housecats. The foxes were noticeably reduced through hunting and trapping by February. There was much skunk sign in warm weather. Of birds of prey, there were three distinct redtails at least partially resident, a pair of horned owls, which nested, rarely a marsh hawk or a Cooper's hawk, one or more barred owls, and an undetermined but fairly large original number of long-eared owls. Many of the latter were eaten by the horned owls in the course of the winter. Buffer species were not especially abundant.

Group XI—Data excellent. Twenty-one birds December 20, 1930; no loss up to last census, February 8, despite habitual hunting of a horned owl in their favorite territory. These quail lived upon acorns and hickory nuts opened by squirrels, supplementing this diet from what ragweed growth they were able to find. They came through strong for the principal reason that the few snows sufficiently heavy to cover the acorns and weed seeds on the ground did not last long—but there were hungry birds two or three times! There was an exceedingly short crop of locust beans.

Group XII—Data excellent. Eleven birds Dec. 20; 10 on March 16. The covey subsisted on ragweed but had easy access to ear corn in the field.

1931-32

The predator population was quite heavy. A pair of horned owls nested, and redtailed hawks were commonly seen. Grey foxes were numerous; housecats and weasels fairly so. A mink came in now and then. There had been some shooting of quail in this area during November.

Group XIII—Data excellent. Eighteen birds (11 + 7) on Jan. 27 feeding on squirrel-opened acorns, hazelnuts and other foods they were able to pick off the bare ground. Mar. 2, after a snowfall, although no losses had occurred (10 + 8), the birds were weakening from hunger and turning to rose hips, poison ivy, sumac and bittersweet berries. More snow, and then the cold. Two birds of the covey of 10 died on their roosts the night of Mar. 5th. By Mar. 22 this covey had dwindled to 4, the birds continuing to starve despite the melting of the snow. The covey of 8, forced by desperation into a farmyard, managed to survive with a loss of only 2.

Group XIV—Data good. First census on Jan. 5th gave 45 birds (17 + 10 + 8 + 10) feeding mostly on ragweed. Jan. 27th showed a gain of 3 (17 + 21 + 10), with the food habits of the coveys remaining about the same except that the covey of 17 was turning to grain-bearing manure and the 21 to locust beans. Feb. 3rd the count was again 45 (16 + 19 + 10). A specimen collected from the locust-feeding covey of 19 (the 10 also feeding on locusts now) was in splendid shape.

By Mar. 2nd there had been a further loss of 3 (14 + 27); Mar. 4th another was missing (14 + 26), and one bird with a crippled leg was collected for examination. Mar. 15, after the cold snap had passed, there were 31 (12 + 19). This later mortality is not due entirely to hunger and cold, for the coveys on the whole remained in good condition. A horned owl was known to get four birds.

AREA E—WEST OF PRAIRIE DU SAC

An area of about 1½ square miles on the Honey Creek bottomlands west of Prairie du Sac was selected for study. The cover as a whole was adequate, of dogwood and alder type, with much natural debris and brush from cordwood cutting piled here and there. The scarcity of utilizable quail food remaining above the snow was probably the greatest factor in limiting the bobwhite population.

1929-30

Group XV—Data fair. Counts of about 17 and 20 were obtained separately on two coveys early in the winter, which censuses were not indubitably confirmed until Jan. 4th. These coveys were chosen for observation because it was apparent from the beginning that they would starve on the meagre ragweed and smartwood available. On Dec. 24 the tracks of the larger covey revealed that the birds had travelled that day in an irregular circle one and three-quarters miles in circumference, bunching up to roost within 80 yards of their starting place. Along their route they had pecked at every conceivable object that might yield them nourishment. Practically all the food they had procured was ragweed seed from a stubble field, but the ragweed growth was wretched and the virtual end of that source of supply in sight. Two specimens collected were down to 177 and 135 grams, the latter dangerously light.

February 1, of the two coveys, 12 birds were seen to be taking advantage of a farmer's corn crib, while only 4 remained of those trying to live independently. Of the latter 4, a redtail ate 2 in the course of the morning. The first was picked up while shelling out the sweet clover seed of a roadside—and sweet clover seed appears never to be eaten in quantities except as a last resort, starvation food (Errington, 1931b). The second had made the stubble field and was wandering amid the barren ragweed stalks when the redtail arrived. The quail flew only 30 to 35 yards before dropping exhausted to flutter along in the snow toward a brush pile.

By February 16, no birds were left except the 12 feeding around the corn crib. These 12 had suffered no loss, nor did they during the rest of the winter, despite the fact that they were compelled to journey 300 yards in the open from their brushy cover to the corn crib and likewise compelled to dodge a yardful of dogs and cats after they got there. But neither the dogs nor the cat caught any, nor did the red-tail, to the attacks of which they were exposed as well as the other quail had been. The birds had alertness, tone, and the ability to fly swiftly and far when they needed to. They had food.

1930-31

A mink, some weasels, skunks, barred owls, and short-eared owls represented the permanent winter predators; red foxes, housecats, horned owls, redtails, and Cooper's hawks came in from elsewhere now and then. As a whole the predator population was diffuse and transient despite the semiwildness of the Bottoms.

Group XVI—Data questionable because of suspected presence of quail other than those under observation. Two coveys totalling 23 birds (14 + 9) on Nov. 25; by Jan. 8 the covey of 14 had been reduced to 10, thus leaving 19 altogether. Feb. 9th there were still 19 birds, though one apparently had changed coveys. Regarding the 4 presumably missing, circumstantial evidence was found that one had been caught by a horned owl and that another had been pot-shot. Food—ragweed and smartweed.

Group XVII—Data excellent. Twenty-five birds Dec. 24; 24 on Jan. 20; still 24 on Mar. 15. Ragweed, waste rye, and grain from manure comprised the food of this covey.

1931-32

Group XVIII—Data fair. Combined figures from separate covey counts gave 71 birds (16 + 20 + 35) for early December, with one small covey located but not censused. A farmer reported the finding of an intact bird dead in a field, likely shot, in view of later evidence. By Jan. 11th a census of 78 (16+20 + 21 + 14 + 1 + 6) was obtained, probably correct within a bird or two. A track and flush census of 77 (16 + 21 + 17 + 19 + 4) birds was made Mar. 3, and one kill by an unknown predator was discovered. At the last census only 35 birds (13 + 18 + 4) could be located, but it is certain that the late cold and snow mortality was not nearly as heavy as this indicates. The 13 were rather plainly the survivors of the former 16 (remains of a dead one found); the 18 occupied a part of the area commonly held by 17; and the 4 were obviously the covey mentioned before. This leaves two large coveys unaccounted for, which, after suffering a limited mortality, apparently left the area. Three jay-picked quail skeletons were found on the night roost of a covey of about twenty, and feathers of another bird were some distance away. The likelihood of these being weak individuals, killed by the cold snap, is hinted by a (shot?) broken and healed tarso-metatarsus among the remains.

These quail were well fed, at least up to March. They had access to a small field of standing corn (which was rarely used by more than one covey at a time), a limited acreage of soybeans (more or less exhausted toward spring by a flock of about 40 prairie chickens), grain spread in manure, three stubble fields with fair ragweed growth, and smartweed seeds and rodent-opened hazelnuts in the bottomlands. The predator population for the area was quite high. Redtailed hawks were often to be seen and one had only to enter the creek bottom woods to flush barred and sometimes horned owls. Mammalian predators were housecats, grey foxes, minks, weasels, skunks, and an otter.

Area F—East of Pine Bluff

Area of about a square mile in partially wooded dairy community in which not all woodlots were heavily grazed. The cover can be adjudged good, being distributed generally on hillsides as briar patches, oak suckers, and slash.

1929-30

Group XIX—Data fair. Two neighboring coveys (25 in all) were first noted, Jan. 23, feeding in a clean-picked field of standing corn. Some of the birds, presumably fortunate enough to find missed nubbins with some regularity, retained sufficient vigor to make strong sustained flights. Others did not fare so well.

Weak birds were to be seen, two of which were caught by hand for specimens. From Jan. 23 to February 3, 7 quail were found dead on their roosts, which quail were in poor flesh, their crops and gizzards containing little of nutritive value. On February 12 only 11 birds could be counted, but this figure perhaps does not show the exact mortality. There was a possibility here that some of the missing birds might have joined one of the outside coveys not kept under close observation. Considerable drifting of coveys was noted about this time, which may be ascribed to the widespread increasing scarcity of natural food (ragweed seed). At any rate, whatever the likelihood of inaccuracies, 7 underweight birds dead on separate roosts and 2 more captured in a semi-helpless condition by hand, gives one something of a mortality index.

Important predators were a redtail, a mink, weasels, gray foxes, and housecats.

1930-31

Predators were gray and red foxes (much persecuted by hunters), weasels, a mink, a huge feral house cat, a horned owl, a redtail, and perhaps a Cooper's hawk (latter not seen—sign only).

Group XX—Data fair. Thirteen birds December 20; same on January 22; 11 on February 12. Two missing in 54 days, one of which was almost certainly killed by the horned owl. This covey lived on ragweed.

Group XXI—Data fair. About 25 birds (exact census not obtained) on December 20; 23 on March 16. Of the 2 (?) missing, one was apparently picked up by the horned owl. The covey was usually to be found in a field of standing corn, exhibiting, however, a preference for ragweed.

1931-32

Predator sign most evident was that of mink, grey foxes, weasels, and housecats. A redtail was usually to be seen, and marsh hawks passed through occasionally.

Group XXII—Data fair. Fifty-four birds (17 + 12 + 5 + 20) on Jan. 4, of which the first three coveys were feeding in two fields of unpicked corn and the fourth mainly upon ragweed and buckwheat. One month later only 45 (17 + 15 + 13) were to be found. The covey of 20 in particular seemed to have suffered heavy mortality, being reduced to 13, one of which was a cripple. The latter, collected, proved to have a wing possibly broken by a shot; this provides one explanation as to how 7 birds could suddenly disappear from a covey without leaving conspicuous evidence. The coveys (17 + 15 + 12) lost 2 birds (16 + 14 + 12) by Mar. 4, at which time they were all feeding upon corn. Three more birds were lost (22 + 17) up to Mar. 22, during the severe spring cold and snow. There was reason to believe one of the missing quail to be in poor shape from injuries.

AREA G—EAST OF PRAIRIE DU SAC

This tract might be described as ordinary south central Wisconsin farming country. The Wisconsin River and timbered ranges of hills enclosed an area of about 5 square miles. The river and hills served more or less efficiently as barriers to prevent resident coveys from mingling with those outside. In 1929-30 the bulk of the work was done in the central 3 square miles of the area, of which the quail actually occupied about 5 quarter sections; in 1930-31 and 1931-32 the entire area was covered. With regard to the area as a whole, cover was deficient, good in places. Some woodlots, badly overgrazed, were of value to the quail only on account of random patches of creeping juniper or a few brushpiles. Cover along fencerows was of great utility.

1929-30

The winter predators regularly active in the central area, as nearly as could be determined, were one or two horned owls, at least one barred owl, several screech owls, 3 redtails, and a rather sparse population of grey foxes and weasels. Dogs and cats occasionally left farm yards to hunt in the woods and fields. Buffer species were not especially abundant except for the meadowmice, the latter of which enjoyed the protection of 6 to 18 inches of snow during part of the winter.

Group XXIII—Data excellent. Seven coveys totalling 106 birds (22 + 8 + 26 + 14 + 17 + 11 + 8) occupied the area at the beginning of the winter (about Dec. 1); 101 (22 + 8 + 24 + 15 + 10 + 22) had come through up to about Feb. 15. One of the missing birds was picked up by a horned owl. Of the 7 coveys, one wintered on ragweed seed and shocked corn; one on ragweed and cribbed corn; three on ragweed, soybeans and cribbed corn; and the seventh (a small one of 8) lost its identity as a covey by joining up with the others.

The splendid survival of these coveys, all of which had ample food, is a significant contrast to the mortality suffered by less favorably situated coveys contemporaneously studied. Like the 12 birds of the Honey Creek Bottoms (XV) which escaped in an intact group the complete disaster that overtook two-thirds of their original number, the wintering of 101 out of 106 Prairie du Sac birds illustrates the role of food in maintaining the fitness requisite for survival. Theirs was the vitality to stand cold, to take punishment. Theirs was the elusive quickness and the stamina that enabled them to move when and where they had to.

1930-31

Resident in the central 3 square miles of the quail country were 10 gray foxes (calculated on the basis of track and den studies), about 6 weasels, some feral house cats. There was a high representation of skunks and raccoons active on warm nights; once in a while a venturesome red fox from outside. Avian predators were 2 pairs of redtails, 2 pairs of horned owls (nesters), a pair of barred owls, screech owls, long and short-eared owls, Cooper's hawks, and passing roughlegs. These predators were subjected to slight molestation by man, and their number appeared to diminish little during the observational period except for the small owls preyed upon by the horned owls, and two foxes (red and gray), a housecat, and 3 or 4 skunks taken by trappers.

Group XXIV—Data excellent. Seventeen birds December 22; same on March 15. Redtail lookout trees 30 to 150 yards from the favorite range of the covey. Food—ragweed and waste wheat.

Group XXV—Data excellent. Twenty birds December 22; same on March 30. Covey observed to be attended and scattered by Cooper's hawk. Food—ragweed, smartweed, and ear corn.

Group XXVI—Data excellent. Sixteen birds Dec. 23; 13 on Feb. 28. One killed by Cooper's Hawk (?), one collected for specimen, and one missing. This covey lived upon ragweed, but had to feed much in the open.

Group XXVII—Data good. Forty-eight birds (9 + 15 + 24) on December 21; 47 (28 + 19) on March 14. One killed by Cooper's hawk and one collected in 83 days. Influx of one, and possibly two, from XXVIII. The three original coveys soon coalesced to form two; the larger (varying between 27 and 30) feeding upon sweet corn, ragweed, and smartweed; the smaller upon ragweed and some sweet clover seed. Sweet clover seed has been shown experimentally to be of exceedingly poor quality as a food (Errington, 1931b). The coveys in this group were persistently harried by Cooper's hawks, but thoroughly "hawk-wise"; in spite of careful searches only the one kill was ever found.

Group XXVIII—Data fair. Twenty-three birds December 21; same on January 25; six missing by February 9, of which one and perhaps two joined XXVII. One was evidently killed by a Cooper's hawk, one was pot-shot, and two or three were unaccounted for, not improbably pot-shot also. From February 9 to March 15 this group retained approximate numbers (no good census after February 9). Birds had access to corn in shock but elected to feed upon ragweed.

Group XXIX—Data good. Ten birds December 21 to February 9, then a gain of one bird from somewhere. Covey observed to be attended and scattered by Cooper's hawk with no loss. Food—soybeans and ragweed.

Group XXX—Data good. Twenty-four birds December 22; 20 on February 1. Loss of 4 in 41 days of which one was evidently killed by a horned owl, one by a Cooper's hawk, and two were unaccounted for. No additional losses apparent up to March 15, although the concluding censuses were too inferior to justify definite statements. Food—squirrel-opened acorns in woods, some ragweed, smartweed, and soybeans.

Group XXXI—Data good. Sixty-two birds (16 + 15 + 31) on December 21; same (10 + 24 + 16 + 12) on February 1. This shows no loss for 42 days, but it must be said that ephemeral snows and a continual splitting and recombining and erratic behavior of coveys caused the dropping of census work too prematurely to ascertain a later mortality. The coveys were confined to an area of about a quarter section between and adjacent to a couple of horned owl nests containing hungry owlets. Consequently, 4 of these convenient quail were known to feed young horned owls during the month of March.

The quail of this group depended upon ragweed and soybeans, for which they were compelled to forage much in clean corn stubble. There were no indications of Cooper's hawks becoming troublesome, but likely because of their chance failure to run across the unduly exposed quail rather than because of any intrinsic security in the latter's position.

1931-32

The census work in this area for 1931-32 was done by Mr. Albert J. Gastrow, of Prairie du Sac, a veteran outdoorsman who not only had been an intimate field associate of Stoddard's but has been of the greatest personal assistance to me in my own studies the two years previously. As my usual companion on field trips about Prairie du Sac throughout the investigation, he, of course, was familiar with my methods long before he was engaged for the season's work. His familiarity with the area in which he was reared and in which he has hunted and trapped all his life was of incalculable advantage. I am then quite ready to vouch for his work as being accurate within reasonable expectations. I also spent enough time at Prairie du Sac the past winter to keep in touch with current developments.

The data from this area are of special interest as the quail population was seen at the start to be top-heavy for the carrying capacity of the land. Coveys stationed themselves in territories lacking food, cover, or both, for no apparent reason other than to relieve the congested condition of better quarters. These unfavorably situated birds were exactly the ones for which severe mortality was predicted—and the predictions were amply fulfilled (see XXXII and XLII). In general the food supply was short, notably the ragweed, but the food, whatever there was, remained available until covered up by the March snow. This statement refers to the birds living independently; those that fed in farmyards all winter didn't feel much of a hunger pinch.

To make the situation of greater significance, in addition to possessing an over-population of bobwhites faced with a food shortage, the area had an unusually high representation of predators, particularly grey foxes. The best calculations gave 21 of the latter for early winter, of which at least 4 were later killed by hunters. No red foxes were resident but 2 were noted to have gone through. There were about 10 weasels, one mink, and a great many skunks. Housecats, too, were numerous and active. Cooper's hawks were seen a few times but they didn't seem to do much to quail. Marsh hawks were recorded quite often, as were short-eared owls. Raptors apparently resident were 2 pairs of redtailed hawks, 3 pairs of horned owls, some barred and screech owls.

Inclusive of 3 coveys (18 + 15 + 19) on the border of the area concerning which data were not thought to be sufficiently reliable to discuss (on account of mingling with uncensused outside birds), the best calculations to be made from early censuses give exactly 400 birds as the area's bobwhite population for about Dec. 1. Of these, 348 birds were in the regularly censused coveys. These 348 dropped to 261, a loss of 87 or 25% in the space of about 4 months.

Group XXXII—Data excellent after Jan. 10; prior to this date, fair. This was one of the coveys that seemed to have no place to go. Its movements were rather satisfactorily traced in gradual stages for nearly a mile and a half from the place where it was first noticed, Oct. 30, to the place where it established itself permanently about New Year. The final territory of the covey was far out in the open, very deficient in cover except for a little brush along a couple of fence rows. Soybeans in corn stubble constituted a good food resource, doubtless the primary reason for the the covey's selecting such a hazardous location. I cannot explain, however, why these birds left far better balanced territories that they passed through, save on the grounds that the others were already quail-occupied.

The best early count was about 26 on Dec. 18. On Jan. 10 the number was 23; Jan. 16, 22; Feb. 3, 16; Feb. 10, 13; Feb. 25, 8; Mar. 3, 7; Mar. 12, 4; Mar 23, 2. This shrinkage represents mortality, not departure from the area, as evidence of kills was scattered all over the place. Most of the depredations were traced definitely to horned owls, though some may have been due to a Cooper's hawk seen here or possibly to 3 grey foxes which ranged the covey's roosting territory by night. There is evidence that night flushes (likely by the foxes) were instrumental in exposing the birds to the horned owls, at least during January. I don't know if the owls eventually learned to hunt for the roosting quail or not—probably not. The story told by the snow and contemporaneous owl pellets was that the horned owls were sitting on fence posts looking for mice, and incidentally picked up quail that happened to draw their attention by movements in the night.

Group XXXIII—Data excellent. Two coveys were feeding about the corn cribs of two neighboring sets of farm buildings. A count of 18 was obtained on one covey Dec. 18; one of 14 on the other, Dec. 22. These numbers held constant despite frequent coalescences until Feb. 10 when the arrangement was 15 + 17. The last census on Mar 23 gave 9 + 23. Regardless of fluctuations in numbers of the two coveys it was to be inferred that the group came through the entire winter without loss, a point of some significance, for the group headquartered on the same wooded bluff occupied by the horned owls that wrought such havoc upon Group XXXII.

Why did the horned owls virtually annihilate group XXXII located a half mile away, yet do no damage to XXXIII, the birds of which frequently worked within 100 yards of the owl nest? I have some theories but I don't know. The difference in vulnerability may be linked with differences in cover, as group XXXIII had access to splendid brush piles (but *night roosts* in the open are commonly safer than those in the brush); or the difference may have to do with the absence of disturbing grey foxes so near the farm buildings (but there were dogs and cats). Anyway the birds with the correct food and cover balance were the ones that survived.

Group XXXIV—Data fair. Count of 19 on Nov. 1; 14 on Dec. 9 when 5 birds apparently joined XXXV. In January the covey dropped to 11, coincident with a gain of XXXVI. Ten birds Feb. 17; 9 on Feb. 27; still 9 on

Mar. 16. The latter missing birds probably represent horned owl mortality. Food—soybeans, with some ragweed, smartweed, and lambsquarter.

Group XXXV—Data poor. Uncensused covey of more than a dozen birds Nov. 10. Twenty birds Dec. 18, a decided gain at about the time that the neighboring covey XXXIV lost 5. Seventeen on Feb. 9; 16 on Mar. 17. A horned owl nearby was known to get one and possibly more quail, presumably from this covey. Food—ragweed and cribbed corn.

Group XXXVI—Data fair. Twenty birds from Oct. 24 to Dec. 21. By Jan. 7 the covey had gained 4 birds, apparently some from XXXIV, though not inconceivably one or two from XXVII. From this date to Feb. 3 the record is very sketchy. The covey dropped to 18, evidently due to the depredations of horned owls; one of the missing, however, was killed by traffic, another flew into a telephone wire to suffer unknown injuries, and on another occasion somebody was seen to shoot beside the road just where this covey was. Track and flush counts of 18 were obtained from Feb. 3 to the last census Mar. 17, though the presence in the territory of a bird with a broken wing is unexplained. Food—soybeans and seeds of a mallow (*Hibiscus trionum*).

Group XXXVII—Data good. About 26 on Dec. 17. On Dec. 21 there was a strong evidence that poachers had found this covey and had reduced it to 22, the count obtained Jan. 4. This number held, with minor fluctuations until Mar. 2, when 21 were counted. There were 19 at the last census Mar. 15. The latest mortality may have been due to the March cold eliminating a couple of birds weakened from some cause, as appeared true for other coveys. Food—wild hemp seed (*Cannabis*) and squirrel-opened acorns in the fall, acorns during early winter, ragweed and smartweed in mid-winter, corn from farm yards in February and March.

Group XXXVIII—Data good. About 35 birds in 2 coveys (15 + 20) Nov. 25. The covey of 20 was inclined to break up into 12-8 and 13-7. On Feb. 4 the count was the same though one had died of steel trap injuries. The indications were that one bird had joined from XXXIX and another from XL. By mid-March the count was 30 (11-5-14), the rather sudden drop of about 5 birds in early March possibly being explainable in terms of under-par birds caught by the cold, as in the next group. Food—pigeon grass seed, acorns, ear-corn on the ground.

Group XXXIX—Data excellent. Total of 23 in two coveys (16-7) on Nov. 3; repeated censuses showed the same number until Jan. 28, when the count was 21. One of the missing two had been collected by myself; the other may have joined XXXVIII. By Feb. 3, however, another was gone and the count remained 20 or 10-10 up to Mar. 10. About this time the covey, which had kept in good condition on a poor food supply by incessant foraging, began to feel the pinch. The last census on Mar. 21 gave 19 somewhat weak birds, and one was found starved and frozen.

Group XL—Data fair. Covey of 17 first censused on Jan. 8, though its presence had been known for some weeks. One bird was caught in a steel trap Nov. 15. Feb. 4 the count was 16, but one bird was thought to have joined XXXVIII. By Mar. 4 the covey was down to 14; to 13 by Mar. 18.

A redtail was much interested in this covey in early March, but no concrete evidence was unearthed that he got any. Birds fed mostly upon ragweed and smartweed, occasionally in a farmyard with XLI.

Group XLI—Data good. Eleven quail (10 young and an adult male) on Oct. 24 were feeding habitually in a farmyard. Feb. 4, 9 birds; Mar. 4, 8; Mar. 21, 7. Fate of the 4 missing birds unknown.

Group XLII—Data good. Uncensused covey of between 20 and 25 on Nov. 12. Good count of 24 on Jan. 11. The food situation had grown increasingly critical by February, the quail living mainly upon smartweed, acorns, and dried insects. The covey too seemed quite inadaptive. On Feb. 4, 18 were to be counted, and remains of a dead one were discovered under a brushpile. Thirteen very weak birds on Mar. 11. Eleven on Mar. 14, of which the strongest of 3 birds I was able to make fly was collected (wt. 139 grams).[2] Scattered remains of a dead one also found, and the intact carcass of a bird that had died (wt. 85 grams). The 10 survivors had dwindled to 8 (remains of another found) by Mar. 21.

Group XLIII—Data fair. Count of 20 Nov. 7; 25 on Jan. 10. It seems reasonable that the influx came from XLIV which was reduced by a half dozen birds some time previously. The covey gradually went down to 21 by Mar. 19. A Cooper's hawk was working in here and probably got some of them. The birds were corn fed but they ranged far out in the open.

Group XLIV—Data fair. Good count of 24 Nov. 16; 18 on Jan. 16. In the fore-part of January the nearest covey (XLIII) gained 5 birds, probably those missing from this group. The 18 kept their numbers until March, despite known visitations to their territory by Cooper's hawks. The cover was excellent (dense mats of creeping juniper) but rather far (200 yards) from the corn shocks in which the quail fed. The birds usually flew this distance. Everything went well until the corn shocks were hauled in and the March snow covered up the feed on the ground. By Mar. 22 the covey had dropped to 13 and these showed weakness. Twelve birds April 6.

Group XLV—Data fair. Between 20 and 25 birds, Nov. 12; 23 from Jan. 3 to Feb. 18; 21, Mar. 11. Food—popcorn, ragweed, and pigeon grass, mainly the former.

Group XLVI—Data excellent. Thirty-three birds in two coveys (21 + 12) feeding with chickens in a farmyard from middle of December on. Same number (19 + 14) on last census Mar. 23.

Area H—Wisconsin River Bottoms, North of Mazomanie

This observational area was in the form of a narrow strip of land (about 400 acres) between the Wisconsin River and the marshy haylands of the Bottoms. The tract was partially under cultivation, partially grown to open oak woods. Dense tangles of vegetation occurred here and there, particularly along dry water courses. Thickets of prickly ash

[2] The normal winter weight of a Wisconsin bobwhite is around 200 grams (see Errington, 1931b).

(*Xanthoxylum*), plum, willow, and dog-wood and scattered brush piles furnished good quail cover generally, though not always near the best food sources.

1931-32

Predators: an ever-present wintering marsh hawk, occasionally a red-tail and a bald eagle, an unknown representation of horned and barred owls, numerous housecats, dogs, and skunks.

Group XLVII—Data good. The best censuses I was able to get from Jan. 7 to 11 totaled 90 birds in six coveys (21 + 13 + 11 + 18 + 20 + 7). Unsatisfactory counts Feb. 5 indicated a population of between 83 and 87. Three birds were known to be missing—one collected for specimen, two killed on fresh snow by unknown raptor, likely by the marsh hawk which was displaying an interest in some of the covey territories. The specimen was in excellent condition. Altogether, the coveys were getting along well, feeding upon climbing buckwheat along the water-courses, ragweed in a fallow field, and squirrel-opened acorns and hazelnuts in the brush. Up to the last of February there had been no heavy snows to cut off the food supply.

However, the March snow brought famine; the famine and the cold brought death. By Mar. 14 the population for the area had dropped to 22 feeble-flying survivors in three desperate coveys (7 + 7 + 8); by Mar. 20 the 22 were down to 15 (1 + 6 + 8). Fifteen dead birds were located in a hasty survey of the area. Thirteen of these had died on roosts and rests (2 carcasses were intact and told unmistakably the story of starvation); the other two (one of which, too weak to fly at all, had fluttered along on top of the snow for 14 paces in an effort to gain cover) had been caught by the marsh hawk.

Group XLVIII—Data fair. Covey of 17 Jan. 9; same number Mar. 20. Food—smartweed and grain about farmyard.

From the data it is to be perceived that quail losses may show all gradations from slow leaks to comparatively sudden annihilations. Groups XV and XLVII illustrate how the latter may come about. Starvation is one type of mortality that sweeps away populations built up in unusually favorable years past the true carrying capacity of the land, the "irruptions" of Leopold (1931); as a mechanism it is obvious.

Far from satisfactory evaluation yet is the role of drifting snow as a mortality factor. The fixed opinion of the public seems to be that quail are almost wiped out over large areas by imprisonment under drifts. Doubtless coveys do die under drifts, though I have never encountered certain evidence of this personally. Do imprisoned coveys smother or starve? How hard or how deep must a snow drift be to prevent strong bob-

RELATION OF FOOD, COLD AND SNOW TO WINTER QUAIL LOSSES

SOUTHERN WISCONSIN, WINTER OF 1929-30

Snow (in inches)	November 1929	December 1929	January 1930	February 1930	March 1930
During month	0.8	3.0	17.6	1.9	5.9
On ground at end of mo.	0.0	trace	8.3	1.0	trace

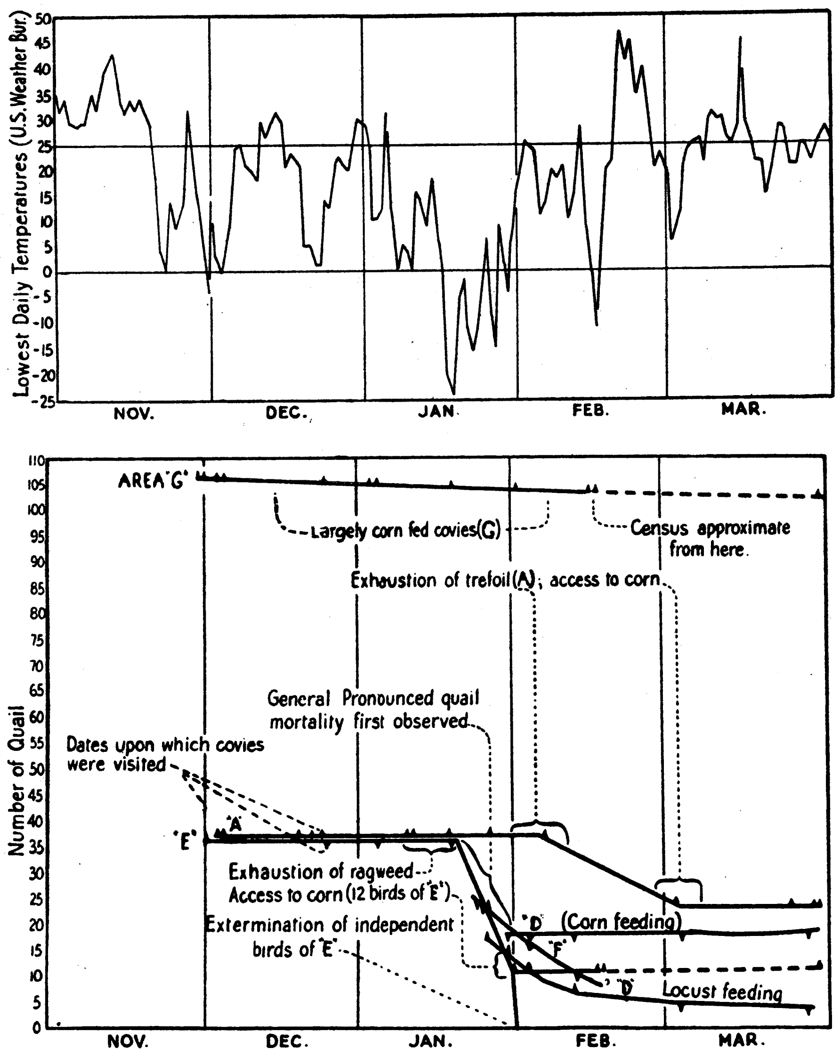


FIG. 1.

whites from breaking through? What is the role of sleet, apart from covering up the food supply?

The role of disease and parasites? Stoddard (1931) found the wild bobwhite a very healthy bird. Green (1929) has reported a natural case of tularemia for the species. Two of my specimens (of about 150 collected in the wild) had cecal pouches that looked tubercular, but the nodules could not be positively diagnosed. Four more wild birds had *Dispharynx* but only one case could have been at all pathological. Four also had varying numbers of roundworm larvae (*Habronema*?) encysted in the pectorals. The *Heterakis* occurring throughout my specimens and the occasional *Capillaria* and tapeworms are hardly to be looked upon as being of unusual import. Indeed, I would judge, on the basis of what little evidence I have, that the probable role of parasitic flora and fauna in determining northern bobwhite populations under present conditions is negligible. Granted that now and then an individual bird might become run down sufficiently through an infectious ailment to be eliminated, I see no reason why we should, at this stage of our knowledge, lay particular emphasis on the possibility of epidemics being responsible for wholesale quail mortalities.

Shooting may at times bring about decimation of quail populations that could be described as cataclysmic, especially where massed birds are "pot shot" on the ground (and this is done!), where scattered birds are flushed singly and systematically for shooting by means of a dog, and where the environment is so poor that the quail have difficulty hanging on anyway. Throughout most of my observational areas the shooting of quail (illegal in Wisconsin) seems a lesser mortality factor, though in some localities (south and east of Madison) farmers complain that their attempts to encourage quail almost inevitably come to naught on account of the depredations of hunters.

Known mortality from predators has rarely taken any form in my observational areas other than a gradual leakage of birds over a period of months. By far the most exceptional directly predacious losses recorded for any covey were those outlined in XXXII, according to which 21 quail out of 23 were lost from Jan. 10 to Mar. 23, largely through horned owls. Although I have records of more kills of quail by horned owls than by all other predators together, such does not necessarily mean that horned owls get more than all other predators; it so happens

COMPARISON OF 1929-'30 AND 1930-'31 WINTER QUAIL LOSSES IN IDENTICAL AREAS, SOUTHERN WISCONSIN

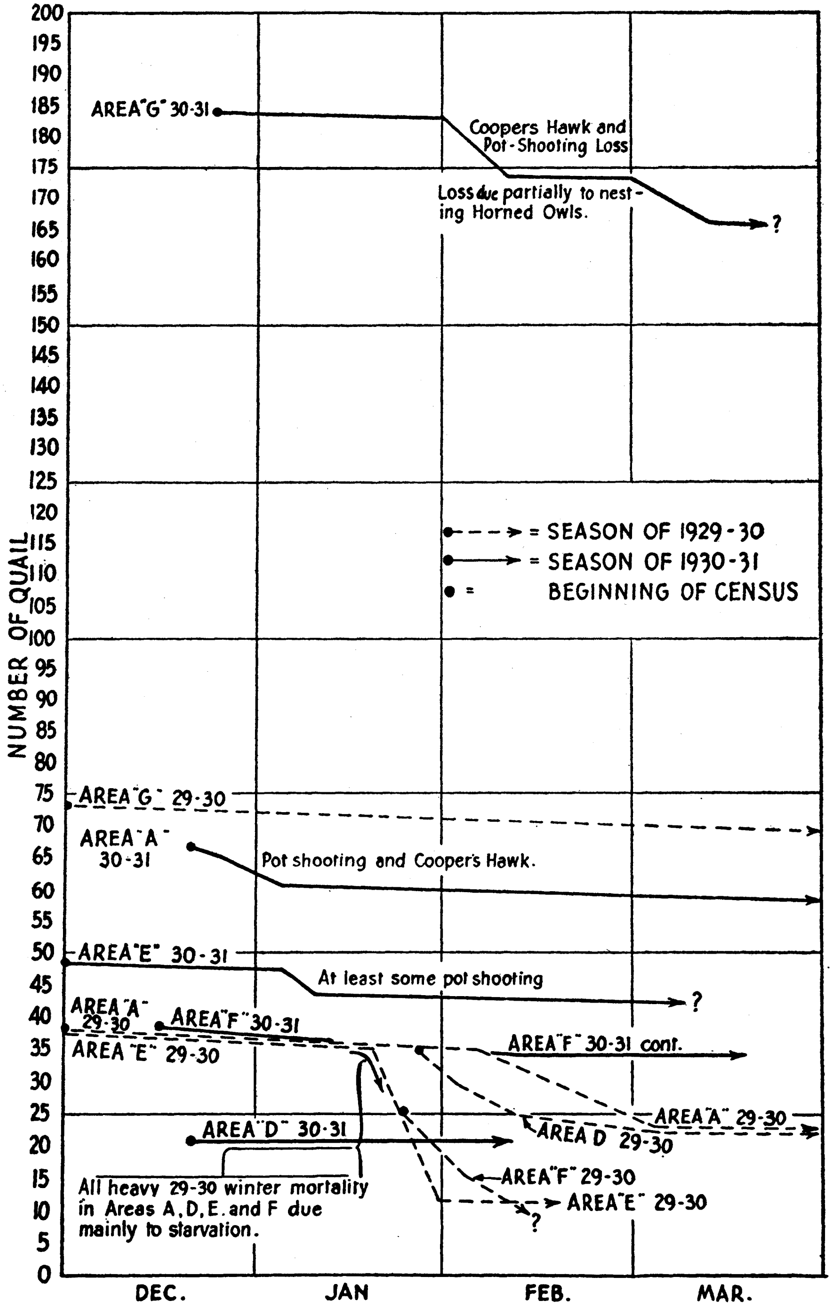


FIG. 2.

that the food habits of the horned owl are easy to check up on; hence the depredations of this species can be expressed numerically while the toll taken by species difficult to study must remain more conjectural.

Second in recorded number only to the quail kills by horned owls are those made by Cooper's hawks. The large, soaring red-tailed hawk is a prominent feature of the winter landscape but he gets few quail except birds already doomed from various causes. Quail so poor in condition that they could be picked up by this slow, clumsy raptor, built to prey upon rodents, almost certainly would perish anyhow in the next cold snap. A similar remark might apply with somewhat less force to the marsh hawk, for I have known the latter to capture some strong bob-whites (by surprise) along with the weak. I have few save negative data from which to calculate the preying of mammals such as foxes and cats upon quail.

I am coming more and more to believe that mechanical accident is a mortality cause much under-estimated by wild life students, except for traffic accidents the effect of which is probably over-estimated. Of 168 quail banded by the University up to the fall of 1931 (according to Professor Wagner's files) 8 were reported dead through accident (4 in steel traps, 3 squashed by auto traffic, 1 with disjointed wing caught by cat) within an average of less than 8 months after banding. I have notes and reports of quail flying into telephone wires, fences, buildings, and other objects; now and then are collected bruised birds, some with torn ligaments or with toes held on only by twisted tendons. What is the story told by this multiplicity of minor injuries—or are they minor? In the aggregate perhaps they constitute a factor as lethal as any in the life equation of the quail.

To recapitulate, the most significant point brought out in the wintering studies was that, in the main, quail having a sufficiency of good food and fair cover within easy flight distance came through without serious loss. The distinction should be made clear that quail winter mortality is not so much a question of freezing as it is one of starvation. Quail freeze even in fairly mild weather if their vitality is lowered as by hunger, but they can withstand the severest cold southern Wisconsin is likely to have if they are strong and well fed.

RELATION OF FOOD, COLD, AND SNOW TO WINTER QUAIL LOSSES

SOUTHERN WISCONSIN, WINTER OF 1931 - 32

Snow (in inches)	November 1931	December 1931	January 1932	February 1932	March 1932*
During month	T	4.8	3.9	1.4	5.1
On ground at end of mo.	0.0	1.1	T	0.0	0.0

*Heavy snowfall in the first part of March seriously lessened the availability of food for about two weeks

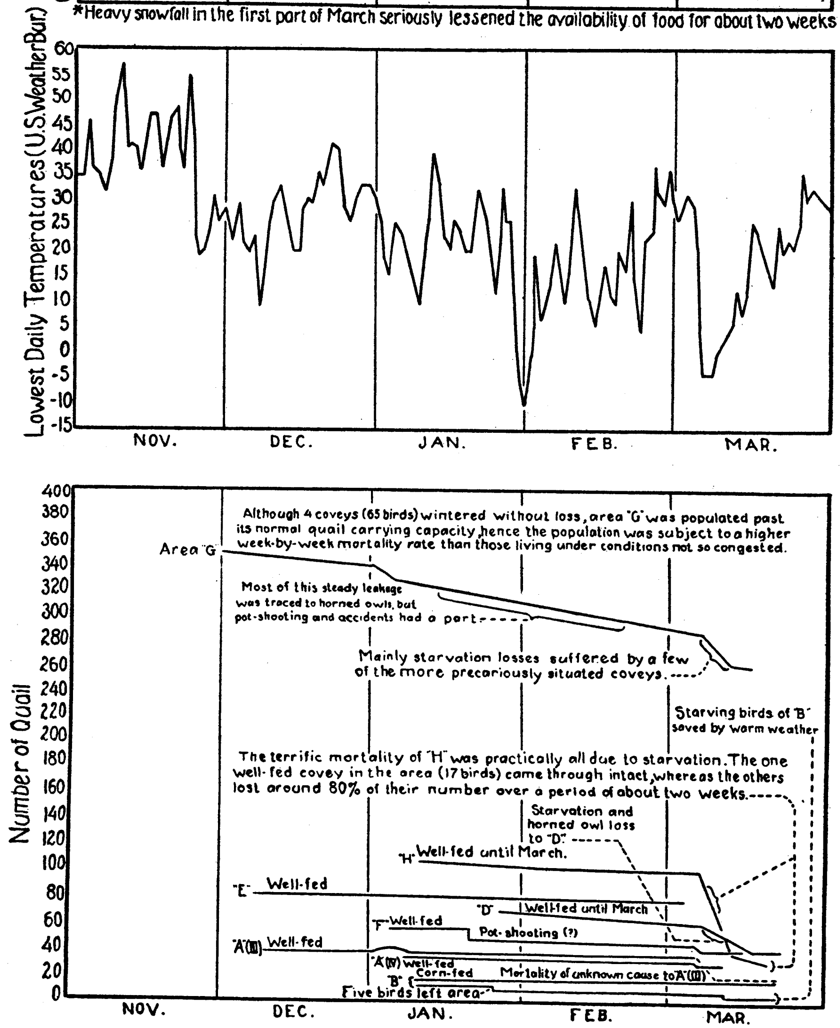


FIG. 3.

Likewise on a reduced physical reserve the species is unable to escape enemies as it should when up to par. This does not ordinarily necessitate campaigning against the usual native enemies, which I regard in reasonable numbers integral to the racial welfare of the bobwhite and other wild life. The best way to protect the bobwhite from predators is to provide cover in which the birds can seek their own safety and to provide food which enables them to reach that cover when they have to. Plump, fit, danger-tempered bobwhites should be equal to looking out for themselves if given an even chance.

Much can be accomplished in quail management merely by the manipulation of the food factor. Beyond doubt the most important quail food for winter *pinch periods* in Wisconsin is corn. Its importance is such that one can nearly estimate a given Wisconsin covey's prospects for wintering on the basis of whether or not it has unmolested access to corn. Other important foods as ragweed and smartweed seeds, soybeans, small grains, etc., have been discussed elsewhere (Errington 1931b).

The most effective feeding station yet observed is the corn shock, in which the corn is always available (unless eaten or filched by pheasants, rabbits, squirrels, rats, or legions of mice) when the birds need it, whether they use it at other times or not. A properly constructed corn shock tied around the top to prevent collapse and with bundles spread at the bottom to give roominess inside and to allow the quail free movement in and out—all directions—is functional for weeks at a stretch, throughout any sleet and snow-storms within probability. Shocks so constructed afford emergency refuge as well as food.

The shocks should be erected and placed near quail-frequented cover in the fall, in order that the birds may become accustomed to them and begin to learn what ear corn is for, if they don't already know. Experiments have demonstrated that quail without previous experience did not know how to open tight-husked ears, but learned either from the example of quail that did know or from increasing familiarity with loose-husked ears having corn kernels in sight at the tips. This education of birds with respect to corn husking under experimental conditions, required in the majority of cases no more than two weeks, ordinarily not that long.

References

Errington, Paul L.

1930. Corn on Cob Saves Wintering Quail. American Game, November-December, pp. 9-12.

1931a. Second winter. American Game, July-August, pp. 56, 60-61.

1931b. The bobwhite's winter food. American Game, September-October, pp. 75-78.

1931c. The bobwhite's winter cover. American Game, November-December, pp. 90-93.

1932. Technique of raptor food habits study. The Condor, Vol. XXXIV, March-April, pp. 75-86.

Green, R. G.

1929. A natural infection of quail by *B. tularense*. Proc. Soc. for Exper. Biol. and Medicine. Paper 4429, Vol. 26, pp. 626-627.

Leopold, Aldo.

1931. A report on a game survey of the north central states. American Game Association.

Stoddard, H. L.

1931. The bobwhite quail.

Wight, H. M.

1931. Quantitative methods in upland game bird investigation. The Auk, Vol. XLVIII, No. 4, October.

PRELIMINARY LIST OF THE HYDRACARINA OF WISCONSIN

PART III

RUTH MARSHALL

Parts I and II of the *Preliminary List of the Hydracarina of Wisconsin* (Marshall, 1931, 1932) recorded thirty-one species belonging to sixteen genera. The present paper adds twenty-two species belonging to the two large and closely related genera, *Unionicola* and *Neumania,* of the family *Hygrobatidae.* Of these, one species is new. Distribution data are given as far as known, and some of the outstanding features of each species, together with one or more drawings. Complete characterizations of the species will be found in the titles listed in the bibliography.

The two genera under consideration have the characters of the super-family *Hygrobatae,* as given in Part II. These water mites are of medium size, usually about one millimeter in length; the integument is soft and often brightly colored, with a tendency to develop chitin in the case of the Neumanias. The first two pairs of legs are especially stout and they bear dagger-like spines. The fourth epimera are large, approximately rectangular in shape and nearly or quite separated from the third pair. The genital areas are close to the posterior end of the body and the plates on either side bear numerous acetabula. The Unionicolas are of special interest since most of the species are parasitic throughout life in the gills or mantle chambers of the fresh water clams. The earlier work of the author on the Neumanias has been revised and corrected.

For most of the material from Green Lake and the lakes of Vilas County the author is indebted to the Wisconsin Natural History Survey; the Unionicolas from Waukesha and Jefferson counties are from the collections of Mr. A. R. Cahn and those from the Madison lakes were sent to the author by Mr. J. P. E. Morrison.

Unionicola crassipes (Müll.)
Pl. I, fig. 1-4.

Most of the Unionicolas are parasitic in adult life as well as in the larval stages; *U. crassipes,* however, is free and active and found only rarely in fresh water mussels. Largest specimens may be one millimeter or more in length. Individuals are recognized by the two nipple-like lateral protuberances which, with the genital plates, are found on the extreme end of the body. The genital acetabula are in four groups of three each; these are borne on two lunate plates in the male, while in the female there are four somewhat triangular plates adjacent to the genital opening. Palpi are large and slim and the fourth segment bears three long papillae. The legs are very long.

European hydracarinologists have recognized forms of this species in which the individuals are smaller than normal with relatively smaller palpi. In the Wisconsin material (all from lakes) such individuals were common.

This species has been reported from all continents. In North America it has been found in Alaska, British Columbia and Ontario; in Washington, Wyoming, Montana, Nebraska, Iowa, Michigan, Indiana, Ohio, New York and Maine. Over three hundred individuals have been examined from Wisconsin; they have been compared with identified specimens kindly supplied by Dr. Viets and with these they appear to conform. They have been found in lakes Winnebago, Mason, Wingra and Spooner; in ponds and lakes near Portage, Wisconsin Dells, Oxford, Waupaca, Green Bay, Elkhorn, Milton, Delavan, Twin Lakes, Powers Lake and in seventeen bodies of water in Oneida and Vilas counties. They have been collected from near the surface to a depth of over seven meters. At Three Lakes large numbers were found in beds of fresh water sponge; Mr. M. C. Olds has found them in similar places in Michigan, as likewise they have been reported by European collectors.

Unionicola pectinata (Wol.)
Pl. I, fig. 12-14.

This species is rare, free swimming in the adult stage. It closely resembles *U. crassipes* in the genital region; it differs from it in having stouter palpi, without conspicuous papillae, as well as in having weaker legs, the first pair of which have unusual pectinate claws. It was described by Wolcott from a few individuals found in Michigan, not well preserved. In the Wisconsin collections but two individuals were found, both females: one in Lake Bragonia, Vilas County, and one in Lake Como. The latter had a fourth small acetabulum on each of the two posterior genital plates.

Unionicola aculeata (Koen.)
Pl. I, fig. 5-8.

A species closely resembling *U. crassipes,* but somewhat smaller, it is chiefly distinguished by the presence of ten rather than twelve large acetabula on the genital plates. In the female each anterior plate on its inner margin is produced into a conspicuous curved process which is tipped with a spine. Piersig (1901) erected a new variety, *U. sayi,* for the North American forms, chiefly on the basis of small differences in the palpi as shown in Wolcott's drawings from Michigan collections. The author believes that this separation is unjustified, since similar variation is found in European reports of the species. Comparison with an identified female from the collection of the late Dr. Koenike confirms this belief.

The species is widely distributed over Europe. In the adult stage it is both free and parasitic in fresh water mussels. In Wisconsin a few individuals were found with other species in clams from lakes Jordan, Wild Cat (Vilas Co.) and La Belle (Waukesha Co.), and free in Green Lake.

Dr. E. C. Faust's account[1] of the species is in error, since his material was evidently *U. abnormipes.*

Unionicola figuralis (Koch)
Pl. I, fig. 9-11.

This species resembles *U. crassipes* and like it is usually found free living in the adult stage. It is distinguished from it by the absence of the large posterior papillae and by the character of the genital area. The genital plates are placed a little more ventrally and they bear but ten acetabula. In the female the inner corners of the plates bear six stout curved bristles; in the male the lunate plates are slightly constricted between the groups of acetabula. The material has been compared with an

[1] Additions to our Knowledge of Unionicola aculeata (Koen.). Trans. A. M. S., v. 37 : 125, fig. 1-6. 1918.

identified female from the collection of Dr. Koenike with which it appears to conform.

The species is widely distributed over Europe and it has been reported also from east Africa and Chili. This is the first record from North America. Eleven individuals were found in lakes of Vilas County; one of these, a female, had but one acetabulum on the anterior genital plate. In an examination of some fifty clams (unidentified) from Jordan Lake, only five of which were found infected, seven adults of this species were found.

Unionicola abnormipes (Wol.)
Pl. II, fig. 24-27.

This is a small species, males measuring 0.57 mm., females, 0.70 mm. The body shows brown patches with a pink or yellow dorsal mark. The distinguishing feature is the unusual development of heavy spines on the fourth and fifth segments of the last leg of the male. The palpus is slender and ends in two large curved claws. The genital areas lie close to the posterior end of the body and bear ten acetabula; in the female there are four wing-shaped plates, similar to those of *U. aculeata.*

Individuals have been found parasitic in several species of clams in New York, Michigan, Illinois and Iowa. In Wisconsin they have been found in lakes Winnebago, La Belle and the Madison lakes and in the Oconomowoc River.

Unionicola intermedia var. *wolcotti* (Piers.)
Pl. II, fig. 21-23.

This small mite has been found parasitic in several species of clams. The body measures 0.50 mm. in the male and 0.75 mm. in the female. The dorsal surface shows brown patches with a yellow dorsal Y-mark. The legs are long and end in large bifid claws. The genital areas are a little removed from the posterior end and resemble those of *U. abnormipes,* with ten acetabula; the four plates in the female are somewhat four sided, with the inner margins produced into outward turned processes bearing spines. In the male the fourth segment of the last leg is somewhat curved.

Piersig (1900) considered the North American forms described by Wolcott a variety of the European species *U. intermedia* (Koen.), chiefly on account of differences in the palpi, the process on the distal end of the fourth segment being large, blunt and flat, rather than small and slim. This difference appears to the author to be constant and important; in addition, in the specimens examined, the genital plates of the female are more angular and the second acetabula of the anterior plates are uniformly smaller than the others.

The species has been reported from Michigan, Nebraska and Iowa. In Wisconsin it has been found in collections from Jefferson and Waukesha counties.

Unionicola serrata (Wol.)
Pl. II, fig. 28, 29.

Specimens of this parasite are found only occasionally, sometimes with other species, in several species of clams. Females are about one millimeter in length; males are smaller. The genital plates are distinctive. In the male there are two lunate plates which bear a variable number of small acetabula; in the female there are four, with small acetabula, the anterior and smaller plates each produced medially into a curved spine-bearing process. The palpi are large and stout; the fifth segment has two spines on the end. The legs are stout; their spines are often serrate.

Specimens have been found in New York, Michigan and Iowa. In Wisconsin they have been found in Green Lake, the Madison lakes and waters of Waukesha County.

Unionicola ypsilophora (Bonz)
Pl. II, fig. 15-18.

This species is one of the largest and commonest of the parasites of mussels, especially the Anodontas. The body is elongated, very dark, with a yellow dorsal T-shaped mark; females may attain a length of 1.50 mm. The genital area, close to the posterior end, is broad and has in both sexes two plates, each of which bears about twenty acetabula, the plates in the female produced outward into two wide lips bearing bristles. The palpi are stout, with three claws on the fifth segment. The legs end in flat and broadened segments with bifid claws.

Piersig (1900) maintained that the North American forms of this cosmopolitan species represented a distinct variety, which he designated as *U. haldemani,* basing this assumption on certain small differences in the legs, palpi and genital plates, as shown by Wolcott (1899). The author, after examining some two hundred individuals in the present collection, does not think that this separation is necessary, as the differences pointed out are well within the limits of variation in so large a group. Koenike (1895) reported the species from Canada; he had only fragments of specimens, but he identified these as *U. ypsilophora.* The author has also examined this material, as well as a slide from the collection of Dr. Koenike from Germany and believes that all of the individuals belong to the same species.

The species has been found in New York, Connecticut, New Jersey, Pennsylvania, Michigan, Illinois, Iowa and Nebraska. In Wisconsin it has been found in Mirror and Green lakes, in four lakes of Vilas County and in large numbers in several collections from Waukesha and Jefferson counties and the Madison region.

Unionicola arcuata (Wol.)
Pl. II, fig. 19, 20; Pl. III, fig. 33, 34.

A species similar to *U. ypsilophora,* but not so common, it has been found parasitic in several species of clams. Individuals measure a little more than one millimeter. They are distinguished from the related species most readily by the character of the legs; these are long and slender, especially in the fifth segment, while the last segment is curved and ends in a rounded projecting tip and short bifid claws. The posterior epimeral group is unusually short. The genital plates are broad, much alike in the two sexes, with a large and variable number of acetabula, two of which on each plate are larger than the others.

This species has been found in Michigan and Pennsylvania and in Waukesha County in Wisconsin.

Unionicola fossulata (Koen.)
Pl. III, fig. 35-38.

A parasite throughout life, this species is common in several mussels. Individuals measure a little over one millimeter. They may be recognized by the genital plates which are placed a little forward of the posterior end and bear on each side five large acetabula, of which the last two lie side by side; in the male these are borne on two lunate plates, while in the female the plate of each side is divided. The legs bear large claws, divided near the tips, and the last segment in each case is narrowed at the end. The epimera resemble those of *U. stricta.*

Dr. Koenike (1895) described the species from Canadian material; this the author has examined. It has been reported also from Michigan, Illinois, New York and Iowa. In Wisconsin it has been found in Green and Trout lakes and in collections from Oshkosh and Waukesha and Jefferson counties.

Unionicola stricta (Wol.)
Pl. III, fig. 30-32.

A species closely resembling *U. fossulata,* and like it a parasite in fresh water clams, *U. stricta* is smaller and rarer, and is distinguished chiefly by differences in the genital plates. Here the five acetabula of each side are placed in a curved line on either side of the cleft. The legs are slender, bear simple claws, and the distal end of each is somewhat dilated at the end.

Individuals have been found in several species of clams in Michigan, Illinois and Nebraska. In Wisconsin a few were found in collections from Waukesha and Jefferson counties.

Neumania semicircularis Mar.
Pl. IV, fig. 44-46.

The species is a large one, females attaining a length of 1.40 mm. Plates and legs are blue tinged. The epimera are relatively small and the groups are well separated; the genital plates are somewhat removed from these and from the posterior end of the body and the body papillae near them are not conspicuous.

The male is now recognized; while the females are common, the male has been found but rarely. The genital plates bear a large number of small acetabula as in the female. The epimera show a fine reticulation and the body surface is covered with very fine denticles.

Specimens have been found in Iowa and Illinois. In Wisconsin they have been collected in Mirror, Mendota, Buffalo, Spooner, Lauderdale, Beulah and Green lakes; in pools near Fontana and Wisconsin Dells and in four lakes in Vilas County. In Green and Big lakes they have been found at depths from the surface to ten meters.

Neumania armata Mar.
Pl. III, fig. 39, 40.

These mites have heavy plates, blue tinged; males measure 0.90 mm., females 0.95 mm. The fourth epimera are very long and the inner posterior corner of each is somewhat projecting. The genital areas are very broad and lie close to the posterior end of the body. The palpi are moderately large.

They have been found in Iowa and Illinois. In Wisconsin collections have been made in Mirror, Lauderdale and the Madison lakes, in two lakes of Vilas County, in pools near Wisconsin Dells and in Green Lake at depths to 15 meters.

Neumania tenuipalpis Mar.
Pl. V, fig. 49, 50.

Males measure 1.00 mm., females 1.30 mm. or more. The species resembles *N. armata* but the plates are not so heavy nor are the genital areas as broad. The palpi are unusually small. The author's former identification of the female (1926) was in error; the specimen described is now seen to be *N. punctata.* Fig. 49 of this paper shows the true female of this species, with its close resemblance to the male. The species name *muttkowski* introduced by the author (1922) is now invalid; two of the three males described are found on re-examination to be *N. tenuipalpis* and the other *N. armata.*

Specimens have been recorded for Iowa and Louisiana. In Wisconsin they have been found in Green Lake, the Madison lakes and lakes in Vilas County and in ponds at Whitewater and in Adams County.

Neumania extendens Mar.
Pl. IV, fig. 47, 48.

These are mites of moderate size, males measuring 0.90 mm., females about 1.00 mm. The epimera are large and the groups rather close together. Specimens may be recognized by the broad genital plates which are close to the posterior end of the body and in both sexes show a concavity on the anterior lateral border, while the body papilla of either side near this is small. Acetabula are small and numerous. The female is now recognized. It was earlier erroneously described as the female of *N. punctata* (Marshall, 1922; fig. 29 is an immature female).

Individuals have been found in Spooner, Green and Trout lakes, in the Madison lakes and in ponds in Adams County.

Neumania papillator Mar.
Pl. V, fig. 53, 54.

This species closely resembles *N. extendens* but is smaller, males being about 0.60 mm. in length and females 0.78 mm. The body is semitransparent. The genital areas at the posterior end of the body have fewer acetabula than in the related species and the body papilla near the outer border on either side is very large. The broad genital plates of the male show a concavity adjacent to the papilla.

The species is probably wide spread, since specimens have been found as far south as Louisiana. In Wisconsin they have been found in the Madison and Lauderdale lakes and in Twin, Storr and Green lakes, in the last to a depth of five meters.

Neumania punctata Mar.
Pl. VI, fig. 58, 59.

The great development of the epimera in the male characterizes this species, as well as the conspicuous papillae which join the genital plates on their lateral borders. Males measure 0.75 mm., females 0.90 mm. or more. The color is blue or occasionally red. The body surface and legs show tiny rounded patches of chitin. The author's original drawing of the female (1922, fig. 29) is now seen to be a young *N. extendens;* fig. 59 of this paper corrects this error. The genital plates are somewhat rounded and lie close to the cleft; they are heavy, as in the male, with the adjacent papillae well developed.

In Wisconsin the species has been collected in Green, Delavan, Mirror, Beulah, Drake, Monona and Nashota lakes and in lakes in Vilas and Adams counties.

Neumania fragilis Mar.
Pl. V, fig. 51, 52.

First descriptions of this species (1922), made from a study of prepared slides, contained some inaccuracies; a more complete and accurate characterization, including the recognition of the male, is now possible. Living specimens of this small and delicate mite are recognized by the magenta tinge of the plates and legs; there is a red Y-shaped dorsal mark and the eyes are large and red. Males measure 0.75 mm. and females 0.83 mm. The surface is covered with very fine denticles. The epimera show a fine reticulation; the underlying processes of the anterior groups are large. The genital plates are placed close to the end of the body; they are broad and in both sexes bear a small number of large acetabula. A large papilla is found close to the outer border of each plate. The fourth legs in the male are one and one half times as long as the body; the fifth segments bear a row of pectinate spines and a few swimming hairs.

Specimens have been found in Michigan and Illinois. In Wisconsin they have been found in lakes Jordan, Green and Nashota and in the Madison and Waupaca lakes.

Neumania hickmani nov. spec.
Pl. IV, fig. 41-43.

One of the smallest species of the genus, males measure 0.42 mm. and females 0.55 mm. The color is reddish brown; the surface is beset with small denticles. The plates occupy a large part of the ventral side. The first and second pairs of epimera are very long; the fourth is unusually narrow on the inner posterior border, with a marked concavity on the posterior side in the female. The genital areas are close to the posterior end; they bear prominent heavy acetabula which are slightly elevated. Just back of the genital plates are three large body papillae. The palpi are moderately large. Legs in the male are all longer than the body; those of the female are relatively shorter and weaker. In the last pair the fifth segment bears a row of pectinate spines and a few swimming hairs, while the sixth segment has two pectinate spines; in the third pair of legs the fifth segment has a few pectinate spines and swimming hairs. There are heavy spines on all legs.

About fifty individuals, mostly females, were found in three lakes of Vilas County in collections made by Dr. J. R. Hickman. One female was found in Green Lake at a depth of ten meters.

Neumania pubescens Mar.
Pl. VI, fig. 55, 56.

When alive, specimens are transparent with plates and legs tinged blue, purple or even red; the dorsal side has brown patches with a central orange dagger-shaped area. Males are 0.675 mm. in length, females 0.80 to 1.00 mm. Hairs on the genital plates are conspicuously long and abundant. The curved bar over the genital cleft in the female is very large.

Specimens have been found in Iowa and Indiana. In Wisconsin they have been collected in Lake Mills, Powers Lake, Goose Pond (Adams County) and in Green Lake (depths to six meters).

Neumania ovata Mar.
Pl. VI, fig. 57.

Females only are known; these measure 1.20 mm. The epimeral groups are widely separated and the underlying processes from the first pair are unusually short. The genital plates are somewhat oval in form and body papillae are only moderately developed.

A few individuals have been found in Iowa, and in Wisconsin in Twin Lakes, and the Madison lakes.

Neumania distincta Mar.
Pl. VI, fig. 60, 61.

Individuals of this large species are recognized by the unusual form of the genital plates: these are very broad, and in the male, the plate of each side is partly divided by a median constriction, while in the female the separation is complete, resulting in the formation of a smaller detached anterior plate. A similar condition is found in the South American species *N. curvipes* Lund. Dr. Lundblad[2] has erected a subgenus, *Tetraneumania,* for the two species. *N. distincta* is also characterized by the shortness of the underlying processes of the anterior epimeral group. *N. okobojica* Mar. (1926) is now recognized as the female of this species, while *N. brevibrachiata* Mar. (1922) is found to be a young and poorly preserved male. In consequence these two names become invalid.

Specimens have been collected in Iowa. In Wisconsin they have been found in Mirror, Green, Lauderdale and Briggsville lakes.

Rockford College,
September 1, 1932.

[2] Südamerikanische Hydracarinen. Zoolog. Bid. Uppsala. Bd. 13 : 32-36.

BIBLIOGRAPHY

Titles are limited to papers containing authors' descriptions of the species cited and to general papers describing cosmopolitan species.

Koenike, F. 1895. Nordamerkanische Hydrachniden. *Abh. Naturwiss. Bremen* 13 (2) : 167-226.

Marshall, R. 1922. The American water mites of the genus Neumania. *Trans. Wis. Acad.* 20 : 205-213, pl. II-IV.

1926. Water mites of the Okoboji region. *Univ. Iowa Studies Nat. Hist.* 21 (9), pl. I-III.

1929. The water mites of Lake Wawasee. *Proc. Indiana Acad. Sci.* 38 : 315-320.

1931. Preliminary list of the Hydracarina of Wisconsin, I. *Trans. Wis. Acad.* 26 : 311-319, pl. VII-VIII.

1932. Preliminary list of the Hydracarina of Wisconsin, II. *Trans. Wis. Acad.* 27 : 339-358, pl. VII-X.

Piersig, R. 1897. Deutschlands Hydrachniden. *Biblio. Zool.* XXII. Stuttgart.

1900. Hydrachnologische Bemerkungen. *Zool. Anz.* 23 : 209-213.

1901. Hydrachnidae und Halacaridae. *Das Tierreich,* XIII. Berlin.

Soar and Williamson. 1927. British Hydracarina. Vol. II. *The Ray Society,* No. 112. London.

Wolcott, R. W. 1899. On the American species of the genus Atax (Fabr.) Bruz. [Unionicola]. *Trans. Am. Micr. Soc.* 20 : 193-259, pl. 28-32.

1905. A review of the genera of the water mites. *Trans. Am. Micr. Soc.* 26 : 161-243, pl. 18-27.

PLATE I

1. *Unionicola crassipes*, right palpus, female, outer side.
2. *Unionicola crassipes*, basal segments of leg I, right.
3. *Unionicola crassipes*, ventral view, female.
4. *Unionicola crassipes*, genital area, male.
5. *Unionicola aculeata*, end of leg I, male (one claw omitted).
6. *Unionicola aculeata*, right palpus, male, outer side.
7. *Unionicola aculeata*, genital plates, male.
8. *Unionicola aculeata*. genital area, female.
9. *Unionicola figuralis*, left palpus, male, outer side.
10. *Unionicola figuralis*, genital area, female (turned).
11. *Unionicola figuralis*, ventral view, male.
12. *Unionicola pectinata*, genital area, female.
13. *Unionicola pectinata*, left palpus, female, outer side.
14. *Unionicola pectinata*, end of leg I, left (one claw omitted).

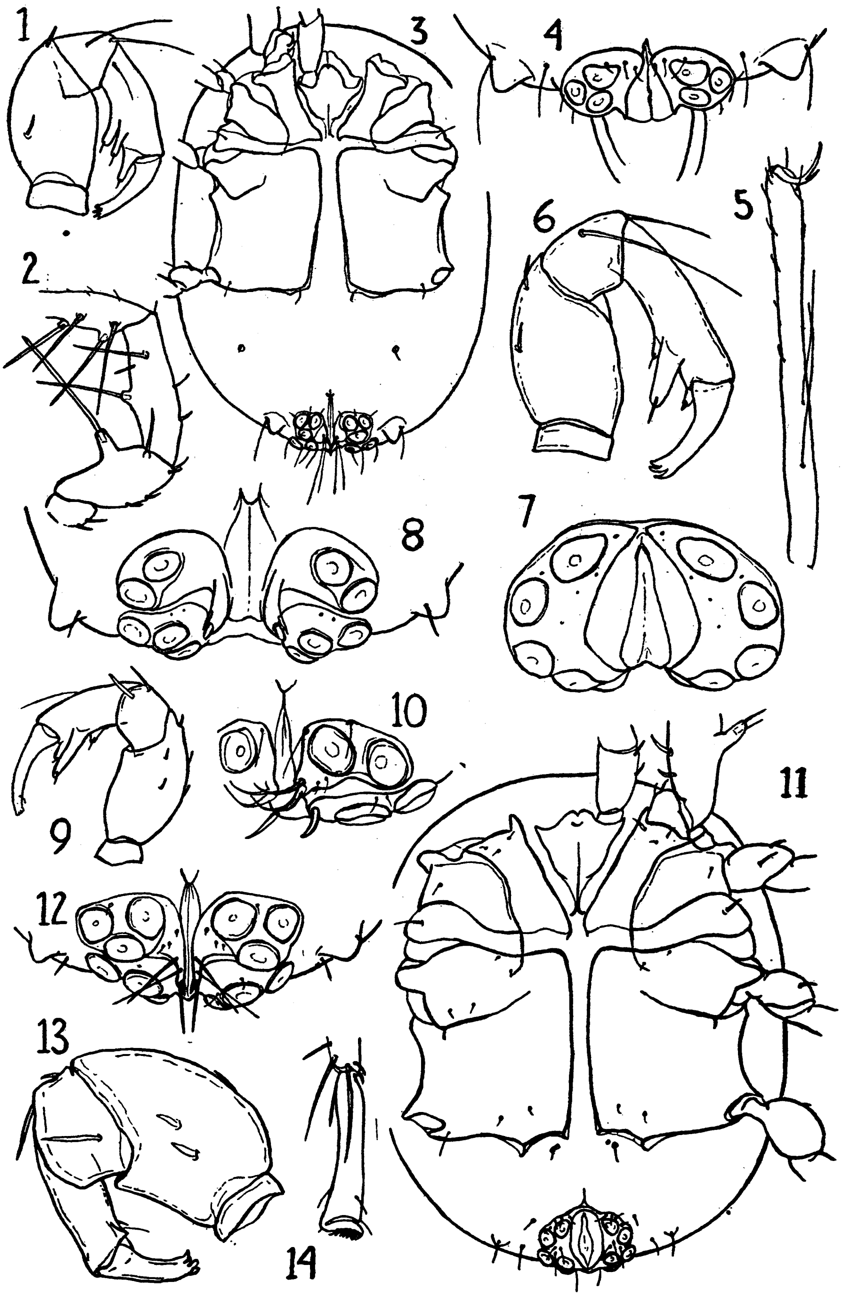

1
2
3
4
5
6
7
8
9
10
11
12
13
14

PLATE II

15. *Unionicola ypsilophora,* right palpus, female, outer side.
16. *Unionicola ypsilophora,* ventral view, female.
17. *Unionicola ypsilophora,* genital plates, male.
18. *Unionicola ypsilophora,* end of leg I, male, left (one claw omitted).
19. *Unionicola arcuata,* epimera III, IV, left, female.
20. *Unionicola arcuata,* end of leg I, right (one claw omitted).
21. *Unionicola intermedia* var. *wolcotti,* left palpus, female, outer side.
22. *Unionicola intermedia* var. *wolcotti,* genital plates, female.
23. *Unionicola intermedia* var. *wolcotti,* end of leg I (one claw omitted).
24. *Unionicola abnormipes,* genital plates, male.
25. *Unionicola abnormipes,* right palpus, inner side.
26. *Unionicola abnormipes,* genital plates, female.
27. *Unionicola abnormipes,* leg IV, left, segments 4, 5, male.
28. *Unionicola serrata,* left palpus, outer side.
29. *Unionicola serrata,* ventral surface and leg I, female.

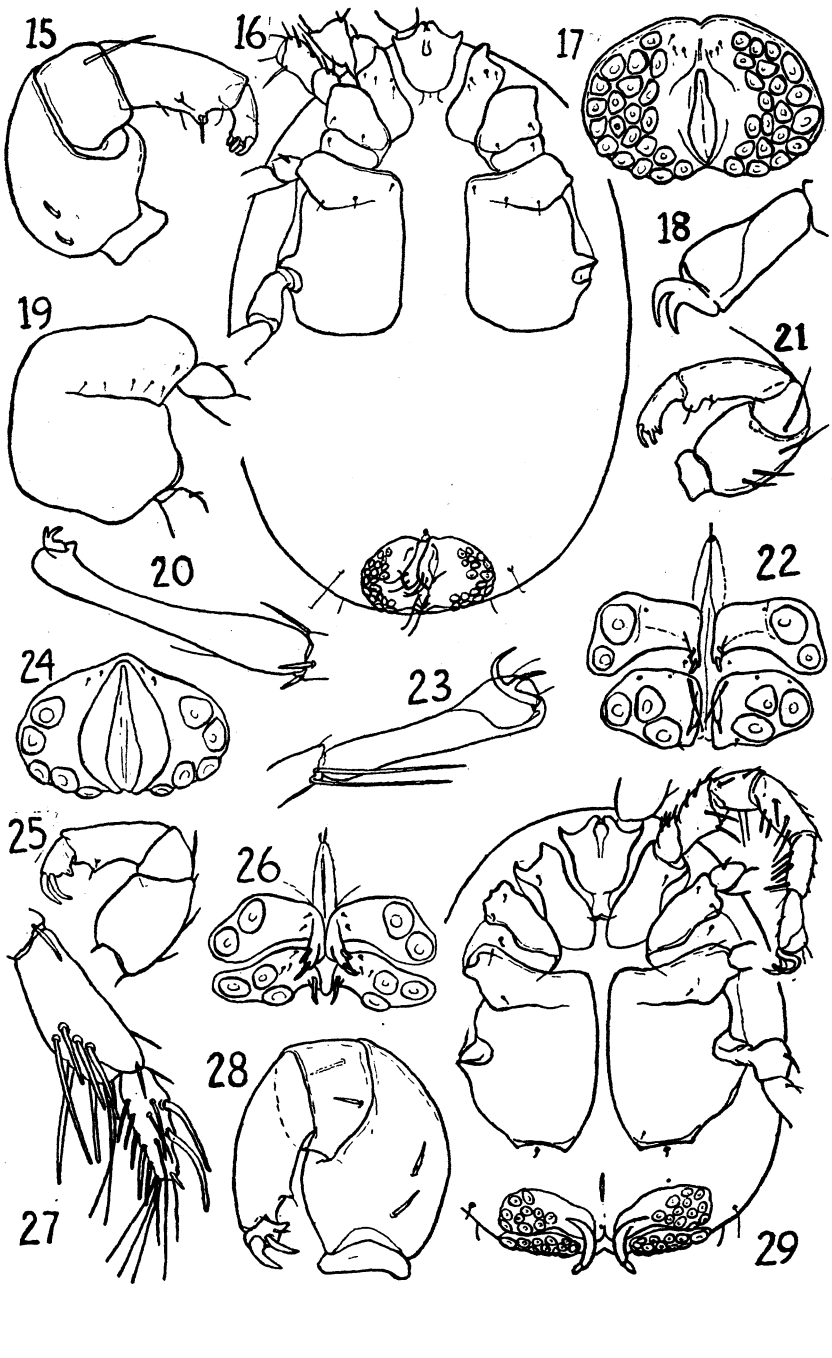

15
16
17
18
19
20
21
22
23
24
25
26
27
28
29

PLATE III

30. *Unionicola stricta,* ventral view, female.
31. *Unionicola stricta,* genital plates, nymph.
32. *Unionicola stricta,* right palpus, outer side.
33. *Unionicola arcuata,* genital plates, female.
34. *Unionicola arcuata,* left palpus, female, outer side.
35. *Unionicola fossulata,* genital plates, male (after Wolcott).
36. *Unionicola fossulata,* genital plates, female.
37. *Unionicola fossulata,* right palpus, female, inner side.
38. *Unionicola fossulata,* end of leg IV.
39. *Neumania armata,* ventral view, male.
40. *Neumania armata,* genital area, female.

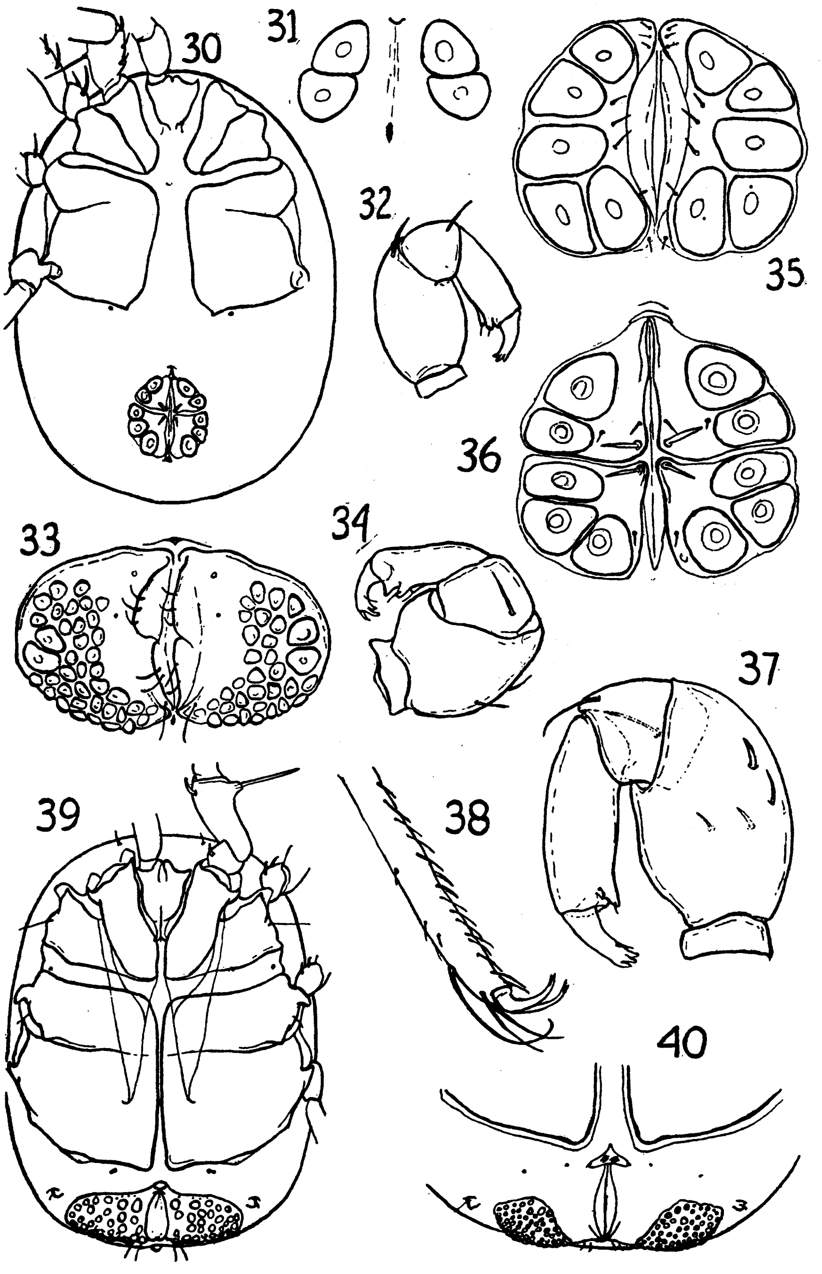

30
31
32
33
34
35
36
37
38
39
40

Plate IV

41. *Neumania hickmani*, genital plates, male.
42. *Neumania hickmani*, ventral surface, female.
43. *Neumania hickmani*, left palpus, female, outer side.
44. *Neumania semicircularis*, genital area, female.
45. *Neumania semicircularis*, ventral surface, male.
46. *Neumania semicircularis*, right palpus, female.
47. *Neumania extendens*, ventral view, female.
48. *Neumania extendens*, genital area, male.

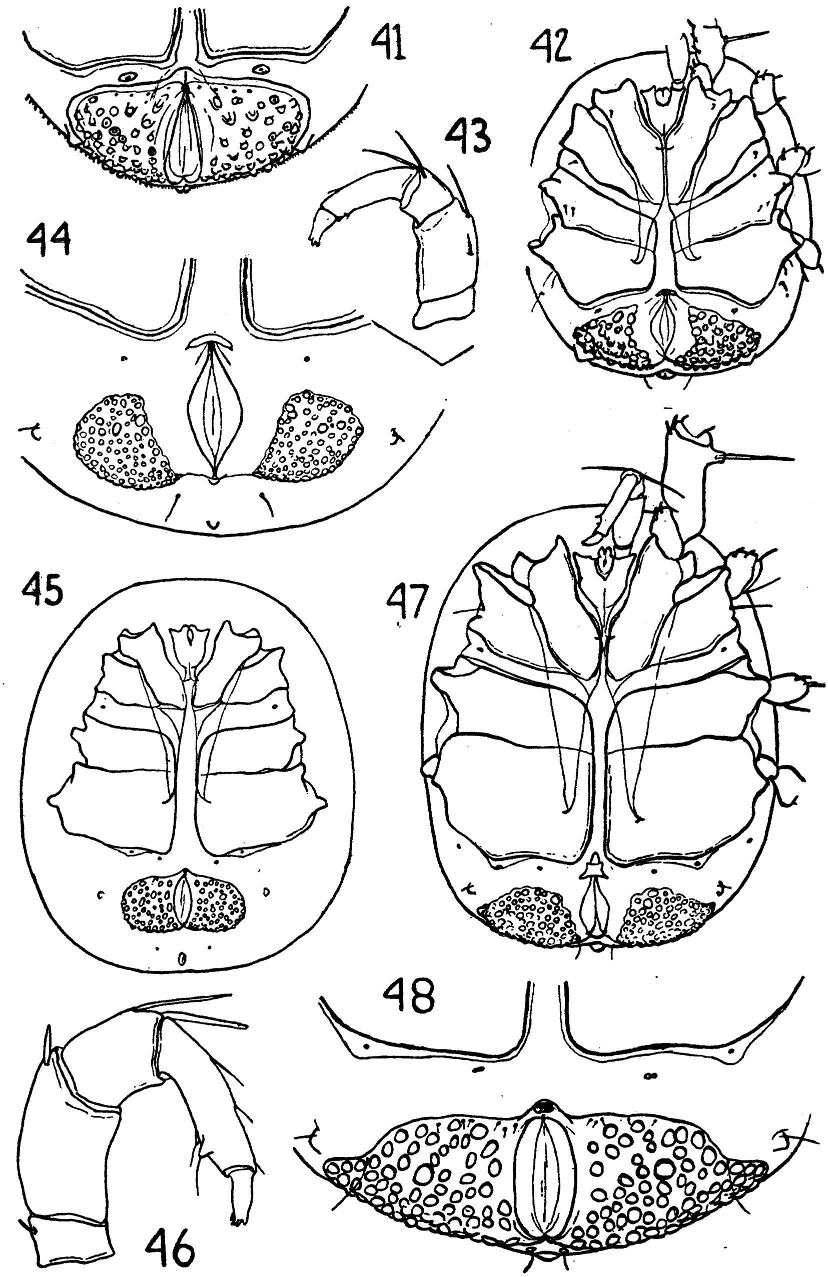
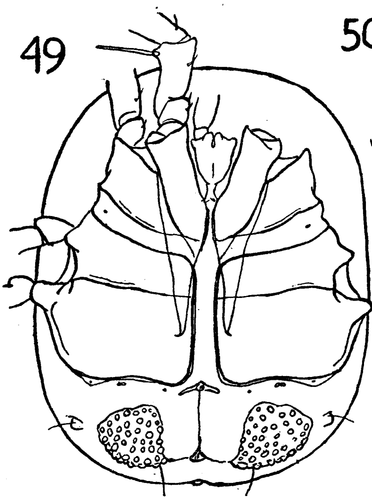

41
42
43
44
45
47
48
46

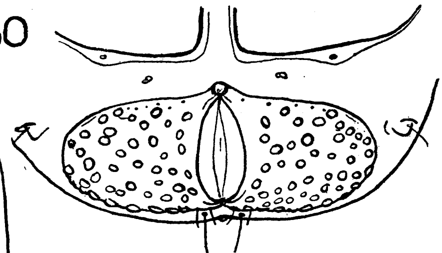
Plate V

49. *Neumania tenuipalpis,* ventral view, female.
50. *Neumania tenuipalpis,* genital area, male.
51. *Neumania fragilis,* genital area, male.
52. *Neumania fragilis,* ventral surface, female.
53. *Neumania papillator,* ventral surface, female.
54. *Neumania papillator,* genital area, male.

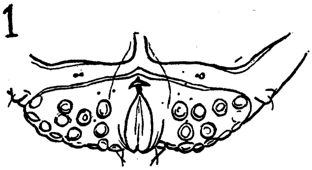
49



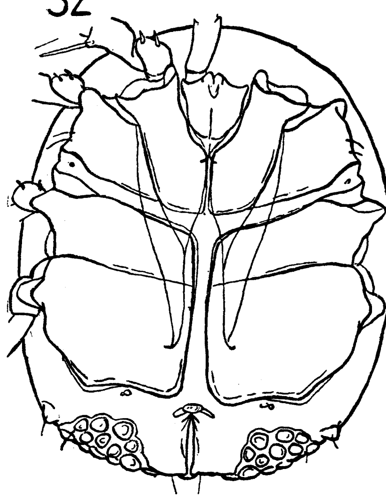
50



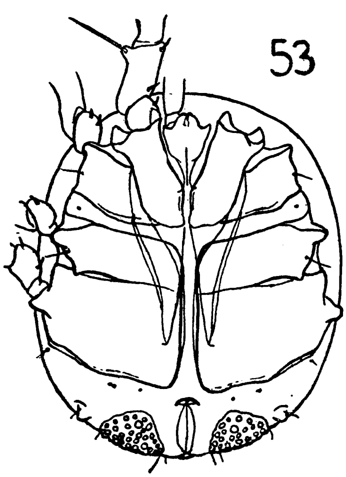
51



52



53



54

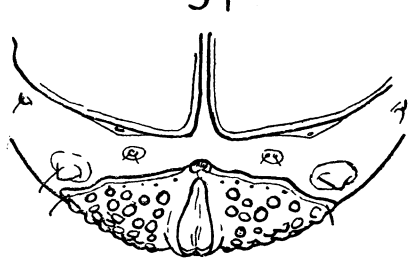
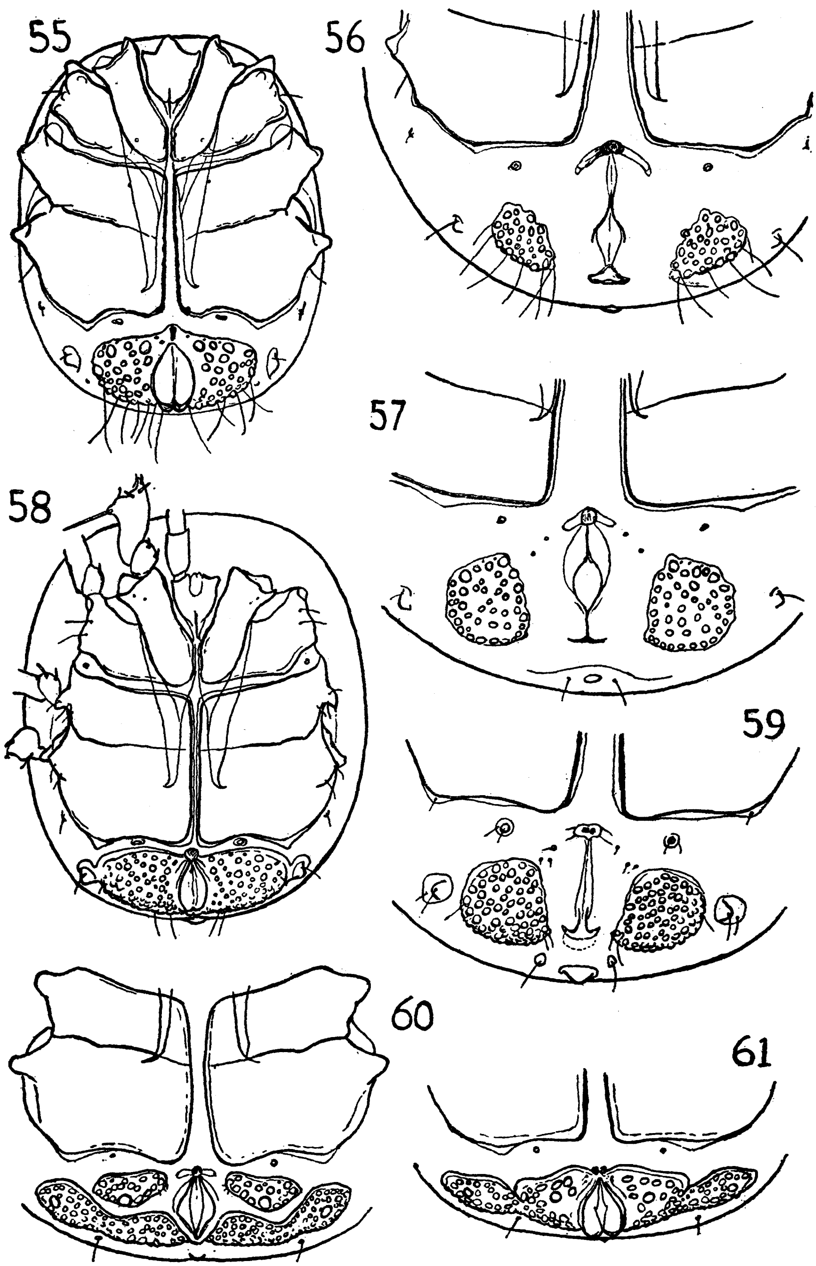


PLATE VI

55. *Neumania pubescens*, ventral surface, male.
56. *Neumania pubescens*, genital area, female.
57. *Neumania ovata*, genital area, female.
58. *Neumania punctata*, ventral surface, male.
59. *Neumania punctata*, genital area, female.
60. *Neumania distincta*, genital area and last epimera, female.
61. *Neumania distincta*, genital area, male.


55
56
57
58
59
60
61

REVISION OF THE SYRPHUS FLIES OF AMERICA NORTH OF MEXICO (DIPTERA, SYRPHIDAE, SYRPHUS *S. L.*)*

PART I

C. L. FLUKE, JR.

University of Wisconsin

The genus Syrphus is a beneficial group of flies, as the larvae of all that are known feed upon soft bodied insects such as plant lice. Too little is known regarding the biology of these flies; the metamorphosis of less than half of them has been described. Before a comprehensive study of the life phases is undertaken the taxonomic status of the adults should be better understood.

The original plans for this revision called for a complete description of all species, giving all synonymical references, and drawings, but the limitations of publication have necessitated a somewhat abbreviated plan. An attempt has been made here to describe in detail the more common members of each distinctive group and then to show how the more recent or in some cases the more rare forms differ. Only the most important references have been given but in each case the original citation has been stated. A number of drawings have been omitted, some through lack of material, some because the species in question could be readily identified without the drawings, and in a few instances because recently published articles are still available. Mr. T. M. Dobrovsky inked most of the drawings after they had been prepared by the author with the aid of a camera lucida. They are not drawn to the same scale, since it was not always possible to use the same microscope. Only about half of the paper appears here; the remainder will be published in later issues of these Transactions.

The amateur, who is working up his collection of the genus *Syrphus s. l.* would do well to secure confirmation of his determinations, especially of the more common forms, before draw-

*Supported in large part by a research grant from Sigma Xi.

ing conclusions as to the possession of the rarer forms. Considerable difficulty will arise in the *wiedemanni-meadii* group until the novice is familiar with the gradations of the undulate bands. The drawings should aid in this understanding.

The use of the character of the metasternum, which is located just in front of the hind coxae, whether hairy or bare, has helped materially in grouping the flies, but cannot be used entirely for generic limitations since the type of the genus *Epistrophe, E. grossulariae,* is the only species of that genus, so far as I know, which has a hairy metasternum.

There have been many students in the syrphid field but few have worked with the Genus *Syrphus.* The most important papers have been written by J. S. Hine, R. C. Shannon, C. L. Metcalf and C. H. Curran. Of these Dr. Curran has accomplished most. His descriptions are models and his keys always understandable. I have utilized his works considerably, especially his diagnostic keys, but take full responsibility for all new synonymy and any errors that may have occurred.

Nearly all of the types that exist in this country have been examined personally by the author, including Williston's at Washington; Osten Sacken's at Cambridge; Snow's at Lawrence, Kansas; Jones' at Fort Collins, Colo.; Curran's at New York and Ottawa; Shannon's at Washington; Hine's at Columbus; and Osburn's at Columbus. The types of *Metasyrphus pauxillus* (Will.), *M. fumipennis* (Thom.) and *M. aenea* (Jones) are lost. I have not seen the type of *M. pacifica* (Lov.) but received through the kindness of the Oregon Agricultural College several of the specimens used in the original description. I was unable to examine Curran's species *M. rufipunctatus* but have seen a specimen from near the type locality, which is, I believe, identical. The type of *M. aberrantis* was also not seen but paratypes have been examined. In addition I have examined the majority of the species of this group which occur in Europe.

For the opportunity to examine the types and for help in various ways I wish to express my appreciation to the following:

To Sigma Xi for a research grant which has made it possible to make this study.

To the Curators at the various Museums for the kind considerations and help which were accorded wherever I went and to many others who have assisted me with specimens and literature; but especially do I wish to thank Dr. R. C. Osburn, Mrs. J. S. Hine, Mr. E. S. Thomas, Dr. J. M. Aldrich, Dr. E. T. Cresson, Dr. C. H. Curran, Dr. C. W. Johnson, Dr. Nathan Banks, Dr. J. McDunnough, Mr. J. W. Brown, Dr. C. L. Metcalf, Dr. R. H. Baemer, Dr. C. R. Jones and Dr. J. S. Collin.

To the various members of the Department of Economic Entomology, and especially R. J. Bushnell for help in the writing of descriptions and checking of keys and Prof. H. F. Wilson, chief of the department, for every encouragement and facility to carry on the studies. I have also received many specimens from various collectors but wish to mention particularly Dr. R. C. Osburn, Dr. C. L. Metcalf, Prof. J. Wilcox and Mr. R. Latta. Through the courtesy of Mrs. J. S. Hine and Mr. E. S. Thomas of the Ohio State Museum I have had the privilege of studying the collection of the late J. S. Hine.

KEY TO THE GENERA OF SYRPHUS *S. L.*

1. Lower lobe of squamae hairy above, metasternum bare, abdomen emarginate .... *Syrphus* L.
   Lower lobe of squamae bare above 2
2. Abdomen emarginate, usually oval; metasternum hairy or bare...... .... *Metasyrphus* Mat. & Ada.
   Abdomen not emarginate, the edges rolled, often slender; metasternum usually bare, if hairy the abdomen distinctly non-emarginate 3
3. Eyes pilose; abdomen long and slender, the base with a pair of large, yellow, anteriorly contiguous spots .... *Ischyrosyrphus* Big.
   Eyes bare or pilose; if pilose without the large basal yellow spots..... .... *Epistrophe* Wk.

The rolled edges of the abdomen are not always a reliable character to observe and the student should follow the other genera if there is some doubt. The metasternum character is also sometimes difficult to observe and considerable care should be used in examination, so as not to mistake the coxal hairs for those of the metasternum.

SYRPHUS *s. s.*

Syrphus Fabricius 1775, Syst. Ent. 772.

Lower lobe of the squamae hairy above, metasternum bare, abdomen emarginate and oval in shape.

Face usually yellow, more rarely with a brown stripe; eyes bare or pilose, holoptic on the male; antennae of moderate size with a dorsal arista; thorax black or aeneous, usually dull, occasionally shining; scutellum usually yellow; legs simple; wings simple, third vein only gently curved; abdomen with prominent yellow crossbands or spots, the first nearly always separated into spots. Type of genus: *Syrphus ribesii* L.

The genus *Syrphus* as limited in this paper contains barely a dozen species in North America, all of which, however, form a natural group. They are generally the largest of the old genus. Of the four genera recognized in this paper this one is the easiest to characterize and no difficulty should arise in placing the species belonging to it.

KEY TO THE SPECIES OF SYRPHUS *s. s.*

1. Eyes pilose .... *torvus* O. S.
   Eyes bare 2
2. Emarginate edges of abdomen continuously yellow, 2nd and 3rd abdominal bands continuous .... **hinei n. sp.**
   Emarginate edges entirely black or alternately black and yellow, if entirely yellow the abdominal bands are interrupted 3
3. Second and third abdominal bands entire and do not reach the side margins .... *opinator* O. S.
   These bands reach the side margins, if not they are separated into spots 4
4. First segment of middle tarsi with only yellow spicules beneath, sides of mesonotum distinctly yellow pollinose .... *knabi* Shan.
   First segment of middle tarsi with black spicules beneath, sides of mesonotum indistinctly yellow pollinose 5
5. Abdominal bands interrupted or greatly excised 6
   2nd and 3rd abdominal bands not interrupted 7
6. Abdominal bands narrow occupying much less than one-half the width of each segment .... *similis* Jones
   Abdominal bands broad occupying nearly one-half the width of each segment .... *attenuatus* Hine
7. Antennae mostly reddish, third segment narrowly brownish above; femora of female entirely pale .... *bigelowi* Cur.
   Antennae mostly blackish 8
8. Face with a median blackish or brown vitta ..*ribesii vittafrons* Shan.
   Face entirely yellow 9

9. Males (eyes holoptic) 10
   Females (eyes dichoptic) 13

10. Pile of face nearly all black, hind femora black on basal two-thirds.. .... *transversalis* Cur.
    Pile of face black on the sides only near the antennae, hind femora black on the basal four-fifths 11

11. The yellow band on the second segment reaches the lateral margins in only about one-fourth its greatest width 12
    The yellow band extends over the side margins in half its greatest width .... *rectus* O. S.

12. Venter unicolorous; tiny black hairs on end of posterior femora sparse .... *vitripennis* Mg.
    Venter usually with transverse blackish markings; tiny black hairs on posterior femora very numerous and extending over the apical third .... *ribesii* L.

13. Abdomen with sides strongly reflexed downward, the apical segments all visible from above .... *transversalis* Cur.
    The abdomen of normal shape 14

14. Bases of the hind femora black .... *vitripennis* Mg.
    Bases of hind femora yellow 15

15. Lower one-third of front pure yellow—femora entirely yellow—females only .... *opinator* var.
    Lower one-third of front of female not entirely yellow 16

16. The yellow band on the second abdominal segment reaches the side margins in almost its full width; posterior femora with a broad, brown preapical band .... *rectus* O. S.
    The yellow band reaches the side margin in not more than half its greatest width; posterior femora rarely brown preapically...... .... *ribesii* L.

1. *Syrphus ribesii* L. (Fig. 1.)

Syrphus ribesii Linn. 1758, Sys. Nat. Ed. 10 : 593 (Musca); Williston 1886, Synopsis, 77; Verrall 1901, Brit. Syrph., 366; Curran 1921, Can. Ent. 53 : 154.

Face and cheeks yellow, pile of face all pale; antennae largely brownish; spots on the first segment of the abdomen reach the side margins in less than half their width; hind femora of female entirely yellowish except the extreme base, of the male all black except the apical one-fifth or sixth. Length 10 to 12 mm.

Male—Face and cheeks entirely yellow, at most only slightly reddish on the upper mouth edge, pile all pale except near the antennae, frontal triangle largely black with dense golden pollen on the upper half and continued more lightly down across the face, the tubercle, however, shiny; pile of front black, a large crescent-shaped black shining area just above the roots of the antennae with a rather indefinite yellowish spot in front; occiput heavily coated with gray pollen and whitish pile except near the vertex where it becomes paler and there are a few black hairs overhanging the eyes; vertical triangle black with black pile. Antennae largely reddish to brownish, lighter on the first two segments and beneath the third segment, arista reddish, darker toward the tip.

Thorax dull, olivaceous to almost brassy in some specimens, with three narrow faint darker stripes in front; pile is light golden, slightly darker on the side margins. Scutellum yellow with black pile and only a few yellow hairs near the base, metasternum bare. Legs yellow with the following black areas: coxae, trochanters, one-third to one-half of the base of the fore front femora, all but the apical sixth of the hind femora, more than the apical half of the hind tibia, and the upper side of the hind tarsi. Pile varies but is rather heavy and black on the hind tibiae, at the tip of the hind femora mostly black; on the front femora, there are a few black hairs mixed with the yellow ones toward the tip. Spicules under middle basitarsi black. Wings hyaline, stigma light brownish; squamae yellowish with light brown fringe, the disc hairy; halteres yellowish.

Abdomen black, very little shining, first segment yellow on the extreme corners, second segment with two large yellow spots separated by a little more than half their greatest width and attenuated so that they reach the side margins in only about one-fourth to one-half their greatest width; spots expand after reaching the sides to the base of the segment; segments three and four with two continuous bands, the first one narrowly separated from the base of the segment and the second almost touching, especially near the middle, the rear margins oblique and slightly convex but greatly attenuated near the sides going over the edges in half their greatest width, they also reach the bases of the segments at the sides; posterior margin of the fourth and fifth segments and the anterior corners of the fifth yellow. Venter yellow with definite oval or irregular black spots on sternites one, two and three, pile rather long and all yellow. The genitalia yellow at the base and blacker at the tip, black and yellow pile.

Female similar; front black with a very broad narrowly interrupted golden pollinose band, yellow immediately above the antennae, pile all black. Antennae usually more reddish. The femora and tibia are entirely pale and only the tarsi reddish to dark brown above. Abdominal bands narrower and reach the side margins about one-half to two-thirds of their width.

Described from specimens from France, England, Wisconsin and British Columbia.

Syrphus ribesii is not a common species in this country, if limited as described, as the varietal forms are met with more frequently. It is more common in the northern sections, especially in Alaska where it almost grades into *attenuatus* and *hinei*. The complete bands distinguish it from *attenuatus*, the black and yellow emarginate edges from *hinei*, the bare eyes from *torvus*, the blacker hind femora from *vitripennis*, the spotted venter from *rectus*, the darker antennae and legs from *bigelowi*, and the pale pile of the face from the male of *transversalis*.

2. *Syrphus ribessii* var. *vittafrons* Shan.

Syrphus ribesii vittafrons Shannon 1916, Proc. Biol. Soc. Wash. 29 : 202; Curran 1921, Can. Ent. 53 : 154.

This variety differs from typical *ribesii* principally in the presence of a brown median stripe on the face, and there is a post median brown area on the hind femora of the female. Otherwise they are practically indistinguishable. It is a very common form throughout the eastern states.

3. *Syrphus ribesii* var. *similis* Jones (Fig. 2.)

Syrphus similis Jones 1917, Ann. Ent. Soc. Amer. 10 : 224; Colo. Agr. Expt. Sta. Bul. 269 : 72 (fig.).

Differs from typical *ribesii* as follows: the abdominal bands are narrower, either entirely interrupted or greatly excised, and reach the side margins very narrowly or not at all. I have figured the extreme variation and if it were not for intermediate forms it would be sufficiently distinct to form a separate species. Length about 11 mm.

The description given by Jones is slightly misleading, as the femora are black on only the extreme basal edges and thus would pass readily as yellow femora.

I have seen females from British Columbia, Ontario, and Wisconsin but no males have appeared which typically belong to this form. I therefore consider it only a variety of *ribesii.*

4. *Syrphus vitripennis* Mg.

Syrphus vitripennis Meigen 1882, Syst. Besh. III : 308; Verrall 1901, Brit. Syrph., 370; Curran 1921, Can. Ent. 53 : 156.

Very similar to *ribesii* L. and considered by some writers as only a variety. The female of *vitripennis* is easily distinguished as the basal two-thirds of the hind femora are black. In the male the most reliable character is the one given in the key; that is, the tiny hairs on the end of the posterior femora are mostly yellowish while they are all black in *ribesii.* Other characters that will help to separate them are: in *vitripennis* the antennae are more rounded, the spots on the second segment reach the side margins in greater width, and the thorax appears darker. Also as a general rule the venter is unicolorous but as often happens in dried specimens this character is unreliable. Curran mentions a dark spot below the eyes but in all the specimens I have examined this spot is absent.

Specimens were examined from England, France, Ontario, British Columbia, Maine, Ohio, and New York.

5. *Syrphus rectus* O. S. (Fig. 3.)

Syrphus rectus Osten Sacken 1875, Proc. Bost. Soc. Nat. Hist. 18 : 140; Shannon 1916, Proc. Biol. Soc. Wash. 29 : 201; Curran 1921, Can. Ent. 53 : 155; Fluke 1929, Wis. Expt. Sta. Res. Bul. 93 : 19.

One of the most common species of the group, yet until one is well acquainted with it one will have difficulty in determining all variations. Typical specimens are about 9 mm. long and are easily distinguished by the careful summary of characters given by Curran. Those with pale unicolorous venters and rather broad yellow sides on the 2nd abdominal segment are readily placed. The males never have black pile on the face except on the sides near the antennae and also do not have a dark spot below the eyes, and the hind femora are black on better than the basal three-fourths. These characters separate the males from *transversalis* Cur. The females of *rectus* are quite distinct with the rather wide abdominal bands which reach the sides in practically their entire width with very little attenuation. The hind femora bear a definite blackish post median band which is quite a bit paler in typical specimens of *ribesii.*

6. *Syrphus torvus* O. S. (Fig. 4.)

Syrphus torvus Osten Sacken 1875, Proc. Bost. Soc. Nat. Hist. 18 : 139.

Readily recognized in this group by its hairy eyes. It is somewhat darker than typical *ribesii,* especially the female which has the hind femora black at the base. The face is always yellow without any median stripe. The hairy eyes will also readily distinguish it from *vitripennis,* its closest relative. Length about 12 mm.

It is a very common species throughout the northern sections of North America, and often occurs in countless numbers.

7. *Syrphus bigelowi* Cur.

Syrphus bigelowi Curran 1924, Can. Ent. 56 : 288.

Similar to *ribesii* L. but the femora are practically wholly pale in the female and broadly pale to reddish apically in the male with very few tiny black hairs; the antennae are reddish yellow and only lightly brownish above on the third segment. The lower part of the front of the female is quite characteristic being slightly swollen and more strikingly yellow than *ribesii.* Length about 10 mm.

The male is quite similar to *vitripennis* Mg. but may be told from that species by the reddish antennae. The females are easily separable by the pale hind femora of *bigelowi.*

The venter is usually unicolorous and there are often black hairs on the face near the central knob. Specimens from Ontario, Alaska, British Columbia, and Wisconsin compared with the type at Ottawa. I have also seen several specimens from Maine.

8. *Syrphus transversalis* Cur. (Fig. 5.)

Syrphus transversalis Curran 1921, Can. Ent. 53 : 155-156; 1924, Occ. Pap. Bost. Soc. Nat. Hist. 5 : 81.

Abdomen beyond the second segment in the female reflexed downwards, apex truncate with all of the segments visible from above. Three principal bands of the abdomen obscure yellow, only the first interrupted. Eyes bare, face, oral margin, and cheeks yellow. Squamae pilose. Male similar to *rectus* O. S. Length 8 to 10 mm.

Female. Face, oral margin, and cheeks yellow, with only a slight indication of brown on the upper mouth edge; pile yellow, sides of face lightly dusted with yellow pollen; facial tubercle moderately large; front black, heavily clothed with yellow pollen on the sides leaving in some cases a large shining black triangle, the black connected by a distinct line with the entirely black ocellar area; sometimes the pollen partly obscures this black line, reducing the triangle to a spot just above the W; a small black spot immediately above each antenna; pile of front black; pile of occiput white, becoming yellowish and with a few black hairs near the ocelli. Antennae yellow, tips of the first two segments and the upper half of the third segment brown to black, arista yellowish to brown.

Thorax greenish to black with 3 or 4 very faint coppery longitudinal lines; the dorsum is very lightly covered with pollen, heavier on the sides, which gives the thorax a sub-shining appearance; pile all yellow, being heavier and longer on sides; the pleura with yellow pollen and pile. Scutellum yellow with black pile, a few yellow hairs near the base.

The front two pair of legs are entirely yellow except the coxae and trochanters, and light infuscations on the tarsi; hind femora and tibiae yellow with a broad preapical dark ring on each segment, tarsi piceous. The pile of the legs is sparse and all yellowish to whitish except black on the outer side of the apical half of the hind femora, the outer side of the hind tibiae, and the upper side of the hind tarsi.

Wings hyaline, the stigma yellow; squamae yellow, fringes brown; disc hairy; plumule yellowish; halteres yellow.

Abdomen opaque black, the first crossband bright yellow, the others obscurely yellow, often almost of a hoary appearance. First segment narrowly yellow on the sides; second segment with a broad interrupted band, more than one-third the length of the segment, inner ends rounded, outer ends reach the sides and extend forward to the base of the segment; third segment with a nearly straight basal band which reaches the side margins in its full width, in the middle there is a small projection on the anterior margin; fourth segment with a slightly narrower but similar band; a rather broad apical band on the fourth and fifth segments. The tips of the remaining segments are also yellow, being readily seen from above due to the upward curling of the fifth segment. First two sternites yellow, the others obscurely brownish; pile of the sternites all yellow and there are no short oppressed black hairs although there are a few yellow ones on the fourth sternite. Pile of the tergites yellow toward the base, black and mostly oppressed posteriorly.

Male—not at all like the female; abdomen of normal shape and very closely related to *rectus* O. S. It differs from this species as follows: abdominal bands slightly narrower; sides of the checks with a black area; pile of scutellum mostly yellow in front, with black hairs behind; pile of face nearly all black; and the hind femora black on only the basal two-thirds. *S. rectus* has all yellow face and cheeks, black pile on the face only near the antennae, nearly all black pile on the scutellum, and the hind legs all black on all but the apical one-fifth, or at most one-fourth. Otherwise the males of these two species are indistinguishable.

Described from five females, compared with the type, collected at Madison, Wis., May to September; one female from Fort Lee, N. J. (R. C. Osburn); and five males, four from Madison, April and May, and one from Orillia, Ont. (C. H. Curran) collected in May. I have also seen specimens from Colorado and Maine.

9. *Syrphus* **hinei** n. sp. (Fig. 6.)

Emarginate edges of the abdomen continuously yellow; 2nd and 3rd abdominal bands not interrupted; femora entirely yellow on the female, nearly so on the male; face and cheeks yellow; antennae mostly reddish. Length 11 to 12 mm.

Female—Face and cheeks yellow, lightly pollinose, heavier on the sides and continued as a broad uninterrupted band across the front; pile of face and cheeks mostly yellow, a few short black hairs on the face near the tubercle; front black above, yellow on the bare area above the antennae, vertex black; pile of front black; occiput black with golden to whitish pollen and pile. Antennae reddish, narrowly black on the upper side of the third segment, arista brown. Eyes practically bare.

Thorax dull olivaceous with three faint, narrow brownish stripes anteriorly; pile golden, darker along the sides, yellow pollinose on the sides; scutellum yellow with black pile, a few yellow hairs along the base. Metasternum bare.

Legs entirely yellow except the coxae, trochanters, and the upper side of the hind tarsi; pile yellow, some black hairs on the apical part of the femora and most of the hind tibiae and tarsi; spicules under the middle metatarsus black.

Wings hyaline; stigma dilutely yellowish; squamae hairy, golden in color, halteres yellow.

Abdomen semi-opaque black with the emarginate edges yellow, pile black along the edges except on the base. First segment black with extreme sides yellow; second segment with a pair of narrow yellow spots which are pointed on their inner ends and reach the sides by a little more than half their greatest width; third segment with a continuous yellow band which occupies the basal half of the segment, attenuated on the sides, reaching both the yellow side margins and the base of the segment, emarginate in the middle and with a small projection in front which nearly reaches the base of the segment; fourth segment similar but the band is nearer the base and the mid-projection reaches the base of the segment; apical margin of segment four rather broadly yellow; fifth segment yellow with a broad black triangle. Venter usually yellow with occasionally black on the third and fourth sternites.

Male quite similar; front with a black arc above the antennae, sides heavily pollinose; femora narrowly black on their bases; spots on the second segment of the abdomen much larger; bands broader and scarcely reach the bases of the segments; venter usually darker, not distinctly marked; emarginate edges not as distinctly yellow and there are yellow hairs where the bands reach the sides.

Holotype female—Savanoski, Naknek Lake, Alaska, July 1919, J. S. Hine, Coll. Allotype male—Same place Aug. 1919, J. S. Hine, Coll. Paratypes as follows: four females and two males same data as types; one male Ottawa, Can., marked "28–6"; two females Madison, Wis.; May 13, 1919; C. L. Fluke, Coll., and 2 females Katmai, Alaska, July 1917, J. S. Hine, Coll. Types in the James S. Hine collection, Ohio State Museum. Paratypes in the Hine collection, the American Museum of Natural History and the collection of the author. It is with considerable pleasure that I name this species in honor of the late J. S. Hine.

This species is closely related to *ribesii* L. and *attenuatus* Hine. All the bands of *attenuatus* are interrupted and the bases of the femora in the male are typically more broadly black. The occasional yellow emarginate edges of *attenuatus* suggests that *hinei* may be only a variation, but the bands easily separate the two. There is no indication of the yellow emarginate edges in *rebesii,* and the males of that species have the hind femora largely black.

I have another male caught by Hine at Katmai in 1917 that may belong here but the second band is much wider and deeply cut into posteriorly, and the femora are almost all pale.

10. *Syrphus attenuatus* Hine (Fig. 7).

Syrphus attenuatus Hine 1922, Ohio Jour. Sci. 22 : 144.

Abdomen with three pairs of large yellow spots which are strongly convex posteriorly, emarginate edges often yellow, face yellow, antennae reddish. Length 11 to 13 mm.

Male—Face and cheeks yellow, in some specimens there is a black spot below the eyes; pile of the cheeks yellow, yellow and black mixed on the face, becoming all black along the sides of the antennae; front yellow but in some specimens a small amount of black which is usually covered with yellow pollen, pile black; occiput black with yellow pollen and pile, a few black hairs overhang the eyes as far down as one-third the distance from the vertex to the cheeks; vertical triangle black with black pile. Antennae reddish, slightly dark above on the third segment, the arista reddish, darker at the tip. Eyes bare.

Thorax dull olivaceous to blue, pile all yellow, rather heavy, but darker along the sides; scutellum all yellow with black pile, sometimes the front half with yellow pile. Hine's description is misleading, giving the impression that the scutellar pile as well as thorax is all yellow. Metasternum bare.

Legs yellow with about one-fourth of the four front femora and one-third to one-half the hind femora black; occasionally the hind femora are nearly all pale; the hind tarsi infuscated and there are a few specimens with a slight infuscation on the hind tibiae; coxae and trochanters black; pile of legs all pale, including coxae, except the usual black oppressed pile on the hind tibiae and tarsi.

Wings hyaline to very dilutely infuscated, stigma light brown; squamae light brown, hairy; halteres yellow.

Abdomen opaque black with three pairs of large yellow spots which are only slightly concave in front but decidedly convex posteriorly and reach the sides obscurely in some specimens and more broadly in others; the spots occupy at least one-half of the width of the segments and are greatly attenuated so as to reach the bases of their respective segments; side margins of segment one yellow. Posterior margin of the fourth segment and all of the fifth yellow. Venter practically unicolorous and the pile is all pale, with no short oppressed black hairs; there is a small round dark spot on sternite one and a small elongate spot on the second sternite. One specimen from British Columbia (Osburn) has a large triangular spot on each of sternites two and three.

Female—front black on upper two-thirds and the edge of the black in front forms an inverted V shape, sides of the black heavily dusted with pollen, slightly less in the middle. Cheeks all yellow, pile of face more yellow, abdominal bands narrower; legs all pale except coxae, trochanters, and the infuscated hind tibiae.

Described from four males; two from Savonoski, and one from Katmai, Alaska (Hine); and one from Banff, Alberta; six females, one from Savonoski (Hine), two from British Columbia (Osburn), two from Orono, Me., (Metcalf), and one from Colorado at 9000 feet elevation.

Types in the James S. Hine Collection at the Ohio State Museum. Type locality, Alaska.

11. *Syrphus opinator* O. S. (Fig. 8).

Syrphus opinator Osten Sacken 1877, Bul. U. S. Geol. and Geog. Sur. of Ter. 3 : 327; Williston 1886, Synopsis 83; Curran 1921, Can. Ent. 53 : 157; Fluke 1929, Wis. Expt. Sta. Res. Bul. 93 : 19.

Face lemon yellow in color; femora of female entirely yellow; first abdominal spots reach the side margins, bands on second and third segments entire and usually separated from the lateral margins. Length, 9–12 mm.

A very easily recognized species by its lemon yellow face, characteristically shaped second and third abdominal bands which normally do not reach the side margins; in a few females they extend weakly over the sides but the females have all yellow legs except the coxae and trochanters.

It is a common form occurring from the Rocky Mountains to the Pacific Coast.

12. *Syrphus knabi* Shan. (Fig. 9).

Syrphus knabi Shannon 1916, Proc. Biol. Soc. Wash. 29 : 200; Metcalf 1917, Me. Agr. Expt. Sta. Bul. 263 : 172; Curran 1921, Can. Ent. 53 : 154.

Face yellow, antennae pointed, sides of thorax distinctly yellowish pollinose, legs mostly yellow, abdominal bands extend over the side margins in practically their full width, middle metatarsi with yellow spicules below. Length 11 to 13 mm.

An easily recognized species and there should be no difficulty in placing it. Specimens from Mississippi, Ohio, Ontario and Wisconsin were examined.

Metasyrphus Matsumura and Adachi

The Entomological Magazine (Japan) 2 : 147, 1917.

Lower lobe of the squamae bare, metasternum hairy or bare, abdomen emarginate, usually oval.

Face yellow, with or without a black shining stripe; eyes usually bare, occasionally pilose, holoptic in the male; antennae moderate in size, frequently the third segment more than twice as long as the first two together; thorax usually shining, sometimes dull, without *conspicuous* longitudinal vittae; legs simple; wings simple, the third vein rarely conspicuously curved into the first posterior cell; abdomen oval, emarginate, and usually with prominent yellow crossbands. Type of genus: *Syrphus corollae* Fab.

This is rather a heterogeneous group but one easily separated from true *Syrphus* by the bare squamae and from *Epistrophe* by the emarginate abdomen. A few species in the *emarginatus* group have the edges of the abdomen only weakly ridged but these species are readily grouped by the yellow stripes on the sides of the thorax. *M. nitidicollis* might be the easiest to confuse.

If it were desirable to further split up this genus there would be four quite natural groups which may be separated by the following key:

1. Metasternum hairy .... *Metasyrphus* s. s.
   Metasternum bare 2
2. Eyes hairy .... *amalopis* group
   Eyes bare 3
3. Third longitudinal vein nearly straight, sides of mesonotum usually yellow in ground color .... *emarginatus* group
   Third longitudinal vein distinctly curved into the first posterior cell, sides of mesonotum not yellow in ground color .. *lapponicus* group

Matsumura has not been consistent in the characterization of the genus as he states that the third longitudinal vein is distinctly curved into the first posterior cell and the lateral margins of the abdomen are not distinctly ridged, and yet he names *S. corollae* F. the type. While the third vein of this species does have considerable curvature it is only moderate when compared to *laxus* or *lapponicus*. The sides of the abdomen, however, are very plainly ridged. I have spent many hours trying to associate the North American species with Matsumura's genera but it is an impossible task unless the genotypes can be examined. Shiraki (Syrphidae of Japan) has straightened out many of Matsumura's species but since he does not recognize any splits in the genus *Syrphus* many of the genera proposed by Matsumura will long remain a puzzle.

It might be desirable to utilize some of Matsumura's genera to apply to the groups named above as subgenera of the genus *Metasyrphus* or as coordinate genera, but with the material at hand I am unable to make these associations. If this were done *Metasyrphus* should be restricted to those species with a hairy metasternum; *Dideopsis* might be used for the *lapponicus* group, although the type species belongs to the genus *Asarkina, Conosyrphus* for the *amalopis* group, and possibly *Episyrphus* for the *emarginatus* group. *Dideoides* appears to embrace such forms as *M. laxus* O. S. although this species has hairy metasterna. In view of the many synonyms created by Matsumura, as determined by Shiraki, it appears justifiable to ignore most of the characters he used to form generic groups.

I do not think *Olbiosyrphus* Mik. can be considered for any of these groups although it is an older name. It is apparently closely related to *Xanthogramma* but the eyes are hairy and the abdomen is probably semi-spatulate. It might possibly be used for the *emarginatus* group, which will be considered in a later paper.

For these reasons I prefer to consider these four groups all under one genus, *Metasyrphus*. I firmly believe, however, that in time it will be split up into distinct genera but until someone is able to associate the proper genera for these groups, they will remain as one genus.

KEY TO THE SPECIES OF METASYRPHUS

1. Metasternum hairy 2
   Metasternum bare 43

Metasyrphus s. s.

2. Face entirely yellow—no median black vitta 5
   Face with a median black vitta, at least black on the tubercle 3

3. Eyes pilose 4
   Eyes bare 13

4. Abdominal bands excised or interrupted, antennae black, coxal hairs black, larger species .... *laxus* (O. S.)
   Bands undulate, antennae reddish below, coxal hairs pale, smaller species .... *pingreensis* (Fl.)

5. Abdominal bands blood red in color .... *montivagus* (Sn.)
   Abdominal bands yellow in color.............................. 6

6. Fourth tergite reddish yellow .... *snowi* (Wehr)
   Fourth tergite black fasciate 7

7. Abdominal bands interrupted or greatly excised 8
   2nd and 3rd abdominal bands not interrupted 11

8. Fifth tergite black with yellow spots on the basal corners .... depressus n. sp.
   Fifth tergite reddish yellow 9

9. Abdominal spots separated from the side margins .... talus n. sp.
   Abdominal spots reach the side margins 10

10. Pile of scutellum yellow .... *flukei* (Jones)
    Pile of scutellum black .... *palliventris* (Cur.)

11. Sides of the abdomen continuously yellow, antennae yellow .... *ochrostomus* (Zett.)
    Sides of the abdomen alternately black and yellow 12

12. Third antennal segment almost twice as long as wide .... *lebanoensis* (Fl.)
    Third antennal segment not more than one and one-half times longer than wide .... *latifasciatus* (Mq.)

13. Abdominal bands interrupted 35
    Second and third bands entire or no bands present 14

14. Abdomen entirely black .... nigroventris n. sp.
    Abdomen with yellow bands 15

15. Abdominal bands blood red in color .... *montivagus* (Sn.)
    Abdominal bands yellow in color 16

16. Males—those with holoptic eyes 17
    Females—those with dichoptic eyes 27

17. Abdominal bands usually decidedly undulate 18
    Abdominal bands nearly straight or only weakly undulate 22
18. First two abdominal bands separated into spots, the third greatly excised .... **depressus n. sp.**
    Second and third bands entire 19
19. Wings distinctly infuscated reddish brown ..... *fumipennis* (Thom.)
    Wings hyaline 20
20. Face seldom with a black vitta, abdominal band on second segment usually reaches the sides, front yellow ...... *latifasciatus* (Mq.)
    Face with a black vitta, spots on the second segment either separated from or reach the sides, front yellow or with a black arc 21
21. Pile of face mostly black, abdominal bands greatly undulate and nearly always touching the side margins ....*venablesi* (Cur.)
    Pile of face white, abdominal bands well separated from the side margins .... *meadii* (Jones)
22. Front yellow .... *latifasciatus* (Mq.)
    Front with black spots or an arc above the antennae 23
23. Scutellum white haired, black of cheeks continuous with the facial vitta .... *canadensis* (Curran)
    Scutellum mostly black haired 24
24. Abdominal bands reach the side margins .... *medius* (Jones)
    Abdominal bands separated from the sides 25
25. Smaller species (7 to 8 mm.) .... *pomus* (Cur.)
    Larger species (9 to 10 mm.) 26
26. Black of cheeks connected to facial stripe by a black stripe along oral margin, genital styles small, oval .... *vinelandi* (Cur.)
    Black of cheeks separated from facial stripe by a yellow area, styles long, irregular in outline .... *wiedemanni* (John.)
27. Hind femora black at base 28
    Hind femora yellow at base 32
28. Abdominal bands strongly undulate or excised 29
    Abdominal bands straight or weakly undulate 31
29. Pile of scutellum white .... *canadensis* (Cur.)
    Pile of scutellum black 30
30. Lower third of front pure yellow .... **depressus n. sp.**
    Two black spots above antennae .... *meadii* (Jones)
31. Smaller species (7 to 8 mm.) spots on 2nd segment usually united at middle .... *pomus* (Cur.)
    Larger species (9 to 10 mm.) .... *vinelandi* (Cur.)

32. Hind femora entirely yellow 33
Hind femora at least with a dark ring apically 34

33. Lower third of front pure yellow, without pollen..*latifasciatus* (Mq.)
Lower third of front usually with black markings, pollinose ....
.... *venablesi* (Cur.)

34. Bands on third and fourth tergites reach the side margins ....
.... *medius* (Jones)
These bands separated from the side margins ......*wiedemanni* John

35. Dorsum of 4th and 5th abdominal segments reddish yellow ....
.... *snowi* (Wehr)
4th segment with distinct black markings 36

36. Face and antennae yellow 37
Face with at least the central knob darkened, antennae darker....38

37. Venter of female yellow; of male with black bars..*palliventris* (Cur.)
Venter of female with black bars ....*palliventris* var.

38. 3rd pair of abdominal spots narrowly connected, lower part of front of female pure yellow .... depressus n. sp.
3rd abdominal spots distinctly separated 39

39. Pile of thorax pure white, two black dots above the antennae ....
.... *perplexus* (Osb.)
Pile of thorax yellow to brownish 40

40. Pile of the face and scutellum pale 41
Pile of the scutellum black, of the face usually black 42

41. Abdominal spots narrow and straight, lower one-sixth of front of female yellow ....*rufipunctatus* (Cur.)
Abdominal spots broad and arcuate .... *montanus* (Cur.)

42. Abdominal spots of male almost as broad as long, facial pile of female mostly black, moderately small narrow species (8 to 9 mm.)....
.... *curtus* (Hine)
Abdominal spots of male not so broad; facial pile of female yellow, rather large broad oval species (10 to 12 mm.)................
.... *neoperplexus* (Cur.)

43. Eyes hairy 44
Eyes bare 57

Amalopis Group

44. The bands on the third and fourth abdominal segments entire, at most only notched in the middle 45
Abdominal bands interrupted in the middle 47

45. Abdominal bands reach the side margins in their full width, 2nd and third bands semi-interrupted .... *reflectipennis* (Cur.)
Abdominal bands well separated from the side margins 46

46. Abdominal bands bilaterally oblique, their posterior edges nearly straight .... *lotus* (Will.)
Bands decidedly concave anteriorly and convex posteriorly .... *creper* (Snow)

47. Abdominal spots narrow, (sometimes absent) either transverse or oblique, never greatly excised, their inner ends very little club-shaped 48
Abdominal spots club-shaped and arcuate or greatly excised, often cut in two 53

48. First pair of spots small and elongate oval, thoracic pile brown to black, antennae black 49
First pair of spots larger, longer; thoracic pile white or black 50

49. Second and third pair of spots present .... *limatus* (Hine)
Second and third pair of spots absent .... *limatus* var.

50. Abdominal spots almost transverse, and reach the side margins, pile of scutellum pale, basal joints of antennae yellow (10 to 12 mm.) .... *venustus* (Mg.)
Abdominal spots oblique and separated from the side margins 51

51. Basal antennal segments mostly black; front femora of female black at base, pile of thorax of male black; epistoma produced below.. .... *pauxillus* (Will.)
Basal antennal segments mostly reddish yellow, epistoma very little produced 52

52. Front femora of female yellow, pile of mesonotum of female and male pale .... *laticaudus* (Cur.)
Front femora of female black at base, pile of mesonotum of male black .... *pacifica* (Lovett)

53. Second and third pair of spots do not reach the side margins 54
Second and third pair of spots reach the side margins 55

54. Second and third pair of spots excised so that there are 4 spots on each of segments three and four .... *amalopis* (O. S.)
Second and third pair of spots not excised .... *creper* (Sn.)

55. Abdomen very broad and flat, the spots concave posteriorly and reaching the bases of the 3rd and 4th segments laterally; abdomen shining; length 12 mm. .... *laticaudatus* (Cur.)
Abdomen not unusually broad, the spots scarcely concave posteriorly, or if so, the abdomen not shining 56

56. Antennae mostly black, especially first two segments; pile of scutellum black .... *amalopis* (O. S.)
Antennae yellowish, pile of scutellum mostly white ... *osburni* (Cur.)

57. Third longitudinal vein nearly straight, sides of mesonotum usually yellow in ground color 61
Third longitudinal vein distinctly curved into the first posterior cell, sides of mesonotum not yellow in ground color 58

Lapponicus group

58. Abdominal bands interrupted 59
Second and third bands entire .... *aberrantis* (Cur.)

59. Facial stripe reddish brown and abbreviated, pile black, length 13 mm. .... *marginatus* (Jones)
Facial stripe black, more extensive, pile mostly pale, length seldom over 12 mm. 60

60. Three pairs of abdominal spots present .... *lapponicus* (Zett.)
Only one pair of spots present .... *lapponicus* var.

Emarginatus group

61. Abdominal bands isolated into spots 62
At least one band entire 63

62. Bases of front femora black, face between eyes and mouth opening dark ....*divisus* (Will.)[2]
Front legs entirely yellow, face usually all yellow, anterior corners of third and fourth abdominal segments yellow ..... *weborgi* (Fl.)[2]

63. Band on second abdominal segment does not reach side margins...64
Band on second segment reaches side margins 65

64. First and third bands interrupted, the second entire..*invigorus* (Cur.)[2]
Second and third bands entire .... **metcalfi n. sp.**

65. Antennae entirely yellowish 66
Antennae brown to black above, yellowish below 67

66. Scutellum entirely yellow haired, cheeks yellow, abdominal bands broad, the side margins continuously yellow..*ochrostomus* (Zett.)
Scutellum black haired, cheeks partly black, abdominal bands narrower, side margins alternately black and yellow .... *nitidicollis* (Mg.)[2]

67. Wings infuscated, antennae larger and mostly black (*infuscatus* Fluke) .... *felix* (O. S.)[2]
Wings hyaline, antennae smaller and at least reddish below 68

[2] To be discussed in a later paper.

68. Anterior corners of the third and fourth abdominal segments yellow .... *emarginatus* (Say)[2]
Anterior corners of the abdominal segments black .... *aenea* (Jones)[2]

13. *Metasyrphus wiedemanni* (John.) (Figs. 10, 36).

Syrphus americanus Wied. 1830, Ausser. Sweif. Ins. 2 : 192; Osten Sacken 1875, Proc. Bost. Soc. Nat. Hist. 18 : 145; Williston 1886, Synopsis, 82; Metcalf 1912, Ohio Nat. 12 : 477.
Syrphus wiedemanni Johnson 1919, Can. Ent. 51 : 32.

Face with a median black vitta; front rather heavily pollinose with two small brown to black dots just above the antennae; hind femora of female yellow at the base and narrowly at the tip; abdominal bands broad, almost straight, and separate from the side margins; first abdominal band frequently entire. Length 10 to 12 mm.

Male—Face yellow with yellow pile, a narrow black vitta which does not reach the antennae and which extends narrowly only a short distance down the sides of the mouth; cheek shining black with white pile and partly covered with white pollen, rather broadly yellow below the mouth opening; frontal triangle yellow with two small brownish dots just above the antennae, broadly yellow pollinose along the orbits, pile black; occiput heavily greyish pollinose, pile white below, yellow above; frontal triangle black with black pile, yellow pollinose behind the ocelli. Antennae rather large, the third segment one and one-half times as long as the first two combined, black, with yellow on the lower third of the last segment; arista reddish, darker at the tip.

Thorax shining aeneous to bronze, pile all pale, slightly yellowish along the sides; scutellum yellow, pile rather fine, somewhat kinky and yellow and black intermixed but the light colored pile predominates. Metasternum hairy.

Legs yellow; one-fourth to one-third of the four front femora, three-fourths to four-fifths of the hind femora, and a broad median band on the hind tibiae black. Wings hyaline, stigma brownish; squamae white with light yellow fringe, halteres yellow.

Abdomen black with three principal yellow bands, all separated from the sides and from the basal margins of the segments; bands are broad, occupying one-half or more of the width of the segments, their fore-margins nearly straight and

[2] To be discussed in a later paper.

their rear margins only very little concave; posterior margins of the fourth and fifth tergites broadly yellow and the basal corners of the fifth also yellow. Venter yellow with rather broad black bars on sternites two, three and four; fifth sternite entirely yellow; genital cerci long, slender, and yellowish red in color. Pile on the first two sternites long, white, and kinky; on the third partly white and partly short black; all black on the fourth and fifth, and mostly depressed.

Female—front with a broad pollinose band which is distinctly interrupted to form an inverted black Y, with two prominent black spots above the antennae. Antennae larger and blacker than in the male. Legs more yellow, only the basal one-fifth of the four front femora, a broad median ring on the hind femora, and a narrow ring on the hind tibiae black. First abdominal band frequently not interrupted; fifth sternite with a black bar.

A very common species throughout the eastern and southern United States and Canada. It does not occur west of the Rocky Mountains. The Western species are referable to *meadii* (Jones), *medius* (Jones), or *venablesi* (Cur.). Osten Sacken's description of this species is very distinct and does not include any of the above related forms.

14. *Metasyrphus vinelandi* (Cur.) (Figs. 11, 37).

Syrphus americanus var. *vinelandi* Curran 1921, Can. Ent. 53 : 172; Metcalf 1913, Ohio Biol. Sur. 1 : 55 (*S. sp.*); Fluke 1929, Wis. Agr. Expt. Sta. Bul. 93 : 18. (var.)

This is a distinct species, although closely related to *wiedemanni;* typical specimens are readily told by the black on the base of the hind femora of the female, and by the small black genital styles (much longer in *wiedemanni*) of the males. Because of the decided differences in the genitalia I consider these two distinct.

In addition, the antennae are slightly larger, the abdominal bands are narrower and the posterior margins of the second and third decidedly emarginate, the black of the cheeks of the male is usually connected to the black stripe of the face, and the fifth tergite of the female is usually blacker. The larvae are quite easily told as they are decidedly greenish. Found throughout the range of *wiedemanni* and sometimes more common.

The genital styles of this species are similar to those of *pingreensis* except they are blacker and slightly smaller. The pile of the face of *vinelandi* is usually predominently pale while it is all black in *pingreensis*.

15. *Metasyrphus pomus* (Cur.) (Fig. 12).

Syrphus americanus var. *pomus* Curran 1921, Can. Ent. 53 : 172.

Quite like *wiedemanni* (John.) and considered by Curran as only a variety. They are usually readily told by their smaller size, 7 to 8 mm., narrower abdominal bands, darker legs, darker oral margin, and in general an entirely darker appearance. Certain specimens might be confused with *canadensis* (Cur.) but in that species the abdominal bands are very narrow and distinctly sinuate and the pile of the scutellum is white.

16. *Metasyrphus canadensis* (Cur.) (Fig. 13).

Syrphus canadensis Curran 1926, Can. Ent. 58 : 172.

A very distinct species with unusually narrow undulated abdominal fasciae, and the scutellar pile is normally all pale. It is closely related to *pomus* (Cur.) but the undulated bands, blacker oral margin, and pale haired scutellum should readily distinguish it. The males will be more difficult to separate than the females as the bands are broader in the male than in the female. Length 7 to 10 mm.

Male—Face yellow with a distinctive black vitta which tapers above and connects with that of the oral margin and cheeks, which are broadly black; pile all pale except the black hairs near the antennae which are continued on to the front. Frontal triangle yellow with two black shining spots which are almost in the shape of an arc, pile black. First two segments of the antennae black, the third reddish brown, only briefly lighter beneath.

Thorax blue shining with all white hairs; scutellum obscurely yellow, pile practically all white, only occasionally a black hair.

Legs yellow with the basal third of the four front femora, all but the tip of the hind femora, and an obscure ring on the hind tibiae black; the apical segments of the tarsi are dark above.

Abdomen—First segment shining blue, remaining segments semi-opaque black with three yellow crossbands, all separated from the sides; the first band interrupted, the inner ends pointed, the outer ends truncate, their corners rounded; second and third bands well removed from the basal margins of the segments, their fore margins almost straight, their rear margins emarginate; there is a median anterior projection on each band; posterior margins of the fourth and fifth tergites narrowly yellow. Venter yellow with broad median black crossbars on sternites two, three, four and five. Genital cerci short, about one-half as long as those on *pomus* (Cur.).

The female is very distinctive because of the narrow undulate bands, otherwise much like the male.

Described from two males and seven females from Ontario, Idaho (J. M. Aldrich), and Wisconsin. I have followed the entire metamorphosis of this species in Wisconsin. The larvae look remarkably like bird droppings and feed upon *Chaitophorus populicola* on *Populus spp.* Metcalf has sent me nine specimens from Maine, mostly reared material.

17. *Metasyrphus medius* (Jones)

Syrphus medius Jones 1917, Ann. Ent. Soc. Amer. 10 : 224; 1922, Colo. Agr. Expt. Sta. Bul. 269 : 29, fig.

Face with a narrow median vitta, legs mostly yellow with a preapical dark ring on the hind femora (female); the abdominal bands are all entire, reach the side margins in about half their width, and are almost straight.

The nearest relative of *medius* is *venablesi* (Cur.), but the two may be separated by the entire first abdominal band, shape of the bands, and dark ring on the hind femora of *medius*. From *wiedemanni* it is distinguished principally on the bands attaining the lateral margins.

It is not a common species but is distributed over most of the United States and Canada. I have examined specimens from Wisconsin, Michigan, Louisiana and California.

18. *Metasyrphus meadii* (Jones) (Figs. 14, 38).

Syrphus meadii Jones 1917, Ann. Ent. Soc. Amer. 10 : 223.
Syrphus nitens authors in part.[1]

Eyes bare, black facial stripe usually separated from the black cheeks by a brown or yellow area, face with whitish pile, front with two black spots just above the antennae, hind femora

[1] The genuine *Metasyrphus nitens* (Zett.) has not yet been reported from this country, but inasmuch as many European species have been introduced there is a possibility that it may be found here at some later time. For this reason a figure of this species has been included in this paper (Pl. VIII, fig. 15).

of both sexes black at the base, pile of scutellum black, abdominal bands undulate and well separated from the side margins.

Only through considerable experience and knowledge of related forms can one definitely determine this species. Specimens with weakly undulate bands are told with difficulty, often being confused with *wiedemanni* and *vinelandi.* The black areas on the hind femora of the female will help to distinguish them from *wiedemanni* and the antennae are usually smaller than those of *vinelandi.* Those with strongly undulate bands may be confused occasionally with *pingreensis* if the hair of the eyes is rubbed off of the latter; in such a case the pile of the face is a good character, and the first pair of spots of the female are always well separated from the side margins in *meadii.*

There might be some difficulty in separating the males from those of *venablesi* (Cur.) but the latter species usually has less extensive black on the facial tubercle and the pile is black, the front is usually mostly yellow, the hind femora are black only on a little more than the basal half, and the second and third abdominal bands almost reach the side margins. The yellow hind femora readily separates the females.

S. meadii is typically a western form although specimens have been taken more rarely in Ontario, Wisconsin, and other eastern sections.

19. *Metasyrphus fumipennis* (Thom.) (Fig. 16).

Syrphus fumipennis **Thomson 1868, Kong. Svenska Freg. Eng. Resa Omkring Jorden 1 : 499; Williston 1886, Synopsis 293.**

Very closely related to *meadii* (Jones) and *venablesi* (Cur.) but the wings are decidedly infuscated with reddish brown. Eyes bare, facial pile black, front with two black dots, mesonotum with reddish pile, hind femora black on the basal four-fifths, and the abdominal bands undulate and well separated from the side margins. Length 11 mm.

Male—Face yellow; cheeks and upper mouth edge black, which is extended over the prominent tubercle but ends at the deepest part of the concavity of the face, the black stripe is diffused on the sides by reddish brown; yellow just below the mouth opening; pile of cheeks white, of face mostly black; front yellow with two brownish dots just above the antennae, pile black, pollinose next to the eyes; vertex black with black pile; occiput heavily greyish pollinose and covered with short white to yellowish pile, with a few black hairs over-hanging the eyes above. Antennae brown, yellow beneath the third segment.

Thorax shining aeneous with light brown pile which is reddish brown along the sides; scutellum yellow with black pile. Legs yellowish red, one-third of the four front femora black at their bases and all but the tip of the hind femora; hind tibiae reddish. Metasternum hairy.

Wings infuscated reddish brown, paler posteriorly; squamae yellow with brownish edge and fringes; halteres yellow.

Abdomen black with three yellow undulate crossbands, the first interrupted, and all well separated from the side margins; apical margins of the fourth and fifth tergites and the basal corners of the fifth reddish yellow; bands are rather broad but well removed from the basal margins of the segments. Venter black, incisures yellow; styles of genitalia long, slender, and reddish in color.

This description is made from a single male collected at Pasadena, Calif., by F. Grinnell Jr. and is located in the National Museum at Washington. It is entirely like *meadii* except for the infuscated wings, black pile of the face, and brownish pile of the thorax.

This may not be Thomson's species but it appears close enough to consider it as such rather than leaving the species as well as the single male specimen unknown.

20. Metasyrphus venablesi (Cur.) (Figs. 17, 39.).

Syrphus venablesi Curran 1929, Can. Ent. 61 : 45.
Syrphus nitens Metc. (not Zett.) 1916, Me. Agr. Expt. Sta. Bul. 253 : 242, figs.

Face with a narrow median vitta, eyes bare, front of female heavily pollinose, pile of scutellum black, hind femora of female yellow, abdominal bands undulate and usually all reaching the side margins narrowly. Length 10.5 to 12 mm.

Male—Face yellow; cheeks, upper oral margin, and a median vitta on the face black; pile of cheeks white, of face black; frontal triangle yellow with two brownish dots just above the antennae (these spots are practically absent on the allotype), pile black. The black of the cheeks is connected with that of the upper mouth edge by a reddish brown area. Antennae black, considerably yellowish below.

Thorax aeneous, shining; pile yellowish to golden along the sides, whitish on the pleura; scutellum yellow, corners darker, pile black.

Legs yellowish red, basal one-third of the four front femora and the basal one-half of the hind femora black.

Abdomen with three pairs of undulated yellow bands which meet the sides very narrowly by their anterior corners; first band interrupted; all separated from bases of segments except on sides where the narrow angulations reach forward to the bases of the segments; apices of fourth and fifth, and the basal corners of the fifth tergites yellow. Venter black, incisures broadly yellow, genital styles comparatively short and yellow.

Female—Front broadly pollinose on the lower two-thirds but usually with two black dots above the antennae (absent in the type but generally occur), occasionally the pollinose band is sub-interrupted; facial stripe narrow; pile of face yellow.

Legs are all reddish yellow except very narrowly black on the four front femora. Abdominal bands narrower than on male, and frequently do not attain the lateral margin.

Described from four males, one from LaFayette, Ind., J. M. Aldrich, collector, three from Calif., and more than 50 females from Alberta, British Columbia, Oregon, Idaho, New York, Montana, Ontario, and California. Apparently it is a common species in the Vera Cruz Valley, California. The male, from Indiana compared favorably with the type, the only difference was the presence of the brown spots above the antennae.

The female is readily told from *meadii* (Jones) by the yellow femora but the male will probably be recognized with difficulty. The undulate bands will separate it from *medius* (Jones), otherwise, however, the two species are remarkably similar. Since the above was written I have seen Metcalf's specimens and they seem to be the same. This extends the range of this species across the continent. The remarkable spiracles of the larvae of Metcalf's specimens suggests a distinct species but I can find no structural differences between the adults.

21. *Metasyrphus laxus* (O. S.)

Didea laxa **Osten Sacken 1875, Bul. Buff. Sci. Nat. Sci. p. 56; 1878, 2nd edition Catalog. 245.**

The largest species of the genus and easily recognized by the hairy eyes, black stripe of the face, black antennae, abdominal bands which reach the side margins and are often interrupted, and by the anteriorly pointed black fasciae on the sternites. The metasternum is hairy. A few specimens lack the black stripe of the face and the legs are often nearly all pale. It is a common species in the West but occurs more rarely over the eastern part of North America.

22. *Metasyrphus pingreensis* (Fluke) (Fig. 40).

Syrphus pingreensis Fluke 1930, Ann. Ent. Soc. Amer. 23 : 137.

Eyes with very short white pile, faintly so in the male; face with a median black stripe; abdominal bands entire except 1st, sub-interrupted in some cases, only the 1st band on the females reaches the margins. Length 9 to 11.5 mm.

Female—Eyes short white pilose, face yellow with a conspicuous brown to blackish line which does not reach the base of the antennae, broadens out gradually to the oral opening and passes down the sides of the mouth only a short distance; cheeks black, but separated from the facial line and also separated below the mouth; pile of the face is mostly black but is paler below and along the eye margins, heavier and blacker along the sides of the antennae; pile on the cheeks and below the oral opening white, continued white along the occiput, but yellow above on the vertex, pile of front all black. Front rather broad, dark shining, with a broad wide Y-shaped marking above the antennae; this is distinctly separated by a yellow area from the two distinct black dots which are immediately above the base of the antennae; these spots are shining and devoid of pile. Antennae rather large, oval and dark, with light areas beneath each segment, arista rather thickened.

Thorax shining with bronze reflections, pile rather heavy and all tawny, scutellum yellowish with long tawny pile, but with a few black hairs intermixed.

Legs yellow with the following black areas; coxae, trochanters, a little more than the basal third of front femora, a little less than a third of the middle femora, all but the tip of the hind femora, and the upper sides of the outer four segments of the hind tarsi. The hind tibiae and the tip of the hind basitarsi dusky; the front and middle tarsi, except basitarsi brownish. Pile of legs mostly black, rather heavy on outer sides, bent forward at the tips of the hairs.

Wings hyaline; squamae pale, but the rather long pile on the edges is tawny, disc lightly pilose.

Abdomen broadly oval, black, partly shining, with three yellow undulate moderately broad cross-bands. First band interrupted by a distance less than the width of the band, reaching the side margins by the extreme anterior corners, broader than the two following ones. Band on third segment undulated, distinctly separated from the side margins and does not touch segment in front; in some specimens sub-interrupted, with the rear margin cut in rather deeply. Next band similar, nearer basal margin of segment, yet distinctly separated the entire distance. Posterior margins of segments four and five, and the anterior corners of five yellow. Venter with distinct black bands on sternites two and three, indefinite on the others.

Male—Similar; the specimens I have examined are slightly smaller than the females. The pile of the face darker and a little longer. The black of the cheeks more brownish and connected to the oral margins. The pilosity of the eyes is sparse. Abdomen darker, the first band seldom reaches the side margins, all the sternites with black bands. Legs much darker, the black of the femora more extensive and the yellow areas almost brownish. Pile on the sternites long and mostly blackish beyond the second segment.

The pile of the eyes although very sparse in some specimens amply distinguishes this species. It is in general appearance very much like *venablesi* (Cur.), but the color of the legs will readily separate them if the pile of the eyes is not apparent. The black pile of the face will separate it from *meadii* (Jones).

Described from numerous specimens taken in Colorado, British Columbia, Oregon, Wisconsin, Manitoba, and Maryland.

23. *Metasyrphus latifasciatus* (Mq.) (Fig. 18).

Syrphus latifasciatus Macquart 1827, Lille Mem. Sco. Sci. 242.
Scaeva abbreviata Zetterstedt 1849, Dipt. Scand. VIII, 3136.
Syrphus abbreviatus Williston 1886, Synopsis, 81.
Syrphus latifasciatus Verrall 1901, British Flies, Syrph. 371.
Syrphus pallifrons Curran 1924, Kans. Univ. Sci. Bul. XV : 172.

A very variable species recognized by its yellow face; yellow front; broad abdominal bands which are sometimes straight, sometimes undulated, and which may or may not reach the side margins; fasciate venter; and rather reddish antennae. Length between 9-10 mm.

Male—Face and frontal triangle yellow with black pile except near the facial tubercle where it is sparse and white; cheeks black or brown with white pile; antennae nearly all yellowish or reddish, although in some specimens the third segment is darkened above.

Thorax shining aeneous black with all golden or yellowish red pile, scutellum yellow with mostly pale pile but usually some black hairs intermixed, and the pile may all be black.

Legs yellow except the basal one-fourth of the four front femora and the basal one-half of the hind femora; the hind tarsi are infuscated above.

Abdomen with broad yellow crossbands; the one on the second tergite separated into two large triangular spots which reach the sides by their upper corners and are often sub-united in the middle; next two bands occupy about two-thirds the width of the segments, notched posteriorly, and usually reach the side margins; apical margin of the fourth yellow; fifth yellow with an oval black spot in the middle. Venter yellow with definite black fascia on sternites two, three and four.

Female—similar; lower one-half of the front pure yellow which almost reaches the frontal depression, rest of front black, all shining; facial pile lighter, abdominal bands usually narrower, occasionally quite undulate, and often do not reach the side margins; legs paler with often the extreme bases of the femora black, other times same as males, venter similar.

The description is made from numerous specimens from "Prussia," British Columbia, New York, New Jersey, Massachusetts, Indiana, and Wisconsin; including two paratypes of *Syrphus pallifrons* Cur. I have been unable to separate Curran's species from the many variations which occur in this species. Verrall has listed several forms and *pallifrons* probably comes the nearest to his variety "d". The characters pointed out by Curran do not seem to warrant a separation of the species.

24. *Metasyrphus lebanoensis* (Fluke)

Syrphus lebanoensis Fluke 1930, Ann. Ent. Soc. Amer. 23 : 139.

Face and upper mouth edge yellow; frontal triangle yellow; front in both sexes pollinose; abdomen with three bands, the first separated into spots which reach the sides, the next two well separated from the sides. *Third joint of antennae on female exceptionally large.* Length 11-12 mm.

This species belongs to the latifasciatus group although some females have black Y markings on the lower part of the front. Its nearest relative is *latifasciatus* but the front in both sexes is pollinose, the antennae are larger and much darker, the legs of the females are all yellow, and the 2nd and third abdominal bands are straighter and well separated from the sides.

It is a western form occurring from New Mexico on the south and British Columbia on the north.

25. *Metasyrphus snowi* (Wehr)

Syrphus ruficauda Snow (not Bigot) 1892, Kans. Univ. Quar. 1 : 36. fig.
Syrphus snowi Wehr 1922, Univ. Studies (Nebr.) *22* : 19 (change credited to Curran but this is the first published record)

Easily recognized by the reddish fourth and fifth tergites, the black cheeks and oral margin, and the yellow face and front.

The only species it could possibly be confused with is *palliventris* (Cur.). but the color of the fourth tergite, the more black oral margin, and the black on the bases of the front femora of the female readily characterizes *snowi.* Occasionally specimens occur on which the second and third bands are not interrupted. It is not a common species and occurs only in the mountains of the West.

26. *Metasyrphus flukei* (Jones) (Fig. 25).

Syrphus flukei Jones 1917, Ann. Ent. Soc. Amer. 10 : 22. (male).

Face yellow, cheeks black, scutellum yellow-haired, abdomen with three pairs of yellow spots which attain the lateral margin.

Female—Face, lower one-half of front, and third segment of antennae yellow, no stripe on the face; cheeks aeneous, shining; oral edge narrowly but not definitely outlined brownish; pile all pale except on front where it is short and black; front mostly shining with small side dust spots.

Thorax shining aeneous; scutellum yellow, pile all yellow, slightly brownish on dorsum of thorax. Legs yellow, tarsi infuscated above.

Abdominal spots reach the sides after attenuating and extending forward, inner ends of the third pair touch the base of the segment. Sternites two and three with black fasciae.

M. palliventris (Cur.) is a close relative, differing only in the black hairs on the scutellum, the narrower abdominal bands, and the unicolorous venter. Described from a female taken in Colorado, contained in the C. V. Riley collection.

27. *Metasyrphus* **talus** n. sp. (Fig. 41).

Face yellow, eyes bare, metasternum hairy, abdomen with three pairs of broad yellow spots, fifth segment reddish, genital styles remarkably long and slender. Length 12 mm.

Male—Face and frontal triangle almost entirely yellow; the upper mouth edge light brown, and in certain lights an indication of a light brown cast to the tubercle; face slightly puffed out, pile white; face and front lightly white pollinose; two very pale light brown spots above the antennae, pile black on front; cheeks shining black with black pile; vertical triangle black with black pile but there are no black hairs overhanging the eyes. Antennae black, yellow below on each segment. Eyes practically bare.

Thorax shining, with a bluish cast, pile all pale yellow, slightly brownish along the sides. Scutellum yellow when viewed from the side, bluish opalescent from above, the pile yellowish white except about a dozen intermixed black hairs on the disc. Legs reddish yellow, basal one-third of the femora black, tarsi infuscated above. Wings hyaline, stigma brown; squamae pale brownish, halteres yellow.

Abdomen velvety black, shining along the segmental junctures, with three pairs of broad isolated yellow spots; first pair semi-triangular, outer ends broader than the rounded inner ends; second and third pairs arcuated, their inner ends nearer the base of the segment than their outer ends; apical margin of fourth and all of fifth reddish. Venter reddish yellow, black fascia on sternites two and three, pile mostly pale on the first three, black on the remaining sternites. Genital styles are extremely long and narrow, slightly broader at their bases and less so at the tips; about five or six times longer than broad.

Type male Mt. Hood, Ore., 7-18-31, J. Nottingham, collector; deposited in the University of Kansas Museum. Two paratype males, collected same place and date, one by Nottingham in the author's collection, the other by R. H. Beamer in the Kansas collection.

A very striking species with its reddish abdominal tip, isolated spots, yellow face, and extremely long genital styles. Its nearest relative appears to be *M. palliventris* (Cur.) but the abdominal spots are well separated from the sides and the scutellum is practically yellow haired. The reddish fifth segment and the long styles separate it from *M. neoperplexus* (Cur.).

28. *Metasyrphus palliventris* (Cur.) (Fig. 19).

Syrphus palliventris Curran 1924, Kans. Univ. Sci. Bul. 15 : 173.

Eyes bare, face yellow, metasternum hairy, abdomen with arcuated yellow spots, fifth tergite yellowish red.

It is related to *snowi* but differs from that species in the following characters: fourth tergite black, with yellow fascia; oral margin yellow; usually a few black hairs on the scutellum; abdominal spots broader, more arcuate, and usually reach the side margins. In addition the 4th sternite of the male is yellow with a black crossbar while that of *snowi* is all yellow. The yellow on the front of the female of *palliventris* is more extensive; in *snowi* it ends rather sharply at the frontal depression. There is a distinct difference in the "facies" which is rather difficult to describe but easily noted after examining the two species.

The following description of the male is taken from a specimen collected at Priest Lake, 4-mile Camp, Idaho, Aug. 1920 (A. L. Melander). The type female was taken in Alberta and I have examined, in addition to the type, two females, one from Alberta (O. Bryant), and the other from Park Co., Mont., (A. A. Nichol); and one male from Bull Frog Lake, Fresno County, Calif., 10,000 feet elevation, collected by E. C. VanDyke. I feel confident that these specimens are the male of *palliventris*.

Male—Length 11 mm. Face and frontal triangle entirely yellow, only narrowly light brownish on the oral margin; cheeks black with light pile; pile of face yellow, of front black; antennae yellowish red, third segment darker above.

Thorax shining greenish black, pile all yellow, more golden along the sides; scutellum yellow opalescent, the corners black, pile mostly yellow but with a few black hairs on the disc. Legs yellow with the basal one-third of the four front femora and the basal one-half of the hind femora black. The black of the femora turns to a reddish brown at the extreme bases, which would suggest that there might occur at times specimens which have paler legs.

Abdomen black with three pairs of unusually broad spots, the second and third pair very narrowly connected in the middle. The first pair of spots occupies more than half the width of the segment, triangular in shape and reach the side margins very obscurely. The second and third pair are arcuated, as broad as the first pair, attenuate and reach the sides, extending forward narrowly to the bases of the segments as in the female. The venter is yellow with definite spots on sternites two, three and four. The long pile on the first three sternites is pale, on the fourth black.

The California specimen shows no particular differences except the face is broader and the antennae more yellowish. This species resembles *flukei* (Jones) which has a pale-haired scutellum and black faciae on the sternites; otherwise they are closely related.

29. *Metasyrphus* **nigroventris** n. sp. (Fig. 20).

Face yellow with a prominent black tubercle, abdomen shining black, without spots or bands. Length 11 mm.

Female—Face yellow; prominent tubercle, broad mouth edge, and cheeks shining black; pile of face pale, of cheeks white; upper two-thirds of front shining black, lower one-third shining yellow, pile black and continued down the sides of the face below the antennae; eyes bare; antennae reddish brown; arista brown.

Thorax shining aeneous, pile nearly white, very pale yellow along the sides; scutellum yellow, pile white except for a few scattering black hairs near the apex. Metasternum hairy. Legs black, tips of femora, basal thirds of the four front tibiae yellowish to brownish. Wings hyaline, squamae white, halteres yellow, stalks brown.

Abdomen shining black, slight indication of yellow borders on the fourth and fifth tergites. The incisures of the sternites narrowly pale. Pile of the tergites is black except white patches where yellow bands might be expected.

Even if the abdomen were spotted or banded the peculiar face and front sets this species apart from any known to me. It should be readily recognized by the sharp tubercle, color of front, and the shining abdomen. Apparently its nearest relative is *latifasciatus*.

Described from a single female, the type, with the following data: "Patoot, 6-8 : 8; Grőnland Nordskj. Exp. 83. Greenland Acc. No. 71429." Type in the National Museum at Washington.

30. *Metasyrphus* **depressus** n. sp. (Fig. 21).

Related to *latifasciatus* and *palliventris* but the first two abdominal bands are isolated into spots and the third one nearly so, the facial tubercle has a brownish vitta, and the fifth tergite is black with only the anterior corners and the posterior margin yellow. All the spots are well away from the side margins. Length: 8 to 9.5 mm.

Female—Face yellow; cheeks, the oral margin, and an abbreviated median vitta on the face black or brown; front black shining on the upper two thirds, yellow shining below; pile of face and cheeks pale, on the front black and rather short; pile of occiput white below becoming pale yellowish above. Antennae small, brownish, yellow underneath the third segment; arista short, brown. Eyes bare.

Thorax shining aeneous black with sparse pale pile which is lightly golden along the sides but almost white on the pleura; scutellum yellow with black pile except along the base.

Legs yellow, the basal one-fourth to one-third of the femora black, on the hind femora rather indefinitely black on the base, tarsi infuscated above; pile mostly short black and depressed. Wings hyaline, the stigma dilutely yellow; squamae yellow, bare above; halteres yellow. Metasternum hairy.

Abdomen semi-opaque black with three pairs of isolated spots, the third pair narrowly connected in the middle; the first pair is slightly narrower than the other two; the second and third pairs gently concave in front and convex behind, inner ends almost pointed, outer ends squared and all well separated from the lateral margins; apical margins of the fourth and fifth tergites and the basal corners of the fifth yellow. Venter black; the incisures, sides, and fifth sternite yellow; pile of first and second sternites pale and erect, on the third and following sternites short, mostly black, and depressed.

Male—Frontal triangle all yellow with black pile, practically no pollen; antennae smaller and unicolorously reddish brown, arista short, brown. Legs blacker than the female, the basal half of the front femora and the basal three-fourths to four-fifths of the hind femora black, tarsi dark brown from above. Abdominal spots similar to female except the first pair are more triangular.

Holotype female—Healy, Alaska, VI-27-21, J. M. Aldrich, Coll. in the U. S. National Museum. Allotype male—Nantucket, Mass. V-31-25, C. W. Johnson, Coll. in the Cambridge Museum. The male is a slightly imperfect specimen. Paratype female—

Low Bush, Ont. Lake Abitibi, VI-23-1925, N. K. Bigelow, Coll. in the Canadian National Museum at Ottawa.

The shape of the abdominal spots suggests *Metasyrphus curtus* (Hine) but the yellow front in both sexes separates it from that species.

31. *Metasyrphus rufipunctatus* (Cur.)

Syrphus rufipunctatus **Curran 1924, Kansas Univ. Sci. Bul. 15 : 180, fig.**

The peculiar facies of this species relates it to *snowi* and *palliventris* but the abdomen with its three pairs of narrow isolated spots, relates it to *perplexus*. The face is yellow with a prominent black tubercle, and pale pile; cheeks and oral margin broadly, shining black; front characteristically pure yellow on the lower one-fifth or sixth just above the black antennae; eyes bare; thorax shining with pale yellowish to whitish pile; scutellum with pale pile; metasternum hairy; femora broadly black, narrowly yellow at the tip on hind legs, and about one-third on the tips of the four front femora. Length 10 to 12 mm.

The type female was collected in British Columbia and I have seen a female from Washington, taken at an elevation of 6 to 8,000 feet on Mount Rainier. This specimen is in the Metcalf collection.

32. *Metasyrphus montivagus* (Snow)

Syrphus montivagus **Snow 1893, Kans. Univ. Quart. 3 : 236 (male); Fluke 1930, Ann. Ent. Soc. Amer. 23 : 141, (female), fig.**

This species is easily recognized by the broad dark blood-red crossbands which are somewhat narrower in the female.

The dorsum of the fifth and following segments are red in both sexes. The pile of the thorax is tawny and this character along with the color of the crossbands will readily separate it from *palliventris* (Cur.) its nearest relative. The facial vitta and black cheeks is also quite characteristic but there are occasionally specimens in which only the tubercle of the face is brownish. It is an high altitude species taken at 10,000 to 11,000 feet elevation.

33. *Metasyrphus perplexus* (Osb.) (Fig. 42).

Syrphus perplexus **Osburn 1910, Jour. N. Y. Ent. Soc. 18 : 55.**
Syrphus arcuatus **authors in part.**

Metasternum hairy; eyes bare, face with a black stripe; front with two large black spots just above the antennae; pile of thorax white; third longitudinal vein only gently curved; abdomen with three pairs of spots, all separated from the side margins. Length 10 to 11 mm.

Male—Face yellow with a black shining stripe which ends in a diffuse point well before reaching the base of the antennae, cheeks also black, occasionally brownish, and there is a shiny brownish connection between the stripe and cheeks, in some specimens it is almost yellow, in others black; beneath the oral opening there is always a very narrow yellow area; frontal triangle yellow, shining, with two prominent black spots just above the antennae; vertical triangle black, shining. Pile of head black; yellow on the cheeks, occiput, except a few overhanging hairs near the vertex, and sparsely on each side of the facial stripe; the black hairs occur along the eye margins and there is an indefinite band crossing the face to the tubercle, quite definite in some specimens. Antennae dark brown, lighter below; arista reddish.

Thorax steely blue shining with rather heavy white pile, longer and thicker on the pleura, scutellum yellowish to opalescent, darker at the basal corners, the pile mostly black, metasternum hairy.

Legs yellow; coxae, trochanters, basal third of front femora, basal half indefinitely of middle femora and all but the tip of the hind femora black; the hind tibiae and all the tarsi, particularly the rear tarsi infuscated to black above. Pile of the legs is mostly black, on the outer and posterior sides of the femora and tibiae the hairs are rather long, those of the front two legs bent outward toward their tips; on the coxae and trochanters white except a few stiff hairs which are black on the front edge of the coxae; most of the hairs on the front tibia and tarsi and the under-sides of the hind metatarsi are yellow, short, and appressed.

Wings hyaline, stigma dilutely yellowish. Squamae white with white to yellowish fringe; plumule white; halteres yellow, the stalk brown.

Abdomen sub-shining, more shining on the edges of the segments; with three pairs of spots or lunules, always well separated and not reaching the side margins; first pair a little better than twice as long as wide, pointed on their inner ends, rounded on their outer ends; second pair usually broad, reaching forward and rounded on their inner ends, truncate on their outer ends; third pair similar, smaller, slightly oblique, and situated almost on the basal half of the segment; apical margins of the fourth and fifth segments narrowly yellow, but not reaching side margins. Pile mostly white basally, blacker apically. Venter variable, usually black shining with narrow yellow cross-bands at the junctures of the segments, more yellow basally, sometimes the yellow is as broad as the intervening black areas. Pile of venter long and white, becoming black on the fourth sternite; a few short semi-appressed black hairs on the 3rd and 4th sternites. Genitalia black with black pile although there is a small patch of white hairs at the tipe of the exposed area. Styles of the genitalia long but evenly oval.

Female—similar; front black, shining, with a pair of triangular pollinose side spots which diffuse below into the yellow of the face, the spots above the antennae large, often connected and usually joined to the black of the upper part of the front, sometimes there is a separation which gives the front a black inverted Y, cheeks often yellowish; antennae larger, pile of face almost all yellow; pile of scutellum frequently nearly all yellow; spots of abdomen longer, narrower, and usually straighter.

Described from specimens from Wisconsin, Colorado, New Jersey, British Columbia and Oregon.

Strange as it may seem this species is a close relative of the *wiedemanni* group. It is only a short step through *meadii* (Jones), through *pingreensis* (Fluke), to *wiedemanni* (John.). The larval characters also show this close relationship as explained by the author (Wis. Res. Bul. 93, p. 17.)

34. *Metasyrphus neoperplexus* (Cur.) (Fig. 43).

Syrphus neoperplexus Curran 1924, Kans. Univ. Sci. Bul. 15 : 93.

Metasternum hairy; face with an abbreviated diffused brownish to black stripe; thoracal pile yellowish; third longitudinal vein only gently curved. Length 12 mm.

The type of this species a male, has only a brownish opalescent diffused stripe on the facial tubercle but I believe that it is slightly teneral as other specimens which agree in nearly all other respects have a more definite black stripe, even though quite abbreviated. I have examined a rather long series from Low Bush, Ont. (N. K. Bigelow) and believe they all belong to this species. The pile of the face is mostly black on the males and the hind femora are black on the basal three-fourths, there is also a black ring on the hind tibiae. The genital styles are of medium length, not more than twice as long as their greatest width which is at their extreme bases.

The female is very similar with the exception of the abdominal bands which are much narrower and the outer ends are obtuse, pointing slightly forward and the second and third spots almost reach the sides. The upper two-thirds of the front is shining aeneous, and there are two large black spots above the antennae, pile black.

The principal differences between this species and *perplexus* (Osb.) is the yellow pile of the thorax, and diffused, abbreviated stripe of the face. It is entirely different than *lapponicus* (Zett.) as that species has no hair on the metasternum and the third vein is rather strongly curved downward.

This species might possibly be confused with *luniger* (Mg.) an European species but the inner ends of the spots of *luniger* are closer to the basal margins of the segments than the outer ends and the legs are much paler.

If the true *arcuatus* (Fall.) has a hairy metasternum, and I strongly suspect it has, then this species will prove to be a very close relative. We have no proof, however, that Lundbeck correctly identified *arcuatus*. This particular tangle will not be entirely unravelled until European writers clear up the status of *arcuatus*. The presence or absence of hair on the metasternum helps considerably to straighten out these species but the last word will not be written until someone makes an exhaustive study of the genitalia of all species after careful comparisons with the types.

In addition to the Ontario specimens I have examples of *neoperplexus* from Wisconsin, Oregon and Colorado.

35. *Metasyrphus curtus* (Hine) (Fig. 22).

Syrphus curtus Hine 1922, Ohio Jour. Sci. 22 : 145.

Abdomen with three pairs of isolated spots, very broad in the male, face with a black stripe, frontal triangle usually yellow, basal segments of antennae black. Length 8 to 9.6 mm.

Male—Face and frontal triangle yellow; cheeks, oral margin and a facial stripe shining black; cheeks somewhat reddish just below the mouth; pile of cheeks pale, of face and frontal triangle black. Antennae small, the basal segments usually black, third reddish brown, yellow below at the base, arista short, reddish.

Thorax shining aeneous with golden pile, there are occasionally a few black hairs intermixed on the disc. Scutellum yellow with mostly black pile.

Legs reddish yellow, basal one-half of the four front femora and the basal three-fourths of the hind femora black; hind tibiae and tarsi considerably infuscated.

Wings hyaline, stigma dilutely yellowish; squamae light brownish, halteres yellow.

Abdomen black with three pairs of broad yellow spots; first pair sub-triangular, their inner ends pointed, outer edge straight; second and third pairs almost as broad as long, occupying more than one-half of the width of the segments, foremargins moderately concave, posterior margins broadly and evenly convex; inner ends nearer the basal margins; apical margins of fourth and fifth segments yellow; two yellow spots at the basal corners of fifth segment. Venter yellow, a large black spot on sternites two to four, pile of first three long and all yellow except a few shorter black hairs on three, shorter and black on remaining sternites.

Female—Front black, shining on the upper two-thirds, with rather inconspicuous side dust spots; two brown spots above the antennae; abdominal spots much narrower than those of the male, but similarly shaped.

Described from two paratypes from Alaska through the courtesy of the Ohio State Museum.

The male will be recognized readily by the large kidney-shaped spots but the female will be told with more difficulty. There may occasionally be some confusion with *neoperplexus* (Cur.) and *montanus* (Cur.), but the former has pale pile on the face, and the latter has yellow hairs on the face and scutellum. The size and narrow abdomen of *curtus* will help to separate it from *neoperplexus*.

36. *Metasyrphus montanus* (Cur.)

Syrphus montanus Curran 1924, Kans. Univ. Sci. Bul. 15 : 174, fig.

Very closely related to *curtus* (Hine) and the only differences to be noted are the yellow hairs of the face and scutellum. It is doubtful if these differences are enough to warrant specific separation. Hine's description of *curtus* is a little misleading, particularly as to the color of the legs and of the hairs of the face and scutellum. The type of *montanus,* a male, is to my knowledge the only known representative.

37. *Metasyrphus lapponicus* (Zett.) (Figs. 23, 44).

Scaeva lapponica Zetterstedt 1838, Insecta Lap. 598.
Syrphus arcuatus authors in part.
Syrphus lapponicus Curran 1924, Kans. Univ. Sci. Bul. 15 : 175, (notes that *arcuatus* does not occur in this country).

Eyes bare. Face with a median black stripe, thorax yellowish pilose, scutellum black haired; abdomen with three pairs of isolated spots, the last two pair arcuated; third longitudinal vein decidedly looped. Length 8 to 13 mm., average 11 mm.

Male—Face yellow with a median black stripe which comes to a point before reaching the antennae, and which continues around the mouth edge and connected to the cheeks which are all black; facial tubercle narrow but rather sharply pointed; frontal triangle yellow with narrow connected arcs above the antennae; vertical triangle black. Pile of cheeks white to yellowish, of the face and frontal triangle mostly black although in some specimens there are pale hairs below and near the tubercle; pile of vertical triangle black; on the occiput white, with a few of the overhanging hairs near the vertex black. Frontal triangle and face on the sides lightly dusted with yellow pollen. Antennae reddish to dark, usually lighter on the underside; usually smaller than other species of this group, arista about as long as the antennae, reddish.

Thorax shining with a slightly greenish tint as contrasted with the bluish shine of *perplexus;* pile almost white with a decided yellowish tinge on the pleura, more whitish on the venter. Scutellum obscurely yellowish on the disk, darker in the corners, the pile all black except the short white hairs extending below the edge. *Metasternum bare.*

Legs yellow, the coxae, trochanters, basal half of front and middle femora, all but the tip of the hind femora, the front and middle tibiae, the hind tibiae except a broad black mid-ring, and the outer segments of the tarsi, especially from above, black or dark brown. Pile of the legs black except on the front four tibiae and tarsi and the bases of the femora. The hairs on the outer sides of the femora and hind tibiae are rather heavy, with a mixture of short and a few longer hairs on the hind femora.

Wings hyaline, stigma brown, third vein bent into first posterior cell. Squamae yellowish with light brown fringes, plumule white, halteres yellow.

Abdomen sub-shining black with three pairs of isolated yellow spots, the second and third pairs arcuated; none of them reach the side margins and they are well separated in the middle. The first pair are broad and both ends are rounded; second and third pair progressively more basal, distinctly arcuated, inner ends rounded, outer ends straight with the upper corners coming to a point, almost reaching the side margins in a few cases, normally well separated. Apical margins of 4th and 5th segments and basal corners of 5th segment yellow. Venter yellow with 3 or 4 broad black crossbars. Pile of the abdomen black with yellow hairs basally, short on the tergites, long and white on the first three sternites, black with more appressed than erect hairs on the 4th and remaining sternites.

Female—Very little different, the abdominal bands are slightly narrower but there is not the difference as noted between the two sexes in *M. perplexus* (Osb.); the legs are not so black, less than half the femora and the hind tibiae are reddish. The front is black with black pile and the sides are yellow pollinose, leaving a black shining stripe down the middle connecting the vertex with the black arc just above the antennae. Described from numerous specimens from Oregon, Colorado and Wisconsin.

The eastern specimens are all larger but aside from the size I can see no differences. As Lundbeck has already pointed out our species cannot be the European *arcuatus* (Fall.) as the first spots reach the side margins. In the American forms these spots are distinctly separated although those on the 3rd and 4th segments may reach the margins by their extreme upper corners. The only closely allied species are *perplexus* (Osb.) and *neoperplexus* (Cur.) but in both these species the metasternum is hairy and the third vein is only gently curved. *M. aberrantis* (Cur.) has a curved vein but the bands on the 3rd and 4th segments are not interrupted.

There occurs in Labrador and in high altitudes of the West a variety which lacks the abdominal spots except a small pair on the second segment. I have before me a male and female from Michel, B. C., C. Garrett, collector; and four females from Hopedale, Labr., W. W. Perrett, collector.

This variety may be Gerschner's *arcuatus,* var. *bipunctatus,* but I am unable to decide the question.

38. *Metasyrphus marginatus* (Jones)

Syrphus marginatus Jones 1917, Ann. Ent. Soc. Amer. 10 : 222.

Belongs to the *lapponicus* group but the facial stripe is reduced to a narrow indefinite dash on the tubercle; facial pile black; thoracal pile pallid on the dorsum, light yellow on the sides; third longitudinal vein distinctly curved. Length 13 mm.

Male—Face yellow, with a prominent tubercle, stripe reddish brown, narrow and confined to the tubercle, connected to the narrowly brownish upper mouth edge obscurely, pile all black; cheeks black with white pile; frontal triangle yellow, lightly dusted with white pollen, except just above the antennae where there is a narrow black double arc, pile black. Antennae brown, yellow on the first two and below on the third segment. Eyes bare.

Thorax shining aeneous black, pile pallid, light yellow along the sides. Scutellum yellow, pile black, yellow on the basal corners. Legs yellow, front four femora black on the basal one-fourth to one-third, hind femora on the basal two-thirds to three-fourths, tarsi infuscated. Wings hyaline, third vein dipped. Metasternum bare.

Abdomen semi-opaque black with three pairs of spots, first pair straight, three times as long as wide, inner ends narrowly rounded, outer ends reaching forward obscurely to the edges; second and third pairs isolated and arcuated, outer basal corners reaching forward almost to the basal corners of the segment, posterior margins almost straight. Posterior margins of fourth and fifth and the anterior corners of the fifth yellow. Venter black with yellow incisures. Genital styles broad at the base, evenly curved, yellow in color.

This species is certainly closely related to *lapponicus* (Zett.) but its large size, almost entirely yellow face with black pile, and somewhat different abdominal spots distinguishes it.

Described from two males from Bear Wallow St. Catalina Mts., Arizona, 8000 ft. elevation. They were compared with the type in the Jones' collection at Fort Collins, Colorado.

39. *Metasyrphus aberrantis* (Cur.)

Syrphus aberrantis Curran 1924, Kans. Univ. Sci. Bul. 15 : 90, fig.

A very easily recognized species with its bare metasternum, curved third longitudinal vein, and entire crossbands on the third and fourth segments. Occasionally the bands are quite undulated and may be almost divided at the middle. It is a common species in the far West, particularly Washington, Oregon, and British Columbia.

40. *Metasyrphus creper* (Snow) (Fig. 26).

Syrphus creper Snow 1895, Kans. Univ. Quart. 3 : 234; Curran 1924, Kans. Univ. Sci. Bul. 15 : 180, places as a variety of *lotus* (Will.)

Eyes hairy, face with a median black stripe, cheeks yellow, abdominal bands separated from the side margins. Length 8.5 to 11 mm.

Male—Face and cheeks yellow, face with a sharply outlined black stripe which reaches almost to the base of the antennae and continues around the mouth edge only half way thence across the lower face to the eyes; frontal triangle black shining, lightly dusted with white pollen, the pile black which extends down on the sides of the face only a short distance, rest of the pile of face and cheeks sparse and pale; sides of face very lightly dusted with white pollen; vertical triangle black with black pile, occiput black with white pile becoming intermixed with a few black hairs which overhang the eyes near the vertex. Antennae blackish brown, slightly yellow beneath the first two segments and at the base below the third; arista reddish brown, not quite as long as the antennae.

Thorax metallic bluish black or sometimes slightly greenish black, in the one male specimen before me there is no indication of olivaceous stripes although they are readily evident in the female; pile moderate, light yellow in color, more yellowish on the sides but more whitish on the pleura. Scutellum dull yellow with the anterior corners black, pile black except the short hairs on the extreme front margin and the under edge of the posterior margin which are pale.

Legs yellow with the following parts black; basal third of the front and middle femora, all but the apical fifth of the hind femora, a mid-ring on the hind tibiae, the apical segments of the hind tarsi, and all the coxae and trochanters except the apex of the front coxae. Pile of the legs mostly pale except the short hairs on the outer edge of the hind tibiae and tarsi.

Wings hyaline, the stigma brownish. Squamae white with pale yellow fringe, plumule white, halteres yellow, the stalks darker.

Abdomen black, sub-shining, more opaque basally, with three oddly shaped yellow bands, none of which reach the sides. Second segment with a pair of slightly arcuate median spots, rounded to pointed on their inner ends, truncate on their outer ends; the spots on the third segment almost touching in the middle, the spots oblique, the front margin greatly concave, the rear margin gradually convex. The concavity is due mostly to the widening out of the spots both on the inner ends and the outer ends, the inner ends curving forward, spreading out and all but touching the basal margin of the segment but leaving a median basal black spot triangular in outline. The spots on the next segment are similar except they unite at the base of the segment, the ends reaching the base of the segment. Narrow apices of the 4th and 5th segments yellow. In some specimens the spots are united in the middle. Venter yellow with three broad black transverse bars. Pile of abdomen black above, white toward the base; white on the venter with a depressed short black hairs on the fourth and fifth sternites.

Female quite similar; the pile of the face is almost all black especially along the sides; the front is black with a broad transverse pollinose band; three very faint stripes are noticeable on the thorax; and there is a pair of spots at the basal corners of the fifth segment. Occasionally the bands on the 3rd and 4th segments are divided in the middle but usually they are entire.

Type locality Arizona.

Described from seven specimens from Colorado and Oregon, 7,000 to 9,000 ft. elevation. Occurs generally in high altitudes of the West. It belongs to the *amalopis* group but the bands are narrowly if at all separated and do not reach the side margins.

41. *Metasyrphus lotus* (Will.) (Fig. 24).

Syrphus lotus Williston 1886, Synopsis 75.

Known only by the type, a female from Arizona; thus all of the published records of *lotus* probably refer to *creper* (Snow). The abdominal bands are bilaterally oblique with nearly straight posterior edges and lack the peculiar "hook" on the anterior inner margin so characteristic of *creper*.

Face and cheeks pure yellow with a brownish median stripe on the face which does not quite reach the antennae; tubercle prominent; pile of cheeks white, yellow on the face, becoming black on the sides and near the antennae; front black but with a very broad pollinose band which is not interrupted, pile dark brown to black.

Thorax shining black but with two median pollinose stripes anteriorly; pile tawny, a few black hairs intermixed; humeri strongly pollinose, pleural pile longer and brownish. Scutellum entirely yellow with long black pile, a few yellow hairs in front.

Legs yellow except basal one-third of four front femora and basal half of hind femora, hind tibiae missing. Wings hyaline, stigma dark brown.

Abdomen black with three yellow crossbands, the first narrowly interrupted and all separated from the lateral margins; the second and third bands are bilaterally oblique, their foremargins only slightly concave and touching the bases of the segments, their posterior margins almost straight; apical margins of the fourth and fifth, and the basal corners of the fifth yellow. Venter black with incisures broadly yellow.

Most of the specimens identified as *lotus* agree with Williston's amended description of a female from New Mexico. While the type specimen may be teneral, and this would account for the yellow cheeks and mouth edge and perhaps for the more yellow legs, yet it would not explain the very decidedly different crossbands.

Since the above was written, I have seen a male from Walnut Creek, California, which is essentially like the female except the band on the third tergite is quite distinctly interrupted. It is undoubtedly closely related to *albostriatus* (Fln.) of Europe.

42. *Metasyrphus reflectipennis* (Cur.)

Syrphus reflectipennis Curran 1921, Can. Ent. 53 : 157.

Eyes pilose, face with an indefinite broad black stripe, head of the appearance of *M. creper* and abdomen of *S. torvus.* Length 11.5 mm.

The head of this species readily places it in the *amalopis* group and it is easily characterized by the torvus-like abdominal bands which reach the side-margins in their full width;

the first band is broadly interrupted and the second and third semi-interrupted. The venter is black with narrow yellow transverse bars. Male unknown.

Its nearest relative is probably *creper* (Sn.) but is readily told by the abdominal bands, their shape and because they reach the side-margins.

43. *Metasyrphus amalopis* (O. S.) (Fig. 27).

Syrphus amalopis Osten Sacken 1875, Proc. Bost. Soc. Nat. Hist. 18 : 148; Williston 1886, Synopsis 69; Curran 1924, Kans. Univ. Sci. Bul. 15 : 179. *Syrphus intrudens* Osten Sacken 1877, Bul. U. S. Geol. and Geog. Surv. Ter. 3 : 326. *Syrphus disgregus* Snow 1895, Kans. Univ. Quart. 3 : 233.[1]

Abdomen with three pairs of spots, the second and third pairs arcuated, their inner ends club-shaped, their outer ends reaching the sides; spots often cut in two; antennae dark, pile of scutellum black. Length 9 to 11 mm.

Male—Face yellow with a broad black stripe which occupies less than a third the width of the face, tubercle rather flat with only a gentle concavity between it and the antennae, pile usually black although there are often some white hairs near the mouth; cheeks and oral margin broadly shining black but may be reddish brown in some specimens below the mouth; pile yellowish, a few black hairs near the eye margins; frontal triangle black with black pile, yellow pollinose along the eyes; vertical triangle black with black pile; occiput very narrow above, broader below, covered with grey pollen and heavy white pile, with brownish to black hairs above overhanging the eyes. Antennae black on first two segments, more reddish on third segment.

Thorax shining aeneous with yellow or sometimes black pile which is darker along the sides; scutellum opalescent yellow, the corners black, pile black, with a few white hairs basally. Metasternum bare.

Legs yellow to reddish; basal one-half to three-fourths of the four front femora, basal five sixths of the hind femora, a median ring on the hind tibiae, and the dorsal sides of the hind

[1] Since the above was written I have seen a series of specimens from New Mexico and have concluded that *disgregus* Sn. is a distinct species; recognized by the spots on the second segment which are less than two times as long as broad and by the narrower facial stripe. It is also a smaller species, 8 to 9 mm. long.

tarsi black. The color varies considerably, and the hind legs are almost entirely black in the more northern specimens.

Wings dilutely yellowish, the stigma brown; squamae yellow, fringes brownish; halteres yellow.

Abdomen semi-opaque black with three pairs of yellow spots, the first pair isolated from the sides, the second and third pairs greatly arcuated and occasionally separated into four spots, but usually reaching the side margins. The inner ends of these spots are club-shaped, giving the posterior margin an even convex curve and the anterior margin deeply concave, almost to the shape of a wide U. Alaskan specimens and others occasionally are deeply excised or completely severed into separate spots; under such conditions the side spots are usually separated from the lateral margins. Apical margins of fourth and fifth segments, and the sides and corners of the fifth, yellow. Venter yellow with three complete crossbands, crossing over the thin side membranes, posteriorly located on sternites two, three and four. Sternite two with a median, anterior, round black spot; sternite one black; narrow apical margins of all sternites yellow. Pile of venter long, yellow basally, black apically, with seldom any short appressed black hairs.

Female very similar. The front shining black with two prominent pollinose side spots which often coalesce into a crossband. Cheeks sometimes reddish.

A very variable species and there are no constant differences which would separate *intrudens* from *amalopis*. Many western specimens will match perfectly the type of *amalopis* and the reverse is also true. The three specimens mentioned by Williston undoubtedly belonged to *osburni* (Cur.).

44. *Metasyrphus laticaudatus* (Cur.)

Syrphus laticaudatus **Curran 1924, Kans. Univ. Sci. Bul. 15 : 176, fig.**

A very close relative of *amalopis* (O. S.) differing only in its large size, broad abdomen which is shining, and the peculiarly shaped abdominal spots which are concave posteriorly. Otherwise I can see no differences of specific value. A longer series of specimens from British Columbia may show it to be only a large variety of *amalopis,* which is undoubtely a variable species.

The pile on the lower part of the cheeks is pale, but the ground color is black even below the mouth opening. Only about the basal one-third of the anterior four femora black. Two large broad specimens, a male and female from Oregon, approach this species but the abdomen is only semi-shining, and the spots are straight posteriorly.

45. *Metasyrphus osburni* (Cur.) (Fig. 28).

Syrphus osburni Curran 1924, Kansas. Univ. Sci. Bul. 15 : 177, fig.

Very similar to *amalopis* (O. S.). The facial tubercle is very little prominent and the epistoma is not produced below. The first pair of spots reach the sides by a narrow semi-distinct streak. The antennae are always yellow and the pile of the scutellum is all pale. The vitta on the face is narrower than on *amalopis*. Length about 9 mm. I have two males from Quebec (C. H. Curran) and one female from Ontario (G. S. Walley). The males agree perfectly with the type.

46. *Metasyrphus venustus* (Mg.) (Fig. 29).

Syrphus venustus Meigen 1822, Syst. Beschr. 3 : 299; Curran 1922, Can. Ent. 54 : 117.

Eyes hairy; face usually with a comparatively narrow black stripe; antennae reddish, and the abdomen black with three pairs of narrow, transverse spots, all of which extend over the side margins. Length 10 to 12 mm.

Male—Face shining yellow with a black shining stripe which narrows to a point near the base of the antennae and connected very narrowly along the oral margin with the black of the cheeks; frontal triangle black, shining, lightly dusted with white pollen near the eyes; pile of the vertical triangle, frontal triangle, sides of face, and upper part of cheeks black, yellow elsewhere, although there are a few black hairs intermixed along the sides of the facial stripe, lower cheeks, and in some specimens among the overhanging hairs on the upper part of the occiput. Antennae yellow to reddish brown, arista brown to black; eyes with pale pubescence.

Thorax shining aeneous black with rather long yellow pile; scutellum yellow becoming dark at the corners, pile long and yellow, rarely are any black hairs present. Metasternum bare.

Legs yellow with black as follows: the coxae, trochanters, basal half of front and middle femora, basal two-thirds of hind femora, and the upper sides of the terminal three or four segments of the tarsi brownish to blackish, darkest on the hind tarsi; there is also a light brownish area on the hind tibiae. Pile of legs mostly yellow, with some black pubescence on top of the hind tibiae and tarsi and occasionally the hind femora. Most of the pile is short and appressed except in the femora, particularly toward their bases, where it is long and weak.

Wings nearly hyaline, stigma brown. Squamae light with light brown fringes, plumule white; halteres yellow.

Abdomen shining black, a little duller anteriorly, with three pairs of briefly lunate spots which extend well over the side margins. First pair well separated, rounded and narrower toward their inner ends, outer ends slightly attenuated before reaching side margins, the spots are mid-way between fore and rear margins; second pair sub-basal and narrower, concave in front, slightly convex behind, separated by less than their width, but reach the sides in their full width, somewhat extending forward; third pair similar to second, more basal, inner ends almost reaching the base of the segment; fourth and fifth segments with their apical margins narrowly yellow, corners of fifth also yellow. Pile of the first segment yellow, on the following segments the same as the ground color, although there are some yellow hairs on the black of the base of the second segment. Venter yellow basally with an indefinite brown spot on the second sternite, black beyond with a yellow band crossing the base of the fourth segment. Pile of venter yellow basally, black apically; there are no short appressed black hairs on the male specimens which I have examined.

Female—quite similar; front black with black pile and a pair of large spots, covered with white pollen, which almost meet in the middle; the pollen extends along the eyes to the yellow of the face. Pile of the eyes and thorax sparse, on the scutellum of one female from Wisconsin all black. Basal third only of anterior femora black. The abdominal bands are narrower and almost straight.

Described from numerous specimens, from France, (Bazin and Hambleton collectors), Bexley, England; and Wisconsin.

Type located in Paris museum.

Related to *limatus* (Hine) but easily separated as the facial stripe is much narrower; the pile of the thorax and scutellum is usually all pale; the antennae are yellowish to reddish; the legs more extensively yellow; the hind tibiae has only a dark apical ring, and the tarsi are pale except the apical segments of the hind legs. The first pair of abdominal spots nearly always reach the side margins and are separated much less than those of *limatus*.

There is a variety *hilaris* (Zett.) occurring in Europe, in which the facial stripe is absent but I have not seen this form in North America among more than fifty specimens.

47. *Metasyrphus limatus* (Hine)

Syrphus limatus Hine 1922, Ohio Jour. Sci. 22 : 146; Curran 1924, Kans. Univ. Sci. Bul. 15 : 178, fig.

Eyes hairy; face with a broad black stripe; pile of thorax black; abdominal spots rather narrow, nearly transverse, and the second and third pairs reach the side margins. Length 11 to 12 mm.

Male—Face yellow with a prominent very broad black stripe, pile practically all black; cheeks and broad oral margin shining black with black pile except some yellow hairs along the lower or under edge; frontal triangle shining black with rather heavy black pile; grey pollen occurs only narrowly next to the eyes on the frontal triangle and extends down to the cheeks and around below the eyes where it broadens out on the occiput which has white hairs with strong black pile overhanging the eyes, only a few from the cheeks to about one-half the way to vertex where they are longer and more numerous. Antennae reddish to black, the two basal segments, measured on the mesal side nearly equal in length to the third segment; arista black, thick at the base and tapering rapidly beyond the basal third.

Thorax aeneous to dark blue shining with black to dark brown pile, lighter on the pleura, scutellum opalescent yellow, black on the basal corners, pile mostly black.

Legs mostly black, yellowish to brownish on the apical half of the four front femora and all of the tibiae, the knees of the hind legs, and slightly lighter in color on the fore-tarsi; pile of femora long, usually black.

Wings hyaline, stigma brown; squamae white with light brown fringe, halteres yellowish, base brown.

Abdomen black with three pairs of narrow transverse spots, first pair wider, oval, and do not reach the sides as do the others; the spots are nearly basal with the inner end broader and rounded; basal corners of the fifth and apical margins of the fourth and fifth tergites narrowly yellow. Venter black, shining, with the incisures broadly yellow anteriorly, more narrowly posteriorly, the genitalia black.

Female—Very similar to the male; the abdominal bands are usually narrower, and there are more pale hairs on the cheeks and thorax. Front black, all shining except the triangular side dust spots which are definitely separated. The facial stripe is frequently broader, occupying more than one-third of the width of the face.

The species does not vary very much except occasionally a melanic form in which the abdominal spots are obsolete or nearly so.

Described from paratypes from the James S. Hine Collection, one female from British Columbia (Osburn), and one male from Healy, Alaska (Aldrich). The types are in the Ohio State Museum at Columbus.

48. *Metasyrphus pauxillus* (Will.) (Fig. 31).

Syrphus pauxillus Williston 1886, Synopsis 74.

Face with a black stripe, epistoma produced below, basal segments of the antennae black, pile of thorax mostly black, abdominal spots narrow, oblique and well separated from the side margins. Length 8 to 8.5 mm.

Closely related to *limatus* but readily told by the characters given above. It is somewhat smaller than *limatus* and the third segment of the antennae is usually more reddish. The hairs on the pleura and coxae are nearly all pale; the legs are almost all yellow in the female except the basal one-third of the four front and two-thirds of the hind femora. In the male the femora are more extensively black and there is a broad black area on the hind tibiae.

This species occurs at high altitudes in the southwest section of the United States; two males and one female from Colorado and one female from California have been examined. I have been unable to locate the type.

S. pacifica (Lov.) is close but the produced epistoma and black antennal segments of *pauxillus* easily separate it. The pale pile of the thorax, the yellow basal segments of the antennae, and the less produced epistoma of *laticaudus* (Cur.) separates this species from *pauxillus*.

49. *Metasyrphus pacifica* (Lov.). (Figs. 30, 32).

Syrphus pacifica Lovett 1919, Calif. Acad. Sci. 9 : 245.

An unique species, easily recognized by the three pairs of narrow oblique bands, the second and third pair concave *anteriorly,* but not decidedly arcuate. Abdomen convex both transversely and longitudinally. Eyes short white pilose, face yellow with a black stripe, cheeks broadly shining black. Length 7.5 to 9.5 mm.

Male—Face yellow with a distinct black shining stripe which does not quite reach the base of the antennae, and narrows slightly before reaching the oral margin. Face in profile is almost devoid of a tubercle, gently rounded and receding gradually to the mouth opening. Cheeks and frontal triangle shining black; black of cheeks reaches a little higher than the front projection of the epistoma; pile black on the face, black and longer on the frontal triangle, black on the cheeks, becoming yellow below. Ocellar triangle black with black pile; occiput entirely bluish black except very narrowly below the mouth, pile of occiput black above, tawny below. Antennae brownish to black, slightly lighter on the under sides of the third segment. Arista brown.

Thorax black, sub-shining, a faint indication of two median pollinose stripes anteriorly. Pile of the dorsum of the thorax is light brown to black, rather long, longer and black on the pleura; scutellum opalescent to dark, pile all black, long.

Legs mostly yellow, the front two pair of femora black on the basal third, basal three-fourths of the hind femora black, coxae and trochanters entirely black, hind tibiae infuscated about the middle, 2nd, 3rd, and 4th tarsal joints brownish above; pile of the legs mostly black.

Wings infuscated, marginal cell and stigma light brown. Squamae dusky, the fringes brown. Halteres yellow, stalks brown.

Abdomen slightly oval, decidedly convex transversely, less so longitudinally, with three pairs of narrow, slightly arcuate, oblique, yellow crossbands, all separated in the middle and from the side margins. First segment entirely black with black pile. Second segment subopaque, with a pair of elongate slightly oblique yellow spots, which are well separated from each other; their distance apart is almost twice their width. Third and fourth segments with similar elongate spots which are arcuate and oblique; the inner ends are about their width apart and from the margin of the preceding segment; the outer ends of the spots situated about mid-way on the segments; the ground color is mostly subopaque and the pile nearly all black, a few light colored hairs on the yellow spots. Fifth and sixth segments each narrowly yellow posteriorly, not reaching side margins; genitalia black. Venter black with yellow along the sutures, pile sparse, light colored and longer on the first two sternites; black and shorter on the other sternites.

Female—Similar except the abdomen is more shining; the legs darker, four front femora black on almost the basal half and the hind femora all but the tip; pile of the thorax especially of the pleura lighter; pile of cheeks pale. Front is broad, black, and shining with a pruinose band, pile short and black. Yellow areas of the sternites broader.

Described from twenty-one specimens, from Oregon, Idaho, Alberta, and British Columbia, through the courtesy of Prof. J. Wilcox, the Oregon Agricultural College, and Dr. R. C. Osburn.

A distinctive species easily recognized by the convex abdomen, oblique crossbands, and stripe of the face.

50. *Metasyrphus laticaudus* (Cur.) (Fig. 33)

Syrphus laticaudus Curran 1924, Kans. Univ. Sci. Bul. 15 : 175, fig.

Face with a broad black stripe, cheeks broadly black, basal antennal segments yellow, pile of thorax normally pale, abdominal spots oblique and normally separated from the sides although the first pair often reach the margins obscurely on the female. Length 8 to 9 mm.

Male—Cheeks broadly, upper mouth edge narrowly, and a facial stripe broadly, above the tubercle, more narrowly below, and the frontal triangle shining black; pile of the cheeks mostly pale, of the face, frontal triangle and vertical triangle black; frontal triangle very narrowly next to the eyes grey pollinose, very lightly pollinose on the cheeks, heavier on the occiput; pile of occiput nearly all white. Antennae yellow on the basal segments, darker on the third segment but yellow below, arista brown at the base, blacker at the tip.

Thorax shining aeneous, practically devoid of pollen, pile mostly pale, a few black hairs along the sides; scutellum opalescent yellow, broadly black on the corners, pile yellow with black hairs along the edge. Pile of the pleura white, sparse, with the tips kinky.

Legs yellow, the basal one-third of the four front and two-thirds of the hind femora black, an indefinite broad reddish brown preapical ring on the hind tibiae and the apical segments of the tarsi are infuscated.

Wings hyaline, stigma dilutely yellowish; squamae white, fringes light brown; halteres yellow, the stalks and base brown.

Abdomen semi-opaque anteriorly, more shining posteriorly, convex, with three pairs of oblique elongated yellow spots; the spots are slightly arcuated, their inner ends rounded, their outer ends truncate with tendency to a sharp point on the anterior corners; apical margins of the fourth and fifth tergites narrowly yellow. Venter black with broad yellow incisures. Pile of the first and second sternites long and mostly pale, on the other sternites shorter and black.

Female—Very similar; front shining black with triangular side dust spots; scutellar pile nearly all pale, abdominal spots sometimes reach the side margins, especially those on the second tergite, a pair of spots on the basal corners of the fifth tergite; legs nearly all pale except a brownish area on the hind femora and the usual infuscation of the apical segments of the tarsi.

Closely related to *pauxillus* (Will.) and *pacifica* (Lov.). The differences are dealt with under those two species.

Described from a pair collected at Jaffrey, New Hampshire, and compared with the types at Ottawa.

Emarginatus group

The species occurring in this group have been included in the key but the descriptions will be discussed in a later paper. *M. ochrostomus* (Zett.) is apparently closely related to *M. nitidicollis* (Mg.) but the former has a hairy metasternum, and for this reason the description is given at this time.

51. *Metasyrphus ochrostomus* (Zett.) (Fig. 34).

Scaeva ochrostoma Zetterstedt 1849, Dipt. Scand. 8 : 3133.

Face, cheeks, oral margin, and antennae entirely yellow; lateral edges of the abdomen continuously yellow, the bands broad. Length 10 to 12 mm.

Male—Face, oral margin, cheeks, frontal triangle, and antennae yellow, with only a small indefinite brown spot in the middle of the frontal triangle; pile all sparse and pale except on the front where it is black; arista reddish brown; eyes bare.

Thorax shining aeneous with two grayish median stripes, pile yellowish, more golden on the sides, which are also lightly yellow pollinose; scutellum yellow with yellow pile. Legs entirely reddish yellow, only the middle coxae brown; a single European specimen before me has the bases of the femora infuscated. Metasternum sparsely hairy. Wings hyaline, stigma luteous, halteres yellow.

Abdomen largely yellow, the sides continuously yellow and the crossbands broader than the black intervals. First segment black at the base, second black on the anterior and posterior margins, connected in the middle by a broad black stripe which widens anteriorly, obliquely to the sides; third and fourth segments with a conspicuous black posterior border which has a median projection on the anterior margin; posterior edge of the fourth segment yellow. Near the sides on the anterior edges of segment three there is a very narrow black line. Venter yellow, the dorsal black bands show through in places.

Female—quite similar, the abdomen is more oval and the edges inconspicuously emarginate; yellow less extensive, the spots on the second segment basal, large, occupying two-thirds the width of the segment; black bands on three and four equal in width to the yellow bands; the edges less extensively yellow; the fifty segment with a median black cross band.

Described from three specimens, a male from Europe and a male and female from Ithaca, N. Y., June 9 and 10, 1916.

A very easily recognized species by the extensive yellow bands on the abdomen, yellow face, cheeks, and antennae. Superficially it resembles *Epistrophe xanthostomus* but is a true *Metasyrphus* even though the female might alone fall into the other genus.

52. *Metasyrphus* **metcalfi** n. sp. (Fig. 35).

Face and cheeks yellow, metasternum bare, abdomen emarginate with three yellow crossbands which do not reach the side margins. Length 13 mm.

Face and cheeks yellow with pale pile, upper mouth edge very narrowly brownish; face covered with whitish pollen which extends along the eyes onto the front as large side dust spots; front black with short black to brown pile; antennae brown, lighter underneath the third segment which is extremely large, more than two times the length of the first two combined; occiput heavily coated with grey pollen and white pile; eyes bare.

Thorax shining aeneous, the sides indistinctly yellowish, the pile whitish on the dorsum, more yellowish on the sides; scutellum opalescent yellow with white pile; metasternum bare. Wings hyaline, stigma luteous; third longitudinal vein straight; halteres yellow. Legs yellow, only a broad brown ring on the hind femora and tibiae. Erect pile of legs all pale.

Abdomen mostly shining black with three yellow cross bands, all separated from the side margins. The first band narrowly separated into spots, the inner ends obtuse and separated by only a narrow black line, outer ends broader; second and third bands situated near the bases of the segments, their anterior margins gently convex, their posterior margins evenly and more concave, outer ends obtuse and well away from the sides. Sides of first segment, anterior corners of second segment briefly and the anterior corners of the fifth segment broadly, yellow. Venter yellow with characteristic arcuated posterior to each segment, except first, black cross bands; third sternite obscured with black; a median longitudinal black stripe shows on the first and second sternites.

Type female, Swannanoa, N. C., April 17, 1913, C. L. Metcalf, collector. Deposited in the collection of Dr. C. L. Metcalf. It gives me considerable pleasure to name this species in honor of Dr. Metcalf.

The abdominal bands suggest *wiedemanni*, but because of the bare metasternum the species does not belong to that group. It is more nearly related to the *emarginatus* group and probably closest to *felix* but the shape of the abdominal bands, and the size of the antennae should readily distinguish it.

Plate VII

FIG. 1. *Syrphus ribesii* L., abdomen of male.
FIG. 2. *Syrphus ribesii* var. *similis* Jones, abdomen of female.
FIG. 3. *Syrphus rectus* O. S., abdomen of female.
FIG. 4. *Syrphus torvus* O. S., abdomen of male.
FIG. 5. *Syrphus transversalis* Cur., abdomen of female.
FIG. 6. *Syrphus* **hinei** n. sp., abdomen of female.
FIG. 7. *Syrphus attenuatus* Hine, abdomen of male.
FIG. 8. *Syrphus opinator* O. S., abdomen of male.
FIG. 9. *Syrphus knabi* Shan., abdomen of male.
FIG. 10. *Metasyrphus wiedemanni* (John.), abdomen of female.
FIG. 11. *Metasyrphus vinelandii* (Cur.), abdomen of male.
FIG. 12. *Metasyrphus pomus* (Cur.), abdomen of female.

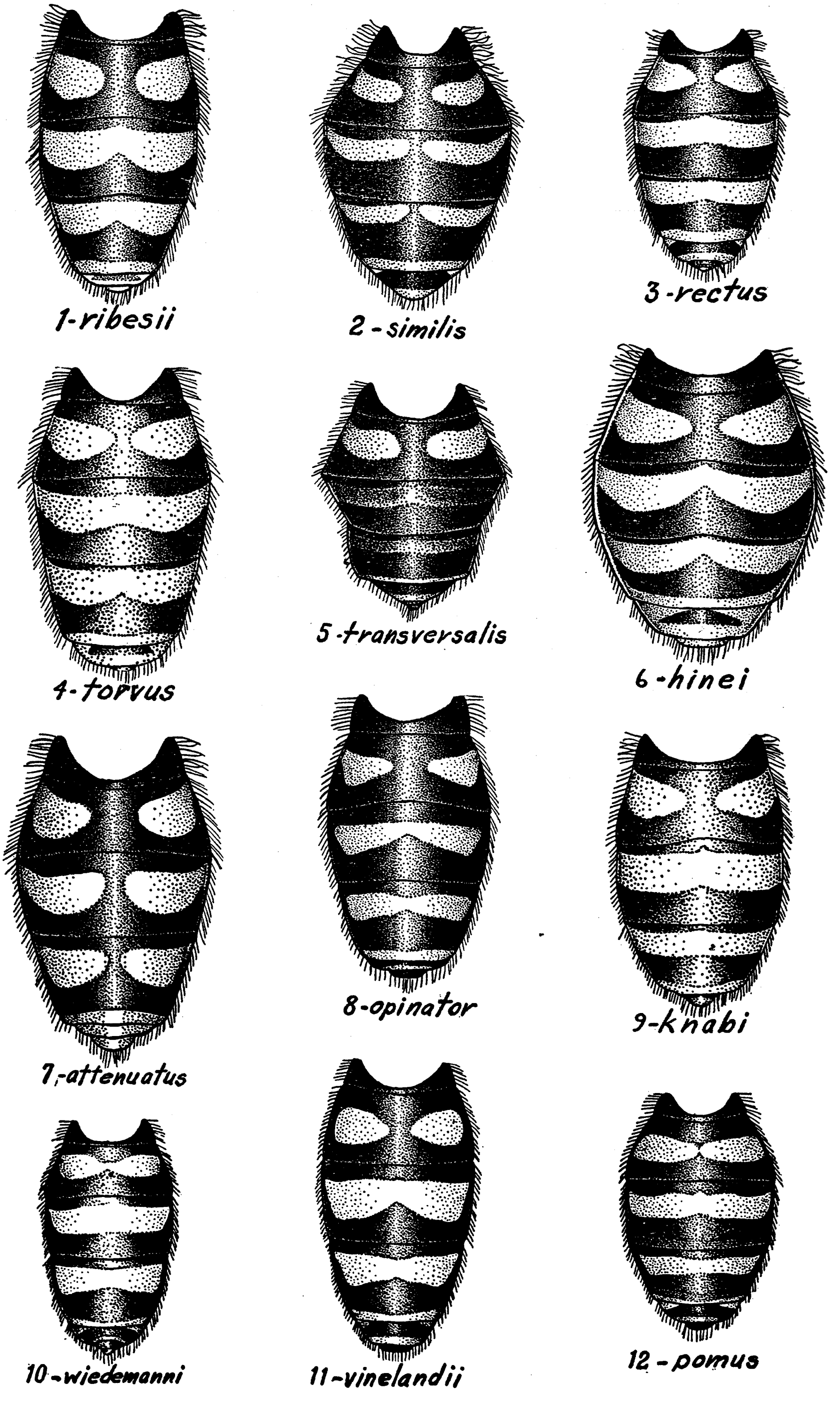
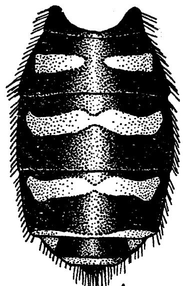
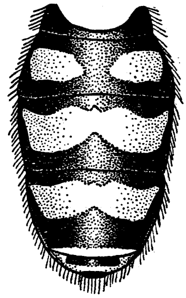

1-ribesii
2-similis
3-rectus
4-torvus
5-transversalis
6-hinei
7-attenuatus
8-opinator
9-knabi
10-wiedemanni
11-vinelandii
12-pomus

Plate VIII

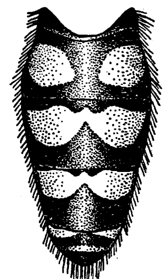
Fig. 13. *Metasyrphus canadensis* (Cur.), abdomen of female.
Fig. 14. *Metasyrphus meadii* (Jones), abdomen of male.
Fig. 15. *Metasyrphus nitens* (Zett.), abdomen of male.
Fig. 16. *Metasyrphus fumipennis* (Thom.), abdomen of male.
Fig. 17. *Metasyrphus venablesi* (Cur.), abdomen of female.
Fig. 18. *Metasyrphus latifasciatus* (Mq.), abdomen of male.
Fig. 19. *Metasyrphus palliventris* (Cur.), abdomen of female.
Fig. 20. *Metasyrphus* **nigroventris** n. sp., head of female.
Fig. 21. *Metasyrphus* **depressus** n. sp., head of female.
Fig. 22. *Metasyrphus curtus* (Hine), abdomen of male.
Fig. 23. *Metasyrphus lapponicus* (Zett.), abdomen of female.
Fig. 24. *Metasyrphus lotus* (Will.), abdomen of female.



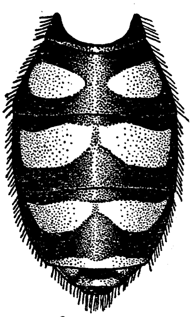
13-canadensis



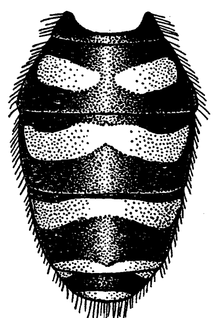
14-meadii



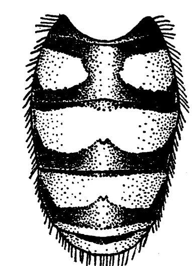
15-nitens



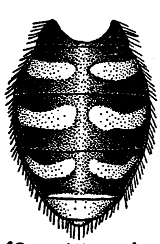
16-fumipennis



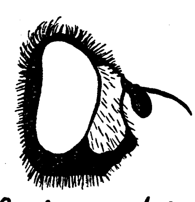
17-venablesi



18-latifasciatus

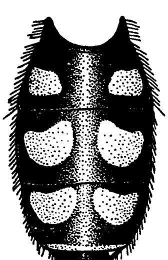


19-palliventris



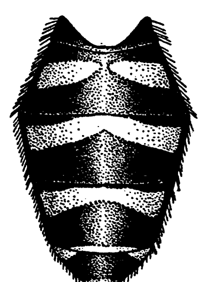
20-nigroventris

21-depressus



22-curtus

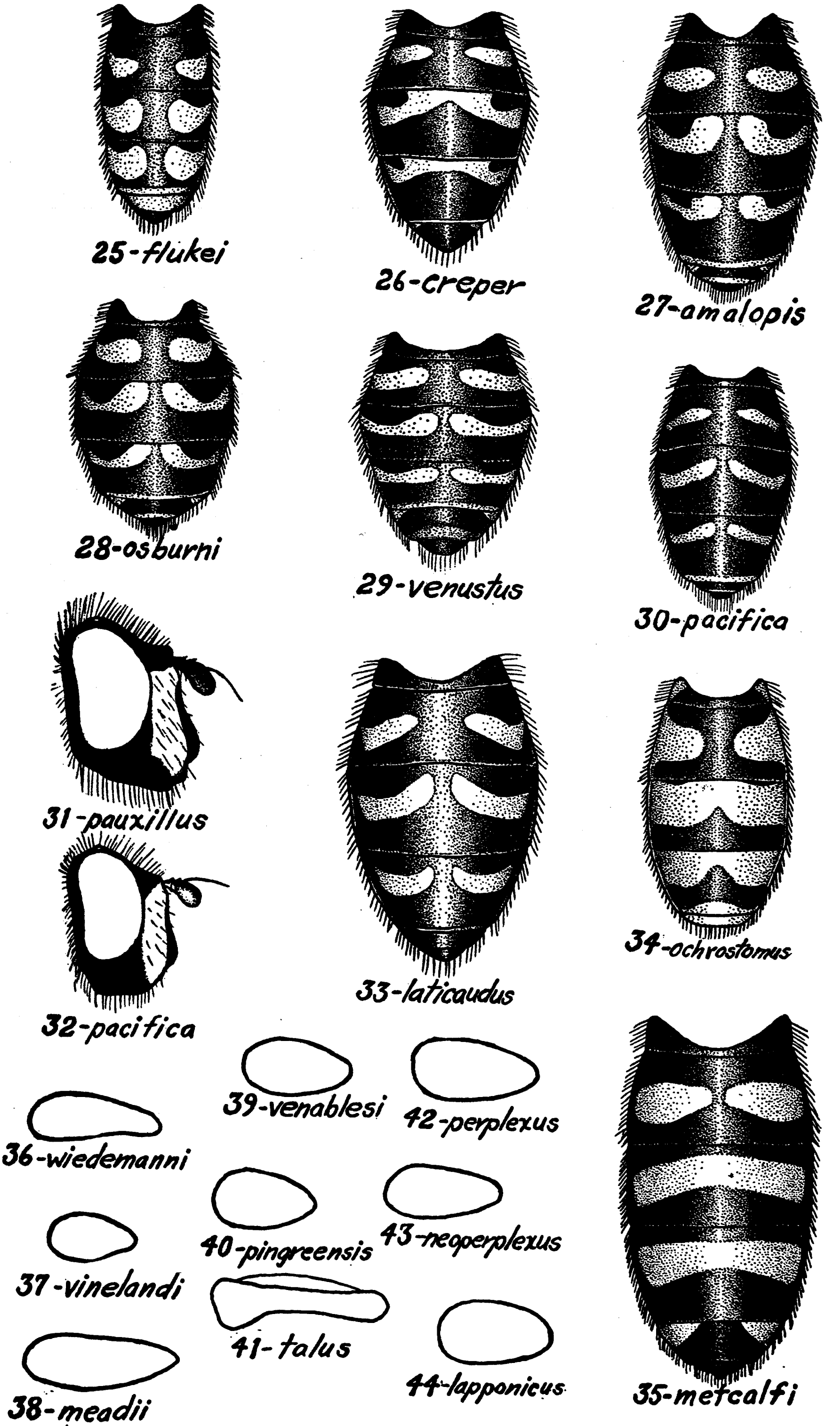
23-lapponicus



24-lotus

Plate IX

Fig. 25. *Metasyrphus flukei* (Jones), abdomen of male.
Fig. 26. *Metasyrphus creper* (Sn.), abdomen of female.
Fig. 27. *Metasyrphus amalopis* (O. S.), abdomen of male.
Fig. 28. *Metasyrphus osburni* (Cur.), abdomen of male.
Fig. 29. *Metasyrphus venustus* (Mg.), abdomen of female.
Fig. 30. *Metasyrphus pacifica* (Lov.), abdomen of male.
Fig. 31. *Metasyrphus pauxillus* (Will.), head of female.
Fig. 32. *Metasyrphus pacifica* (Lov.), head of female.
Fig. 33. *Metasyrphus laticaudus* (Cur.), abdomen of male.
Fig. 34. *Metasyrphus ochrostomus* (Zett.), abdomen of male.
Fig. 35. *Metasyrphus* **metcalfi** n. sp., abdomen of female.
Fig. 36. *Metasyrphus wiedemanni* (John.), genital style.
Fig. 37. *Metasyrphus vinelandii* (Cur.), genital style.
Fig. 38. *Metasyrphus meadii* (Jones), genital style.
Fig. 39. *Metasyrphus venablesi* (Cur.), genital style.
Fig. 40. *Metasyrphus pingreensis* (Fl.), genital style.
Fig. 41. *Metasyrphus* **talus** n. sp., genital style.
Fig. 42. *Metasyrphus perplexus* (Osb.), genital style.
Fig. 43. *Metasyrphus neoperplexus* (Cur.), genital style.
Fig. 44. *Metasyrphus lapponicus* (Zett.), genital style.


25-flukei
26-creper
27-amalopis
28-osburni
29-venustus
30-pacifica
31-pauxillus
32-pacifica
33-laticaudus
34-ochrostomus
35-metcalfi
36-wiedemanni
37-vinelandi
38-meadii
39-venablesi
40-pingreensis
41-talus
42-perplexus
43-neoperplexus
44-lapponicus

BELOIT, WISCONSIN: A STUDY IN URBAN GEOGRAPHY

LYNN HARVEY HALVERSON

THE CITY PATTERN

Astride the Rock River as it approaches and crosses the southern boundary of Wisconsin lies the Beloit urban development, made up of two municipalities, Beloit, Wisconsin, and South Beloit, Illinois. Though separated politically by the State Line and their own municipal limits, the division is artificial, and in most of the activities of the district the two political units function as one, to the advantage of each. Originating as a small village on the valley bottoms of the Rock River and Turtle Creek, the specific site being the point of land between these streams just above their confluence, the community has spread in all directions (Plate X).

During the period of city growth there have been many adjustments to Rock River, to Turtle Creek, and to the land form conditions resulting from the erosive work of these streams. The major departures of the city pattern from the common rectangular forms are related to these natural elements in the landscape. For example, the rectangular street pattern is deranged at the approaches of the bridges crossing the Rock River, and since a bridge is impracticable when each street abuts on the river, a large proportion of east-west streets end at or near the stream.

Turtle Creek, the only permanent tributary of Rock River in the vicinity of Beloit, flows in a generally westerly direction, part of the course being in Beloit, though its junction with the Rock River is south of the State Line. As Pleasant Street follows the base of the bluff along the Rock River, so East Grand Avenue marks the base of the valley side of Turtle Creek from Prospect Street to Wisconsin Avenue. On the west side of the river, the failure to plat the area north of Olympian Boulevard, and south and west of Ridgeland Avenue, is obviously due to the valley of an intermittent stream, known as Lenigan Creek. This stream floods its bottom land with a fair degree of regularity, definitely curtailing the desirability of that land for residential use. The utilization of this land as a municipal golf course is a happy adjustment to the natural conditions.

Angling streets, with resulting odd-shaped blocks, odd-shaped lots, and five corners, are particularly common on the older, east side of the city, though they are found as well on the west side and in South Beloit. The most extensive area of angling streets is found adjacent to Prairie Avenue on the east side. Prairie Avenue is the longest of these streets, and apparently the key to an explanation of the angling pattern. The original rectangular plat ended on the north with Woodward Avenue. Beyond this section the land was not platted, and since the main road to Janesville followed the upland or "prairie" along the section line which is now the eastern limit of the city, it was natural that travelers should follow a straight line between the platted section of the city, and the section line road. In the platting of the district north of Woodward Avenue the angling road was perpetuated, together with certain streets paralleling it.

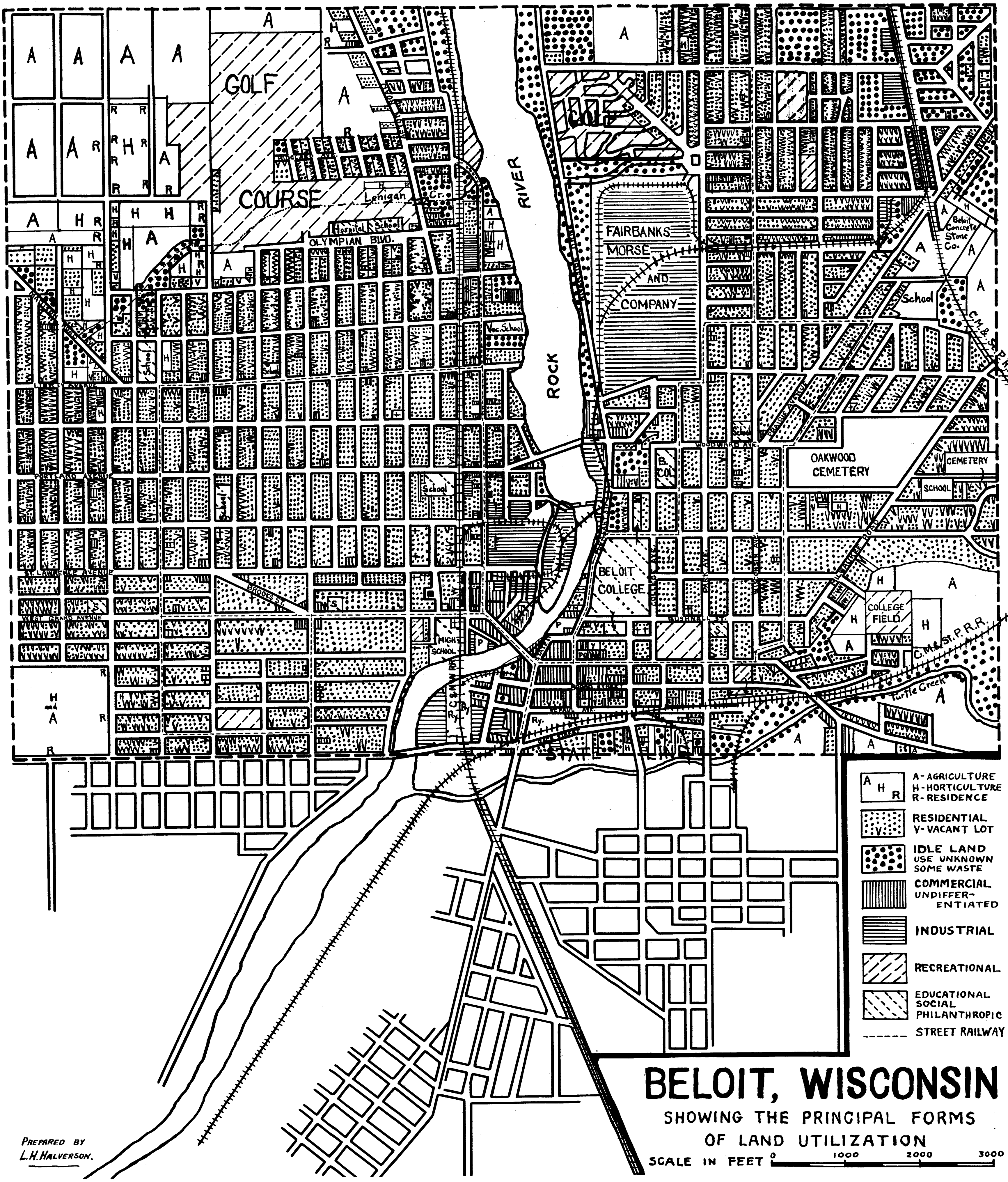
Another factor of fundamental significance to the city pattern of Beloit is the fact that the site is generally underlain by gravels which permitted roads to be located wherever the early settlers willed, except on the lowest bottom lands, and the steep valley sides. As one historian put it, "they [the early settlers] knew the . . . value of having gravel under their feet."[1] That most of the area is more or less deeply covered with surficial deposits of gravel and sand, carried by glacial streams from the Wisconsin ice front, is important in several other connections also. The exploitation of these deposits is continuously carried on.

The City as a Star-Shaped Developing Organism. Cities as they develop tend to become roughly star-shaped,[2] as a result of what has been called axial growth.[3] In the case of Beloit the land form conditions have tended to concentrate the urban development along the long axis of the Rock River valley. The

[1] Whitney, Henry M. Wisconsin Historical Society Proc. 1898, p. 135.

[2] When one considers the general shape of an urban development, it is necessary to consider the pattern irrespective of political boundaries. The scale of the accompanying map, and the arbitrary limiting of this detailed study to the corporate limits of Beloit and South Beloit, cuts off certain of the star-point extensions.

[3] Dorau, H. B. and Hinman, A. C. *Urban Land Economics,* Macmillan 1928, pp. 62-64.


BELOIT, WISCONSIN
SHOWING THE PRINCIPAL FORMS
OF LAND UTILIZATION
SCALE IN FEET 0 1000 2000 3000
A - AGRICULTURE
H - HORTICULTURE
R - RESIDENCE
RESIDENTIAL
V - VACANT LOT
IDLE LAND
USE UNKNOWN
SOME WASTE
COMMERCIAL
UNDIFFERENTIATED
INDUSTRIAL
RECREATIONAL
EDUCATIONAL
SOCIAL
PHILANTHROPIC
STREET RAILWAY
PREPARED BY
L. H. HALVERSON.
GOLF
COURSE
ROCK
RIVER
FAIRBANKS
MORSE
AND
COMPANY
BELOIT
COLLEGE
OAKWOOD
CEMETERY
COLLEGE
FIELD
OLYMPIAN BLVD.
STATE LINE
HIGH SCHOOL
Vac. School
Beloit Concrete Stone Co.
C.M.&St.P.R.R.
Turtle Creek

metropolitan area (urbanized area irrespective of political boundaries) has as a result a greatly elongated star-point to the north along both sides of the Rock River, though more extensively developed on its eastern bank. Possibly this northward extending point is related to the interurban electric rail line to Janesville which earlier followed the east side of the river north of the city, as well as to the more favorable sites available there for summer residence locations. The summer residences were followed by year-around residences in many instances. At present the concrete road and the cheap automobile give accessibility to this section. The other greatly elongated star-point is found in South Beloit east of the river, extending somewhat over a mile south of the State Line. This southward extension occupies in the main a valley bottom site, made up in part of the Turtle Creek bottoms and in part of the Rock River bottoms.

On the east and west sides of the metropolitan area the relatively uniform extension of urban population is related to the general uniformity of the upland surface. Peripheral irregularities here are insignificant, and are commonly related to the earlier improvement of the more important highways. The rather abrupt termination of urban development on the southeast margin of the city is related to the wet valley bottoms of Turtle Creek, which serve as a definite barrier to urban utilization. It is apparent that while the outline of the Beloit metropolitan district conforms somewhat, though very crudely, to the star-shaped development, its features are related to the physiographic conditions of its site, particularly to its north-south trending Rock River valley.

The Industrial City

Industries serving the local community and a small tributary area developed in Beloit with the earliest settlement. Turtle Creek offered power for the sawing of logs for house building, and for the grinding of wheat for flour. It is safe to assume that the presence of Turtle Creek, small and easy to harness, but providing sufficient power for the tasks at hand, was one of the very potent factors in the selection of the particular site upon which the early settlement was located. While there is some conflict of opinion over the actual dates, one record states that the first boards were sawed in the first mill, commonly known as Goodhue's, on April 15, 1837.[4] A grist mill was built the year following the completion of the saw mill. The site near the mouth of Turtle Creek favored the utilization of water from the stream, for from Beloit Junction to the mouth of the creek at the Rock River the fall is 27 feet.[5] In 1884 Turtle Creek was utilized by another mill upstream from the first, with a head of water of sixteen feet.

But Turtle Creek furnished only enough power to run small semi-subsistence industries, while the larger Rock River offered greater possibilities. The legislative act authorizing a dam was dated April 1, 1843, and the construction was begun in the month of August, 1844.[6] The head of water at the dam was 6 feet, and the total flow for power development was figured at 13,333⅓ inches, to be divided among the users of power. The Beloit Waterpower Company was not organized until 1871, but was at that time, and is still, made up of owners of inches of waterpower. The first use of the power was in an extensive saw mill, capable of cutting 4,000 feet of hardwood in 24 hours.[7]

At the dam the river was near the eastern valley side, the more extensive valley bottom land being west of the river, and as a result the raceway was led off on the west side. The importance of this raceway and the associated natural conditions can hardly be overestimated in explaining the early direction of growth taken by the city and its accompanying manufactural development. The early establishment of the west side industrial district may be definitely related to the favorable conditions there for the development of the waterpower, as well as to the favorable site locations for factories on the flattish, though wet, valley bottoms. With equally direct dependence upon the natural set-up of conditions, the power-using industries of the east side were using Turtle Creek, and were, therefore, situated on the Turtle Creek bottoms. The raw materials, with the exception of iron, were mainly of local origin, wagoned to the settlement from the surrounding countryside. Any power-using industry in the early period had to be located within the distance traversible by a power shaft motivated by the

[4] Brown, William Fiske. *Rock County, Wisconsin, A History of its Cities, villages, Etc., from the Earliest Time Up to Date.* 2 Vols. Vol. 1, p. 132.

[5] Wheeler, W. H. In an interview, Nov. 1, 1929.

[6] *The History of Rock County, Wisconsin.* Western Historical Company, Chicago 1879, pp. 617, 641.

[7] *Ibid.*, pp. 617, 641.

waterwheels turned by the waters of the Rock River or Turtle Creek. The present congestion in the west-side valley bottom industrial district of Beloit, adjacent to the raceway, is a direct heritage from the early days when, before the coming of coal by rail into the community, the wheels of industry were turned by direct waterpower. Even when coal became available, and steam power was in use, industries capable of making some use of the waterpower located beside it.

Industries from the Opening of the Railroad Period to the Present.

With the coming of the railroads during the decade following 1850, and later, Beloit manufacturers were able to reach outside the local area both for raw materials and markets. Many new industries were organized, and older industries reorganized, in the years between 1860 and 1914. It was during these years that most of the present industries began or expanded rapidly. The period of the World War saw a few years of exceedingly great activity, for Beloit, a city with a large number of metal working establishments, was particularly well equipped to take advantage of the needs of the war years.

The industries of Beloit group themselves by the nature of their activities and products into a few general types, as follows: metal working, shoe making, public utilities, gravel and its products, knitting and sewing of wearing apparel, processing foodstuffs, and miscellaneous minor industries. Of these industries, the metal working group is by far the most important, including not only the single establishment employing the largest number of men but also employing a large proportion of all the wage earners of the city. In the winter of 1929-30,[8] four of the largest metal-working establishments together employed a few more persons than the total number of wage-earners reported for the city in 1927.[9]

The Metal Working Group. Uniformity of type of manufactural processes among the industries of Beloit is a fact that must impress any close observer of the present-day industries

[8] During the course of this study (September, 1929 to June, 1930) the industries were in a normal, healthy condition, with rather an upward trend during 1929.

[9] Data for 1929-30 based upon interviews.

Data for 1927: *Market Data Handbook of the United States*, Domestic Commerce Series No. 30, p. 215.

of the city. Regardless of what the name of the plant may imply as to the processes carried on, upon investigation one will find the business to involve, in the great majority of cases, the secondary processing and machining of metals. This type of industry has been important since the early industrial development of the city and has resulted in a large group of workers trained and experienced in the operation of machines used in the various processes. The industrial establishments of this group occur on three types of sites; first, on the valley bottoms of Rock River and Turtle Creek, second, on the upland surface adjacent to the valley side, and third, on the upland in the northeastern corner of the city, adjacent to the tracks of the Janesville branch of the "Milwaukee" railroad. The valley bottom site is the most favored from the standpoint of the number of industries so located. The bottoms of Turtle Creek are used as industrial sites only in South Beloit, since they are most largely within its area. In Beloit proper the greatest concentration of industrial establishments is west of the river on the valley bottoms adjacent to the waterpower, thereby reflecting the early dependence of the industries upon that power. This section is at present congested, and the industries have little or no room for expansion. At least one of the larger establishments owns land in South Beloit on which it might erect a new plant, but the cost of moving would probably be excessive. It should not be thought that the valley bottom of the west side is completely utilized by industries, for that portion above or north of waterpower is largely occupied by mediocre to poor residences. It is apparent that this upstream portion of the bottom lands in the period of direct waterpower could not be utilized as industrial sites, and as a result was built up early. Now the section might be called a "blighted" or low grade residential area, yet the price at which land is held prohibits its purchase for industrial expansion. It is a typical case of the impasse which may develop as the result of the totally undirected growth which has been so characteristic of American city development. This residential section, with poor drainage, and other undesirable characteristics, adjacent to an industrial area, can never improve greatly, yet at the present time at least it can not be economically turned to a use to which it is more suited. Were this land available to industries, it would solve to a degree the expansion problems of certain of the present establishments.

The outstanding manufacturing industry of the city is that of Fairbanks, Morse and Company. It occupies a site east of the river on the upland adjacent to the valley site, spilling over the edge of the bluff at some points. This was not the site of the original plant, which manufactured windmills, that being early located on the millrace west of the river. Later the plant of the Beloit Wagon Works on the present site was acquired. With ample room for the expansion which followed the shift to steam power, this establishment has not suffered from the congestion which at present hinders expansion and the development of "straight-line" production methods along the waterpower west of the river. Although the site of this establishment is isolated from those of other industrial developments, the building of the Joint Switch track has given it connections with each of the railways serving the city.

Since there are no available industrial sites on which to build modern plants in the older industrial sections of Beloit proper, a new manufactural district has been developed recently in the city. The type of industry common in Beloit uses power in relatively small quantities as compared with the primary metal industries, and individual electric motors, or carbo-electricity produced in the plant, are the two most common forms of power in the newer factories. Thus the site requirements are cheap level land and a railroad siding. These requirements were met in the northeastern section of the city, and two establishments have located there. There is room for other plants in that district. Across the State Line in South Beloit is an industrial section analagous to that west of the river in Beloit.

From this consideration of the metal-working industries and their locations in Beloit, it is clear that they are of about the same type as to materials and labor requirements. Relatively small quantities of the heavier raw materials are required, since the operations are of the secondary type. Pig iron, scrap iron, coal and coke are used in some quantity, but in small quantities as compared with those used by the primary metal industries. Semi-finished materials are used, but these generally are sufficiently valuable to stand some transportation, and the distance from Gary, or even from the Pittsburg district, is not excessive for the relatively small quantities of the type of materials moved. Finished accessories assembled with the manufactured product are sufficiently valuable to stand long hauls, especially when moved in large quantities. Further, certain classes of the required materials are distributed from Chicago or Milwaukee, and the transport costs are based upon the distance from these factory branches. In obtaining this class of materials Beloit enjoys a distinct advantage. For all of the larger establishments shipments of raw materials and the finished products are in carload lots.

Perhaps the most commonly recognized factor in the success of the metal-working establishments in the Beloit district is the quality of the labor available. The early establishment of the metal-working industries, and their growth and expansion through several decades, has produced not only skilled machine operators, but technical and engineering skill of a very high order. It appears that the Beloit sites, and the situation of the city in the nation with relation to materials and markets, are sufficiently advantageous to enable the present metal-working establishments to continue successfully, providing efficient management exists in manufacturing and sales organizations. New industries of the same type should find here also a set of conditions favorable to successful operation.

The Shoemaking Establishments. Beloit village in 1845 listde among its industries two shoemaking shops.[10]. In 1870 John Foster organized an establishment, said to have employed 60 hands in the manufacture of fine shoes, with a daily production of 12 dozen pairs.[11] In addition there was an early glove and mitten factory, which may have been a factor in providing workers experienced in cutting and sewing leather. In short, when the managers of the present establishments came to Beloit, there was something of a supply of labor experienced in the operation of shoemaking machinery, and with the expansion of the present establishments the supply has been gradually increased. Normally in the grade of shoes produced in Beloit over half of the wage-earners are women. The light nature of the materials and machinery used makes possible the use of second or even third floor levels in certain manufacturing processes. The larger establishment occupies a site on the Rock River valley bottom on the east side, a short distance north of the State Line. This is essentially a continuation of the west side valley

[10] *History of Rock County,* Western Historical Company, p. 617.

[11] *Ibid.,* p. 264.

bottom industrial district type of site, though the river and the West Grand Avenue commercial section intervene. The site of the other establishment is adjacent to the Joint Switch track, in the northeastern part of the city, but not as far northeast as the new industrial section. The cheap handling of raw materiais in carload lots demands a railroad siding, and both establishments have that service. Both have room for expansion, and expansion upward is always possible, if for any reason lateral expansion is not feasible.

These establishments exemplify the decentralization of the shoemaking industry in recent decades. Chicago is the principal market, and shoes are largely moved to market by motor truck. The situation of Beloit is excellent with respect to leathers obtained from the Milwaukee tanneries and apparently is without particular disadvantages in relation to the bringing in of raw materials from distant sources, while its advantageous situation with regard to the Chicago market is important. Perhaps the most important factor, at least in bringing the establishments to Beloit rather than to some other city having equal advantages of situation, was the supply of labor. Other shoe manufacturing establishments could find equally satisfactory sites in Beloit, with definite advantages of situation and labor supply, and with equally satisfactory management should make comparable success.

The Public Utilities. The early importance of waterpower in the development of the Beloit district has been emphasized. The power potentialities of Turtle Creek are now too small for economical development in these times of large power demands. The Rock River is still used to a small degree, although a public utilities corporation now owns a voting control of the waterpower. Through a period of years all the public utility services, with the exception of the street railway and the telephone systems have been united under the ownership of the Wisconsin Light and Power Company. This corporation, through its district and city organizations provides gas, water, and electric services, and in addition has an important commercial function in marketing electrically operated appliances. The company serves a large area in southern Wisconsin.

The various units of this company in Beloit are housed separately, because they were earlier individually owned and operated and their functions, to a degree, resulted in different site demands. The gas producing unit is located on the valley bottom adjacent to the river on the east side, and between the river and the Northwestern Line tracks. This location when purchased gave cheap land for producing and storage units. These units have a capacity at present which permits production far in excess of the needs of the Beloit district, and a pipe line has been constructed to Janesville and Edgerton, and is projected farther, eliminating multiple plant investments and coal transport. The producing unit is located in Beloit, as the district consumes about four times the volume of gas consumed in Janesville. The important raw materials are coal and fuel oil, the source of the coal being eastern Kentucky. Even with this grade of coal, supplementary fuel oil is used to "step-up" the gas to the required B. T. U. level. The location of the plant is central in location in relation to the two sides of the river, and not far from South Beloit.

The Water Supply. The natural conditions are favorable to the procuring of a large supply of good water from shallow wells at the water horizon of the glacial gravels, deeper wells tap the St. Peter Sandstone, while the deepest wells reach the horizon of the Cambrian Sandstone, with its great supply of water. From the standpoint of organic impurities all of these sources are safe if the wells are properly cased. A drawback for certain industrial uses is the hardness of the water, producing scale in boilers. The pressure is maintained by means of a standpipe of 200,000 gallons capacity, located upon the top of the bluff on the east side of the river. The Wisconsin Light and Power Company uses water from its mains in the gas-producing plant, but the large volume of water used in the carbo-electric plant, in boilers and condensers, averaging 1,500 gallons a minute, comes from the Rock River.

The Electrical Energy Supply. The electrical energy supplied locally is generated on a typical riverside site, (whether the source be a carbo-electric or hydro-electric). The plants are at the east end of the dam across the Rock River, on the relatively narrow valley bottom between the mill pond and the eastern valley side. As has been stated, a large volume of river water is used in the carbo-electric unit, and the availability of such a water supply is one of the prime site requirements of such an installation. The plant is served by a siding from the Joint Switch track, making coal available in carload lots. This carbo-electric installation has a generating capacity in the neighborhood of 10,000 kilowatts. In addition, the unit installed in the hydro-electric development on the same site has a capacity of about 475 kilowatts, the total output of the two types of installations being the electrical energy possible of development under ideal conditions. The Rockton installation a few miles south now has a capacity of about 1,300 kilowatts, the energy feeding in to Beloit. These three installations comprise the total electrical energy capacity of the Beloit area, and power needs over and above the volume produced must come from outside sources. To supplement the power resources already named, the corporation has a high tension line from Belvidere, Illinois, which feeds energy north into southern Wisconsin. It would seem that Beloit is tied up with an electrical power supply system not only capable of meeting the industrial demands of the present, but capable of expansion to meet future demands.

Waterpower. The head of water at the dam at Beloit is figured normally at about 8 feet, and the flow at 8,000 second-feet. With an efficient centralized hydro-electric installation there might be developed a power supply of about 2,000 kilowatts. The present capacities of the water wheels total about 1,500 horsepower, but it has been estimated that the power actually developed is not over 500 or 600 horsepower. The small users of power along the race-way in the industrial district west of the river develop power from shafting connected with old style water wheels. There is little incentive for any individual owner or group of owners of waterpower shares to develop a modern installation, since the fluctuation of flow characteristic of a river such as the Rock makes an auxiliary source of power necessary, if the power needs are at all large. As a result many of the holders of shares in the waterpower have sold to the Wisconsin Light and Power Company. The position of this public utility company in the utilization of the potential hydro-electric power development is quite different from that of an individual owner-user. This company could more efficiently use the small quantity of power developed, since it already has multiple sources of power, so that the drawbacks of fluctuations would be minimized. This corporation has as well a full 24 hour demand for power, with multiple sources of outlet through its various services, while its interlocking transmission lines make possible the sale elsewhere of any excess energy developed in the Beloit district. It should be realized, however, that the natural conditions are not favorable to a large power development on the Rock River, and it would not be economical for the utility company to develop the potential power resource, when it already has energy producing units in efficient operation, unless the costs of the development, including the cost of procuring the shares in the waterpower, were kept at an absolute minimum. Yet it would be unfortunate if the present inefficient utilization of the power potentialities of the Rock River at Beloit should be continued indefinitely.

The Gravel and Sand Industries. This development, most active in South Beloit, is of a dual nature, in that in at least one instance affiliated establishments carry on different activities. The major activity is the exploitation of outwash gravel deposits, with sand as a by-product. Accessory to the gravel exploitation is the manufacturing of cement and concrete products, with sand, and some gravel, as the raw materials. Cement blocks, concrete pipe and tile, are the finished products. The working of the gravel pits is seasonal, the work stopping in the winter, but the manufacturing activity may be carried on throughout the year, with somewhat greater activity in the warmer season. The total male labor employed in all the gravel producing and using industries was reported as numbering 138.[12] The manufacturing phase of the gravel industry is an attempt to find a profitable outlet for the sand, which normally is a drug on the market.

There are at least two factors of geographic significance to be considered in dealing with this industry. They are, first, the concentration of gravel deposits of high grade in great thickness, related to the glacial history of the area, and, second, the situation of these rich deposits of fresh gravels within a short distance of the Chicago metropolitan market. The deposits now being worked are being utilized first, and at the lowest cost, because of their situation with relation to railroad transport already on the ground. The gravel produced in the Beloit area must compete with gravels from points much nearer Chicago,

[12] Beloit Industrial Survey, 1927, pp. 54-55.

such as those deposits located west of the Valparaiso morainic system at Joliet and at other points less than 50 miles from Chicago. While a large proportion of the gravel goes into the Chicago district, the market for the products of the manufacturing is quite different. The small manufacturers of concrete blocks market locally, but the concrete tile and pipe find more distant markets in Wisconsin, Illinois, and Iowa. The gravel exploitation industry, and manufacturing activity growing out of it, are type cases of human utilization of natural resources which are particularly favorably situated. While the industries are not heavy employers of labor, they do their share along with other industries, in the upbuilding of the district. They are particularly important in that they provide a large share of the railway freight tonnage moving out of the Beloit district.

Knitting and Sewing Industries. The knitting and sewing industries are relatively unimportant in the Beloit district. Among the various types of such establishments in operation there is something of a division on the basis of the labor used. These establishments find cheap land or cheap rentals important, with the added requirement of easy accessibility to a female labor supply. The sites in Beloit represent varying compromises. Before any new industry of this general type is brought to Beloit a careful analysis of the particular type of labor demanded should be made. There is apparently some surplus of female labor in Beloit, but it is of various types, not equally suited to all industries.

Foodstuffs Processing Group. The establishments considered under this heading are mainly engaged in the processing and manufacturing of milk and its products, and the making of breads and pastries, with flour as the bulk raw material. In addition there is a little slaughtering of meat animals, some candy making, and bottling of beverages. In practically all cases the markets are limited to the Beloit district, and a small immediately tributary area.

The sites of the establishments processing, bottling, and manufacturing dairy products are apparently located in part in relation to the distribution locally of the merchantable products. The largest single establishment is located west of the river, but its site is such in relation to river crossings that it can serve the east side as well as the west. Further, it is accessible to farm territory on either side of the city, without crossing the whole city. This establishment handles a full line of dairy products from bottled milk to ice cream and butter. Other establishments occupy less central sites, possibly related to areas served in the city, as well as the farm area outside the city from which raw milk comes.

A bakery establishment has two possible outlets for its products—the wholesale and the retail trade. The choice of site for the establishment will depend to a degree upon the nature of the outlet. In Beloit the bakeries are in two types of locations, depending upon whether their outlet is wholesale or retail, or both. Retailing in turn is of two phases, that of merchandising over the counter in a desirable commercial location, and through vending the product on established routes through the residential section of the city. One baking establishment mainly engaged in wholesaling is located on the far west side, even though much of its selling is to grocers on the east side. This location, in the heart of a residential district, is an attempt to avoid the high rents charged in more central locations. The site is not favorable in relation to the marketing of the products, but apparently in this case the advantage of a cheap site is of more importance than nearness to consumers. Three establishments have sites in the downtown commercial district and retail their products over the counter. The largest of these has its plant in the rear on cheaper land off the thoroughfare, but the site is such that it is accessible to both sides of the river on wagon routes. Various combinations of marketing functions exist in the case of the baking industry in the Beloit area in an attempt to get volume sales in the face of chain store and other competition.

Miscellaneous Industries. There are industries which do not fall naturally into any of the groups so far enumerated, yet industries of some significance, such as the Central Radio Corporation, Young Manufacturing Company, Beloit Box Board Company, and a number of others.

The Beloit Box Board Company is an interesting modern industry, for the paper making industry early developed in Beloit, using rye straw as a raw material, and through much of the life of the city there has been an operating mill within its borders. The present mill manufactures box boards and building paper. The raw materials are waste paper and rags collected largely from nearby sources. Sulphite pulp comes from Nekoosa, Wisconsin. Though steam is now the main source of power, direct waterpower is still used to some extent. As might be expected, the site of this mill is at the end of the dam across the Rock River, on the west side of the valley bottom.

Beloit Industries: Conclusions

The industries of the Beloit district have been treated in varying detail as regards their geographic aspects, but from that consideration rather definite conclusions may be drawn: (1) Beloit industries use relatively light weight valuable raw materials, capable of bearing fairly heavy transportation costs. (2) The industries use relatively large quantities of semi-finished and finished accessories, capable of bearing heavy transport costs when moved in quantity. (3) The industries use materials which suffer little loss in weight through use. Coal is the marked exception, and industries using large quantities of coal so far from the source of supply are paying freight charges on a large quantity of tare, in the form of ash, moisture, and other unused constituents. (4) Beloit industries give a high proportion of added value to the materials used, through the expenditure of relatively large quantities of skilled labor upon them, with an additional increment in value as a result of the costly highly specialized machinery used in the operations. (5) For industries of most types Beloit has a supply of highly satisfactory labor, both common and skilled, not only drawn from the Beloit district proper, but from the adjacent villages and cities within automobile commuting distance. (6) There is an adequate supply of reasonably priced electrical energy available for the use of industries of the district. (7) Certain Beloit industries in the valley bottom west of the river are in need of room for expansion. Though there is ample room for expansion in new sites, the cost of such a change is likely to be too high. (8) Industries find in Beloit a situation with relation to the great middle western consuming market, including the Chicago metropolitan area, which is favorable to the distribution of the relatively high valued products. (9) Industries find in the Beloit district excellent home-owning possibilities for their wage-earners, leading to a settled, dependable, wage-earning group, an asset to any industrial section.

The public utilities and foodstuffs processing group, since they specialize in service to the community, do not conform to the above pattern, nor do the gravel industries, directly located to exploit that resource. Though there are other exceptions in varying degrees to the above generalizations, they cover in a broad way the industrial complex in the Beloit district. The congestion in the industrial district west of the river is a condition which must be met step by step as acute periods develop, but safeguards should be developed to prevent the same condition arising again as industry projects itself into new areas. Constructive, directive planning should begin now to insure that within 20 years the present far northeastern district industries are not so circumscribed by residential developments as to make desirable expansion impossible.

THE COMMERCIAL CITY

The situation of the Beloit community, in this period of automotive transportation, is unfavorable to the development of any extensive wholesale activity. The trade area is notably circumscribed, being cut off to the north about half-way to Janesville by the competition of that city, while to the south the Rockford trade area extends more than half-way to Beloit. On the west the county line marks off a fairly definite division between the trade areas of Beloit and Monroe, while to the northwest the area is cut off about three miles short of Orfordville due again to the competition of Janesville. Though there are several small towns to the east, the Beloit trading area apparently extends to about a north-south line through Clinton, since east of this dividing line Delavan and Harvard are centers of importance. The area thus outlined might be termed the immediate trading territory, while in certain specialties, such as furniture, electrical equipment, and radios, there is an extensive twilight zone which includes localities which are by no means limited to Beloit in their buying. The almost entire absence of wholesale establishments, except those distributing perishable products such as meats, fruits, and ice cream, is concrete evidence that no important local wholesale trade serving this very circumscribed area exists.

The explanation of this condition is not difficult to find. The development of concrete and other types of surfaced roads has made accessible to truck delivery all of the smaller towns of the district, and in turn has made Beloit accessible to truck delivery from Chicago and Milwaukee. In addition, the surfaced roads have made it possible for sales representatives from the large centers to call weekly or oftener at the retail stores. This combination of conditions, related in the main to changed modes of selling and distribution, has effectually eliminated the small wholesaler who carried a stock on hand from which the local retailer could order daily to meet local needs. Further, the price competition forced by the omnipresent chain store, particularly in the grocery field, has so narrowed the margin in handling the merchandise that the small wholesaler can no longer profitably stay in business. These findings as related to the grocery field are borne out by the investigations of the United States Department of Commerce, showing Chicago and Milwaukee as the wholesaling centers which serve most of southern Wisconsin and northern Illinois.[13] The same methods and conditions which have eliminated the wholesaling of any but perishables in the foodstuffs line, have operated in a similar fashion in most other lines. It is apparent that the advantages of situation which have made the great Chicago market accessible to the manufactured products of the Beloit district have reacted generally to eliminate the local wholesaler in favor of Chicago and other large city establishments.

The Retail Trade and Trade Area of Beloit. To some degree the same circumscribing limits which apply to Beloit as a wholesaling center apply in relation to the retail trade. The Beloit retailer feels the competition of the neighboring cities, particularly to the north and south. This competition may be concretely illustrated by the sales of establishments handling certain types of merchandise in Beloit contrasted with sales of similar establishments in other Wisconsin cities. Definite merchandising quotas are determined for such establishments on the basis of population, number of telephones in service, or on other bases known only to the members of trade associations. A comparison of the projected quotas and the actual merchandise sales for Beloit and a comparable city are given in Table I. These data demonstrate that Beloit in this particular line of merchandise does not have a market capable of absorbing goods

[13] Domestic Commerce Series No. 30, Map of Wholesale Grocery Territories.

in as high a proportion as a comparable city, but a city with a less circumscribed trade area. This point is further emphasized by the fact that in Beloit proper, not including South Beloit, in 1927, almost a million dollars more in wages was paid than in the city with which it was compared. In addition, the industries of South Beloit, which is a unit commercially with Beloit, pay in the neighborhood of a million dollars in wages annually. This indicates that it must be the more extensive trading area in the case of the comparable city which gave it the advantage in sales during the period involved. In retail grocery establishments, some index to the staple consumption of a district, the Beloit metropolitan district out-numbers the comparable city about two to one.

TABLE I

City	Index figure	Mdse. Quota	Mdse. Sales	Mdse. sales per residence customer per month
Beloit (1929)	9,605	$110,057	$ 94,100.07	.74
Comparable city (1929)	9,235	105,829	123,255.18	.96

A study of national scope dealing with retail selling through department stores shows Beloit to lack importance as an outlet for the types of merchandise handled by such establishments.[14] It is apparent that the retail establishments are largely dependent upon the trade of the local urban area, including the college population as a significant element, plus the rural trade of a relatively circumscribed area. If the trade area is to be extended, the most logical lines of expansion are due west and southwest into a section not now served by concrete roads leading to Beloit, and southeast into a section of Illinois which is relatively isolated. The expansion of the Beloit trade area to include these favorably located sections will depend largely upon road improvement developments within the next few years. Local merchants should realize that even though trade does not naturally flow to Beloit in volume, conditions are not so unfavorable but that by aggressive methods the trading zone may be extended, to the particular advantage of retailers dealing in

[14] Domestic Commerce Series No. 30, maps showing the Retail Shopping Area by Important County Centers, by the J. Walter Thompson Company.

other than staple foodstuffs, though the latter should benefit to an appreciable degree.

The Sites of Retail Establishments. The sites of retail establishments may be roughly classified as (1) downtown central commercial district, (2) strategic outlying commercial centers, and (3) neighborhood sites. The river crossing by means of the Grand Avenue bridge is a strategic factor in the development of the central commercial district, and Grand Avenue, on both sides of the river, is the strategic street. Traffic converges on East and West Grand Avenue as the bridge is approached, resulting in the most dense traffic stream developed in the city. It is this concentration of traffic flowing to and fro across the bridge that makes frontage on downtown Grand Avenue most desirable for commercial establishments able to afford the rentals such sites entail. The central commercial district in Beloit, as in most cities of its size, covers a considerable area and the actual area covered is related to natural conditions. Since there is here available a large area of valley bottom which is suited to commercial utilization, with resulting relatively low priced ground rents, commercial sites are not used intensively. This is reflected in the prevalence of two story buildings in the retailing district, with the district stretched out rather thinly. Concentrated development is normally much easier for the shopper, since establishments are more accessible to each other, with resulting saving in time and effort. One of the very necessary elements in the extension of the trade area of Beloit lies in providing some solution of the automobile parking problem in the downtown commercial district. This problem results in part from the wide extent of the district and the tendency of patrons to shop by automobile rather than on foot.

Zonation in the Central Commercial District. Within the downtown commercial district there is zonation. For a long period the downtown corner occupied by the Goodwin Block has been the most intensively used piece of real estate in Beloit. The ground floor of this building is in part occupied by a chain drug store, a typical use of such key sites. Shoe stores, jewelry shops, and department stores are found in the heart of the district. Furniture stores, with their large showroom space requirements are normally just outside the center of the district, where rents are somewhat lower. Grocery stores, meat mar-

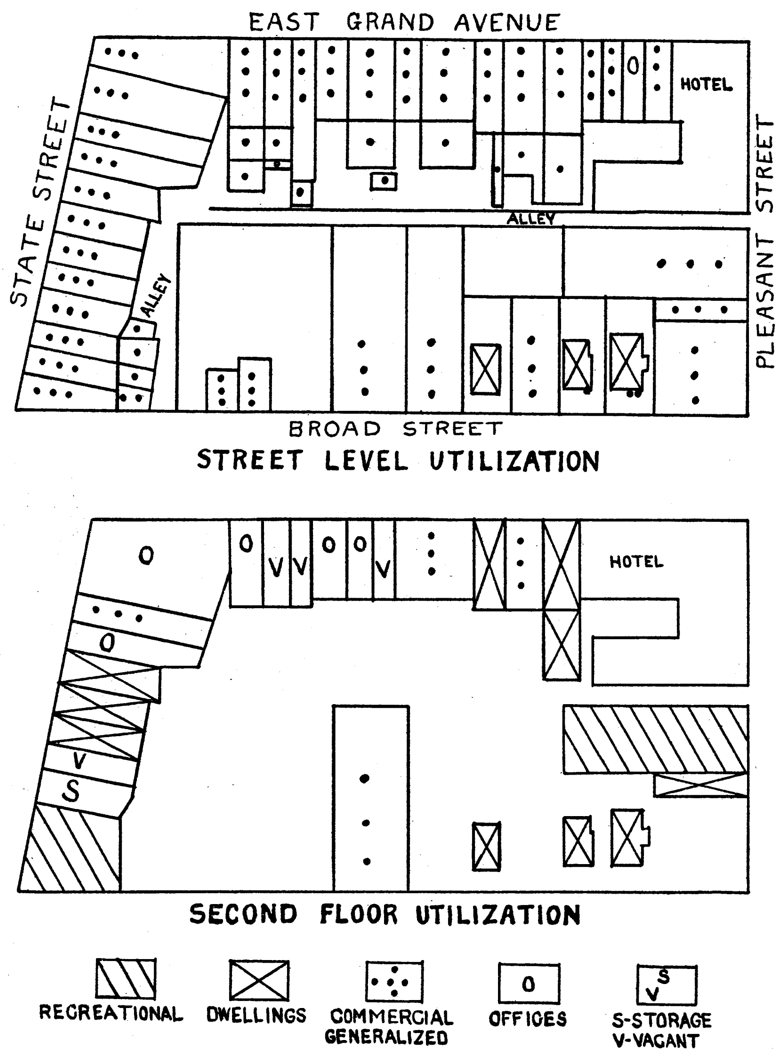


FIG. 1. Diagrams showing site use in the commercial district. Only the first and second floors are shown. The office building on the upper left has four floors; the recreational building on the lower left and the hotel on the upper right have three floors; otherwise there are no buildings in this block more than two stories high.

kets, and other providers of staples are commonly on the outer fringes of the central retailing district, though there are special exceptions. The general exceptions to the conditions outlined are provided by the chain stores, regardless of the line of merchandise handled. Illustrations of this condition are numerous in the Beloit downtown commercial district.

A sample of the type of drawing designed in connection with this study to show the lack of intensive use of high grade sites in the central commercial district is shown in Fig. 1. From such drawings several conditions of significance may be determined, and generalizations formulated as follows: (1) The average number of floors above the basement is two. (2) Passenger elevators are few in number in Beloit, as a result of the lack of intensive use of any but a few of the most strategic sites. (3) The spread of the retailing district discourages the shopper going from store to store to compare values, and the difficulty in making such comparisons may deter out-of-town buyers from attempting to purchase in Beloit. (4) Second floor levels very near to the most strategic corner in the central commercial district, that at the intersection of East Grand Avenue and State Street, are used as dwellings. This use is very common toward the edges of the district. (5) The lack of intensive use of even some of the more strategic sites is without question in part related to the attempt to develop dual commercial centers, one on either side of the river.

Sub-surface utilization is not indicated in detail, since with the lack of intensive use of the surface, with few exceptions basements are used only for storage. One exception is significant, in that a furniture store affiliated with a chain uses some basement space for the showing of kitchen goods. This establishment is located in a central site where rentals are sufficiently high to cause it to use but the first floor of the building, supplemented by the basement space. An independent furniture store could not well function under such an arrangement as it needs more show-space for stock which it does not turn over as rapidly as does the chain store. Furniture stores on more typical sites toward the edge of the central commercial district utilize second or even third floors for show room and storage space.

Outlying Commercial Centers. The sites of outlying commercial centers are apparently related to three factors of significance, first, distance from the downtown commercial district, second, concentration of traffic flow, and third, the character of the tributary neighborhood area. Outlying centers are located in many cases, on sites which were once the commercial frontiers of the city. As the city grew outward new commercial centers developed to care for the retailing needs of the new urban developments, in fact in some cases anticipating those needs too far in advance. In the vanguard of this outer fringe of urban development today is the gasoline and oil service station.

Another location favorable to retail commercial development is at the crossing of streets which are important traffic carriers, outside of the central commercial district. The neighborhood stores do not reveal in their sites the operation of locating factors as do the outlying trading centers. There is normally an attempt to serve a small neighborhood free of competitive establishments, yet in some instance the stores are very close together. Probably the most important factor in site selection is remoteness from the downtown commercial district. Prior to the general use of the automobile the neighborhood store undoubtedly occupied the place on the city's frontier now occupied by the oil and gas station. Many of the neighborhood groceries were established on the outskirts of the city, and now the city has surrounded them.

The Eastward Trend of Commercial Development. An eastward trend in the expansion of the commercial district is manifesting itself, indicated by the site of the new theatre and the movement of other retailing establishments. One of the factors involved in the lack of new developments in the commercial district west of the river is lack of suitable space for expansion. The slope of the valley side at the western edge of the district along West Grand Avenue makes the real estate less desirable for commercial utilization. The railroad tracks are somewhat of an obstacle to westward expansion, but their removal would not offset the other disadvantage. The fact that there is not room for expansion need not mean that the section will become decadent, as its situation with relation to the populous residential and active industrial areas west of the river gives it noteworthy possibilities. A possibility is to develop a grouping of definite types of stores in this district. Furniture stores should find here satisfactory site conditions, and if a number of such establishments were grouped here the buyer would hesitate to shop for such merchandise without visiting this district. It must be by the exercise of such constructive judgment that this portion of the downtown district west of the river will be enabled to maintain healthy retail establishments.

From this consideration of the commercial aspect of the Beloit district in the light of its geographic implications rather definite conclusions may be drawn:

1. It is to the mutual advantage of both Beloit and South Beloit that they be served by a single central commercial district, since it makes available to residents of South Beloit a trading center far more complete than the buying power of that community alone would warrant, while it gives added volume of business to the merchants of Beloit, making more and better establishments possible, to the advantage of all.

2. More intensive utilization of the most central sites is desirable, making shopping less difficult and more satisfactory. A long train of minor advantages should follow the accomplishment of this ideal.

3. The Beloit central commercial district is spread out thinly. Greater concentration is desirable and is certain to occur. The outer edges of the central district should meet the concentration of certain types of establishments in the heart of the area by specialization by districts, comparable to the specialization in automobile sales in the Broad Street area, but more concentrated in its nature.

4. The situation of Beloit with relation to competing trading centers, such as Janesville, Rockford, Milwaukee and Chicago, necessitates a conscious effort on the part of local establishments to hold and extend the trade area. At present the parking problem aggravates this unsatisfactory condition, and before a campaign to draw in trade is begun, means of handling the traffic must be provided.

5. While the situation of Beloit is far from ideal for the development of an outstanding commercial center, there are possibilities beyond the present level of utilization. These possibilities can be realized only through the fullest co-operation of the merchants and other agencies in the community, with constructive planning to make the most of the natural endowment of site and situation.

The Residential City

In the Beloit community the industries have spread out of the valley bottom to the upland, the forms of commercial utilization have likewise encroached upon the upland, but though there is residential utilization of portions of the valley bottoms, there is no first-class residential district upon such a site. This single fact is significant in showing a definite relationship between site and the quality of residential development. The residential section of the city in the period of early settlement was in the valley bottom, but allocation of land use between the industries, commercial establishments, and residential utilization early developed, as is indicated by the following quotation: "The division of the city which put the factories and business center in the valley and the homes on the hill was a most fortunate one. . ."[15] The natural vegetative cover may have been an additional factor in causing the inhabitants early to utilize the higher upland sites for residences, as "burr oak openings" were typical of this section, while a "grove of heavy timber covered the lower grounds, now the business part of the city."[16]

The Upland. On the upland where much of the residential area of Beloit has developed, there still are variations in the desirability of sites resulting from differences in natural conditions. The most desirable natural site is at the edge of the upland overlooking the valley. Sites overlooking the valleys of the Rock River and Turtle Creek are occupied by such developments as the Beloit College campus, Hillcrest, Bluff Street through part of its extent, and the residential sites outside of the city along the east side of the River Road. Fairbanks, Morse and Company's plant on this type of site is an accident growing out of a set of circumstances of no general significance. The remaining expanse of the upland level offers few relief features of significance in affecting residential utilization.

The Spotted Nature of Residential Land Utilization. The natural conditions which are characteristic of a first class residential site have been tabulated as follows: moderate elevation, good drainage, access to sunshine and air, and attractive views. To these has been added for large cities, proximity to a boule-

[15] Beloit Daily News, June 22, 1897.
[16] Brown, William Fiske, *History of Rock County,* Vol. I, p. 130.

vard system, making the site accessible through the use of the automobile.[17] It must be understood that the encroachment of a single undesirable factor, such as a railroad right-of-way, or an industrial or commercial establishment, may partially or completely nullify the natural advantages. The presence of the Fairbanks, Morse and Company plant has made undesirable for high grade residential use natural sites near it that have inherently excellent qualities. Since this industry has long occupied its present site the residential development adjacent is in harmony with the presence of the establishment.

The presence of industrial and commercial establishments on upland sites in Beloit is a factor of great significance in residential land utilization. The Joint Switch track opens a large area of land to industrial and commercial use, yet the potentialities of such use apparently were not generally realized until recently. The Joint Switch track, with its adjacent storage, commercial, and industrial establishments, cuts a swath directly through the residential section of the east side.

The Valley Bottoms. The valley bottoms present a much more uniform condition in relation to classes of residential land use than does the upland. On the valley bottoms the status of residential site improvements is only fair in the better sections and very poor in the worst. Thus, on the bottoms adjacent to Turtle Creek along Race Street, veritable hovels house a portion of the Negro, Mexican, and other population of the community. The nearness to the industries and railroads, added to the natural factors of low elevation and poor drainage, causes these sites to be so low in real value that no quality improvements are justified.

Beloit, like most unplanned America cities, is characterized by great variation in residential improvements, in many cases totally unrelated to the site characteristics, and presenting a condition which when mapped in great detail shows great variations within short distance. The selection of a site by the prospective home owner in Beloit consequently presents a complicated and difficult problem. As a result of the continuously changing condition of urban land utilization to meet the needs of industrial, commercial, and residential establishments, and the lack of directive planning and comprehensive zoning of any high scientific quality, there are too many variable items con-

[17] Dorau and Hinman, *op. cit.*, pp. 68, 312.

fronting the investor. It is to the owner of the cheaper home that this problem is particularly acute. There are many owners of cheap homes in Beloit who have seen their property depreciate greatly in the last fifteen years through the development of nuisances beyond the control of the individual.

Summary

1. The valley bottoms with their typical industrial commercial, and railroad utilization, are marked by residential utilization of rather low grade, due to the natural characteristics of this type of site, as well as to the major forms of utilization.
2. The spotted nature of the residential development on the upland is mainly related to the presence of industrial, commercial, and railroad forms of utilization, and the lack of functioning private or public controls in residential real estate development.
3. The condition of urban site use cannot be revolutionized, since industrial, commercial, and railroad utilization of the upland areas is an established fact, but future residential utilization should show intelligent adjustments to the presence of such forms, as well as to the site characteristics desirable in residential land.
4. Controls and restrictions should make difficult the subdivision of unripe sites, unable to meet the restrictive requirements of moderately good grade residential developments. This should eliminate the most undesirable forms of garage-house occupance of sites.

THE CULTURAL CITY

The New England cultural background is outstanding in the Beloit community. Though not the first settlers on the site, the members of the New England Emigration Company with their arrival and settlement gave a quality to the community which has persisted. Representatives of this group of settlers searched the middle west for a desirable site, and finally selected Beloit. It is apparent that certain of the site conditions made a definite appeal to the agents of the company. There were prairie lands not needing clearing, oak openings which furnished fuel and fence material, as well as easily harnessed sources of waterpower to turn the wheels of grist and saw mills.[18] It is further

[18] Western Historical Company, *op. cit.*, p. 609.

suggested that they were attracted by the New England-like look of the country.[19] That the land available for purchase included a hundred acres already broken may have been an additional factor of some significance in influencing the selection.

New England traditions demanded schools for the children of the community, and when the general organizations of the Congregational and Presbyterian churches projected an institution of higher learning for the new region of the Northwest Territory opened for settlement by the Blackhawk War, citizens of Beloit made a determined effort to secure the college, in which they were successful. In the selection by the church organizations of the place in which the projected college was to be situated, the location of Beloit at the territorial boundary line, in a position to draw students from both Illinois and Wisconsin, was a situation factor of significance.[20] The situational advantage of Beloit, about half-way between Lake Michigan and the Mississippi River, has been suggested as another factor considered as favorable in its selection.[21] Through the years the college faculty and their families have been the moving spirits in the cultural history of the Beloit community. Their direct and indirect influence in the spiritual, cultural, educational, and even commercial and industrial activities in the city has been immeasurable. It is apparent that there are elements of geographic import related to the New England settlement on the Beloit site, the establishment and persistence of the college in its situation, and the resulting cultural personality of the community.

In conclusion it may be said that the Beloit community, but more especially Beloit proper, has a rather definite personality, related to its New England cultural background, and the New England elements which still persist in its population. Its industries today reflect the influence of typical New England ingenuity and mechanical skill. Its outlook is essentially conservative, but not reactionary. In its city improvements, its recently adopted city-manager form of government, and its attempts to meet the problems of urban land utilization by a zoning act, the municipality demonstrated that it is alive to its local problems.

---

[19] Whitney, *op. cit.*, p. 133.
[20] Chapin, R. C. Semi-Centennial Anniversary of Beloit College, June 1897, p. 44.
[21] Smith, Professor E. G. Interview.

STRIKE SLIP FAULTING IN THE ACADIAN APPALACHIANS

H. D. SQUIRES

This paper is primarily concerned with the deformation of the crust of the earth as seen along the coast of Maine, the Bay of Fundy coast of New Brunswick, and farther east in the mainland of Nova Scotia, a region which is popularly known as Acadia. In Maine and New Brunswick geological mapping has been confined chiefly to areas along the coast on the north side of the Bay of Fundy. Farther inland a meager amount of information may be obtained from the description of the various quarries and of deposits of the economic minerals of the region.

Definition. According to Reid and others,[1] a strike slip fault is present "where the net slip is practically in the direction of the fault strike."

CRUSTAL MOVEMENTS AFFECTING THE ACADIAN REGION

Deformation of the rocks in this region has been produced by compression acting in two directions nearly at right angles to each other. The more spectacular effects have been produced by compression effective in a direction at right angles to the Bay of Fundy syncline. Movements so generated have developed great folds in the earth's crust. This same compression developed numerous small folds by a minor wrinkling of the earth's crust. These lesser folds are parallel to the axial direction of the greater folds and are an effect of the same shortening movement. The Bay of Fundy lies in a downfold, while the mainland of Nova Scotia and the land mass of New Brunswick and Maine represent the widespread, upbowed portions on either side of it. Following this earlier deformation, the mountain building forces were inactive for a considerable period of time. Then the region was compressed in such a fashion as to develop folds nearly at right angles to the earlier series.[2] This

[1] Reid, H. F. & Others—Report of the Committee on the Nomenclature of Faults. p. 176.

[2] Bastin, E. S. & Williams, H. S.—Description of Eastport Quadrangle, Maine. Structure Sections, p. 13.

effect of structural adjustment is not nearly so prominent as the folding parallel to the Bay of Fundy, but it is quite definitely present.[3] After the passage of a considerable time in the earth's history, compressive forces once again became effective in a direction normal to the axis of the Bay of Fundy. This time the

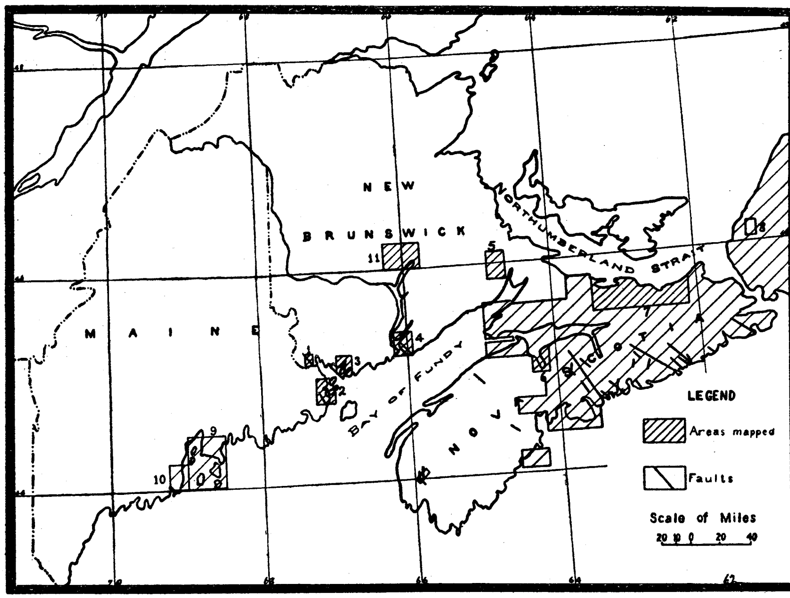


FIG. 1. The mapped areas indicated by numerals are as follows: 1. St. Stephen Area. 2. Eastport Quadrangle. 3. St. George Area. 4. St. John Area. 5. Moncton Area. 6. Horton-Windsor Area. 7. Northumberland Straight Area. 8. Lake Ainslie District. 9. Penobscot Quadrangle. 10. Rockland Quadrangle. 11. Minto Coal Basin.

rocks which previously had been closely folded responded to the need for adjustment by fracturing, followed by the overthrusting of huge blocks or slices of the earth's crust over each other. At this time, too, there was lateral displacement along approximately vertical faults, the blocks affected having, in general, a horizontal movement relative to each other. Overthrusting, folding, and normal faulting are all present in the younger rocks of the region, but no cases of strike slip faulting are described. It is of interest to find that the deformation of this

[3] Squires, H. D.—Cross Warping in the Acadian Appalachians.

region has continued to be active even since glaciation in the St. John Area (Fig. 1, No. 4) where numerous very small overthrusts have been found in glaciated outcrops. An instance is cited by Hayes[4] in which he says, "In an exposed area, measuring thirty feet across the strike, thirty overthrusts were counted with throws varying from one-quarter inch to three inches."

Strike Slip Faulting Near the International Boundary

St. Stephen Area. Along the shore of the Bay of Fundy for a few miles on either side of the International Boundary Line, strike slip faulting has played an interesting part in the development of rock structures. This type of faulting is found in three different localities in the district near St. Stephen and St. George in New Brunswick and Eastport in Maine. Near St. Stephen (Fig. 1, No. 1) the writer first found strike slip faulting of importance while mapping a gabbro mass upon which the town was built. Numerous vertical faults cut the gabbro and the polished sides of these are often exposed in the road cuts and in the so-called "gravel pits" from which materials have been dug to resurface the roads. The faults attracted particular attention because the striations on the exposed surfaces are almost always horizontal, showing that the crustal blocks forming the two sides of each fault have moved by each other in a horizontal direction. Faults are seldom found in which the movement is in a direction normal or oblique to the strike.

A careful analysis of the direction of displacement along all the faults found in the gabbro shows that the movement in nearly ninety per cent of the cases is in the horizontal direction, never departing from that direction by more than ten degrees. The strike, or cross country direction, followed by the faults is, on the average, north forty-five degrees west. There is also some multiple faulting. In one outcrop less than one hundred feet in diameter the writer saw no less than ten faults. Shear zones are also common. Rapid disintegration in these broken zones has given rise to the so-called "gravel pits" in which fully three-fourths of the decayed rock is small enough to be used as surfacing material for the secondary roads. Strike slip faulting is present to the exclusion of practically all other types in this

[4] Hayes, A. O.—Geology of the St. John Map Area, New Brunswick. p. 234.

district as there is little evidence of either oblique faulting or overthrusting.

Eastport Quadrangle. This same type of crustal adjustment appears again in the Eastport Quadrangle (Fig. 1, No. 2) about thirty miles to the southeast of St. Stephen. Strike slip faulting is found only occasionally in this district, one instance being cited[5] where this type of faulting is combined with an overthrust sheet of sedimentary rock which moved in the same direction. This peculiar combination is due to the movement which took place between two horizontal beds of sediments, the margins of which were folded down at right angles to the remainder of the sheets.

St. George Area. A union of the two fault types present around St. Stephen, New Brunswick and Eastport, Maine is found in the St. George[6] Area (Fig. 1, No. 3). The first type to be noticed is the strike slip faulting common to the region with a strike lying between north and west. In addition to this, however, there is a second system of faults which also appears to be related in time and cause to those just mentioned. This second group has a strike of about fifteen to thirty degrees east of north. The relation of the group striking east of north to that striking west of north seems very indefinite until it is seen that in practically every case the faulting follows the line of folding developed by the cross warping along the southern portion of the International Boundary Line. When considered in the light of this fact, it is quite natural to expect the fractures to be formed along the line of weakness already developed in the folded portion of the rocks. At least one of these faults formed the northwestern boundary of a sheet which had been thrust westward in the cross warping movement and later pushed north-northeast at the time of the formation of the strike slip faults.

Faulting in Other Districts

St. John Area. Farther east in the St. John Area (Fig. 1, No. 4) is another instance of strike slip faulting. In this case,

[5] Bastin, E. S. & Williams, H. S.—Description of the Eastport Quadrangle, Maine. p. 13.

[6] Squires, H. D.—Cross Warping in the Acadian Appalachians.

Hayes[7] says that "overthrusts from the southeast combined with cross faulting parallel with the direction of movement."

Mainland of Nova Scotia. Across the Bay of Fundy in the mainland of Nova Scotia there is a similar movement along vertical faults in the rocks of the Goldenville series.[8] In some cases displacement along these faults has separated formerly adjacent points in various structures by as much as one and one-quarter miles, measured along the strike of the faults. The general cross country direction of these faults is almost without exception northwest-southeast. Numerous examples of these are seen along the southeastern coast of the mainland of Nova Scotia. Along this coast, fault after fault has been described by Malcomb and Fairbault.[9] The major portion of the movement has been in a horizontal direction between nearly vertical surfaces. Less mapping has been done in the southwestern portion of the peninsula of Nova Scotia and in consequence fewer faults have been located there to date.

Areas Not Affected by Strike Slip Faulting

Northumberland Strait Area. In contrast to the abundance of strike slip faulting along the southeastern coast of Nova Scotia, there is a notable lack of this type of structural adjustment in the districts bordering the northern coast [10, 11] (Fig. 1, No. 7). The strike slip faulting is found northward to the southern margin of the younger Pennsylvanian rocks.

Cape Breton Island. To the east in the Lake Ainslie District[12] (Fig. 1, No. 8) and in the southern part of the Sydney Coal Field,[13] there is a similar lack of strike slip faulting.

New Brunswick. Much farther west in the Moncton Area (Fig. 1, No. 5) Wright[14] makes no mention whatever of strike slip faulting and the latest faulting indicated on the map of the area is older than the Pennsylvanian rocks. In south central New Brunswick in the Minto Coal Basin (Fig. 1, No. 11)

---

[7] Hayes, A. O.—Geology of the St. John Map Area, p. 234.
[8] Malcomb, W. & Fairbault, E. R.—Gold Fields of Nova Scotia, p. 27.
[9] *Ibid.*
[10] Bell, W. A.—Carboniferous Formations—Nova Scotia.
[11] Williams, M. Y.—Arisaig-Antigonish District, Nova Scotia.
[12] Bell, W. A.—Petroleum in Lake Ainslie District, Cape Breton Island.
[13] Hayes, A. O. & Bell, W. A.—Sydney Coal Field, Nova Scotia.
[14] Wright, W. J.—Geology of Moncton Map Area, New Brunswick.

Dyer[15] found no sign of strike slip faulting and but one tension fault.

Maine. This type of faulting, so common near the International Boundary Line, is absent farther to the southwest in the Penobscot Quadrangle[16] and in the Rockland Quadrangle[17] as well.

EXTENT OF STRIKE SLIP FAULTING

The area then, over which this strike slip faulting is in evidence is limited on the north by a mantle of Pennsylvanian and younger rocks. This applies in general to Cape Breton Island, to the north shore of Nova Scotia, and to the southern third of New Brunswick. The western limit of the strike slip faulting apparently lies in eastern Maine, while on the east and south, the region so affected passes beneath the Atlantic Ocean.

GENESIS OF THE FAULTS

General Features. While working on the problem of the mechanics of strike slip faulting, the writer has found that the descriptions of the structural geology of the Muddy Mountains Area[18] and the Goodsprings Quadrangle,[19] both in Nevada, supplement rather nicely the record found in Acadia. The composite record of the three regions gives a comprehensive idea of the history of such structural developments. In the two areas in Nevada a maximum of 13,000 feet of previously undisturbed sedimentary rocks is involved in the strike slip faulting and associated structural adjustments. These sediments form a great blanket overlying the older and more metamorphosed rocks. In Acadia, in contrast, the equally great blanket of sedimentary rocks has been almost entirely eroded. In consequence, the strike slip faulting as exposed is found chiefly in the original basement of closely folded early Silurian and older rocks.

The depth of formation for the faults varies from a few thousand feet as exposed in the younger formations of the

---

[15] Dyer, W. S.—Minto Coal Basin, New Brunswick.

[16] Smith, G. O., Bastin & Brown—Description of Penobscot Bay Quadrangle, Maine.

[17] Bastin, E. S.—Description of Rockland Quadrangle, Maine.

[18] Longwell, C. R.—Geology of the Muddy Mountains, Nevada, pp. 103–126.

[19] Hewett, D. F.—Geology and Ore Deposits of Goodsprings Quadrangle, Nevada. pp. 42–55.

Goodsprings Quadrangle to a known maximum of three miles for Acadia and probably as much as five miles in localities where erosion has been more active.

As a whole, the information available concerning the effects of strike slip faulting under such a wide range of rock conditions gives a rather good opportunity for the study of the various genetic relations of this type of faulting. The most frequent association of strike slip faulting is with the formation of overthrust faults, but it is also clear that strike slip faults are formed in folded rocks in cases where overthrust faults are not developed at all.

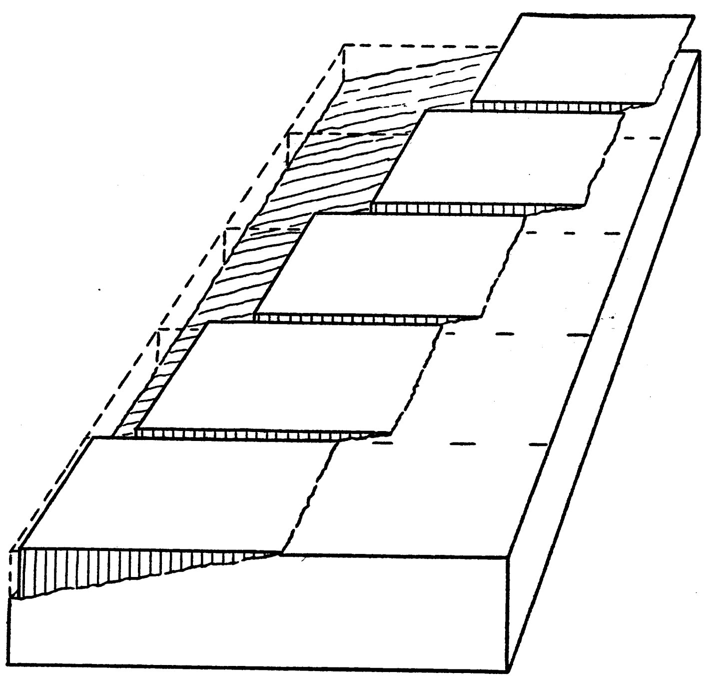


FIG. 2

Genetic Relation to Overthrusts. A careful study of the aggregate structural features of the Muddy Mountains Area, the Goodsprings Quadrangle, the Eastport Quadrangle, and the St. Stephen, St. George and St. John Areas, gives a comprehensive idea of the relationship between strike slip faulting and the development of overthrust faults. The most common and definite association of strike slip faulting and overthrusts is found where strike slip faults form the lateral margins of thrust blocks. Examples of this are found in all the areas named above. Minor movements within the thrust blocks themselves are commonly accomplished by horizontal movement along strike slip faults as illustrated in Figure 2. A single set is shown in this diagram. Numerous instances of minor faults are found in the thrust blocks in the Goodsprings Quadrangle and in the St. George Area. It seems very probable that they are no less abundant in the Eastport Quadrangle since unless these faults bring dissimilar rocks into contact, it is almost impossible to see them. Also, unless one side of the fault is laid bare, the horizontal nature of the movement is so very definitely concealed that normal faulting is likely to be given credit for the displacement. In any event, the irregular advance westward of the different segments of the great thrust fault block of the Edmunds Formation, separated as they are by faults, strongly suggests adjustment, at least in part, along strike slip faults.

Commonly one set of these faults is prominent in an area, but a second set is usually present also, as seen in the granite porphyry of the Goodsprings Quadrangle. In this porphyry the orientation of the faults in each group is in close agreement with that of the faults found in one of the adjacent thrust fault blocks. One set agrees with the fault block to the northwest, and the other with that of the thrust block to the southwest. The presence of thrust fault blocks, in which the direction of motion is nearly at right angles to each other, strongly suggests a variation in the direction of the application of the force which developed the thrust blocks themselves. Since the overthrusts and the strike slip faults develop simultaneously, in many instances, a change in the direction of the application of the diastrophic forces is evidently one cause for the variation in the direction of the strike slip faults. Previous structures in the rocks, together with differences in the type of rocks affected, in turn give rise to further variations of these structures.

A double set of such faults is found in Acadia as well as in Nevada and can be seen in the fault pattern of the major faults as shown in Figure 1. In the St. George Area the divergence of direction of movement is noticeable in overthrust sheets and fault blocks of sandstone. In this case striations between folded beds and in small overthrust sheets show that pressure was applied from the east at an early date. Later the same folds were cleft several times each, nearly parallel to the axial planes, by faults striking north-northeast and having a major movement in the horizontal direction. Wherever the movement could be determined, the eastern side of the fault had moved to the north.

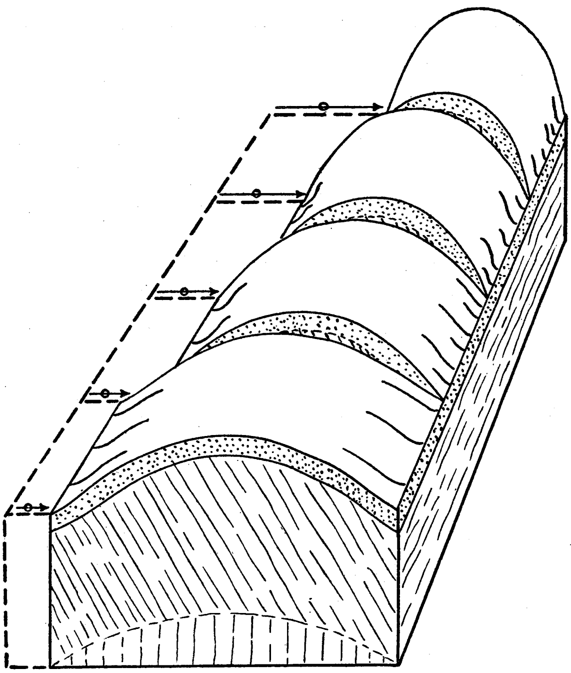


FIG. 3

Genetic Relation to Folding. A careful study of strike slip faulting shows that it is not limited to districts that have undergone overthrust faulting. Strike slip faults are found cutting across folds, both in cases where folds are obviously situated in overthrust fault blocks, and in other cases, where the folds are apparently entirely independent of thrust faulting.

In relation to the folds, as in relation to the thrust faults, the strike slip faults are quite clearly the result of an irregular advance of the different portions of the fold. This means that some portions of a fold are more actively affected by compression than others, and in consequence are either more closely folded than the adjacent portions of the fold, or are pushed forward out of alignment with it. The type of structures developed under such conditions is illustrated in Figure 3 and

Figure 4. An example of the closer folding of a syncline on one side of a strike slip fault which cuts across it is seen in the Clam Harbor District of Nova Scotia.[20] In this instance, two small parallel anticlines, but five hundred feet apart, are cut by

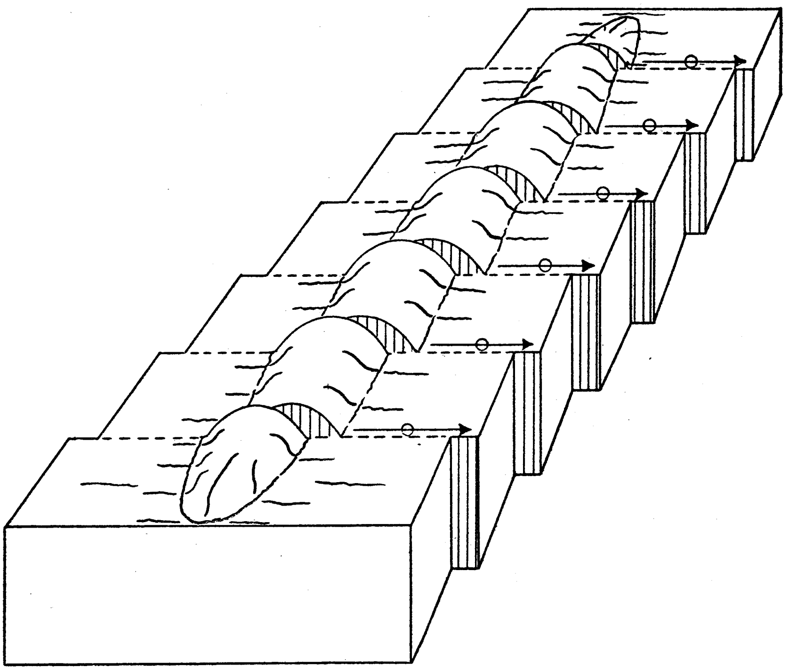


FIG. 4

the same strike slip fault and in one, the displacement is ninety feet, while in the other, it is but a few feet. An example of the axial displacement has been mapped in the Goodsprings Quadrangle[21] about two miles southeast of the Ironside Fault. Again in the Muddy Mountains Area,[22] a strike slip fault which definitely forms the lateral boundary of an overthrust block cuts directly across two anticlines which thus terminate abruptly against the fault. Further the mere fact of such termination indicates that the folds were formed prior to the overthrust and were cut across by the strike slip fault during the formation of

[20] Malcomb, W.—Gold Fields of Nova Scotia, p. 72.

[21] Hewett, D. W.—Geology, Ore Deposits of Goodsprings Quadrangle, Nevada. p. 162, plate 11.

[22] Longwell, C. R., Geology of the Muddy Mountains, Nevada, Fig. 6.

the overthrust. This represents a much more excessive dislocation than that illustrated by Figure 4.

Role Played by Rotational Stresses. According to Leith,[23] "In geological usage the force tending to deform a rock is often spoken of as a stress; the deformation, that is, the change in shape or size, resulting from the application of stress is a strain."

A valuable key to the results of rotational deformation in the generation of strike slip faults is found in Acadia. In this region a combination of strike slip faulting and folding of the rocks in the Eastport Quadrangle and the St. George Area aids materially in determining the mode of formation of the regional structures. Faulting in the post-Silurian intrusives and in the still earlier folded rocks presents additional data. The series of large and small folds strikes as a group almost due north. The strike slip faults fall into groups, one of which strikes approximately northwest, and the other north to northeast. The youngest rocks involved in these structures are of Mississippian age as seen in the St. George Area and along Northumberland Strait.[24] These structures do not occur, however, in the later Carboniferous rocks of the latter area nor in those of the Horton-Windsor Area,[25] the Moncton Area,[26] or the Minto Area.[27]

During the Appalachian revolution the approximate direction along which crustal shortening took place in Acadia was quite definitely between north and northwest. The closing of the Acadian geosyncline as shown in diagrams by Schuchert[28] gives evidence of this. At first glance the relation between this regional movement and the formation of the minor structures described above seems somewhat obscure. In general, either non-rotational or rotational pressure might be responsible for these structures.

It seems very doubtful that non-rotational pressure would have produced these particular structures for two reasons. First, pressure effective in a north to northwest direction would have developed folds striking east to northeast. The folds found in the area strike nearly due north. Second, it seems equally

---

[23] Leith, C. K.—Structural Geology, p. 15.
[24] Bell, W. A.—Carboniferous Formations, Northumberland Strait.
[25] Bell, W. A.—Horton-Windsor District, Nova Scotia.
[26] Wright, W. J.—Geology-Moncton Map Area, New Brunswick.
[27] Dyer, W. S.—Minto Coal Basin, New Brunswick.
[28] Schuchert, Chas.—Orogenic Times of the Northern Appalachians, pp. 701 etc.

improbable that the pressure would have been applied in an east-west direction since an entirely new and separate source of pressure would have been necessary, and there is no evidence that such a pressure has been active. In addition, the direction of greatest pressure would, in many cases, be at an angle of as much as sixty degrees to each of the two sets of strike slip faults formed. Experimental work of Leith's[29] has shown that under simple non-rotational pressure, rocks break at angles of somewhat less than forty-five degrees to the direction of greatest pressure. This experimental fact makes it seem extremely doubtful that these faults were formed by non-rotational forces.

The action of rotational stress best explains the structures found between the towns of Eastport, Maine and St. George, New Brunswick. Experimental work by Mead[30] shows that folds such as those present could have been formed by shearing deformation acting along either a northwest or a northeast direction. When the strike slip faults are also taken into consideration, the northwest direction alone is feasible. This is so because the more important plane of maximum shear strikes nearly northwest in this region. In the St. Stephen Area only one shear plane is well developed as the strike of nearly all the strike slip faults (planes of maximum shear) is within a few degrees of northwest.

Folds overturned to the west-northwest are common near the eastern margin of the area of north-striking folds. This indicates pressure toward the north-northwest and not toward the north-northeast as would have been the case had the greatest applied pressure been effective in a northeast direction. Pressure effective in a northwest direction also fits in with the other structural development of the region, while shear along a northeast direction does not.

These structures, then, lying between the towns of Eastport and St. George indicate that the strike slip faulting throughout Acadia is the result of the Acadian portion of the earth's crust being pushed northwest relative to New England.

Summary

Strike slip faulting occurs chiefly along the western half of the north shore of the Bay of Fundy and in that portion of the

[29] Leith, C. K.—Structural Geology, p. 20.

[30] Mead, W. J.—Notes on the Mechanics of Geologic Structures, p. 519.

mainland of Nova Scotia which borders the Atlantic Ocean. In this part of the Acadian region, strike slip faulting locally overshadows all other types of faulting. The average direction of the faults is northwest; the dip is steep, being approximately vertical, and the movement between adjacent surfaces of the crustal blocks follows the horizontal direction, the average departure therefrom being less than ten degrees. Locally structures present prior to the formation of the faults may cause variations in their strike. The other characteristics are strikingly constant.

This type of crustal adjustment plays an interesting part in the structure of the north shore of the Bay of Fundy, but the most spectacular results of strike slip faulting are seen along the coast of Nova Scotia where formerly adjacent points are now distant from each other by as much as one and one-quarter miles, measured along the fault.

The structural history of the region begins, so far as is known, with regional folding along axes striking approximately northeast-southwest. This was followed in late Paleozoic time by shearing deformation which developed local warping with a north south trend. Overthrusts to the west and strike slip faults were also developed by the shearing deformation. Still later, overthrusting, folding, and normal faulting, all with axes in a general northeast direction, followed the strike slip faulting. This movement continued to some extent even after glaciation in the St. John Area.

The age of the strike slip faulting is post-late-Devonian (or early Mississippian) and predates the deposition of the late Pennsylvanian rocks.

Bibliography

Bastin, E. S.—Description of the Rockland Quadrangle, Maine. U. S. G. S., Geol. Atlas, Rockland Folio No. 158. (1908)

Bastin, E. S. & Williams, H. S.—Description of the Eastport Quadrangle, Maine. U. S. G. S., Geol. Atlas, Eastport Folio No. 192. (1914)

Bell, W. A.—Carboniferous Formations of Northumberland Strait, Nova Scotia. Geol. Surv. Can., Sum. Rpt. 1924, pt. C. pp. 142-180. (1926)

Bell, W. A.—Prospects for Petroleum in Lake Ainslie District, Cape Breton Island. Geol. Surv. Can., Sum. Rpt. 1926, pt. C. pp. 100-109. (1927)

Bell, W. A.—Horton-Windsor District, Nova Scotia. Geol. Surv. Can., Mem. 166. (1929)

Dyer, W. S.—Minto Coal Basin, New Brunswick. Geol. Surv. Can., Mem. 151. (1926)

Hayes, A. O.—Geology of the St. John Map Area, New Brunswick. Geol. Surv. Can., Sum. Rpt. 1913, pp. 228-243. (1914)

Hayes, A. O. & Bell, W. A.—The Southern Part of the Sydney Coal Field, Nova Scotia. Geol. Surv. Can., Mem. 133. pp. 1-89. (1923)

Hewett, D. F.—Geology and Ore Deposits of the Goodsprings Quadrangle, Nevada. U. S. G. S. Prof. Paper. 162. (1931)

Leith, C. K.—Structural Geology, Henry Holt & Co., N. Y., 1923.

Longwell, C. R.—Geology of the Muddy Mountains, Nevada. U. S. G. S. Bull. 798. (1928)

Malcomb, Wyatt—Gold Fields of Nova Scotia. Geol. Surv. Can. Mem. 156. (1929)

Mead, W. J.—Notes on the Mechanics of Geologic Structures, Journ. of Geol. vol. 28, pp. 505-523. (1920)

Smith, G. O., Bastin, E. S. & Brown, C. W.—Description of the Penobscot Bay Quadrangle, Maine. U. S. G. S., Geol. Atlas, Penobscot Bay Folio No. 149. (1907)

Squires, H. D.—Cross Warping in the Acadian Appalachians. (In preparation)

Williams, M. Y.—Arisaig-Antigonish District, Nova Scotia. Geol. Surv. Can., Mem. 60. (1914)

Wright, W. J.—Geology of the Moncton Map Area, New Brunswick. Geol. Surv. Can., Mem. 129. (1922)

PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. XXI. GERANIALES

NORMAN C. FASSETT

These maps are compiled from specimens in the following herbaria: the University of Wisconsin (including hosts of fungi), Milwaukee Public Museum, Northland College, Lawrence College, the Field Museum, and the private herbarium of Mr. S. C. Wadmond. The writer gratefully acknowledges the courtesies of the curators of these herbaria.

LINACEAE—One genus, LINUM.

a. Petals blue; capsule 10-12 mm. in diameter; sepals not glandular
  b. Sepals, or at least the inner ones, ciliate
    c. False partition of capsule not ciliate .... *L. usitatissimum.*
    c. False partition of capsule ciliate .... *L. humile.*
  b. Sepals not ciliate .... *L. Lewisii.*
a. Petals yellow; capsule 3-6 mm. in diameter; sepals glandular-margined
  d. Petals more than 1 cm. long; sepals deciduous from the mature fruit; false partition of capsule not ciliate; leaves without glands at base .... *L. rigidum.*
  d. Petals 4-8 mm. long; sepals persistent on the mature fruit; false partition of capsule ciliate; leaves with 2 dark glands at base .... *L. sulcatum.*

L. USITATISSIMUM L. Common Flax. (Fig. 1). This is to be expected as an escape almost throughout the state, since there are (or were in 1927) but 17 of Wisconsin's 71 counties in which flax is not a crop plant.[1]

L. HUMILE Mill. (Fig. 2, dots). Much less common.

L. LEWISII Pursh. (Fig. 2, circles). This is recorded from Wisconsin in Gray's Manual, ed. 7, and in Britton & Brown's Illustrated Flora, ed. 2. Dr. Percy Wilson writes me from the New York Botanical Garden that they have there no specimen from this state upon which the report might have been based; Professor M. L. Fernald in a letter tells me that the report is

[1] U. S. D. A. and Wis. D. A. Crop Reporting Service Bull. 90 : 54–55. 1928.

not based on any specimen in the Gray Herbarium, but probably on the inclusion of this species by Russel in his Check list of the Flora of Milwaukee County.[2] This report, in turn, goes back to that of W. J. Bennetts, who wrote,[3] "I found this species or the *L. perenne* of Europe for two successive years growing in a vacant lot on the east side." I have not seen any specimen to substantiate this record.

A collection of this species on railroad ballast at Minong, Washburn County, July 6, 1917, *Charles Goessl*, no. 7522, might be referred to *L. pratense* (Norton) Small, since it has sepals but 4 mm. long, but it agrees rather with *L. Lewisii* in that these sepals are fully $\frac{2}{3}$ as long as the mature capsule. Doubtless adventive from farther west.

L. RIGIDUM Pursh. (Fig. 2, cross). A single collection was made along the railroad track at Lyndon Station, Juneau County, June 30, 1917, *J. J. Davis*.

L. SULCATUM Riddell. (Fig. 3). Dry hillsides, sand dunes, railroad embankments, etc., in the southwestern half of the state. Our only native species.

OXALIDACEAE—One genus, OXALIS.

a. Plants stemless; flowers white or purple

b. Flower solitary on each scape; petals usually white with purple lines; plant with a creeping rootstock .... *O. montana.*

b. Flowers several in an umbel; plants with a scaly bulb

c. Petals purple .... *O. violacea.*

c. Petals white .... *O. violacea,* f. *albida.*

a. Plants with leafy stems; flowers yellow

d. Stems creeping, rooting at the nodes .... *O. corniculata.*

d. Stems erect or decumbent, but not rooting at nodes

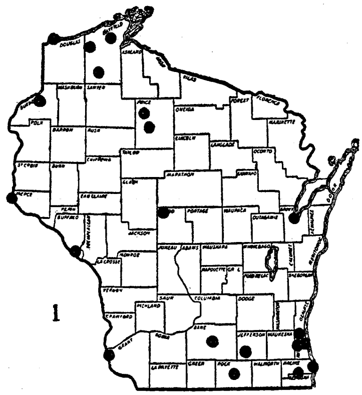
e. Flowers 1-3 on a peduncle, usually umbellate; fruiting pedicels horizontal or deflexed, with erect capsules; capsule and pedicels with fine and dense, closely appressed, hairs

f. Capsule with some loose viscid hairs. .... *O. stricta.*

f. Capsule with only short appressed hairs .... *O. stricta,* var. *piletocarpa.*

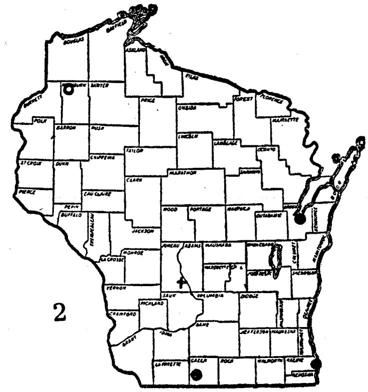
[2] Bull. Wis. Nat. Hist. Soc. 5 : 206. 1907.

[3] Ibid. 1 : 164. 1900.



1

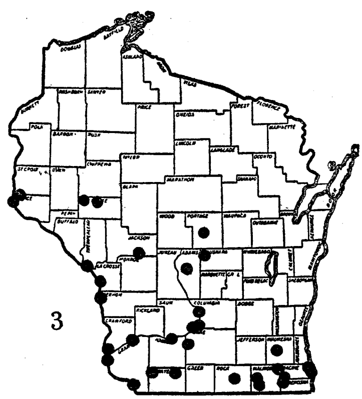
Linum usitatissimum



2

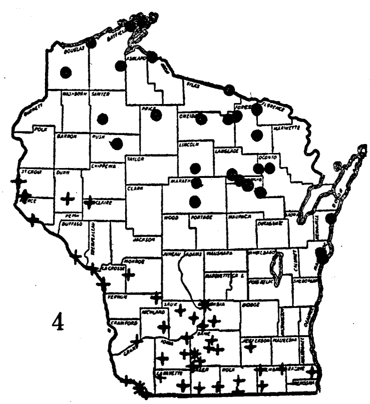
● Linum humile ✚ Linum rigidum

○ Linum Lewisii



3

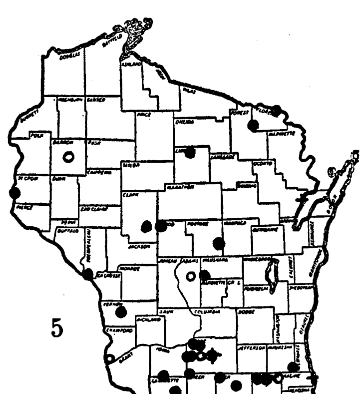
Linum sulcatum



4

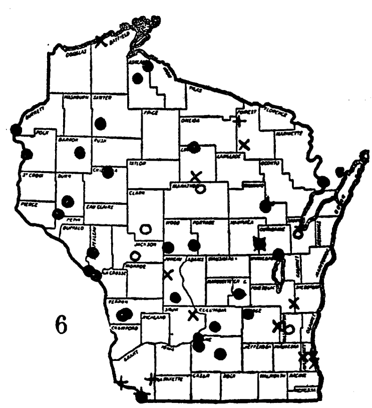
● Oxalis montana ✱ Oxalis violacea f. albida

✚ Oxalis violacea



5

✚ Oxalis stricta ● Oxalis stricta var. piletocarpa



6

● Oxalis europaea ✚ Oxalis europaea f. cymosa

○ Oxalis europaea f. pilosella × Oxalis europaea f. villicaulis *e*. Flowers usually 3 or more to a peduncle, cymose; fruiting pedicels spreading or ascending; capsules glabrous or only with spreading hairs

g. Upper surface of leaflets glabrous

h. Hairs on pedicels appressed

i. Stem glabrate or with appressed hairs .... *O. europaea.*

i. Stem with spreading hairs .... .. *O. europaea,* f. *pilosella.*

h. Hairs of pedicels spreading

j. Stems nearly or quite glabrous .... *O. europaea,* f. *cymosa.*

j. Stems with spreading hairs ......*O. europaea,* f. *villicaulis.*

g. Upper surface of leaflets with scattered hairs

k. Hairs on pedicels appressed

l. Stems with spreading hairs ...... *O. europaea, var. Bushii.*

l. Stems with appressed hairs or glabrate .... *O. europaea,* var. *Bushii,* f. *subglabrata.*

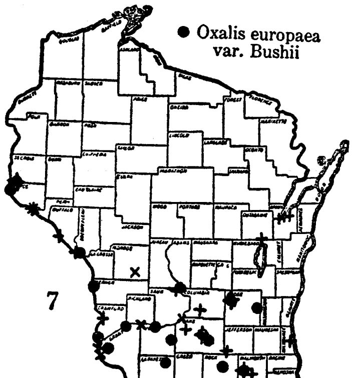
k. Hairs of pedicels spreading..*O. europaea, var. Bushii, f. vestita.*

O. MONTANA Raf.; Fernald, Rhodora 22 : 143-144. 1920. *O. americana* Bigel.; Fernald, Rhodora 20 : 76-78. 1918. *O. Acetosella* of American authors, not L. Wood Sorrel. (Fig. 4, dots). Mostly in coniferous woods, northward.

O. VIOLACEA L. Violet Wood Sorrel. (Fig. 4, crosses). Bluffs and gravelly hillsides, southwestward. O. VIOLACEA, f. **albida,** n. f., corollis albis. Occasional with the purple-flowered plant. TYPE in Herb. Univ. of Wis., Lewiston, Wis., May 18, 1929, *N. C. Fassett & Henry Winkler,* no. 9916. (Fig. 4, asterisks).

O. CORNICULATA L., Wiegand, Rhodora 27: 120. 1925, not of Gray's Manual, ed. 7. *O. repens* Thunb. Apparently not at all common. Russel, *l. c.,* records it from Milwaukee County as a weed in city gardens, and there is a specimen in the Milwaukee Public Museum from a garden (presumably in Milwaukee), September 17, 1900, *Wm. Finger.*

O. STRICTA L. Yellow Wood Sorrel. (Fig. 5, crosses). Scattered, in fields and on hillsides, often on lawns, mostly southern, as is the more common var. PILETOCARPA Wiegand (Fig. 5, dots). I have found the two forms growing together as weeds on a Madison lawn. Specimens not in fruit, so not determinable as to variety, are represented by circles in Fig. 5.

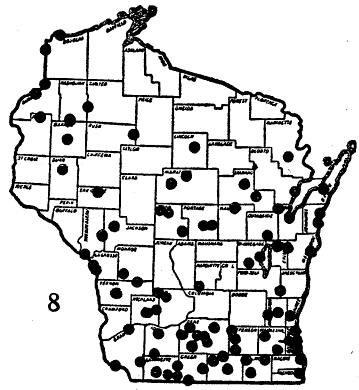


● Oxalis europaea var. Bushii

7

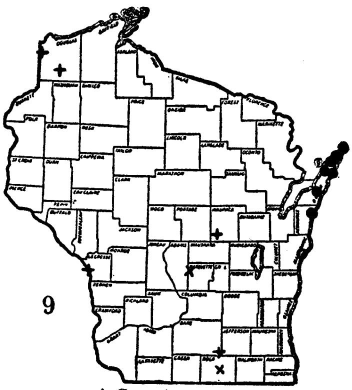
+ Oxalis europaea var. Bushii f. subglabrata

✕ Oxalis europaea var. Bushii f. vestita



8

Geranium maculatum



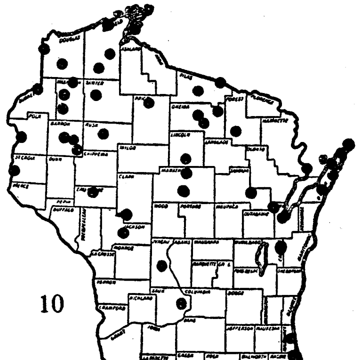
9

+ Geranium carolinianum

● Geranium Robertianum

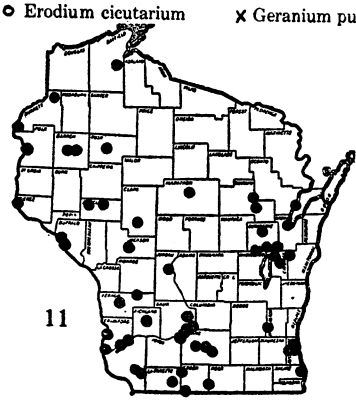
○ Erodium cicutarium

✕ Geranium pusillum



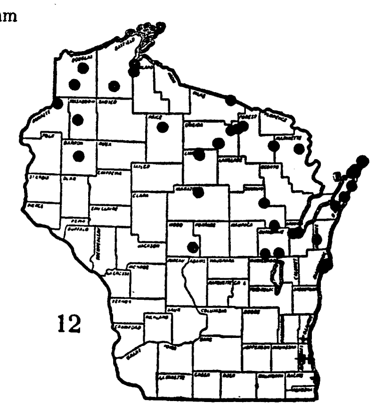
10

Geranium Bicknellii



11

Xanthoxylum americanum



12

+ Ptelea trifoliata

● Polygala paucifolia

O. EUROPAEA Jord.; Wiegand, *l. c.*, 134. *O. corniculata* of Gray's Manual, ed. 7, not L. Yellow Wood Sorrel. (Fig. 6, dots). Throughout the state, often as a weed in lawns, under hedges, in greenhouses and gardens, etc. Forma PILOSELLA Wiegand (Fig. 6, circles), f. CYMOSA (Small) Wiegand (Fig. 6, crosses), and f. VILLICAULIS Wiegand (Fig. 6, x's) occur sopradically, often with the typical form.

O. EUROPAEA, var. BUSHII (Small) Wiegand (Fig. 7, dots) and its f. SUBGLABRATA (Small) Wiegand (Fig. 7, crosses) and f. VESTITA Wiegand (Fig. 7, x's) are decidedly southern in range, running northward along the Mississippi River. This study of Wisconsin material tends to corroborate the opinion of Professor Wiegand, that while pubescence of stem and pedicels is of little taxonomic value in this species (hence the disposition of these variants in the category of forms), the plants differing in having pubescence on the leaflets are more segregated geographically, and are better treated as constituting a variety.

GERANIACEAE

GERANIUM MACULATUM L. Wild Geranium; Cranesbill. (Fig. 8). Throughout the state except in a limited north-central area. The albino, f. ALBIFLORUM (Raf.) House, N. Y. State Mus. Bull. 243-244: 48. 1923, has been collected near Madison, northeast of Lake Mendota.

G. ROBERTIANUM L. Herb Robert. (Fig. 9, dots). Door County, where very abundant, often occurring as a weed in cleared ground. It is especially common on cobblestone beaches.

G. CAROLINIANUM L. (Fig. 9, crosses). This species has, to judge from material in herbaria, been somewhat confused with the next. It is much less common than is *G. Bicknellii*, and is perhaps adventive, at least northward.

G. BICKNELLII Britton. (Fig. 10). Mostly northward, coming south to the Baraboo Hills in Sauk County, and along the Lake Michigan shore, as do a number of other predominantly northern plants in this state.

G. PUSILLUM Burm. f. (Fig. 9, x's). Adventive; rare.

ERODIUM CICUTARIUM (L.) L'Her. Storksbill. (Fig. 9, circle). Adventive; Manitowoc.

RUTACEAE

XANTHOXYLUM AMERICANUM Mill. Prickly Ash. (Fig. 11). Mostly southward. Recorded as being common in Racine and Kenosha Counties.[4]

PTELEA TRIFOLIATA L. Hop Tree. (Fig. 12, crosses). In a few southeastern counties. Wadmond[4] records this as "Rare; thickets and stream borders," while Russel[5] writes, "Common in Menomonee Valley" of Milwaukee County.

POLYGALACEAE—One genus, POLYGALA.

a. Flowers 1.5–2 cm. long, 1–4 on each stem .... *P. paucifolia.*

a. Flowers 5 mm. or less long, in a spike

b. Leaves all alternate

c. Plants with numerous cleistogamous flowers on underground branches; aerial flowers with pedicels about 2 mm. long. .... *P. polygama.*

c. Plants without underground flowers; pedicels 1 mm. or less long

d. Stems many in a cluster from a stout rootstock, usually not branched, covered with minute spreading gland-like hairs just below the inflorescence

e. Leaves not over 1.5 cm. wide .... *P. Senega.*

e. Leaves reaching 4 cm. in width .... *P. Senega,* var. *latifolia.*

d. Stems solitary, often branching, glabrous

f. Petals united into a fringed tube 6–7 mm. long...*P. incarnata.*

f. Petals not united into a long tube

g. Spikes 8–10 mm. thick

h. Flowers at least tinged with purple

i. Flowers purple .... *P. sanguinea,* f. *typica.*

i. Flowers greenish, with some purplish ones intermixed .... *P. sanguinea,* f. *viridescens.*

h. Flowers all white .... *P. sanguinea,* f. *albiflora.*

g. Spikes about 4 mm. thick .... *P. verticillata,* var. *ambigua.*

b. At least the lower leaves whorled

j. Spikes sessile or nearly so, 8–18 mm. thick. .... P. *cruciata.*

j. Spikes peduncled, about 4 mm. thick .... *P. verticillata.*

---

[4] Wadmond, Trans. Wis. Acad. 16 : 848. 1909.
[5] Bull. Wis. Nat. Hist. Soc. 5 : 206. 1907.

P. PAUCIFOLIA Willd. Fringed Polygala. (Fig. 12, dots). Northern.

P. POLYGAMA Walt. (Fig. 13). Mostly in sandy regions; rare northwestward.

P. SENEGA L. Seneca Snakeroot. (Fig. 14). Southern; also on a railroad embankment at Minong, Washburn County. Grades into var. LATIFOLIA T. & G., which is represented by a specimen from Waterworks Woods, Wauwatosa, Milwaukee County, August 3, 1891, *Ruben M. Strong.* This is apparently the basis of Russel's record from Wauwatosa, while Wadmond, *l. c.*, lists this variety as "Rare; wooded bank along Pike Creek, Somers, Kenosha Co."

P. INCARNATA L. (Fig. 15). Rare, southern Wisconsin. The Jefferson County collection was made by T. Kumlien in 1860, who noted on the sheet, "now exterminated."

P. SANGUINEA L., f. TYPICA Farwell, Am. Mid. Nat. 11: 63. 1928, (Fig. 16, dots), f. ALBIFLORA Millsp. Fl. W. Va. 333. 1892, (Fig. 16, crosses), and f. VIRIDESCENS (L.) Farwell, *l. c.* (Fig. 16, x's) occur mostly southward, with apparently no correlation between color and geographical distribution.

P. CRUCIATA L. (Fig. 17). Rare, mostly southward. Check marks in Polk and Marquette Counties represent old collections without precise localities, by T. J. Hale and J. Townley, respectively.

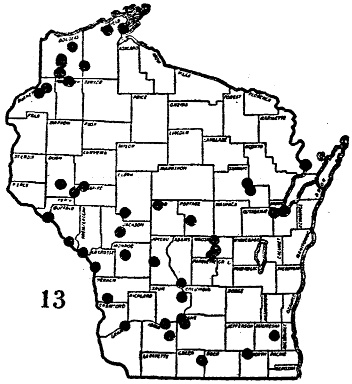
P. VERTICILLATA L. (Fig. 18, dots). Southward and westward. The extreme northwestern station is on moist rocks, not common, Eau Claire, July 26, 1915, *Charles Goessl,* no. 1730. A specimen of well-marked var. AMBIGUA (Nutt.) Wood (Fig. 18, cross) was collected at Chippewa Falls by Goessl in 1913.

EUPHORBIACEAE

CROTON

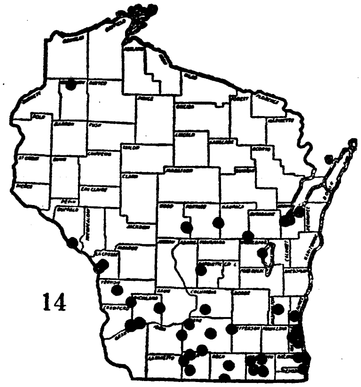
C. TEXENSIS (Klotzsch) Muell. Arg. Railroad tracks by the Kinnickinnic River, Milwaukee, September 4, 1899. *Wm. J. Bennetts.* This is without doubt the basis of the report by Russel[6] from the same locality.

[6] Bull. Wis. Nat. Hist. Soc. 5 : 207. 1907.



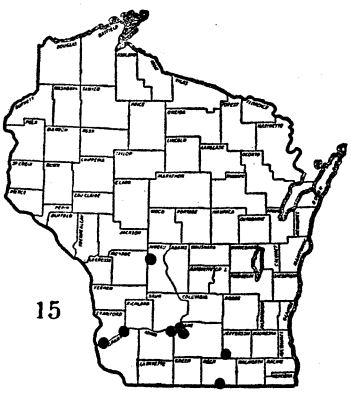
13

Polygala polygama



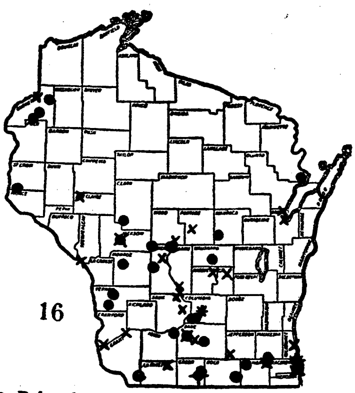
14

Polygala Senega



15

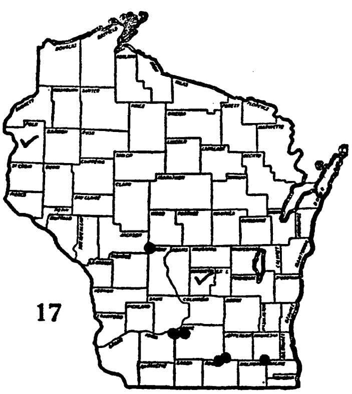
Polygala incarnata



16

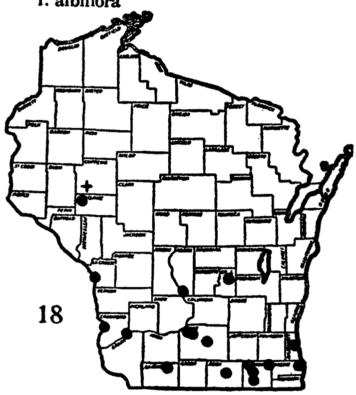
● Polygala sanguinea ✗ Polygala sanguinea f. viridescens

+ Polygala sanguinea f. albiflora



17

Polygala cruciata



18

● Polygala verticillata

+ Polygala verticillata var. ambigua

ACALYPHA

A. VIRGINICA L. Three-seeded Mercury. (Fig. 19). Mostly southward, frequent. Wadmond, *l. c.*, records it only from Wind Lake in Racine County.

EUPHORBIA

a. Glands of the involucre with petal-like usually white or rose-colored margins or appendages

b. Leaves all opposite, oblique at base; stipules present and persistent; stems low, depressed or somewhat ascending, much-branched

c. Seeds smooth and even; leaves entire

d. Leaves oblong-linear .... *E. polygonifolia.*

d. Leaves oblong-ovate .... *E. Geyeri*

c. Seeds roughened or wrinkled; leaves more or less finely serrulate

e. Capsule glabrous

f. Capsule less than 1.5 mm. long; seeds reddish

g. Seeds slightly cross-wrinkled; leaves narrowed to the base .... *E. serpyllifolia.*

g. Seeds strongly cross-wrinkled; leaves rather cordate at base .... *E. glyptosperma.*

f. Capsule 1.5 mm. or more long; seeds black

h. Capsule 2.25 mm. long, rounded at summit; seeds 1.77 mm. wide, with short and sharp irregular ridges; stems glabrous or nearly so; leaves 20–35 mm. long, usually with a red spot .... *E. nutans.*

h. Capsule 1.75 mm. long, retuse; seeds about 0.7 mm. wide, with a few shallow furrows or nearly even; stems hirsute; leaves 8–18 mm. long, rarely with a red spot..*E. Rafinesquii.*

e. Capsule pubescent

i. Seeds with about 4 grooves across each side .....*E. maculata.*

i. Seeds minutely roughened .... *E. humistrata.*

b. Leaves, except the uppermost, scattered, equal at base; stipules lacking or deciduous; stems tall and mostly erect

j. Uppermost leaves with conspicuous white margins...*E. marginata.*

j. No leaves white-margined .... *E. corollata.*

a. Glands of the involucre without petal-like appendages

k. Involucres in terminal clusters, each with 1–few glands *l.* Upper part of stem with close short pubescence as well as scattered hairs; leaves usually all alternate, essentially uniform in shape and color .... *E. dentata.*

l. Stem glabrous above except for scattered crisped hairs; leaves, except the lower, opposite, rhombic (sometimes deeply lobed) or linear to lanceolate, usually with both types on the same plant, those of the inflorescence usually red toward the base ..... *E. heterophylla.*

k. Involucres in umbel-like inflorescences, each with usually 4 glands

m. Glands broad and round; leaves usually serrate ... *E. Helioscopia*

m. Glands crescent-shaped or 2-horned; leaves entire

n. Leaf-blades linear or lanceolate, at least 3 times as long as broad; plants perennial

o. Leaves 2–6 cm. long; floral bracts 1–1.5 cm. wide ... *E. Esula.*

o. Leaves 0.5–2 cm. long; floral bracts about 5 mm. wide .... *E. Cyparissias.*

n. Leaf-blades about as broad as long; plants annual

p. Upper leaves petioled; pod with 2 narrow wings on each lobe; seed with about 12 deep pits on the back, each about as broad as the space between pits, and 2 grooves on the inner face .... *E. Peplus.*

p. Upper leaves sessile; pod without wings; pits on both faces of the seed and more numerous, small and shallow. .*E. commutata.*

E. POLYGONIFOLIA L. Seaside Spurge. (Fig. 20, dots). Shore of Lake Michigan, mostly southward. Wadmond *(l. c.)* states that it occurs only on the beach in Racine and Kenosha Counties, as does Russel *(l. c.)* for Milwaukee County. This species reaches its western limit in Wisconsin; see D. C. Peattie, Rhodora 24 : 59-60. 1922.

E. GEYERI Engelm. (Fig. 20, crosses). Sandy soil, mostly along the larger rivers.

E. SERPYLLIFOLIA Pers. (Fig. 20, x's). The only collections referable to this species are from St. Croix Falls, Polk County, and Campbellsport, Fond du Lac County.

E. GLYPTOSPERMA Engelm. (Fig. 21). Common.

E. NUTANS Lag. *E. Preslii* Gus. (Fig. 22). Southward, particularly abundant along the Mississippi River, which it follows northward.

E. RAFINESQUII Greene, Pittonia 3 : 207. 1897. *E. hirsuta* Wiegand, not Schur. (Fig. 23). Southeastward, not common.

E. MACULATA L. (Fig. 24). Mostly southward. Recorded by Wadmond as being common in Racine and Kenosha Counties. Northward, this seems to be largely replaced by *E. glyptosperma.*

E. HUMISTRATA Engelm. There is much material so labelled in most of the herbaria consulted, including many sheets so labelled by the writer, but on subsequent study almost all prove to belong to the preceding species. The single exception is a specimen, in the Field Museum, from the Brown County Fairground, September, 1889, *J. H. Schuette.*

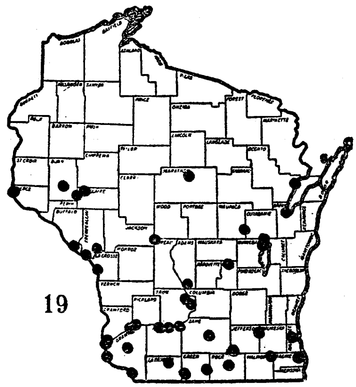
E. MARGINATA Pursh. Snow-on-the-Mountain. This has been found as an escape in Juneau, Rock and Milwaukee Counties.

E. COROLLATA L. Flowering Spurge. (Fig. 25). Common and abundant southward. Like many prairie plants, this is spreading northward along railroads. A record of the collectors' notes in the more northern counties is significant. Bayfield County, "One plant on R. R. ballast," Lenawee [a lumber town, now abandoned], August 6, 1917, *Charles Goessl,* no. 8275; Barron County, "Quite common in R. R. ballast," Barron, August 20, 1917, *Goessl,* no. 8651; Rusk County, "Along R. R., fairly common," Ladysmith, August 13, 1917, *Goessl,* no. 2211; Wood County, "Gravelly soil; fairly common," Marshfield, June 8, 1915, *Goessl,* no 218, and again, "R. R. embankment, not common," Marshfield, September 24, 1915, *Goessl,* no. 3077; Shawano County, "Dry sandy soil, very common," Shawano, July 18, 1916, *Goessl,* no. 4737; Oconto County, "Small colony, sandy soil," Oconto, August 22, 1916, *Goessl,* no. 5772. An older collection is from Lincoln County, near Merrill, July 31, 1893, *L. S. Cheney,* no 2782; this was perhaps introduced with hay in the logging days.

E. DENTATA Michx. (Fig. 27, dots). Local along the Mississippi River in sand or along the railroad; also in hard soil, Walworth, Walworth County, August 13, 1927, *S. C. Wadmond.* Occasional individuals have narrow leaves as ascribed to *E. cuphosperma* Boiss.

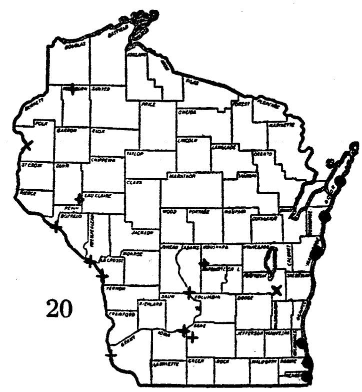
E. HETEROPHYLLA L. Painted Leaf. (Fig. 26, dots). Sandy shores and railroad embankments along the Mississippi River.

E. HELIOSCOPIA L. Wartwort. (Fig. 26, crosses). Occasional; adventive.



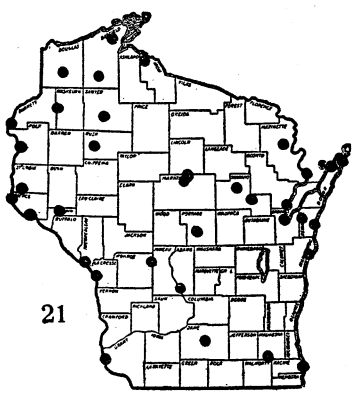
19

Acalypha virginica



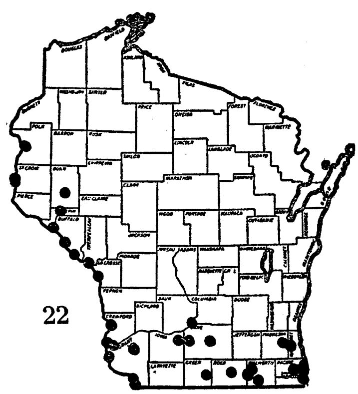
20

● Euphorbia polygonifolia
+ Euphorbia Geyeri × Euphorbia serpyllifolia



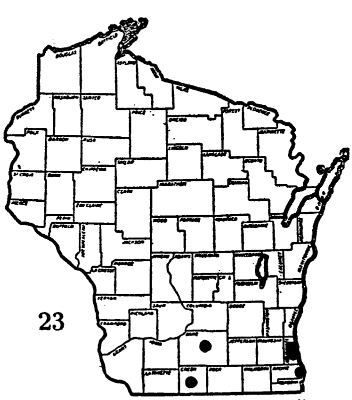
21

Euphorbia glyptosperma



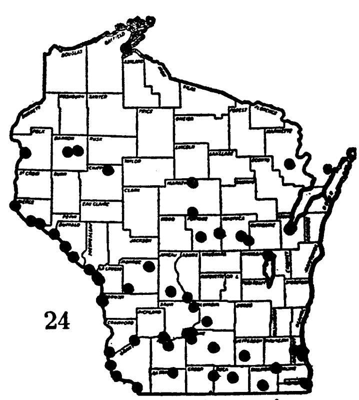
22

Euphorbia nutans



23

Euphorbia Rafinesquii



24

Euphorbia maculata

E. ESULA L. (Fig. 27, x's). Apparently recently adventive, but becoming increasingly common. First collected at Cambridge, Dane County, and in Ozaukee County, in 1925, then in Oconto County in 1928, in a second locality in Ozaukee County in 1928, and a third in 1930, in Adams County in 1930. It was first seen at Madison in 1929, and was observed at a second locality in that city by the writer in 1931, and at Middleton in 1932.

E. CYPARISSIAS L. Cypress Spurge. (Fig. 28). About old gardens; particularly in the sandy regions, where abandoned dwellings are common, lilacs and spurge are conspicuous plants in the spring. Old collections were made in Racine County in 1881, and in Portage County in 1894.

E. PEPLUS L. Petty Spurge. (Fig. 27, crosses). Collected in Dane County in 1889 and 1893, and in Milwaukee County in 1884, 1886, and 1897. Recorded by Russel *(l. c.)* as in "City gardens and waste places. Sparse." in Milwaukee County. Apparently no longer a member of our flora.

E. COMMUTATA Engelm. (Fig. 26, x). Collected at Beloit by T. J. Hale in 1861, again by J. J. Davis in 1910, and seen there by the writer in 1932. Apparently native.

CALLITRICHACEAE—One genus, CALLITRICHE.

a. Upper leaves obovate and 3-nerved, often in a floating rosette; carpels grown together for more than half their width; plants sometimes subterrestrial

b. Fruits 1 mm. or less broad

c. Fruit higher than broad, its lobes keeled .... *C. palustris.*

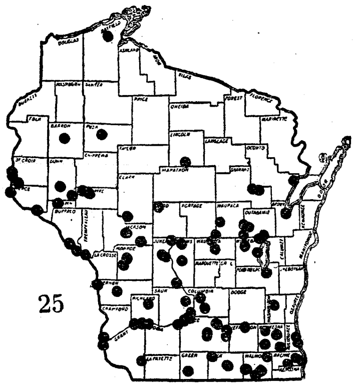
c. Fruit about as broad as high, its lobes obtusely angled .... *C. heterophylla.*

b. Fruit about 2 mm. broad .... *C. stagnalis.*

a. All leaves linear and 1-nerved, with none in floating rosettes; carpels separate nearly to the central axis; plants always aquatic .... *C. hermaphroditica.*

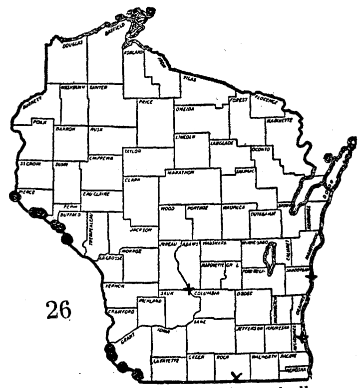
C. PALUSTRIS L. (Fig. 29). Common northward; apparently rare southward.

C. HETEROPHYLLA Pursh. (Fig. 30, cross). Collected in creek pools, Devils Lake, Sauk County, August 5 & 7, 1897,



25

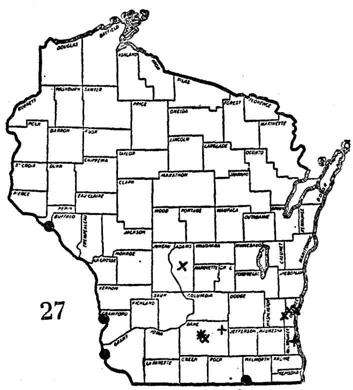
Euphorbia corollata



26

● Euphorbia heterophylla

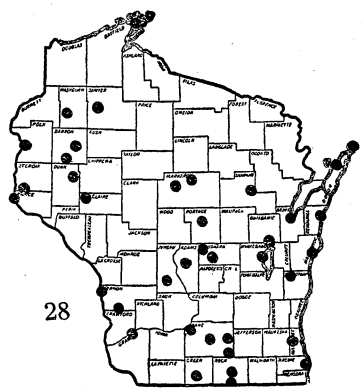
× Euphorbia commutata + Euphorbia Helioscopia



27

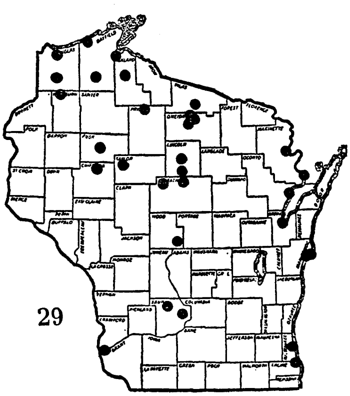
● Euphorbia dentata

+ Euphorbia Peplus × Euphorbia Esula



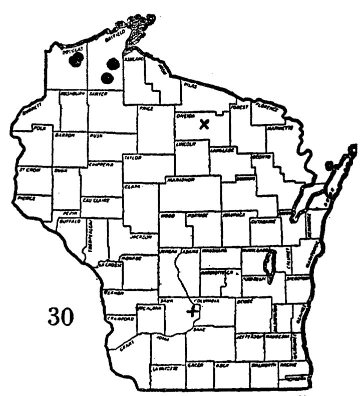
28

Euphorbia Cyparissias



29

Callitriche palustris



30

+ Callitriche heterophylla

● Callitriche hermaphroditica

× Callitriche stagnalis

L. M. Umbach. Not collected in the state since, although *C. palustris* has been more recently collected at Devils Lake.

C. HERMAPHRODITICA L. *C. autumnalis* L. (Fig. 30, dots). Not collected in Wisconsin until 1931, when Mr. John H. Steenis, working on a lake survey project with the Economic Land Survey, found it in two lakes in Douglas County, and in one in Bayfield County, and Mr. Neil Hotchkiss of the U. S. Biological Survey collected it in Bayfield County.

C. STAGNALIS Scop. (Fig. 30, x). This has only recently been reported from the United States[7] and Canada[8]; our sole collection has been identified by Dr. Svenson. It was collected in the swamp south of Rhinelander, Oneida County, August 25, 1925, *J. J. Davis.* This species is quite distinct from *C. palustris* and *C. heterophylla* in its large fruit, equalling in size that of *C. hermaphroditica.* That species, however, never has the floating rosettes of leaves usually characteristic of *C. stagnalis.* A more constant character is in the mature fruit; in *C. hermaphroditica* the carpels may be easily separated from one another with the point of a needle, with almost no tissue being broken, while in *C. stagnalis* they may be so separated only by tearing considerable connecting tissue.

[7] Svenson, Rhodora 34 : 37–39. 1932.
[8] Fernald, Rhodora 34 : 39. 1932.

PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. XXII. CORNACEAE—DOGWOOD FAMILY

A. A. DRESCHER

The following report is a survey of the species of Cornaceae as they are found throughout the state of Wisconsin. It is based on a study of the specimens in the herbaria of the University of Wisconsin, the Milwaukee Public Museum, Northland College, Lawrence College and of Mr. S. C. Wadmond. The writer was very fortunate in that the material in the Wisconsin herbarium had previously been checked by Mr. C. C. Deam of Indiana.

KEY TO THE SPECIES IN WISCONSIN

A. Flowers perfect, 4-parted; petals 2–5 mm. long; ovary two-celled

B. Plant herbaceous; rootstock nearly horizontal.

C. Leaves verticillate at summit of stem .... *C. canadensis*

C. Leaves borne in pairs at internodes below upper whorl .... *C. canadensis* f. *elongata*

B. Plants woody; shrubs erect, ranging from 1–5 meters in height.

D. Leaves alternate, grouped toward end of twig.....*C. alternifolia*

D. Leaves opposite.

E. Leaves broadly ovate, with 7–9 pairs of veins, the lower surface woolly pubescent; one-year old twigs usually blotched..*C. rugosa*

E. Leaves ovate, oblong-ovate or ovate-lanceolate, with generally 3–6 pairs of veins, the lower surface woolly or appressed pubescent; twigs not blotched.

F. Branchlets usually reddish-brown, pubescent toward the tip; pith brown; petals 5–6 mm. long .... *C. obliqua*

F. Branchlets glabrous; red or reddish-brown to gray; pith white or brown; petals 3–4 mm. long.

G. Branches red; pith white, usually more than one-third the diameter of the stem.

H. Lower surface of leaves appressed pubescent .... *C. stolonifera*

H. Lower surface of leaves woolly pubescent .... *C. stolonifera* var. *Baileyi*

G. Branches gray; pith usually brown, shading to tawny white, less than one-third diameter of stem .... *C. femina*

A. Flowers polygamous or dioecious; 5-parted; petals minute or none; ovary one-celled .... *Nyssa sylvatica*

1. CORNUS

C. CANADENSIS L. Low or Dwarf Cornel; Bunchberry. (Fig. 1). Abundant in northern portion of state, and following Lake Michigan. Less common throughout the central and southern portions of the state. It reaches its southern limit in Indiana and is abundant northward into Alaska. Common in swamps, along sandy shores or in damp woods; found occasionally on sand bluffs.

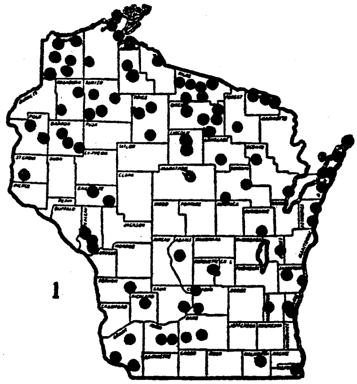
The form ELONGATA Peck, N. Y. State Mus. Bull. 150 : 44. 1911, differs from the typical form of the species in its having opposite leaves at the internodes in addition to the verticillate grouping at the summit. Both types may be borne on the same rootstock.

C. ALTERNIFOLIA L. f. Alternate-leaved Cornel. (Fig. 2). Commonly, though less abundantly, distributed throughout the state. Frequents a moist habitat, such as swamps and shaded river bluffs.

C. RUGOSA Lam. Encycl. 2 : 115, 1786. *C. circinata* L'Her. Cornus 7, pl. 3. 1788. (Fig. 3). Quite general throughout the state, frequenting low, moist situations. Southward it is found usually on dry sandstone bluffs.

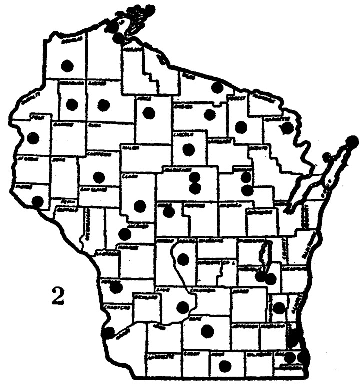
C. OBLIQUA Raf. Pale Dogwood. (Fig. 4). *C. Amomum* of Gray's Man., ed. 7, in part. Common throughout southern part of the state, as far as Marathon and Marinette counties which seem to form its northern limit in Wisconsin.

C. STOLONIFERA Michx. Fl. Bor. Am. 1 : 92. 1803. Red-Osier Dogwood. (Fig. 5). Of general distribution throughout the state; more common throughout the central portion than is indicated by the map. In contrast to var. *Baileyi, C. stolonifera* has a wide distribution throughout North America. Its range extends from Alaska into Newfoundland, south into Virginia and west into Arizona and California. Usually found in swampy or at least moist habitats. Collected in Dane county on dry sandstone bluffs and in Ashland county on dry soil.



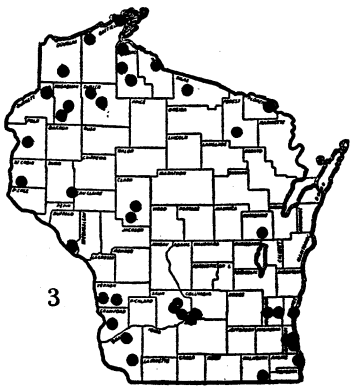
1

C. canadensis



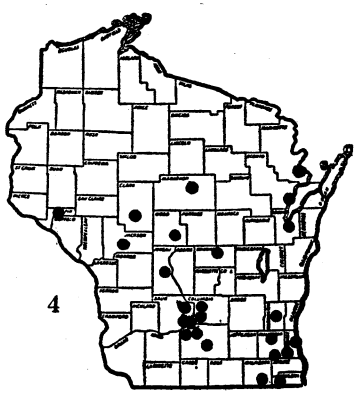
2

C. alternifolia



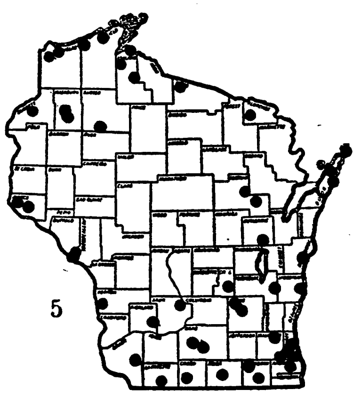
3

C. rugosa



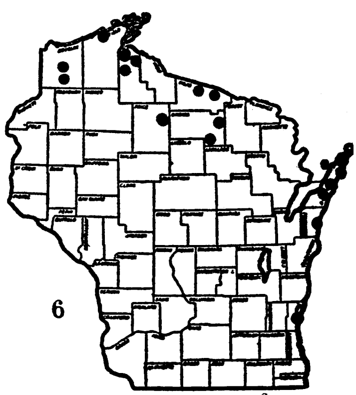
4

C. obliqua



5

C. stolonifera



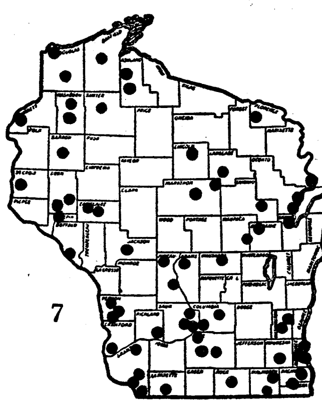
6

C. stolonifera
var. Baileyi

C. STOLONIFERA Michx. var. **Baileyi** n. comb. *C. Baileyi* Coulter and Evans. Bot. Gaz. 15 : 37. 7890. (Fig. 6). Var. *Baileyi* differs from the species only in its pubescence, which is woolly, and in its range which is about the Great Lakes and westward into Wyoming and Winnepeg. In Wisconsin it is limited to the northern and eastern portions of the state.

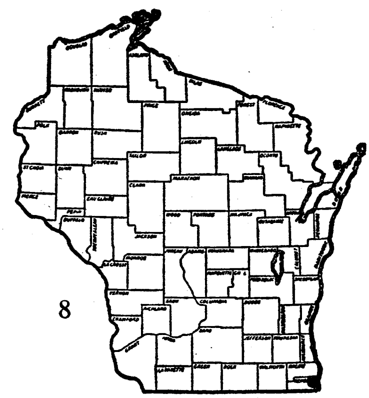
C. FEMINA Mill. Gard. Dict. Ed. 8, Number 4. 1768. *C. candidissima* Marsh, Arb. Am. 35. 1785, not Mill. 1768. *C. paniculata* L'Her. Cornus 9. pl. 15. 1788. Gray Dogwood. (Fig. 7). Common throughout the state. The habitat of this species is more variable than the other dogwoods. It is found both in wet, swampy regions (especially along the margin) and on rather dry road banks and clearings.

7



C. femina

8



Nyssa sylvatica

2. NYSSA

N. SYLVATICA. Marsh. Pepperidge, Sour Gum. (Fig. 8). A species distinctly southern in range, represented in Wisconsin by two trees located at Berryville in Kenosha county.[1]

The writer wishes to express his sincere appreciation to Dr. N. C. Fassett for his advice and criticism in the preparation of this paper and to Mr. C. C. Deam for his aid in the identification and keying of the species.

[1] Wadmond S. C. Flora of Racine and Kenosha counties. Trans. Wis. Acad. Vol. XVI Pt. II p. 857. 1909.

PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. XXIII. URTICACEAE

DAVID F. COSTELLO

This report is based on specimens in the herbaria of the Milwaukee Public Museum, the University of Wisconsin, Mr. S. C. Wadmond, and of the author; and on field data compiled by Mr. L. S. Cheney.[1] Ranges reported by Mr. Cheney are represented by small dots; additions to these ranges are indicated by crosses. Large dots or triangles indicate localities represented by herbarium specimens.

The writer acknowledges the friendly cooperation of Mr. Fuller and Mr. Smith, and of Mr. Wadmond. He is especially grateful to Dr. Norman C. Fassett who assisted in the identification of the nettles in the University Herbarium.

1. ULMUS—Elm

There are three native elms in Wisconsin: *U. fulva, U. americana* and *U. racemosa*. Labels on herbarium specimens indicate that these are frequently confounded. *U. fulva* is distinguished as follows: bud scales rusty pubescent; leaves usually scabrous on upper surface, folded on the midrib; flowers clustered, on very short pedicels; samara with rusty pubescence over the seed. *U. americana* is characterized by leaves very unsymmetrical, long acuminate, with 14 to 17 pairs of conspicuous veins; flowers in umbellate clusters, pedicels long and drooping; samara ciliate on the margins. A form with rough leaves and pubescent twigs is frequently collected in swamps. *U. racemosa* may be distinguished as follows: leaves nearly symmetrical, abruptly acuminate, soft pubescent below, 17 to 21 pairs of conspicuous veins; flowers in racemose clusters; twigs frequently corky ridged; samara white pubescent on both faces.

1. U. FULVA Michx. Slippery or Red Elm (Fig. 1). Common in rich soil along streams, or on rocky slopes or hillsides. Widely distributed throughout the southern two thirds of the state.

[1] See previous reports in this series.

2. U. AMERICANA L. American or White Elm. Occurs in every county in the state and is widely planted as a shade tree. Adaptable to almost any type of soil. The habit of this elm varies considerably. "Vase forms," "plume forms," "weeping-willow forms," and "feathery forms," have been distinguished.

3. U. RACEMOSA Thomas. *U. Thomasii* Sarg. Cork or Rock Elm (Fig. 2). Cheney states that this elm grows on "low, heavy clay soil, rocky slopes, rather high river banks or even dry gravelly uplands" in company with "hard maple, basswood, white elm, white oak and bur oak." It occurs in considerable abundance in three separate areas, as is indicated by the map. In other regions of the state it ranges from abundant to rare.

[*U. pumila* L. and *U. campestris* L. are planted to some extent in cities. The latter occasionally escapes.]

2. CELTIS—Hackberry

C. OCCIDENTALIS L. Hackberry or Sugarberry (Fig. 3). Confined to river banks and bottom lands in the southern two thirds of the state. Occasionally found about the shores of lakes. The range of this tree almost coincides with that of *Quercus bicolor* Willd. in Wisconsin.[2]

C. OCCIDENTALIS var. CRASSIFOLIA (Lam.) Gray. *C. crassifolia* Lam. (Fig. 3, triangles). Occurs with the species. Cheney does not distinguish this variety in his notes. Rosendahl and Butters[3] state that in Minnesota this variety is "apparently far more common than typical *C. occidentalis.*"

3. CANNABIS—Hemp

C. SATIVA L. (Fig. 4). An introduced species common on waste ground. Probably more common than is indicated by the map.

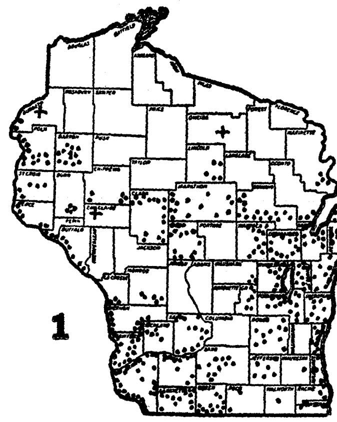
4. HUMULUS—Hop

The majority of plants from Wisconsin correspond closely to *H. americanus* Nutt. as treated by Bailey (Man. Cult. Pl, p. 240. 1924) and by Peattie (Fl. Indiana Dunes, 1930), and are here separated according to these keys. *H. americanus* is doubtfully a distinct species.

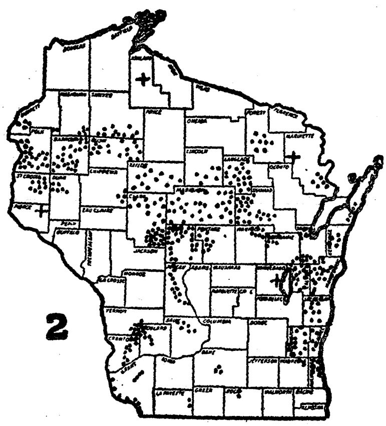
---

[2] See Trans. Wis. Acad. 26 : 277, fig. 4. 1931 .

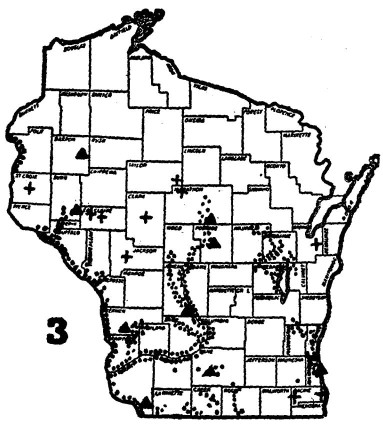
[3] Trees and Shrubs of Minnesota, page 124. 1928.



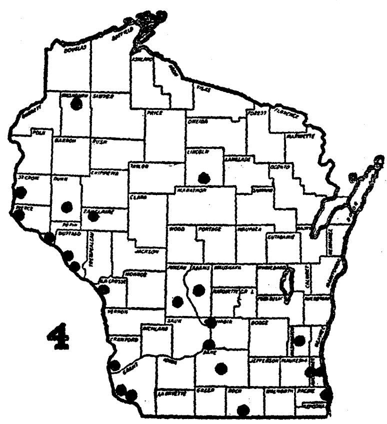
Ulmus fulva



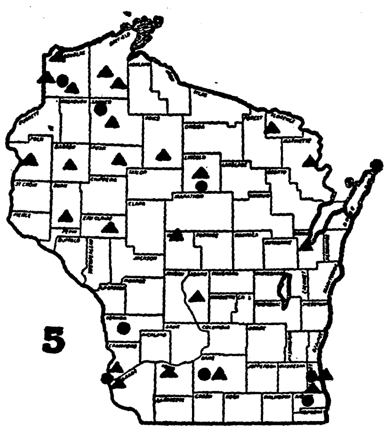
Ulmus racemosa



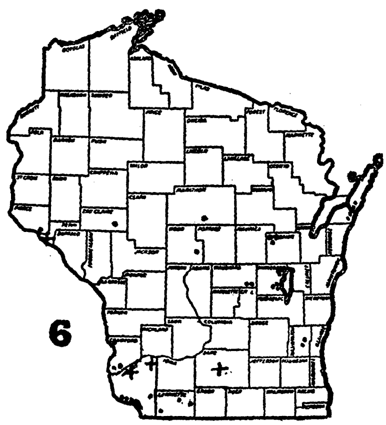
⁘ Celtis occidentalis
▲ C. occidentalis var. crassifolia



Cannabis sativa



● Humulus Lupulus
▲ H. americanus



Morus rubra

1. H. LUPULUS L. Common Hop or European Hop (Fig. 5). An introduced species. Apparently widely distributed.

2. H. AMERICANUS Nutt. American Hop (Fig. 5, triangles). Generally distributed throughout the state. Common in thickets and waste places.

3. H. JAPONICUS Sieb. & Zucc. Frequently collected as an escape from cultivation.

5. MACLURA—Osage Orange

M. POMIFERA (Raf.) Schneider. Has been collected at Livingston, Grant Co., where it was planted.

6. MORUS—Mulberry

1. M. RUBRA L. Red Mulberry (Fig. 6). Found in the southern half of the state on rich moist soil along streams and at the foot of rocky bluffs. It is nowhere abundant. Occasionally planted for its fruit.

2. M. ALBA L. White Mulberry. Sometimes collected as an escape from cultivation.

7. URTICA—Nettle

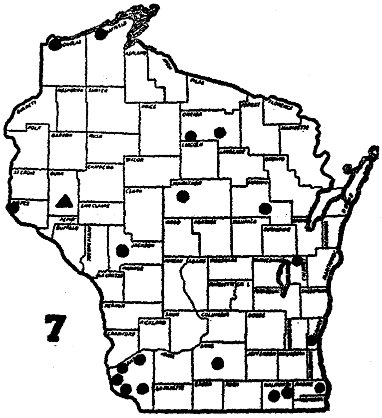
Until recently the identity of our two common nettles has not been clear. It should be noted that *U. Lyallii* Wats., which formerly passed as *U. gracilis* Ait., properly belongs to the north Pacific slope. The following key will serve to distinguish our native species:

a. Stem glabrous or sparingly pilose above; leaves lanceolate to ovate, rounded or cordate at base, middle leaves with 13–23 pairs of teeth; stipules straw-colored, glabrous to pilose .... *U. gracilis*

a. Stem slightly bristly, pilose or puberulent above; leaves usually narrowly ovate lanceolate, middle leaves with 19–35 pairs of teeth; stipules cinereous-puberulent .... *U. procera*

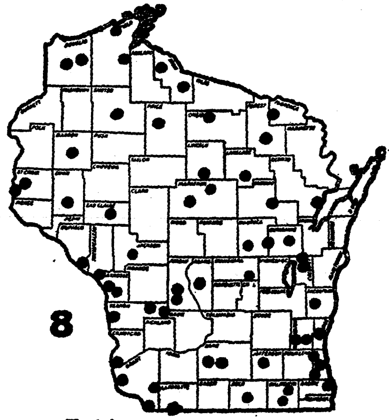
1. U. GRACILIS Ait.[4] *U. Lyallii* of Am. authors, not Wats.; Gray's Manual, ed. 7 (Fig. 7). In moist places throughout the state.

[4] See Rhodora 28 : 191–199. 1926.



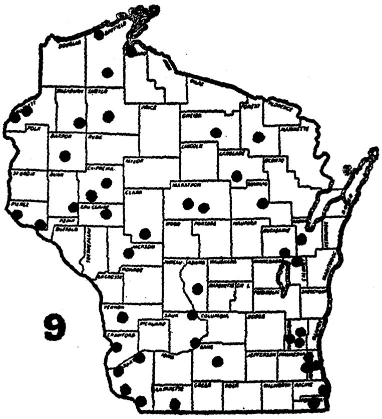
7

● Urtica gracilis
▲ U. dioica



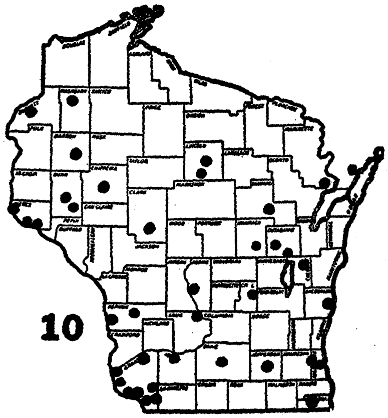
8

Urtica procera



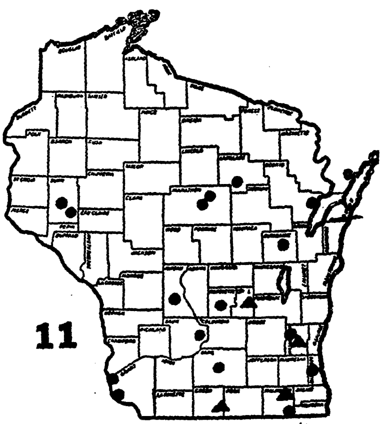
9

Laportea canadensis



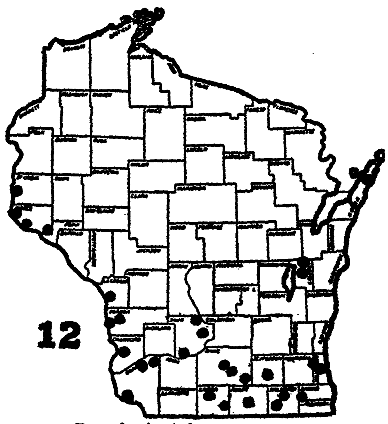
10

Pilea pumila



11

● Boehmeria cylindrica
▲ B. cylindrica var. scabra



12

Parietaria
pennsylvanica

2. U. PROCERA Muhl.[5] *U. gracilis* of most Am. authors; Gray's Manual, ed. 7; not Ait.; (Fig. 8). Common alongside roadsides, in pastures, and moist places throughout the state.

3. U. DIOICA L. Stinging Nettle (Fig. 7, triangle). Represented by a single specimen in the University Herbarium, collected at Menomonie, Dunn Co.

8. LAPORTEA—Wood Nettle

L. CANADENSIS (L.) Gaud. (Fig. 9). Common in rich moist woods.

9. PILEA—Clearweed

P. PUMILA (L.) Gray. Including *P. opaca* (Lunell) Rydb.[6] (Fig. 10). In rich, damp, shaded places north to Marinette, Lincoln, and Washburn counties.

10. BOEHMERIA—False Nettle

B. CYLINDRICA (L.) Sw. (Fig. 11). In wet thickets and shady places north to Oconto, Langlade and Dunn counties. Apparently grades into the following variety.

B. CYLINDRICA var. SCABRA Porter. *B. Drummondiana* Wedd. (Fig. 11, triangles). Southeastern portion of the state; rare.

11. PARIETARIA—Pellitory

P. PENNSYLVANICA Muhl. (Fig. 12). Abundant in moist shaded woods, following closely the areas of limestone.

---

[5] Rhodora, *l. c.*

[6] See Rydberg, Flora of the Prairies and Plains of Central North America, page 273. 1932.

THE QUERCUS ELLIPSOIDALIS–QUERCUS COCCINEA COMPLEX.

S. C. WADMOND

Early settlers coming into Wisconsin terrritory noticed an oak which was tardy in the natural pruning of its lower branches, and they observed that when the branches did break off it was usually at some distance from the trunk, leaving many persistent stumps penetrating to the center of the tree. They remembered an oak from their old homes which did this very thing, and which was there called the Pin Oak. Naturally they called this Wisconsin oak likewise—the Pin Oak—and botanists, apparently, fell into the same error.

The first edition of Gray's Manual (1848) listed *Quercus palustris*, the Swamp Spanish or Pin Oak, as ranging from "South New York to Wisconsin," its occurrence in Wisconsin being validated by Dr. Increase A. Lapham, who had settled in Milwaukee in 1836 and immediately began his work on our flora. This error was perpetuated through four editions of Gray's Manual, and it was not until the 5th edition (1868) that *Q. palustris* was not ranged but simply listed as "In low grounds; rather common." In the 6th edition (1889) it was again ranged this time "From Mass. to Del. and Md., west to Minn., E. Kan., and Ark." which was again erroneous, since this oak is absent from Minnesota as it is from Wisconsin. Gray's 7th edition (1908) finally relegated it to "Mass. to Va., west to Kan. and Ark." Britton & Brown's Illustrated Flora (1896) continued the 60-year-old error by listing it from "Mass. to Wis., Del., and Ark."

Long before the manuals had gotten right on the distribution of *Q. palustris,* it had been discovered that while the Wisconsin tree had the same habit of tardy pruning as the true *Q. palustris,* resulting in persistent dead lateral branches, its acorn was quite different, and that the true *Q. palustris* was absent from Wisconsin. Where, then, should this puzzling oak be allocated? What was this species which persisted for so many years masquerading under the title of *Q. palustris?*

There seemed nothing else to do but to refer it to *Q. coccinea,* the Scarlet Oak, and there it remained for many years. As early as 1870, however, Dr. George Vasey, then a resident of northern Illinois, but editorially connected with the American Entomologist and Botanist, puzzling over this complex, had attempted to divide *Q. coccinea* as he understood it, and one of the forms, his var. *microcarpa* is unmistakably figured (Amer. Entomol. & Bot. 1 : 344-5 f. 213). Wisconsin botanists were also puzzling over an oak with elliptical elongated acorns, quite unlike those described for *Q. coccinea,* but they had no other alternative than to class it as that species, and accordingly both the elliptical and the globose-acorned forms of this tardily pruning oak were grudgingly lumped into *Q. coccinea.*

In 1899, however, Rev. E. J. Hill of Englewood, Ill., an amateur botanist, settled the identity of the elliptical-acorned tree for us by publishing *Q. ellipsoidalis.* (Bot. Gaz. 27 : 204, pl. 2-3), so named because of the elongated acorn. I have in my files a yellowing letter from Mr. Hill in which he naively goes on to say, "It was the difficulty of placing this oak either with *Q. coccinea* or *Q. velutina* that led me to separate it." Mr. Hill made no reference to Dr. Vasey's treatment, published a generation earlier, of this ambiguous oak, nor did he note that Vasey's *Q. coccinea microcarpa* well pictures his own *Q. ellipsoidalis.*

But the ghost was not yet laid. What was to be done with the tree which exactly matched the elliptical-acorned one but with semi-globose acorns? Mr. Hill agreed that the Wisconsin elliptical-acorned tree was a genuine *Q. ellipsoidalis,* but assigned our semi-globose-acorned material to *Q. coccinea.* The good dominie did not quite know the extremes of his own protean-acorned oak, nor did we of Wisconsin. Accordingly it was agreed that both *Q. ellipsoidalis* and *Q. coccinea* were present in Wisconsin, although we were constantly finding intergrading forms which we would put first into one and then into the other. Gray's Manual in its 5th, 6th and 7th editions ranged *Q. coccinea* "West to Minn." which of course would take in our own State.

Eventually, as this group was given more critical study, it became apparent that *Q. coccinea* did not occur in Wisconsin at all, and that the elliptical and globose-acorned trees were extreme forms of the same species, *Q. ellipsoidalis.*

In 1919, Prof. William Trelease, then of the University of Illinois, published "The Jack Oak" (Trans. Ill. Acad. Sci., vol. 12, pl. 139-143). He described and figured typical *Q. ellipsoidalis* and five forms; four of them, *incurva, intermedia, depressa* and *coronata,* depending upon acorn characters. He also included a sketch map showing the distribution of *Q. ellipsoidalis* as then known. He confessed that he found it impossible to recognize *Q. coccinea* in the region in which *Q. ellipsoidalis* occurs.

Most Wisconsin botanists had independently reached the same conclusion. In "Wisconsin Trees" 1927, published by the Milwaukee Journal but largely the work of the botanical department of the Milwaukee Public Museum, p. 55, there is this paragraph which sounds as though written by Curator Huron H. Smith,—"Hill's oak, the latest species to be named in the oak family, passed for many years as the pin oak or the scarlet oak. It was first identified as a different species by the Reverend Elkanah J. Hill, an amateur botanist living in Chicago, who found it growing on the DesPlaines river near Riverside, Ill. As a result of this man's work, we realize that the scarlet oak has never grown in Wisconsin and we know that we have countless representatives of Hill's oak."

In Preliminary Reports on the Flora of Wisconsin XIII. Fagaceae (Trans. Wis. Acad. of Sci., Arts & Letters XXVI : 277-279, 1931) Prof. David F. Costello includes a distributional map of this species, adding that Mr. L. S. Cheney, formerly of the Department of Botany of the University of Wisconsin, now of Barron, Wis., who traveled in the years 1897 and 1898 throughout the state, noting on maps the trees of each region, called this tree *Q. coccinea,* but that there is no doubt but that he described what is now known as *Q. ellipsoidalis,* and that the scarlet oak, *Q. coccinea,* is not known to occur in Wisconsin.

Similar confusion appears to have existed in neighboring states. In "Fagaceae of Iowa," by T. J. and M. P. L. Fitzpatrick (Iowa Acad. of Sci., Vol. VIII, 1901, p. 18) the authors note that *Q. ellipsoidalis* is represented in Iowa by one tree growing near Big Rock, Scott Co. On p. 16 of the same publication they report *Q. coccinea* as widely distributed throughout the state. Prof. Shimek, Curator of the Herbarium, State University of Iowa, writes me that many of the earlier reports from Iowa of *Q. coccinea* were *Q. velutina* (the old *Q. coccinea* var. *tinctoria).*

He is certain that in some cases the varietal name was dropped and the species reported as *Q. coccinea.* In most cases, however, he adds, especially from the northern part of the state, *Q. ellipsoidalis* was reported as *Q. coccinea.* He notes that *Q. ellipsoidalis* is now found to be rather extensively distributed throughout Iowa, but so far no true *Q. coccinea* has been found.

In Michigan the two species have likewise been confounded: Mr. O. A. Farwell in the American Midland Naturalist, March 1928 (Vol. XI No. 2, pg. 81) lists *Q. coccinea* from three counties in Michigan, and adds, "Well distributed over the Peninsula." *Q. ellipsoidalis* is reported from two counties. In the same publication for July 1930 (Vol. XII No. 4, p. 120) Mr. Farwell writes that all the collections listed as *Q. coccinea* are not that species but a variety of *Q. ellipsoidalis* which he separates as a new variety *coccinoides.* Mr. Farwell writes me that he has never seen *Q. coccinea* in Michigan or any material of it from Mich. It is interesting to note, in passing, that his variety *coccinoides* very closely matches in acorn characters collections from Racine County, Wisconsin.

In Indiana, Research Forester Deam writes that he has milled over this complex for a long time without getting correctly oriented. In his Trees of Indiana, ed. 4, p. 141, he maps *Q. coccinea* from five counties in the extreme northwesterly corner of the state. My guess would be that the report of *Q. coccinea* from these northwesterly counties is erroneous; that later research will find them to be *Q. ellipsoidalis* instead, with *Q. coccinea* confined to the southern third of the state.

In Minnesota Drs. Rosendahl and Butters, in "Trees and Shrubs of Minnesota," p. 108, say of *Q. coccinea:* "Less common than the following species [*Q. ellipsoidalis*] with which it has been much confused." Here again my guess is that the tree which they report as *Q. coccinea* will be found to be a form of *Q. ellipsoidalis* and that *Q. coccinea* is absent from Minnesota entirely. My guess is made almost certainty on receiving word from Dr. Ernest J. Palmer of the Arnold Arboretum that one Minnesota collection by Butters & Rosendahl in the Aboretum herbarium labeled *Q. coccinea* has it noted that the autumn leaves are a brilliant red, although it seems to be *Q. ellipsoidalis.*

I might add that Forest Trees of Wisconsin by F. G. Wilson, Forester, published by State Conservation Commission 1928, lists both *Q. coccinea* and *Q. ellipsoidalis,* mentioning the former as "distributed over southern Wisconsin." I am assured by the gentleman, however, that future editions of this publication will omit *Q. coccinea,* since he is now convinced that it is absent from the state.

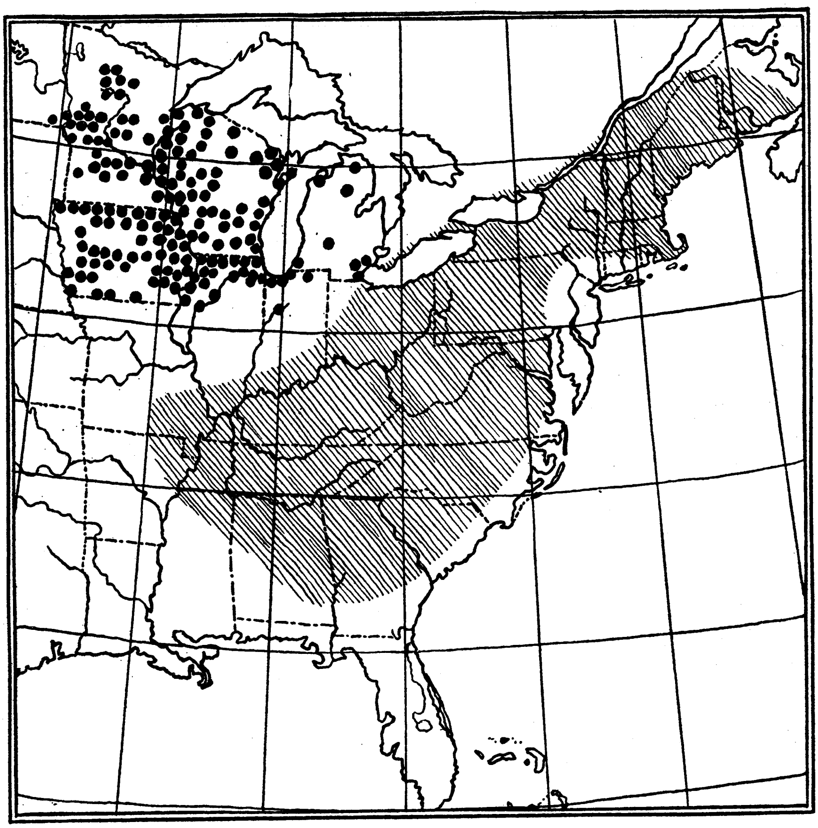


FIG. 1. Map showing the distribution of *Q. ellipsoidalis* (dots) and *Q. coccinea* (shaded area) in the United States.

DISTRIBUTION

In Fig. 1 I have indicated what appears to be the range of *Q. ellipsoidalis* and *Q. coccinea* as now known. The dots show definite localities from which *Q. ellipsoidalis* has been reported, while the shaded area indicates the approximate range of *Q. coccinea* as here understood. It is evident from the map that *Q. coccinea* is more eastern and much more extensive in its range than *Q. ellipsoidalis* which is confined to a comparatively limited area in the north central states. I have not been able to discover that the two species overlap at any point; if they do, it will probably be found to occur somewhere in northwestern Ohio.

Q. ellipsoidalis appears in its western range to cease only where the forests merge gradually into the prairies through a region of prairie groves and savannahs. Dr. Trelease (l. c.) concludes that the peculiar and abrupt ending of the range of the Jack Oak in Illinois may be due primarily to its intolerance of the iron, sulphur, magnesium, etc., with which the rocks of the coal country are charged. So far I have been unable to connect its distribution with evident barriers (except on its western borders), drainage systems, soil belts or glacier limits.

Professor Shimek writes me as follows of its occurrence in Iowa: "As far as its relation to the coal country, there is none noticeable. It is a common species on the borders of prairie groves, especially northward, but this is in no way related to the Carboniferous. The species is less common southward, it is true (this being in the Carboniferous territory in part) but this seems to be due rather to the fact that it has sharper competition with other trees, of which there are many more southward. The species does not stop abruptly at the coal areas. It stops abruptly locally where the forest runs out. It shares with *Q. macrocarpa* the place of a border species, being more common northeastward, while *Q. macrocarpa* extends farther west, being perhaps the more xerophytic of the two species. It rarely occurs in deeper woods."

Rosendahl & Butters (l. c.) find it "rare in the groves of the prairie districts."

Occasionally I find *Q. ellipsoidalis* an inhabitant of the flood plain, but it is essentially an upland species, preferring the sandy gravelly morainic hills so common in our area where it and the hickories seem to possess the land practically unchallenged.

Distinction between Q. ellipsodalis and Q. coccinea.

Dr. Palmer of the Arnold Arboretum writes that he was considerably puzzled by trees which he saw at the Morton Arboretum (Du Page County, Illinois, 25 miles west of Chicago) growing in native woods, since some of the trees there were turning a brilliant red in the autumn while most of them were yellow or orange, although he decided that all of them should be referred to *Q. ellipsoidalis*. He also reports a Minnesota collection previously mentioned on which is noted that the autumn leaves are a brilliant red, although the species appears to be *Q. ellipsoidalis*. It seems quite certain that while the autumn coloration in these two species is ordinarily a distinguishing feature, there is occasional variation in individual trees which has confused many observers and made them think they had found the scarlet oak where it really does not occur.

I have seen freshly gathered material of *Q. coccinea*, from the tree at the Arnold Arboretum so labeled, as well as from the State Forest Reserve of Indiana, and from southeastern Ohio, and it seems to me there should be no confusion between these two species when the freshly gathered acorns and winter buds are at hand. In *Q. coccinea* the buds are rather large, 3-5 mm. long, 1.5-3 mm. wide; in *Q. ellipsoidalis*, rather small, 1-3 mm. long, .75-1.5 mm. wide. In *Q. coccinea* the acorn may be designated as oval or oblong-ovoid with a pronounced shoulder, of a light reddish brown color and dull. In *Q. ellipsoidalis* the acorn varies from the typical ellipsoid form to semi-globose, but always gradually tapering to the point; acorns shiny as though freshly varnished, medium to dark brown, and very frequently striped with darker lines.

The cup scales are strikingly dissimilar; in *Q. coccinea* they are deltoid-lanceolate, acute, yellow with reddish brown edges and not closely appressed; in *Q. ellipsoidalis* they are light brown, homochromous, ovate, obtuse, or truncate, and very closely appressed. I feel that the confusion existing between the two species is largely an inherited one rather than because of the fact that *Q. ellipsoidalis* is not markedly distinct from its congeners.

I should like to express my appreciation to Dr. E. J. Palmer of the Arnold Arboretum, Dr. J. H. Ehlers, University of Michigan, Research Forester Deam of Indiana, Mr. O. A. Farwell, Botanist of Parke, Davis & Co., and Professors Shimek and Rosendahl for information on county records and other helpful data. It has been a real pleasure to correspond with these fine helpful gentlemen.

DELAVAN, WIS.

THE TRANSPARENCY, THE COLOR AND THE SPECIFIC CONDUCTANCE OF THE LAKE WATERS OF NORTHEASTERN WISCONSIN

C. JUDAY AND E. A. BIRGE

Notes from the Limnological Laboratory of the Wisconsin Geological and Natural History Survey. No. 52.*

INTRODUCTION

A general survey of 530 different lakes and lakelets situated in the Highland Lake District of northeastern Wisconsin was made between the years 1925 and 1931, inclusive. In these studies a complete set of field determinations comprised 19 different physical, chemical and biological items. The results obtained in some of these determinations have been presented in previous reports. A general account of the phosphorus content of these lake waters was published in 1931 and a similar report on the dissolved oxygen and oxygen consumed appeared in 1932. The present report deals with the data obtained in three other items included in these determinations, namely the transparency, the color and the specific conductance of these lake waters.

I. TRANSPARENCY

The transparency of the water was determined by means of a white disc 10 cm. in diameter. The standard size of discs usually used for such determinations is 20 cm. in diameter, but the smaller size is more convenient, especially when it is employed in connection with a considerable amount of apparatus required for other phases of limnological work. In a series of experiments the readings obtained with the 10 cm. disc were within 5 per cent of those that were taken with discs having a diameter of 25, 50 and 75 cm. respectively; the readings obtained with the 25 cm. disc were substantially the same as those taken with the 50 cm. and 75 cm. discs, so that there is no ad-

*This investigation was made in cooperation with the U. S. Bureau of Fisheries and the results are published with the permission of the Commissioner of Fisheries.

vantage in increasing the diameter beyond 20 to 25 cm. Since this method gives only a rough determination of the transparency of the water, it was thought best to use the smaller and more convenient size of disc. The results indicated in the tables are stated in terms of the 10 cm. disc and they can be readily changed to those of the 20 cm. disc by adding 5 per cent to them.

The transparency of a lake is affected both by the turbidity and by the color of the water. The turbidity of the water is dependent upon the particles held in suspension; this suspended material consists of silt and organic débris on the one hand and of microscopic living organisms on the other. No attempt has been made to determine the turbidity of these lake waters, but it is very low in some cases where the lakes have neither an inlet nor an outlet; the shores of some of these seepage lakes consist of clean sand which filters the greater part of the silt out of the water that enters them from the land. The living organisms and organic débris constitute the centrifuge plankton and the scarcity or abundance of this material has an important bearing on the transparency of the water; the centrifuge plankton is present only in relatively small amounts in some of these seepage lakes and this scarcity of plankton, together with a comparatively small amount of silt, gives such bodies of water a low degree of turbidity.

The brown color produced by the vegetable extractives derived from bogs or marshes has a very marked effect upon the transparency of the water; this is true especially when these brown colored waters give readings as high as 80 or more on the platinum-cobalt scale. These stains cut off very rapidly the solar energy which penetrates the water, so that the more deeply stained waters have a low degree of transparency even if there is very little turbidity.

Transparency readings were taken on 470 lakes of which 201 have neither an inlet nor an outlet and 269 are listed as having outlets. The former have been designated as seepage lakes and the latter as drainage lakes. A total of 879 disc readings was taken during the investigation and 283 of them represent only a single observation on a lake. The other 596 disc readings include from 2 to 22 observations on each of the various lakes that were visited more than once. The largest number obtained from a single lake (22) was taken on Trout Lake, while Crystal and

TABLE I

Distribution of the various lakes on which transparency readings were taken. The number of seepage and drainage lakes in the different groups is indicated also. See Fig. 1.

Transparency group	Number of lakes		
	Total	Seepage	Drainage
0.3–0.9	37	3	34
1.0–1.4	68	7	61
1.5–1.9	66	14	52
2.0–2.4	65	23	42
2.5–2.9	44	21	23
3.0–3.4	46	30	16
3.5–3.9	27	14	13
4.0–4.4	39	26	13
4.5–4.9	23	16	7
5.0–5.4	22	18	4
5.5–5.9	8	6	2
6.0–6.4	11	9	2
6.5–6.9	6	6	0
7.0–7.4	4	4	0
8.0–8.4	2	2	0
9.0–9.4	2	2	0

Weber lakes, with 11 each, were second in rank and Silver Lake was third with 10 disc readings. Only two or three readings were made on most of the other lakes included in this group.

The separation of the 470 lakes into groups on the basis of the transparency of their waters is indicated in Table I and the results are shown graphically in Figure 1. The unshaded portions of the columns representing the different groups indicate the seepage lakes and the shaded portions the drainage lakes. Where two or more disc readings were obtained on a single lake, the mean of the different determinations was used in assigning the lake to its respective group. Both the table and the diagram show that the great majority of the lakes with low transparency—those in which the disc readings do not exceed 2.4 m.—belong to the drainage type. The four groups with these low transparencies include 236 lakes, or half of the total number on which disc readings have been taken; of this number only 47 are seepage lakes, or 20 per cent of the number in these four groups. This tendency of the waters of the drainage lakes to have a lower transparency than those of the seepage lakes is due partly to the silt and colored water brought into them by affluents and partly to the somewhat larger crop of plankton which they usually contain.

Approximately half of the lakes in the 2.5–2.9 m. transparency group are seepage lakes, that is, 21 seepage to 23 drainage lakes; while the groups with disc readings of 3 m. or more are made up chiefly of seepage lakes. All of the lakes having a transparency of 6.5 m. or more belong to the seepage type.

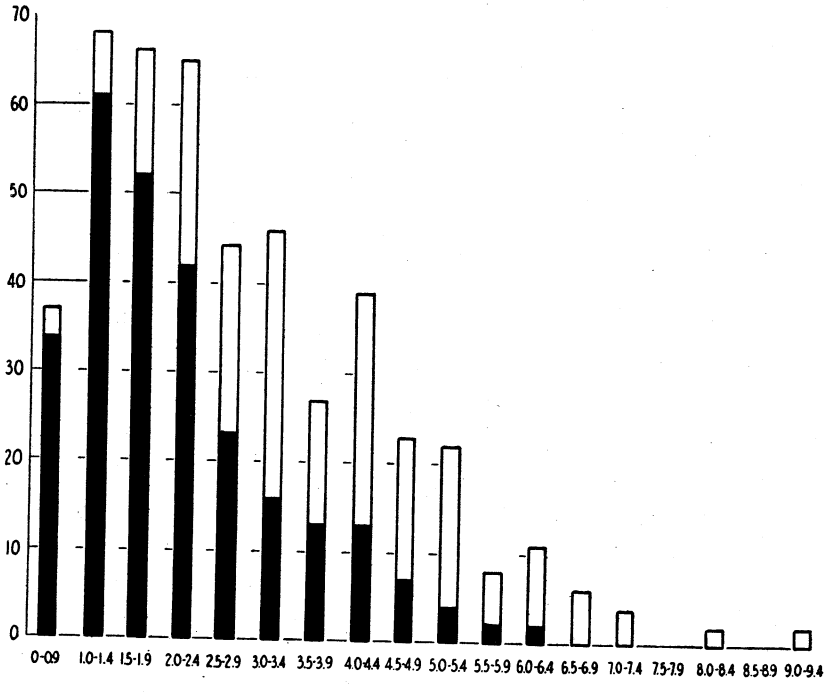


FIG. 1. This diagram shows the grouping of 470 lakes on the basis of the disc readings. The vertical spaces represent the number of lakes in the various groups. The unshaded part of each column shows the number of seepage lakes and the solid black part the number of drainage lakes in each group. The diagram includes 201 seepage and 269 drainage lakes.

Crystal Lake gave the maximum disc reading, namely 13.6 m. on June 26, 1928; another reading of 13 m. was obtained on this lake on August 19, 1931. This is a seepage lake whose water is unusually free from silt and plankton, so that the water is clear and transparent. It is so transparent, in fact, that from 1 per cent to 4 per cent of the solar energy that is delivered to the surface of the lake penetrates to a depth of 18 m., which is within 3 m. of the maximum depth of the lake. In 12 observations on Crystal Lake the disc readings varied from a minimum of 6 m. on May 9, 1926, to a maximum of 13.6; only one reading was less than 7 m. and the mean of the 11 observations is 9.4 m.

Transparencies of 7 m. or more were observed on 18 lakes and 44 readings of this amount were obtained. Eleven of these readings were taken on Crystal Lake, 9 on Weber Lake and 3 each on Diamond, Island and Pauto lakes, with only one or two on each of the other 13 lakes. As previously noted the largest readings were found on Crystal Lake; Pauto Lake was second with a maximum reading of 10.8 m. and Weber Lake was third with 10.3 m. In these 44 readings, there were 27 which amounted to 8 m. or more. These lakes have very little brown stain in their waters or none at all. The maximum color reading obtained on any of them was 16 on the platinum-cobalt scale. In 15 of them none of the color determinations exceeded 9 and no color whatever could be detected in most of the samples from these lakes. The majority of the 18 lakes also yielded relatively small amounts of plankton. The quantity of organic matter in the centrifuge plankton from them varied from 0.27 mg. to 1.33 mg. per liter of water. Catches in excess of 1 mg. were noted in only 5 of the 18 lakes.

TABLE II

Results of transparency determinations on 14 American lakes.

Lake	Disc reading in meters
Tahoe, California	33.0
Crater, Oregon	27.0
Fallen Leaf, California	17.0
Chelan, Washington	14.2
Priest, Idaho	13.0
Skaneateles, New York	10.8
Seneca, New York	8.3
Cayuga, New York	6.2
Crystal, Wisconsin	13.6
Pauto, Wisconsin	10.8
Weber, Wisconsin	10.3
Diamond, Wisconsin	9.0
Little Bass, Wisconsin	8.4
Anderson, Wisconsin	8.0

The maximum transparency of Crystal, Pauto and Weber lakes compares favorably with that of some of the more transparent American lakes, while much larger disc readings have been obtained in others; for purposes of comparison the results for 14 lakes are given in Table II. Tahoe, Crater and Fallen Leaf lakes have a much greater transparency than the Wisconsin lakes; the disc reading on Lake Chelan is only a little larger than the maximum of Crystal Lake, while the readings on Priest Lake and 3 of the Finger lakes of New York fall within the range of those obtained on the 6 Wisconsin lakes included in the table. All of these Wisconsin lakes are much smaller and shallower than the other lakes represented in this table, so that their volumes are much smaller than those of the other lakes; thus their waters are more readily affected by factors that change the transparency. On the other hand, these 6 lakes belong to the seepage class so that they receive very little drainage water from the surrounding land and their waters contain a relatively small amount of plankton.

In the group of lakes with a low degree of transparency, 37 gave readings amounting to less than 1 m.; these lakes are represented in the first column of Figure 1. A minimum of 0.3 m. was noted in Brazell or Allen Lake on July 8, 1928, and another reading of 0.4 m. was obtained in this lake on July 29, 1930. This low degree of transparency was due partly to the color of the water and partly to the presence of a large crop of plankton. The color of the water was 314 on the platinum-cobalt scale on the first date and 240 on the second; on July 8, 1928 the organic matter in the centrifuge plankton amounted to 6.4 mg/l. No plankton catch was taken in 1930. Disc readings of 0.5 m. were obtained on 4 lakes of this group, 0.6 m. on 7 and 0.7 m. on 2, so that the results on 14 of these 37 lakes did not exceed 0.7 m. In 17 of the other members of this group the readings were 0.8 m., thus leaving only 6 lakes with readings of 0.9 m. The mean transparency of the 37 lakes is 0.73 m. (Table III).

The brown color of the water in this group of 37 lakes ranged from 28 to 340 on the platinum-cobalt scale. Color readings of 200 or more were noted on 9 lakes and 12 fell between 100 and 200; the remaining 16 lakes gave readings below 100, but 5 of them were between 90 and 98. The mean color for the group is 138. The organic matter in the centrifuge plankton of these 37

TABLE III

Means of disc readings, color readings and the quantity of plankton obtained in the different groups of lakes represented in Figure 1, together with the standard deviations and the probable errors. The disc readings are indicated in meters, the color in terms of the platinum-cobalt standard and the plankton results in milligrams of dry organic matter per liter of water in the centrifuge catches.

Range of disc readings	No. of lakes	Mean of disc readings	Standard deviations of disc readings	Probable error of average	Probable error of standard deviation	Mean of color readings	Standard deviations of color readings	Probable error of average	Probable error of standard deviation	Mean quantity of plankton	Standard deviations of plankton	Probable error of average	Probable error of standard deviation
0.0—0.9	37	0.73	0.141	0.016	0.011	138.0	76.330	8.50	5.98	2.80	1.631	0.181	0.128
1.0—1.4	68	1.16	0.142	0.012	0.008	100.5	45.830	3.70	2.65	1.95	1.028	0.084	0.059
1.5—1.9	66	1.67	0.150—	0.012	0.009	60.0	32.360	2.70	1.90	1.60	0.649	0.054	0.038
2.0—2.4	65	2.16	0.150	0.013	0.009	35.0	24.600	2.10	1.46	1.30	0.473	0.040	0.028
2.5—2.9	44	2.65±	0.166	0.017	0.012	30.0	18.390	1.90	1.32	1.19	0.440	0.045—	0.032
3.0—3.4	46	3.12	0.132	0.013	0.009	17.0	9.940	1.00	0.70	1.06	0.365—	0.036	0.026
3.5—3.9	27	3.63	0.167	0.022	0.015+	16.0	10.040	1.30	0.92	1.04	0.332	0.043	0.030
4.0—4.4	40	4.13	0.138	0.015	0.010	8.8	6.149	0.66	0.46	0.86	0.208	0.022	0.016
4.5—4.9	21	4.68	0.137	0.020	0.014	8.2	6.436	0.95—	0.67	0.76	0.226	0.033	0.024
5.0—5.4	25	5.14	0.165—	0.022	0.016	7.2	6.607	0.89	0.63	0.70	0.189	0.025+	0.018
5.5—7.4	27	6.25+	0.512	0.066	0.047	5.7	4.869	0.63	0.45—	0.63	0.144	0.019	0.013
7.5—9.4	4	8.70	0.700	0.240	0.167	0.0	0.000	0.00	0.00	0.58	0.056	0.019	0.013

lakes varied from 1.04 to 8 mg/l in the surface samples. Three of these lakes yielded more than 6 mg/l, 8 were between 3 and 6 mg/l and 9 were between 2 and 3 mg/l. That is, the centrifuge plankton of 20 of these lakes yielded more than 2 mg. of organic matter per liter, while 17 fell between 1 and 2 mg/l. The mean quantity of organic matter in the centrifuge plankton of these lakes is 2.8 mg/l.

The means of the disc readings in the other transparency groups are given in Table III; they gradually increase in value from 1.16 m. in the 1.0–1.4 group to 8.7 m. in the 7.5–9.4 group. The color means on the other hand show a decrease in value with increasing transparency as might be expected; that is, the color falls from 138 in the 0.0–0.9 group to zero in the 7.5–9.4 group. The plankton results also are similar to those of color; the plankton crop decreases in quantity with increasing transparency, the mean falling from 2.8 mg/l in the 0.0–0.9 group to 0.58 mg/l in the 7.5–9.4 group. In the groups with low transparency changes in color and in the quantity of plankton are more marked than they are in the more transparent waters; the lakes with transparencies of 3 m. or more show a more gradual change in color and plankton than those with transparencies below 3 m., but there is a gradual change even in the more transparent groups.

In order to obtain enough lakes to give a fair mean, it was necessary to combine all of the lakes falling between 5.5 m. and 7.4 m. into one transparency group and the 4 lakes with transparencies between 7.5 and 9.4 m. have been combined into another.

The standard deviations of the disc readings do not differ greatly except in the 5.5–7.4 and the 7.5–9.4 groups; the readings in these two groups vary more widely than in the others, hence the deviations are larger. (Table III). Also the probable error of the average and that of the standard deviation are much the same except in these two groups. On the other hand the standard deviations of the color readings decline from 76.33 in the 0.0–0.9 transparency group to zero in the 7.5–9.4 group; there are corresponding decreases in the probable error of the average and that of the standard deviation. The plankton also shows similar decreases in its standard deviations and in its probable errors.

Transparency and Color of Water

Figure 2 shows the correlation between the mean transparency and the mean color for the various groups of lakes as given in Table III. The curve in this diagram brings out clearly the relation between high transparency and low color at one end, that is, between transparencies of 4.1 m. and 8.7 m., and that between low transparency and high color, at the other end, from 0.7 m. to 2.1 m. The region of marked change lies between transparencies of 2.1 m. and 4.1 m. where there is a rapid shift from the vertical axis to the horizontal axis. There are some irregularities in the curve in this region of rapid change, but the portions of the curve that lie above and below these limits are quite regular.

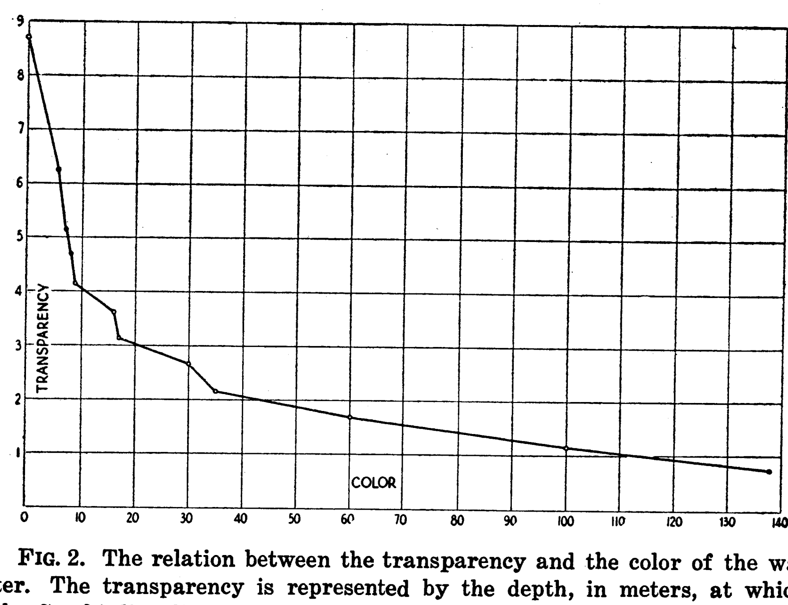


Fig. 2. The relation between the transparency and the color of the water. The transparency is represented by the depth, in meters, at which the Secchi disc disappears from view and the color is indicated in terms of the platinum-cobalt standard.

While there are wide variations in the amount of brown color in the various groups of lakes with approximately the same transparency, the largest variations are such that they tend to neutralize each other. That is, those with a high color will be balanced by those with a low color provided enough lakes, say

25 or more, are included in each group. The range of color in the first group, or those with a transparency below 1 m., is from 28 to 340; 16 of these 37 lakes gave readings below 100, but only 2 of them were below 50, while 8 were above 200. (Fig. 1 and Table III). The mean of the group, however, falls in line with those of the three following groups. In the second group, those with transparencies ranging from 1 to 1.4 m., the color varies from 19 to 206; in 31 of the 68 lakes in this group the readings are less than 100 and 13 of these are below 50. Only 2 lakes in the group gave readings of 200 or more. Similar results were obtained in the other groups, so that it is not necessary to give a detailed discussion of them. It is probable that a larger number of lakes falling between transparencies of 2 m. and 4 m. would eliminate some of the irregularities in the curve between these two points in Figure 2, but each group included in that part of the curve represents from 27 to 46 lakes.

Transparency and Plankton

The correlation between the mean transparency and the mean quantity of organic matter in the centrifuge plankton of the various groups of lakes is shown in Figure 3. There is a fairly regular rise in the curve from the group of lakes having the lowest transparency up to those with a mean of 3.1 m.; the curve has a somewhat steeper gradient between 3.1 m. and 3.6 m., with a more regular gradient above the latter point. It will be noted that the irregularity in this curve between transparencies of 3.1 m. and 4.1 m. is similar to that between these two points in the curve of Figure 2, but no explanation of the similar irregularity in the two curves is evident from the data in hand.

Rather wide variations were also noted in the amount of organic matter found in the centrifuge plankton of the lakes belonging to the various groups, but in this case too the lakes with large amounts of plankton were counterbalanced by those with small amounts. As a result the mean quantities of plankton in the various groups of lakes make a fairly regular and consistent curve when platted against the mean transparencies as shown in Figure 3.

Figures 2 and 3, as well as the results given in Table III, indicate that the decrease in transparency is due to both color and

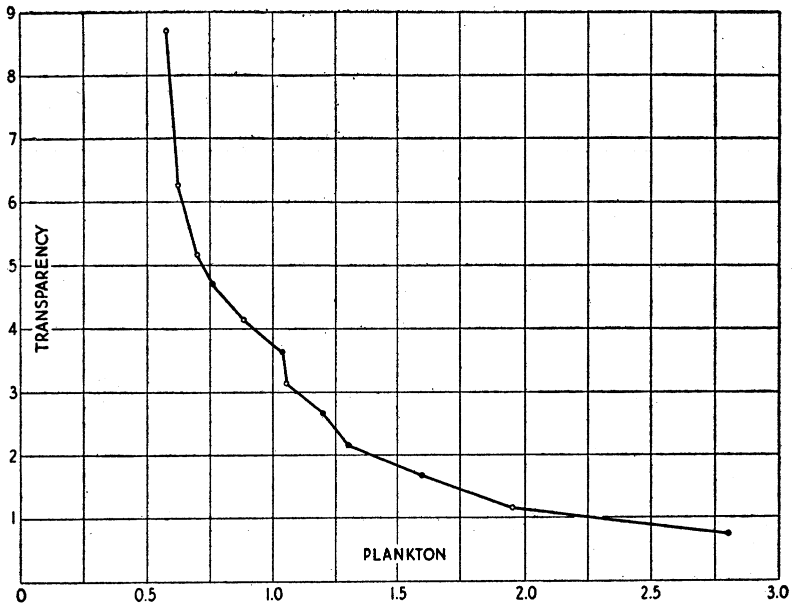


FIG. 3. The relation between the transparency and the plankton content of the water. The results for plankton show the amount of dry organic matter per liter of water in the centrifuge catches.

centrifuge plankton, but color is undoubtedly more important than plankton in the majority of the lakes with low transparency. Part of the vegetable material which produces the brown color consists of particles that are large enough to be removed by the centrifuge and these organic particles make an appreciable contribution to the organic matter obtained in the centrifuge catches. On the other hand the numerical results show that there is a larger number of plankton organisms in the centrifuge catches from the lakes with the lowest transparency than in those with the highest. Approximately 5 times as many plankton organisms were found in the centrifuge catches from the lakes with a transparency of 0.7 m. or less as in those with transparencies of 7 m. or more. The plankton organisms, therefore, must be regarded as an important factor in decreasing the transparency of the water, but they are not as important as the vegetable extractives which impart the brown color to the less transparent lakes.

Transparency and Transmission of Solar Radiation

There is a fairly definite correlation between the transparency of lake waters and their transmission of solar radiation (Birge and Juday 1929). Usually a small number of observations does not reveal such a relation, but readings on a considerable number of lakes or a number of observations on the same lake at different times will show a rough correlation between the depth at which a Secchi disc disappears from view and the transmission of solar radiation. The various observations may show rather wide ranges of transmission for approximately the same degree of transparency, but in a large series of results the low transmissions are usually balanced by the high ones for a particular transparency, so that the mean transmission of the various series will show a rough correlation with the mean transparency.

In Lake Mendota, for example, the transmission ranged from 37 to 50 per cent in the 1–2 m. stratum when the disc reading fell between 2 m. and 3 m. and from 42 to 58 per cent with disc readings of 3 m. to 4 m. In a total of 36 cases on this lake, the mean transmission fell below the mean transparency in 18 cases and at or above the latter in the other 18 instances; in this way the high transmissions and the low ones tend to counterbalance each other and thus yield a mean which is rather definitely correlated with the mean transparency. The same relation holds true for observations on a number of different lakes which possess similar transparencies; that is, low transparencies, in general, are accompanied by low transmissions and high transparencies by high transmissions.

II. Color

Lake waters show a wide range in color, varying from a more or less deep blue through green to yellow, brown and reddish-brown, thus covering a large part of the visible spectrum. This great variation in color is due to a number of factors, some of which are physical, some chemical and others are biological in character.

Several theories have been suggested to account for the blue color of water, but the molecular scattering theory of Raman (1922) is now regarded as the best explanation; it is similar to the molecular scattering theory proposed for the explanation of the blue color of the sky. According to Raman the blue color of the sea and of very transparent inland lakes is due to the diffraction or scattering of the light by the molecules of water. These blue waters contain only a very small amount of finely dispersed matter in suspension, so that the effect of these particles is almost negligible; however, "a large quantity of such matter would cause some increase in intensity, accompanied by a decrease in the saturation of the hue." He states that "suspended matter not very finely dispersed would operate in a different way. With a collection of particles of different sizes, the color of the light scattered would be practically the same as the color of the light incident on the particles in any given layer, and we should find the water exhibiting a greenish-blue or green color according to the quantity of the suspended matter."

In this connection also, the green color of lake waters may be due to the presence of a large crop of chlorophyll-bearing organisms, since the color of these organisms would affect the color of the scattered light. The color range from yellow to reddish-brown is produced by vegetable stains derived from bog and marsh deposits and the various shades of these colors depend upon the quality and quantity of these vegetable extractives or humic substances that are present in the water. Very small quantities of this humic material have an appreciable effect upon the color of the water as well as upon the transmission of solar energy. Spring (1897) found that as little as 1 part of humic material added to 40 million parts of distilled water changed the color of the latter, giving it a greenish-blue color instead of pure blue. Recent experiments with a monochromator show that 0.1 per cent of a lake water having a color of 264 on the platinum-cobalt scale added to distilled water reduces the amount of light transmitted by the latter; most of the decrease is found between the wave-lengths 4100 and 6000 Å. This small amount of lake water, however, did not impart an appreciable brown color to the distilled water, not enough at least to make it detectable with the instrument used for such readings.

The color readings made on the waters of the Highland Lake District of Wisconsin were confined almost entirely to the quantitative determination of the brown color. Up to the present time no good quantitative method has been devised for the different shades of blue and green colors found in lake waters, so that definite quantitative data can not be obtained for this part of the spectrum. On the other hand, a standard quantitative method for the determination of the various shades of brown has been in practical use for more than a quarter of a century. This is the platinum-cobalt method of the United States Geological Survey which was devised by Mr. Allen Hazen (Leighton 1905).

The Forel-Ule scale was devised for the purpose of covering the whole range of colors, from blue to brown, usually found in lake waters, but the various shades of color in this scale are indicated only by arbitrary numbers which have no exact quantitative significance. These arbitrary standards serve the purpose of comparing the color of one lake water with that of another, but they do not yield quantitative data which can be correlated with other physical or chemical characteristics of these waters. While some readings were made with a set of the Forel-Ule color tubes, such determinations were not made regularly because they have so little value from a quantitative standpoint. Determinations of the brown color based on the platinum-cobalt standard, however, do give quantitative results that can be correlated directly with transparency, with the transmission of solar radiation and with the quantity of organic carbon in the water. Readings based on this standard, therefore, have been made regularly during the progress of these investigations on the waters of the northeastern lakes, but no attempt has been made to cover the blue and green colors shown by a few of these lake waters.

The standard comparator of the United States Geological Survey has been used for the color readings. The values of the brown colored discs of this instrument are based upon standard platinum-cobalt solutions and the units of color correspond to the amount of metallic platinum in the solutions in parts per million. A color reading of 10, for example, represents 10 parts of platinum per million in the platinum-cobalt solution which matches the color of the lake water. The 6 amber colored discs represent colors ranging from 8 to 83 and other colors may be determined by using various combinations of these discs. Readings below 8 must be estimated and those below 4 or 5 can hardly be detected with this instrument. Thus some of the lake waters that were recorded as having no brown color may have had a trace of it.

The brown color of the lake waters of northeastern Wisconsin is due to stains that are derived from the leaves of trees, from plankton, from large aquatic plants and from tributary peat bogs, marshes and swamps. These extractives consist of dissolved and colloidal substances which the water acquires when it comes into contact with various materials of vegetable origin and the intensity of the brown color depends upon the quantity of these extractive substances in the water. The amount of extractives, in turn, is dependent chiefly upon the quantity of leaves blown into a lake and upon the amount of peaty material along the shore, or upon the amount of drainage water received from marshes, as well as upon the volume of the lake in proportion to the volume of the inflowing colored water. All of the northeastern lakes are comparatively small and shallow, so that their volumes are correspondingly small and a relatively small amount of inflowing water with a high color will affect the general color of the lake.

The depth of the brown color in many of these lakes is also dependent upon the amount of precipitation, since a large amount of rain will bring a larger amount of drainage water from bogs and marshes into those that receive water from such sources. Bogs and marshes of various sizes are rather abundant in this lake district and all of the streams flowing out of them possess more or less deeply stained waters; as a result, the great majority of the streams of this region contain waters that have a certain amount of stain. The color of 4 streams flowing into Trout Lake ranged from 22 to 202, for example, and that of the Manitowish River was 74. Some of the most highly colored waters, however, are found in bog lakes and lakelets that have neither an inlet nor an outlet, but which have relatively large areas of bog surrounding them. The quantity of the summer precipitation will have an effect upon the color of these bodies of water also; a large amount of rain will dilute the highly colored water already in them and it will bring into the open water more vegetable extractives from the surrounding peaty deposits.

Color readings have been made on the surface water of 530 lakes; of this number 238, or 45 per cent of the total, are seepage lakes, or those without an inlet or an outlet, and 292 (55 per cent) are drainage lakes. Results have been obtained from 1110 surface samples; only one observation each was made on 276 lakes, so that 834 readings were made on the surface waters of 246 lakes. The number for each lake belonging to the latter group varied from 2 to 12. The largest number (12) was taken on Trout Lake and Weber Lake was second with 10 readings.

The color of these surface samples varied from zero up to 340 on the platinum-cobalt standard. The various lakes have been separated into groups on the basis of the color of their waters; the results of these groupings are given in Table IV

TABLE IV

Color ranges of the lake waters of northeastern Wisconsin, the number of seepage and drainage lakes and the total number of lakes in the various color groups.

Range of Color	Number of Lakes			Range of Color	Number of Lakes		
	Seepage	Drainage	Total		Seepage	Drainage	Total
0	49	7	56	140—149	0	8	8
1—9	38	19	57	150—159	0	3	3
10—19	54	48	102	160—169	0	2	2
20—29	43	34	77	170—179	0	0	0
30—39	17	29	46	180—189	0	3	3
40—49	10	13	23	190—199	2	2	4
50—59	8	19	27	200—209	1	2	3
60—69	7	15	22	210—219	0	0	0
70—79	3	12	15	220—229	2	1	3
80—89	1	9	10	230	0	1	1
90—99	1	18	19	244	0	1	1
100—109	1	15	16	260	0	1	1
110—119	0	16	16	268	1	0	1
120—129	0	8	8	314	0	1	1
130—139	0	4	4	340	0	1	1

and they are shown graphically in Figure 4. In the table the lakes that did not show any brown color in their surface waters are placed in a separate group, but in the diagram they are combined with 1–9 to form the 0–9 color group. The table shows that the lakes having colors above 199 are distributed over a wide range and they are omitted from the diagram. Where more than one determination was made on a lake, the mean of the various readings has been used in making assignments to the different groups.

The table shows that no brown color was observed in the surface waters of 56 lakes and only 7 of this number belong to the drainage class. That is, more than 87 per cent of those that did not possess any brown color were classed as seepage lakes and approximately 13 per cent as drainage. These figures represent 20 per cent of the total number of seepage lakes, but only 2.4 per cent of total number of drainage lakes belong in the no brown color group. The readings of 57 lakes fell in the 1–9 color group and of this number 38, or two-thirds of those in this group, belong to the seepage type. Thus only 26 out of 113 lakes in which the color ranged from 0 to 9 on the platinum-cobalt scale were classed as drainage lakes; this entire group, therefore, consisted of 77 per cent seepage and 23 per cent drainage lakes. As indicated in Figure 4 this 0–9 color group contains the maximum number of lakes, namely 113, and the relation between the number of seepage and drainage lakes is well shown in the diagram; the clear portion of the column represents the number of seepage lakes and the shaded portion the number of drainage lakes in the group.

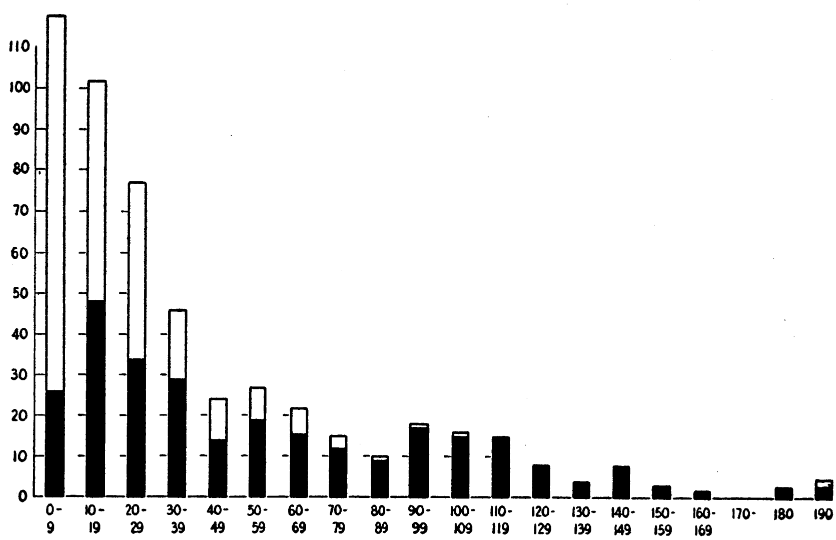


FIG. 4. This diagram shows the grouping of 518 lakes on the basis of the color of their waters in terms of the platinum-cobalt scale. The vertical spaces indicate the number of lakes in the various color groups. The unshaded part of the column represents the number of seepage and the solid black part the number of drainage lakes in each group. The diagram includes 234 seepage and 284 drainage lakes.

The 10–19 color group, with 102 lakes, ranks second with respect to number. In this group there are 54 seepage and 48 drainage lakes; that is, the former constitutes approximately 53 per cent of this group and the latter 47 per cent. The 20–29 group contains 77 lakes of which 43, or 56 per cent, belong to the seepage class and 34, or 44 per cent, to the drainage type. The 30–39 group includes 46 lakes of which 17 are classed as seepage and 29 as drainage lakes; 37 per cent of this number belongs to the former and 63 per cent to the latter type. This is the first color group in which the drainage outnumber the seepage lakes. There is a gradual decrease in the percentage of seepage lakes in the groups having colors of 40 or more; no seepage lakes are found between colors 110 to 189 and only 6 above the latter color. The 6 seepage laks with colors above 190 belong to the bog type; they are small bodies of water in which the open water is surrounded by a rather wide bog.

Combining these lakes into larger groups, Table IV shows that the color of 292 of them fell between 0 and 29; of this number 184, or 63 per cent of them, are classed as seepage and 108, or 37 per cent, as drainage lakes. In the more highly colored waters, on the other hand, the majority of the lakes belong to the drainage type. Thus 238 lakes fall in the groups having colors of 30 to 340 and of this number 184, or almost 78 per cent of the total number, are drainage and 54, or a little more than 22 per cent, are seepage lakes. It will be noted that the number of seepage lakes in the 0–29 groups, namely 184, is the same as that of the drainage lakes in the 30–340 groups. The number of drainage lakes in the 0–29 groups, however, is twice as large as that of seepage lakes in the 30–340 color groups. The small amount of stain in most of the seepage lakes is due to the fact that they have no inflowing streams to bring in organic substances from the surrounding drainage basin and also to the fact that the shores of these lakes are generally composed of clean sand so that all of the water that does enter them from the land is well filtered.

Seasonal and Annual Variations of Color

The depth of color of the brown stained lakes is subject to more or less pronounced seasonal variations; this is true especially of the drainage lakes. These variations are due chiefly to

TABLE V

Seasonal fluctuations in the color and in the specific conductance of the surface waters of 17 lakes.

Lake	Date	Color	Conductance
Allequash	April 26, 1930	26	60
	July 11, 1930	32	60
Black Oak	April 26, 1930	14	42
	July 5, 1930	14	39
Boulder	April 26, 1930	45	53
	July 1, 1930	78	50
Clear Crooked	April 26, 1930	10	32
	July 22, 1930	18	28
Day	April 26, 1930	8	12
	July 9, 1930	6	11
Diamond	April 26, 1930	0	11
	July 9, 1930	0	12
Fishtrap	July 1, 1930	28	70
	February 1, 1931	35	52
Forest	April 26, 1930	14	46
	July 5, 1930	18	45
Island	April 26, 1930	0	12
	July 5, 1930	4	12
Little John	April 26, 1930	14	70
	July 7, 1930	22	68
Little John Jr.	April 26, 1930	18	9
	July 7, 1930	18	8
Mann	April 26, 1930	20	94
	July 23, 1930	32	94
Muskellunge	July 19, 1929	0	41
	April 26, 1930	10	42
Silver	April 26, 1930	8	62
	July 9, 1930	10	57
Trout	April 27, 1930	10	76
	June 30, 1930	14	69
Wild Cat	April 26, 1930	26	118
	July 22, 1930	26	115
Wolf	April 26, 1930	30	96
	July 22, 1930	32	90

the fact that the amount of drainage water coming from bogs and marshes varies a great deal during the course of the year, as well as from year to year. Table V shows the results obtained in spring and summer color readings on 17 lakes; in 16 cases the determinations were made in April 1930, but in Fishtrap Lake the reading was taken in February. No reading was taken in Muskellunge Lake during the summer of 1930 and the result for July 19, 1929 is given instead. Exactly the same readings were obtained in spring and summer in Little John Jr. and Wild Cat lakes, the former a seepage and the latter a drainage lake. In the other 15 lakes the summer color readings were different from those taken in spring. The largest difference was noted in Boulder Lake where there was a change from 45 in April to 78 in July. Readings taken in Boulder Lake during the months of June and July from 1927 to 1929 inclusive, varied from 53 to 65, so that the July result of 1930 was higher than those obtained in previous summers. This lake has an area of 248 ha. and a maximum depth of only 6 m., so that its volume is relatively small in comparison with its size; a fairly large stream, the Manitowish River, flows through the lake and an appreciable percentage of the water, therefore, is subject to constant renewal. Thus the color of the water may vary considerably during a period of two or three months, depending upon the color of the inflowing water. Mann Lake showed the next largest difference, rising from 20 in April to 32 in July, while Muskellunge Lake followed with a color difference of 10. In 9 other lakes the summer readings were from 2 to 8 points higher than those taken in April, but there was a decrease of 2 points in Day Lake.

Whipple (1927) states that "experiments made by exposing bottles of colored water at various depths in reservoirs have shown that the bleaching action that takes place at the surface of a reservoir is considerable, sometimes 50 per cent in a month. It decreases rapidly with increasing depth, and the rapidity with which it decreases below the surface depends upon the color of the water in the reservoir." No experiments of this character have been performed on the highly colored waters found in some of the northeastern lakes, but color decreases of such a magnitude that might be attributed to bleaching have not been observed. The surface water of Tadpole Lake had a color of 120 on July 12, 1932, for example, and the same reading was obtained on August 13, 1932. Several readings taken on the surface water of Mud Lake during July and August, 1932, varied from 32 to 34, so that its color may be regarded as constant during this period of two months. There was a 15 per cent decrease in the color of the surface water of Helmet Lake during a period of almost two months; that is, the color declined from 210 on June 23 to 180 on August 13, 1932. These three lakelets belong to the seepage type, so that the color was not affected by water derived from affluents. In general the results obtained on the various lakes with brown colored waters indicate that the color remains fairly constant for periods of two months or more during the summer.

Annual variations in the color of many of these lakes have been observed. These variations depend principally upon the amount of precipitation, because this determines how much drainage water reaches them from bogs and marshes, which are the chief sources of this brown stain. Some of the lakes with very little or no brown color gave practically the same readings from year to year, while others showed moderate variations. Representatives of these two groups are given in Table VI; Diamond and Franklin lakes represent the first group, while North Two, Pallette, Weber and Wyondock belong to the second. The lakes in these two groups belong to the seepage type. A somewhat wider variation was noted in some of these low color lakes, such as Alma, Black Oak, Presque Isle and Trout. A few of the lakes with more highly colored waters showed only a comparatively small annual variation also, such as Allequash, Armour, Carroll, Long and Rock, while others showed a more marked variation, such as Adelaide, Big Saint Germain and Mary lakes. Maximum differences in the annual variations were noted in Brazell, Little Pickerel and Nixon lakes; a difference of 74 points was noted in the first, 58 in the second and 40 in the third lake. These three lakes are shallow and weedy, with a certain amount of marsh along their shores; Little Pickerel and Nixon lakes have affluents which play an important rôle in producing the color variations in them.

The color of the surface water of Trout Lake varied from zero up to 14. Four of the 12 readings were recorded as zero and 2 as 14; the others fell between 6 and 12. Four streams entering Trout Lake have more highly colored waters, but the quantity of water brought into the lake by them is so small as compared with the total volume of the lake that this stained water has very little effect upon the general color of the lake water. Allequash Creek which enters the lake near the Trout Lake post office has a color of 26; Mann Creek on the south shore of the lake gave a reading of 22; Spring Creek at the north end of the lake was 49 and a marsh creek flowing into

TABLE VI

Annual variations in the color of the surface water of the northeastern lakes

Lake	Date	Color	Lake	Date	Color
Adelaide	Aug. 5, 1927	38	Long (Phelps)	Aug. 25, 1927	26
	July 17, 1928	32		Aug. 21, 1929	24
	Aug. 29, 1929	45		July 27, 1930	30
	Aug. 4, 1930	32			
			Mary	July 12, 1926	100
Allequash	Aug. 15, 1926	26		July 29, 1927	122
	July 7, 1928	30		July 11, 1928	118
	July 27, 1929	36		Aug. 29, 1929	118
	July 11, 1930	32		Aug. 4, 1930	122
Alma	July 5, 1927	8	Nixon	Aug. 11, 1926	78
	July 1, 1928	6		Aug. 5, 1928	90
	July 2, 1930	14		June 29, 1930	118
	Aug. 22, 1931	12			
			North Two	July 22, 1927	6
Armour	July 24, 1927	50		July 25, 1929	8
	Aug. 5, 1928	43		Aug. 7, 1930	8
	Aug. 6, 1929	43			
	July 12, 1930	49	Pallette	Aug. 17, 1925	6
				July 27, 1926	5
Big. St. Germain	July 7, 1927	30		Aug. 17, 1927	0
	July 13, 1928	22		Aug. 22, 1928	0
	July 6, 1929	32		Aug. 26, 1929	6
	July 2, 1930	32			
	Aug. 22, 1931	22	Presque Isle	Aug. 11, 1927	8
				Aug. 9, 1928	12
Black Oak	Aug. 26, 1925	14		July 27, 1929	15
	July 5, 1926	6		July 15, 1930	14
	Aug. 25, 1926	8			
	Aug. 15, 1927	0	Rock	Aug. 17, 1927	30
	Aug. 24, 1928	0		July 1, 1928	34
	July 5, 1930	14		Aug. 18, 1929	32
				July 11, 1930	32
Brazell	July 8, 1928	314			
	July 29, 1930	240	Trout	June 24, 1927	6
				Aug. 20, 1927	0
Carroll	Aug. 12, 1926	18		July 25, 1928	0
	Aug. 13, 1927	18		June 26, 1929	0
	Aug. 3, 1928	20		Aug. 27, 1929	6
	Aug. 11, 1929	20		June 30, 1930	14
	July 8, 1930	20		July 1, 1931	14
Diamond	July 29, 1926	0	Weber	July 5, 1926	6
	July 15, 1927	0		Aug. 18, 1926	0
	Aug. 29, 1928	0		July 13, 1927	0
	July 24, 1929	0		June 28, 1928	0
	July 9, 1930	0		Aug. 29, 1928	0
				June 29, 1929	0
Franklin	July 31, 1927	0		Aug. 21, 1929	0
	July 29, 1928	0		Aug. 14, 1930	6
	July 7, 1929	0		Aug. 25, 1931	Tr.
Little Pickerel	Aug. 28, 1927	109	Wyondock	July 21, 1927	8
	July 1, 1928	97		July 22, 1928	8
	July 6, 1929	128		July 14, 1929	8
	July 16, 1930	150		July 3, 1930	6
	Aug. 22, 1931	92			

the east side of the north part of the lake was 202. The volume of water brought in by these streams is relatively small, however, and all trace of this more highly colored water is lost within a short distance of the mouths of the various streams. On the other hand, the color of the upper water may be affected by the inflowing water when there is an unusual amount of precipitation, such as occurred on August 28-29, 1932. On this date the precipitation amounted to 10 cm. in 24 hours, so that a large amount of drainage water reached Trout Lake at this time. The color of the surface water of the lake rose from 6 previous to this rain to 15 on August 29; it declined to 12 by September 3.

Vertical Distribution of Color

In some of the lakes that are deep enough to be thermally stratified in summer, the color of the water was substantially the same from the surface to within 1 m. of the bottom; all of the bottom samples were taken 1 m. above the mud. This group is represented in Table VII by such lakes as Big Carr, Blue, Clear, Crystal, Diamond and Fence. In some years however, the lower water of part of these lakes may show a slight increase of color toward the bottom, such as found in Big Carr on July 12, 1929, in Blue on August 6, 1929 and in Clear on August 24, 1931.

In the other group, there is a marked increase in the brown color with increasing depth; such results are shown in Table VII for Anderson, Black Oak, Bragonier, George, Mary, Nokomis, Papoose and Two Sisters lakes. In some cases, such as George and Papoose lakes, the increase of color is due to an increase in the quantity of the vegetable stain in the lower water, but in other instances, such as Anderson, Mary and Nokomis lakes, the increase in the brown color of the lower water is due to the presence of iron in these strata. (See Juday and Birge 1932, p. 466).

Color and Transparency

The relation between the color of these lake waters and their transparency is discussed under the section dealing with transparency (p. 213) and no further consideration is necessary in

TABLE VII

Color and specific conductance determinations on samples of water from different depths in 14 lakes, together with disc readings in the upper stratum. The disc readings are indicated in meters, the color is based on the platinum-cobalt standard and the specific conductance is expressed in reciprocal megohms. Tr. *means trace.*

Lake	Date	Depth in meters	Disc	Color	Specific conductance
Anderson	Aug. 8, 1929	0	8.0	0	40
		5		0	40
		10		8	41
		15		180	48
		18		240	54
Big Carr	July 18, 1927	0	4.8	0	12
		10		0	13
		21		0	14
	July 12, 1929	0	5.0	0	12
		10		0	12
		15		8	12
		18		10	12
		21		14	12
Black Oak	Aug. 24, 1928	0	4.5	0	41
		10		8	42
		20		10	43
		25		32	44
Blue	July 8, 1927	0	4.8	0	42
		12		0	43
	Aug. 6, 1929	0	6.0	0	39
		5		0	39
		8		8	38
		10		10	38
		12		16	38
Bragonier	July 19, 1928	0	2.7	28	15
		5		31	16
		8		110	24
	Aug. 10, 1929	0	2.1	45	12
		5		91	19
		8		126	21
Clear	July 27, 1927	0	7.0	0	17
		25		0	16
	Aug. 24, 1931	0	5.0	Tr.	16
		15		Tr.	17
		24		Tr.	
		27		8	18
Crystal	June 26, 1928	0	13.6	0	11
		18		0	11
	Aug. 20, 1929	0	8.8	0	9
		10		0	9
		15		0	9
		19		Tr.	10
Diamond	July 29, 1926	0	9.0	0	12
		11		0	14
Fence	Aug. 23, 1929	0	5.7	14	57
		10		14	57
		20		14	58
		28		16	58

TABLE VII—Continued

Lake	Date	Depth in meters	Disc	Color	Specific conductance
George	Aug. 24, 1929	0	3.0	43	20
		5		43	20
		10		43	20
		15		74	21
		18		200	
		21		220	23
Mary	July 11, 1928	0	1.5	118	21
		5		120	23
		10		120	30
		15		180	48
		21		218	59
Nokomis	Aug. 28, 1929	0	4.9	20	39
		10		20	42
		18		32	48
		20		53	50
Papoose	Aug. 18, 1927	0	4.4	24	98
		8		24	98
		12		30	99
		15		43	102
		18		143	110
Two Sisters	Aug. 13, 1929	0	4.8	14	43
		5		14	44
		10		14	47
		15		32	48
		19		43	54

this section. A definite correlation between them was found in the various lakes and this fact is shown in Figure 2, page 213.

Color and Transmission of Solar Radiation

The vegetable extractives which are present in these lake waters and impart to them their brown color, have a very marked effect upon their transmission of solar radiation. The effect of this brown stain is very variable in the different lakes and it varies somewhat also in the same lake at different times. These brown stains have a selective action upon the solar radiation; they act more strongly on the short wave radiation at the blue end of the spectrum and they are effective in proportion to the amount and kind present in a lake water. In a highly colored water, for instance, very little solar energy will be found at a depth of a meter or two and the greater part of it will consist of the longer wave-lengths toward the red end of the spectrum.

The results obtained on Crystal Lake and Lake Mary will serve to illustrate the effect of this brown stain upon the transmission of solar radiation by their respective waters. (Birge and Juday 1931). The water of Crystal Lake has no brown color and the total amount of radiation present at 1 m. is about 38 per cent of that delivered to the surface of the lake; in Lake Mary on the other hand, with a color of 123, only about 4 per cent of the solar energy delivered to the surface penetrated to a depth of 1 m. In Crystal Lake 42 per cent of the total energy found at 1 m. came from wave-lengths shorter than 5000 Å, while in Lake Mary only 4 per cent of the energy at that depth came from the same region of the spectrum. The percentage of the total energy present at 1 m. which was derived from wave-lengths greater than 7000 Å rose from 7 per cent in Crystal Lake to 34 per cent in Lake Mary. Thus the total quantity of solar energy present at 1 m. in Lake Mary was very much smaller, less than one-tenth as much, than in Crystal Lake and a much larger proportion of the amount that was present at that depth in the former fell in the region of the longer wave-lengths. In Helmet Lake with a color of 268, only 1.1 per cent of the solar radiation incident on the surface penetrates to a depth of 1 m.

The data in hand concerning the relation between color and the transmission of solar radiation have led to the following conclusions: "That in all lakes the characteristic transmission is determined by factors of color and turbidity; that color is the main factor determining the place of the lake in the general scale of transmission; that turbidity causes much variation in transmission, causes overlapping of the several color groups, and wide range of transmission in each group." (Birge and Juday 1932, p. 560).

Relation between Color and Oxygen Consumed

Quantitative determinations of oxygen consumed or oxygen absorbed were made on 290 of these lakes and the general relations between the amount of oxygen consumed and the color of the waters of the various lakes has been discussed by Juday and Birge (1932), so that it needs only a brief consideration at this time. The color of the surface water of the 290 lakes on which oxygen consumed determinations were made ranged from zero up to 268 on the platinum-cobalt scale. The quantity of oxygen consumed by these same lake waters varied from a minimum of 1.2 mg/l in Dorothy Dunn Lake, with a color of 14, to a maximum of 34.5 mg/l in Helmet Lake with a color of 268. Table IX and Figure 34 of Juday and Birge (1932) show that the mean quantity of oxygen consumed by the surface water increased from 3.7 mg/l in the 0–9 color group of these lakes to 15.9 mg/l in the 100–149 color group. The general results, therefore, indicate that there is a rather close correlation between the brown color of the water and the amount of oxygen consumed. From this it appears that the vegetable extractives which produce the brown color are of such a nature that they are readily oxidized by the potassium permanganate solution in proportion to the amounts present in the water.

In some of these lakes the lower water was more highly colored than that at the surface; in all cases where the increase in the color of the lower water was due to an increase in the amount of vegetable extractives present, there was a corresponding increase in the quantity of oxygen consumed. In some instances, however, the increased color in the lower water was due to the presence of iron and in these cases there was no increase in the quantity of oxygen consumed corresponding to the increase in color.

Relation of Color to Organic Carbon

As already indicated, the brown stains found in these lake waters consist of vegetable extractives or humic substances derived chiefly from peat and marsh deposits. Chemical analyses show that these substances are mainly carbon compounds. While there is usually a larger amount of organic nitrogen present in the residues from lakes with highly colored waters than in those with little or no color, the larger quantity of nitrogen is by no means proportional to the larger quantity of organic carbon found in the former. That is, the carbon-nitrogen ratio is much larger in the lakes with highly colored waters than in those which show little or no brown color.

The relation between the color of these lake waters and the quantity of organic carbon present in them is shown in Table

VIII and also in Figure 5. All of the color groups represented in Table VIII show a wide variation in the quantity of organic carbon in the several lakes belonging to each group, but the means of the various groups show a definite increase in the amount of organic carbon correlated with an increase in the color of the waters. This is well shown in the solid line curve of Figure 5 which indicates the results obtained by platting the mean quantity of organic carbon in the different groups against the mean color of the respective groups. The lakes with colors above 200 have not been included in the diagram because they are so few and they cover such a wide range of color that it is impossible to obtain a fair mean for them. The broken line curves shown above and below the one representing the means indicate the maximum and minimum amounts of organic carbon respectively in the various color groups.

Taking the entire group of lakes, the average amount of organic carbon is about 7 mg/l, while the average color is 43.

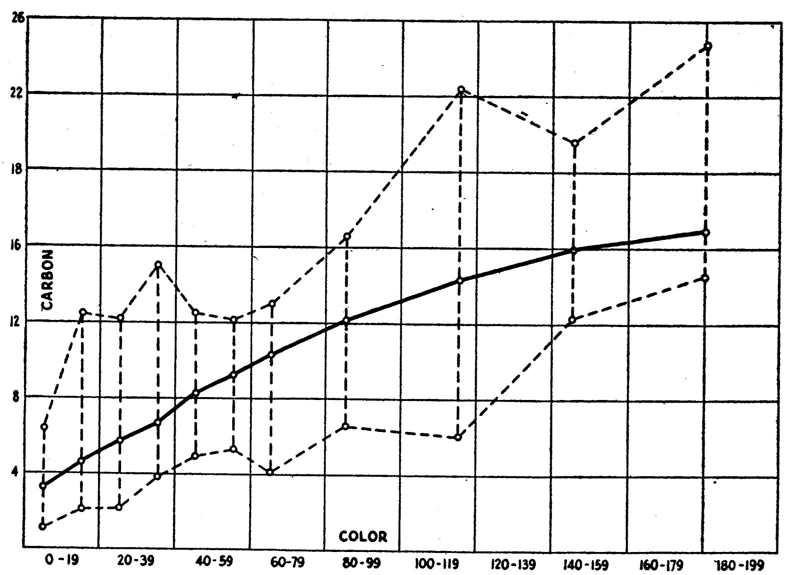


FIG. 5. The relation between the color of the water and its organic carbon content. The upper curve shown by a broken line represents the maximum amounts of organic carbon found in the various color groups; the lower broken line curve shows the minimum amounts of organic carbon. The solid line curve between them indicates the mean quantities of organic carbon in the various color groups. (See Table VIII).

The standard deviation of the organic carbon is 4.64 and that of the color is 43.5; the coefficient of correlation between the organic carbon and the color is 0.91.

It will be noted that no brown color was observed in the surface waters of 56 lakes and that these lakes yielded the smallest mean quantity of organic carbon, namely 3 mg/l; they showed a range from 1.2 to 4.5 mg/l, or approximately a fourfold difference. In the entire 0–9 color group the range is from 1.2 to 6.4 mg/l, which represents a little more than a fivefold difference. There is approximately a sixfold difference between the maximum and minimum amounts of carbon in the 10–19 and the 20–29 color groups, but in the higher color ranges the variations are not proportionately so great; the difference between maximum and minimum in the 130–159 and in the 160–199 groups is less than twofold, for example, but the quantitative difference in these two groups is larger than in the groups having low colored waters. The difference between maximum and mini-

TABLE VIII

The relation between the color of the surface waters of the lakes in northeastern Wisconsin and the amount of organic carbon in them. The lakes are separated into groups on the basis of their brown color in comparison with the platinum-cobalt standard; the maximum, minimum and mean quantities of organic carbon are indicated in milligrams per liter of water for the various color groups, as well as the number of lakes in each group. The lakes are grouped by color ranges of 10 up to 69, but the number in the various 10 groups above this color is so small that they have been combined into larger color groups in order to obtain a fair mean. See Fig. 5.

Color	Number of lakes	Organic Carbon		
		Maximum	Minimum	Mean
0	56	4.5	1.2	3.0
1—9	57	6.4	1.7	3.6
0—9	113	6.4	1.2	3.3
10—19	101	12.5	2.1	4.6
20—29	77	12.2	2.2	5.7
30—39	46	15.0	3.9	7.7
40—49	23	12.5	4.9	8.3
50—59	27	12.3	5.3	9.2
60—69	22	13.0	4.0	10.3
70—99	44	16.6	7.5	12.1
100—129	40	22.4	6.0	14.3
130—159	15	19.6	12.3	16.0
160—199	9	24.8	14.5	17.1
200—340	12	25.8	13.5	21.4

mum carbon in the 0–9 group is 5.2 mg/l, while it is 10.3 mg/l in the 160–199 group and 7.3 mg/l in the 130–159 group.

Spring (1897) studied the color of various dilutions of a deeply colored bog water. This bog water had an organic content by combustion of 128 mg/l and the dilutions with distilled water were based upon the amount of humic material in the water. A tube 5 m. long was used for the experiment. The bog water had a black color when viewed by reflected light and a coffee-brown by transmitted light. His qualitative tests showed that a mixture containing 1 part of the combustible organic matter to 500,000 parts of water gave a yellow-brown color, while 1 part of the former to 20 million of the latter was green and 1 to 40 million was greenish-blue; 1 part to 50 million, however, did not produce any appreciable change in the blue color of the distilled water.

Observations have been made on the transmission of light through various dilutions of some of the highly colored waters of the northeastern lakes by means of a monochromator and the results obtained on one of them may be considered briefly in this connection. The sample of water from Helmet Lake, a small bog lake, had a color of 264 on the platinum-cobalt scale and an organic content of 55 mg/l based on organic carbon and organic nitrogen determinations. Adding 1 cc. of this bog water to 999 cc. of distilled water did not produce any brown color that could be detected with the standard color instrument, but when this diluted water was examined with the monochromator the amount of light transmitted between the wave-lengths 4078 and 6000 Å was about 5 per cent less than that transmitted by the distilled water. The distilled water used for this experiment transmitted 10 per cent of the light at 8000 Å, 58 per cent at 7000, 84 per cent at 6000 and 94 per cent at 4078, while the above mixture of 0.1 per cent bog water gave a transmission of 83 per cent at 6000 Å and 87 per cent at 4078; the transmission of the mixture was about the same as that of the distilled water between 8000 and 6000 Å. This dilution represented approximately 1 part of organic matter to 180 million parts of water.

A dilution of 10 cc. of Helmet Lake water to 990 cc. of distilled water gave a color reading of about 4 or 5 and the transmission of this mixture was 79 per cent at 6000 and 65 per cent at 4078 Å. This dilution contained about 1 part of organic matter to 18 million parts of water. When 100 cc. of the bog water were added to 900 cc. of distilled wafer the resulting mixture had a color of 25; its transmission was 48 per cent at 7000, 53 per cent at 6000 and only 4 per cent at 4078 Å. These results show clearly how rapidly the vegetable stains in such waters reduce the transmission of light, especially toward the blue end of the spectrum. The undiluted water of Helmet Lake gave a transmission of about 5 per cent at 8000 Å, a maximum of 12.5 per cent at 6900 and it declined substantially to zero at 5460 Å. This is in good agreement with the result indicated for this lake on a previous page; that is, it was found that only 1.1 per cent of the solar radiation incident on the surface of Helmet Lake penetrated to a depth of 1 m. and all of this energy belonged to the longer wave-lengths.

It should be noted, however, that certain kinds and amounts of organic material may be present in lake waters without imparting an appreciable brown color to them. This is shown by the fact that the surface waters of 56 lakes did not possess any brown color that could be detected with the standard instrument used for such readings, yet these waters contained from 1.2 to 4.5 mg/l of organic carbon some of which, most probably the greater part, had a vegetable origin. The peat deposits of marshes and bogs, together with leaves, are the chief sources of the vegetable extractives that are responsible for the brown color in lake waters, but there are other vegetable derivatives which do not impart a color to the water as indicated by these 56 lakes with uncolored waters.

Raymond and Stetson (1931) found a practically colorless jelly-like substance of vegetable origin in suspension in ocean water. Similar material has been observed in Green Lake, but it has not been noted in any of the northeastern lakes.

III. Conductivity or Specific Conductance

The quantity of electrolytes held in solution by the waters of the Highland Lake District varies widely in the different types of lakes. These bodies of water are situated in a glacial region where the deposit ranges from 40 to 70 m. in depth and the underlying rock consists of granite, quartzite, slate, iron formations and schist. The glacial material contains relatively small amounts of calcium and magnesium in most cases; a survey of the region by Whitson and others (1916) demonstrated that most of the soils have an acid reaction owing to the scarcity of calcium carbonate. In some instances it would require nearly 6 metric tons of lime per hectare to correct this acidity for agricultural purposes.

As already indicated 238 of the lakes that have been studied possess neither an inlet nor an outlet (seepage lakes), while 292 of them have outlets and many of them both an inlet and an outlet. As a result of the scarcity of calcium and magnesium in the surrounding glacial material, the seepage lakes contain comparatively small amounts of electrolytes, some of them very small amounts in fact. The drainage lakes, on the other hand, possess waters that have come into contact with larger quantities of glacial débris and have thus acquired larger amounts of electrolytes; while the waters of these drainage lakes usually have a larger electrolyte content than those of the seepage lakes, they are by no means to be regarded as hard waters when compared with those of lakes situated in limestone regions. They may be regarded as ranging from rather soft up to medium hard waters; the waters of the seepage lakes are to be regarded as soft.

Determinations of conductivity or specific conductance were made on the surface waters of the 530 lakes that have been visited. These readings were taken with a Digby and Biggs Dionic Water Tester manufactured by Evershed and Vignoles of London (Evershed 1911). The instrument is well adapted for field use and it requires only a minute or two to make a determination. It is provided with a compensating conductivity tube so that an adjustment can be made for the temperature of the sample; in this way the specific conductance can be determined directly without computing a temperature correction. The scale readings of the meter indicate directly the conductance at 20° C. in terms of reciprocal megohms; that is, specific conductance is the reciprocal of specific resistance and the unit used for the calibration of the scale of this instrument is the reciprocal of one megohm. A reading of one on this scale indicates that a cube of water having a dimension of one centimeter on each edge offers an electrical resistance of one megohm, or one million ohms. A series of comparisons with a more elaborate and more accurate instrument shows that the limit of error of the Dionic Water Tester used for these determinations does not exceed 5 per cent; usually it falls between 0 and 3 per cent.

Table IX gives a summary of the general results obtained for the surface waters of the 530 lakes. This table is based on 1113 observations of which 284 were single determinations on a lake, leaving 829 readings for the other 246 lakes. The number of observations on each of the latter group of lakes ranged from 2 to 14; the maximum number (14) was taken on Trout Lake and Weber Lake was second with 10. Where more than one reading was made on the surface water of a lake, the mean of the various results obtained on it was used in assigning it to a group.

The 5–9 conductivity group includes 35 lakes in which the conductance did not exceed 9 reciprocal megohms. A minimum reading of 6 was noted in the Cardinal Bog, a small bog pond in which the open water is only about 20 or 25 m. in diameter. Five surface samples were taken in this bog between 1926 and

TABLE IX

The conductivity or specific conductance of the seepage and drainage lakes of northeastern Wisconsin. The results for specific conductance are expressed in terms of reciprocal megohms resistance at a temperature of 20° C. Based in surface samples.

Range of specific conductance	Seepage Lakes		Drainage Lakes		Total	Mean specific conductance
	Number	Per cent	Number	Per cent		
5—9	34	14.29	1	0.34	35	8.3
10—14	126	52.94	5	1.71	131	12.1
15—19	45	18.91	14	4.80	59	17.1
20—24	11	4.62	14	4.80	25	21.9
25—29	7	2.94	6	2.05	13	27.1
30—34	4	1.68	16	5.48	20	32.4
35—39	6	2.52	18	6.17	24	37.1
40—44	3	1.26	21	7.19	24	42.2
45—49	2	0.84	16	5.48	18	47.0
50—54	0	----------	22	7.54	22	52.3
55—59	0	----------	23	7.88	23	56.5
60—64	0	----------	30	10.80	30	62.3
65—69	0	----------	36	12.33	36	66.9
70—74	0	----------	19	6.51	19	72.0
75—79	0	----------	16	5.48	16	76.4
80—84	0	----------	7	2.39	7	82.0
85—89	0	----------	10	3.42	10	87.0
90—94	0	----------	7	2.39	7	93.0
95—99	0	----------	4	1.37	4	96.5
100—124	0	----------	7	2.39	7	107.7

1931; two samples gave readings of 6, two were 7 and one was 8. These were the only readings as low as 6. Three other surface samples gave readings of 7 and 17 were recorded as 8; the other lakes and bogs in this group gave readings of 9. The small amount of electrolytes in this first group can be more fully appreciated by a comparison with distilled water; in ordinary distilled water obtained from a metal still the conductance will range from 3 or 4 up to 9 reciprocal megohms, while glass distilling apparatus must be used and other precautions must be taken in order to reduce the conductance of the distilled water below 3. Thus the amount of electrolytes in the lakes belonging to the first group is not much larger than that of ordinary distilled water.

In the second group of lakes the specific conductance falls between 10 and 14; the maximum number of lakes, namely 131, is found in this group. The third group, ranging from 15 to 19, ranks second in the number of lakes and the 65–69 group is third with 36 lakes; the first group is next in order with 35 lakes. The number of lakes falls to 13 in the 25–29 group and then rises to 36 in the 65–69 group; following the latter the number falls to 19 lakes in the 70–74 group and then to 4 in 95–99 group. Only 7 lakes were found that showed specific conductances of 100 or more and they are included in the 100–124 group. A maximum conductance of 132 was noted in the surface sample of Wild Cat Lake on July 11, 1926, but the mean of 7 readings taken on this lake at different times, chiefly in different summers, is 120. A large percentage of the lakes, however, belong to the low conductance groups; that is, more than 42 per cent of them are found in the first three groups in which the conductance does not exceed 19 reciprocal megohms. The last column in Table IX shows the mean conductance of the various groups of lakes; it rose from 8.3 in the 5–9 group to 96.5 in the 95–99 group and to 107.7 in the 100–124 group.

Figure 6 shows the distribution of the seepage and drainage lakes in the various groups; the unshaded part of each column represents the number of seepage lakes in the group and the solid black part shows the number of drainage lakes. This figure serves to bring out more clearly than the table the fact that the waters of most of the seepage lakes contain only small amounts of electrolytes. The conductivity of 34 of them, which is more than 14 per cent of those belonging to this class, did not exceed 9; that of 126 lakes, or 53 per cent of the total number of seepage lakes, fall in the 10–14 conductance group and 45, or about 19 per cent of them, belong to the 15–19 group. Thus the conductivity of 86 per cent of the 238 seepage lakes did not exceed 19, leaving only 14 per cent of them with higher conductivities. The number of seepage lakes in the 20–24 group falls to 11, or a little less than 5 per cent of the total number; beyond this group the number of seepage lakes declines to 2 in the 45–49 group, with none in the higher conductivity groups. The two lakes in the 45–49 group are Forest and Laura, with mean conductances of 46 and 47 respectively. While these two bodies of water are typical seepage lakes, their waters seem to obtain a fair amount of electrolytes from their limited drainage basins. Likewise the three seepage lakes in the 40–44 conductivity group are typical land-locked lakes, but in spite of this fact their

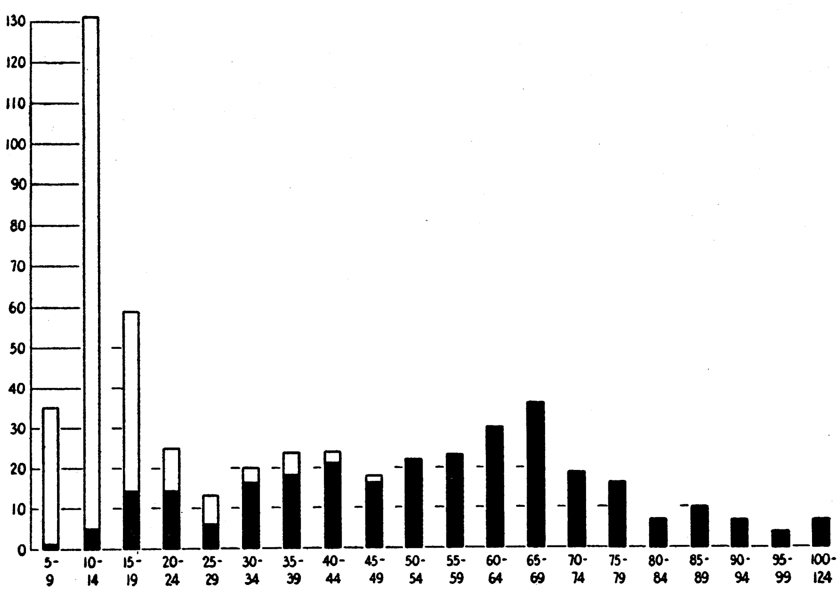


FIG. 6. This diagram shows the grouping of 530 lakes on the basis of the specific conductance of their surface waters. The vertical spaces show the number of lakes in the various conductance groups, ranging from those with a specific conductance of 5–9 up to those with 100–124. The unshaded part of each column represents the seepage and the solid black part the drainage lakes; 238 of the former and 292 of the latter are included. The 10–14 group contains 53 per cent of the seepage lakes.

waters also contain a moderate amount of electrolytes. Muskellunge Lake possesses a small outlet when the water reaches an unusually high stage, but Anderson and Blue lakes do not have any visible outlets.

The solid black part of the columns in Figure 6 shows the distribution of the drainage lakes in the various specific conductance groups. They are more widely distributed throughout the conductance range of the lakes in this Highland Lake District than the seepage lakes, so that there is a much smaller number in the maximum group of the former class than in that of the latter. The number of drainage lakes in the various conductivity brackets rises from 1 in the 5–9 group to 36 in the 65–69 group; beyond the latter the number falls to 19 in the 70–74 group and then declines more or less regularly to 4 at 95–99, with 7 lakes ranging from 100 to 120. The 60–64 group ranks second with 30 drainage lakes and 55–59 is third with 23. The wide distribution of the drainage lakes is well shown by the fact that the maximum of 36 constitutes only a little more than 12 per cent of the total number in this class, namely 292, while the maximum of 126 seepage lakes in the 10–14 group makes up 53 per cent of the total number belonging to that class, namely 238.

The only drainage lake in the 5–9 conductance group is a small body of water known as Bass Lake which is situated near the Woodruff fish hatchery. Its mean conductivity for 5 determinations is just a little more than 9 with a range of 8 to 10. Only a small intermittent stream flows out of this lakelet, so that it is essentially a seepage lake. The 5 drainage lakes in the 10–14 group are situated at the heads of small streams and they have rather small drainage basins with no regular inlets. Three of these lakes are situated at the southern limit of the lake region which has been included in these investigations and the other two are toward the northern edge of the district. All except one of the 14 drainage lakes included in the 15–19 group are situated in the northern half of the lake district, while one, Summit Lake, lies at the southern edge.

Three of the 4 lakes in the 95–99 group are situated in the northern part of the lake district which is occupied by the Winegar moraine and the ground water of this moraine contains a rather large amount of electrolytes. The fourth lake belonging to this group lies a short distance south of the region occupied by this moraine. Five of the 7 drainage lakes having conductances of 100 or more lie within the Winegar moraine or near its southern edge; the other two lakes of this group are situated in the vicinity of the Muskellunge moraine. Six of the lakes belonging to this group, namely Dollar, Little Martha, Mann, Twin Island, Van Vliet, and Wild Cat, are shallow, the maximum depth not exceeding 14 m., and they receive relatively large amounts of spring water. Presque Isle Lake, on the other hand, has a maximum depth of 29 m. and receives only a small amount of spring water in comparison with its volume.

Seasonal and Annual Variations in Conductance

Ruttner (1914) found that the specific conductance of the surface water of Lower Lunz Lake showed considerable seasonal variation; minimum readings were obtained in May and maximum readings in autumn and winter. No attempt has been made to follow the seasonal changes in the specific conductance of the waters of these northeastern lakes throughout an entire year, but observations have been made on the surface waters of 17 of them at other times than the summer season. The results of these determinations are given in Table V. In Allequash, Mann and Island lakes the same conductivity readings were obtained in April and July. In Diamond Lake, a slightly higher conductance was noted in July than in April. In 12 lakes the summer readings were lower than those obtained in April; the difference ranged from a minimum of 1 unit in 4 instances to a maximum of 7 units in Trout Lake. Wolf Lake was second with a decrease of 6 and Silver was third with a decline of 5 reciprocal megohms. In Fishtrap Lake the conductance was 18 units higher in July than in February.

Ruttner (1921) found that Elodea and other aquatic plants produce a more or less marked decrease in the electrolyte content of water through their photosynthetic activities. In the process of assimilation these plants remove some of the half-bound carbon dioxide from the bicarbonates, especially that of calcium, and thereby form calcium carbonate which readily precipitates because it is only slightly soluble in water. This loss of calcium carbonate results in a decrease of the specific conductance of the water.

Large aquatic plants are scarce in the majority of the northeastern lakes on which these seasonal conductivity observations were made, so that they did not play any important rôle in producing the decrease in those lakes that showed this phenomenon. On the other hand, Allequash and Mann lakes possess rather large crops of these plants, but the conductance readings in them were the same in April and July, while Wolf Lake, which produces a crop of about the same size as the former, showed a decrease in conductance between April and July. The decrease in conductance noted in Trout Lake can not be attributed to the large aquatic plants, because it has such a small crop of them. Thus the data in hand at present do not suggest any explanation of these decreases noted in the specific conductance between April and July. Seasonal differences in precipitation may be a factor, but no data on the precipitation in the vicinity of these lakes have been obtained up to the present time.

Decreases in conductance during the summer months have been observed in the surface water of Trout Lake. In 1928 for example, a reading of 84 was obtained on June 24 and 76 on August 25. Only a small summer decrease was noted in 1930 when the surface reading was 70 on June 30 and 69 on August 22. In 1927 on the other hand, a reading of 80 was obtained on June 24 and 82 on August 20. In 1931 the specific conductance of the surface water of Silver Lake fell from 58 on July 25 to 55 on August 28, while in 1926 it was 68 on July 8 and 66 on August 19.

Some of the lakes on which conductance readings have been made for 3 to 6 different summers show very little or no variation from year to year, while considerable differences have been noted in others. In Armour Lake for example, the conductivity of the surface water was 38 in 4 different summers in the month of July, 1927 to 1930 inclusive. The same conductance was obtained in the surface waters of Buffalo, Carlin, Ike Walton and Little Rudolph lakes and in Little Star Bog for 3 to 4 different summers; these are seepage lakes which are not greatly affected by inflowing water, but Armour Lake has a small stream flowing through it. In all of the other lakes which have been visited for 3 different summers or more, the conductivity of the surface water was not the same for the various years. Minimum differences of 1 unit were found in Finley and Pallette lakes, both of which belong to the seepage type. The maximum annual variation was noted in Turtle Lake; during the 4 summers in which observations were made on this lake, the conductivity of the surface water varied from a minimum of 80 on July 17, 1930 to a maximum of 100 on July 2, 1929. Differences of 18 units were found in 3 other lakes. In Allequash Lake the readings fell between 60 and 78 in 5 different summers, in Carroll Lake between 80 and 98 in 5 different summers and in Wolf Lake between 90 and 108 in 6 summers. The 4 lakes with maximum annual variations in conductivity belong to the drainage type and all of them are relatively shallow, so that the affluents of these lakes undoubtedly play an important rôle in the production of these variations.

In two other lakes the annual difference in conductivity amounted to 17 units; Arbor Vitae ranged from 61 to 78 in 4 summers and Wild Cat from 115 to 132 in 7 different summers. Both of these lakes also belong to the drainage class. In the majority of the lakes on which conductance observations were made for 3 summers or more, the differences in the readings did not exceed 6 to 8 units in those having rather high conductivities and 2 to 3 units in those with low conductances; thus the quantity of electrolytes in the surface waters of the majority of the northeastern lakes may be regarded as fairly constant from year to year.

Vertical Distribution of Electrolytes

The various chemical and biological processes that take place in a lake during the summer period of stratification have a marked effect upon the vertical distribution of the electrolytes in some lakes, while in others there is very little or no change in distribution throughout this season. Representative sets of readings which show the range of variation in vertical distribution in 14 lakes are given in Table VII. In Big Carr, Clear, Crystal, Fence, Weber, and Yawkey lakes the conductivity readings were substantially the same from surface to bottom; in some instances the surface and the bottom were the same, while in others the bottom was only 1 or 2 units higher than the surface. All of the bottom samples were taken 1 m. above the mud. In other lakes, such as Black Oak, Dead Pike and Long Lakes, the differences were somewhat larger, the bottom readings being 3 to 4 reciprocal megohms higher than the surface, or in some series as much as 5 or 6. In 11 series which have been taken on Trout Lake the maximum difference between surface and bottom has not exceeded 5, and in most of them it has been between 2 and 4 reciprocal megohms. In the three series taken on Presque Isle Lake, the conductivity of the bottom water (28 m.) was between 5 and 9 points higher than that of the surface; on August 11, 1927, for example, the surface reading was 111 and the bottom 120, and on August 9, 1928 the respective readings were 108 and 113.

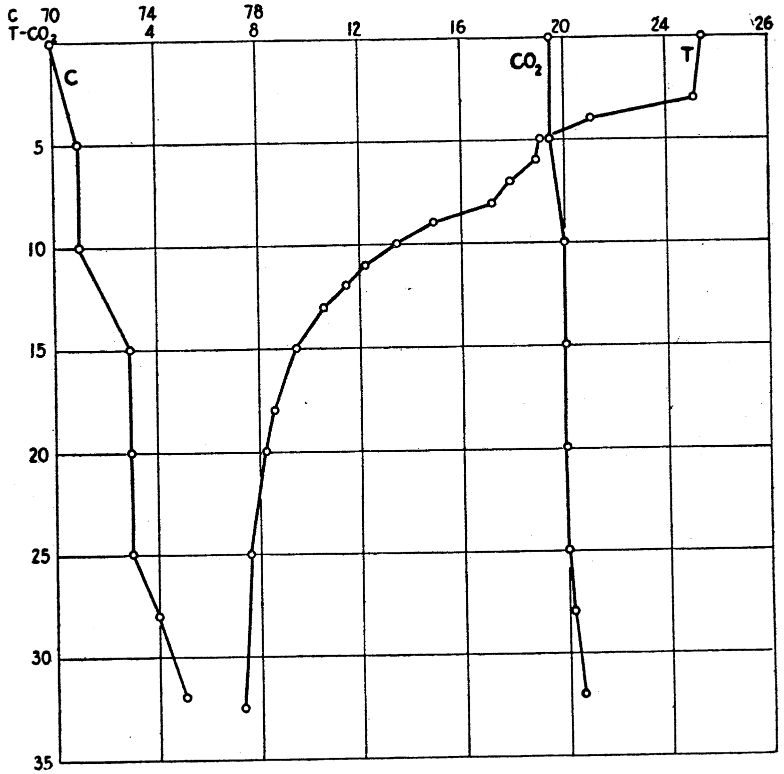


FIG. 7. Vertical distribution of temperature *(T)*, specific conductance *(C)* and fixed or bound carbon dioxide (CO_2) in Trout Lake on July 1, 1931. The upper scale shows the specific conductance in terms of reciprocal megohms; the lower scale shows the temperature in degrees centigrade and the fixed carbon dioxide in milligrams per liter.

The maximum difference between surface and bottom conductivities was noted in Wild Cat Lake where a reading of 128 was obtained at the surface and 179 at the bottom on August

24, 1926, thus making a difference of 51 units; a difference of 33 was found in two other series taken in this lake.

In the Cardinal Bog there was a twofold difference, the surface water having a specific conductance of 6 and the bottom (5 m.) sample 12. There was almost a threefold difference in Lake Mary; the surface reading was 21 and the bottom (21 m.) 59 on July 11, 1928. In three other series the difference was more than twofold. More than a twofold difference was found in Nebish Lake where the conductivity of the surface water was 18 and that of the bottom (14 m.) was 43 on August 29, 1931. In another series the readings ranged from 18 at the surface to 37 at the bottom; in three additional series, however, the differences were less than twofold.

Another type of difference may be mentioned in this connection. In several lakes a slightly higher conductivity reading was obtained at the surface than at depths of 3 to 5 m. These differences have never exceeded one unit on the meter of the Dionic Water Tester, but they show distinctly and they have

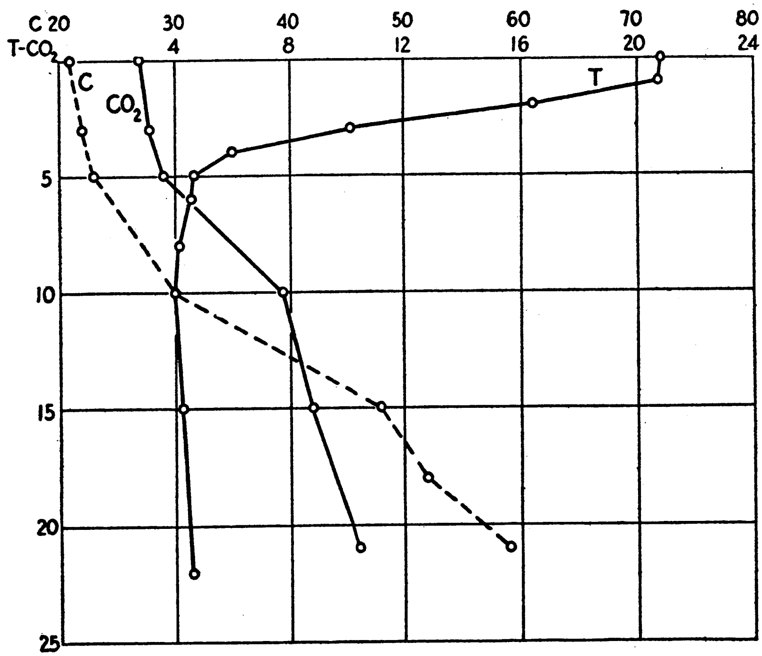


Fig. 8. Vertical distribution of temperature, specific conductance and fixed or bound carbon dioxide in Lake Mary on July 11, 1928. (See Fig. 7 for further explanations).

been observed by three different individuals who have taken conductivity readings at various times. No explanation has yet been found for this phenomenon. Ruttner (1914) obtained similar results on Lower Lunz Lake, but in a number of cases he obtained greater differences than those noted on the Wisconsin lakes.

The vertical distribution of the electrolytes is shown graphically in four diagrams which represent the different kinds of distribution except that in which they are uniform from surface to bottom. Figure 7 shows the results obtained on Trout Lake on July 1, 1931 when the specific conductance ranged from 70 at the surface to 75 reciprocal megohms at the bottom (32 m.). This lake represents the class in which the difference between surface and bottom conductivities is comparatively small; lakes with smaller differences are not included in the diagrams, but they are indicated in Table VII. The diagram shows that there was only a small increase in the quantity of fixed or bound carbon dioxide in the lower water of Trout Lake correlated with the small increase in conductance.

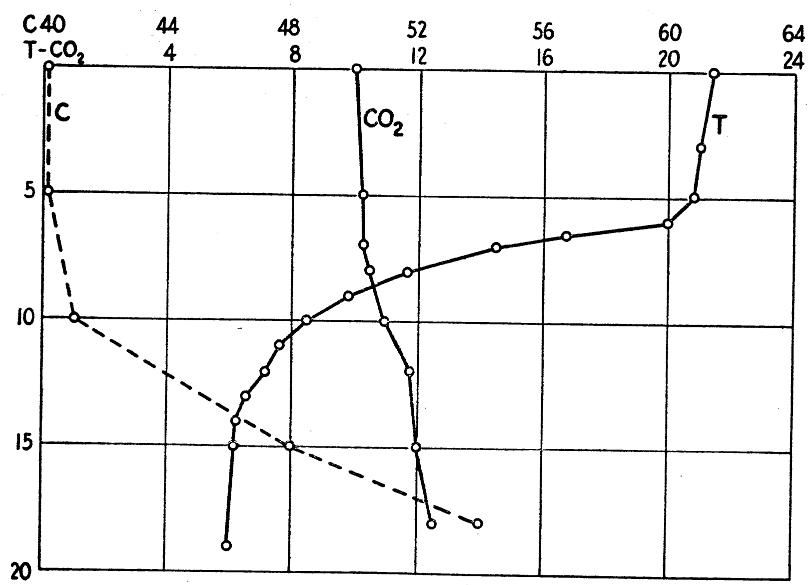


FIG. 9. Vertical distribution of temperature, specific conductance and fixed or bound carbon dioxide in Anderson Lake on August 8, 1929. (See Fig. 7 for further explanations).

Figure 8 shows the results obtained in Lake Mary on July 11, 1928. The specific conductance of the water ranged from 21 at the surface to 59 at the bottom (21 m.), while the fixed or bound carbon dioxide rose from 2.8 mg/l at the surface to 10.5 mg/l at the bottom, representing nearly a fourfold difference. In Anderson Lake (Figure 9) the conductivity increased from 40 at the surface to 54 reciprocal megohms at the bottom (18 m.), while the fixed carbon dioxide was 10 mg/l at the former and 12.5 mg/l at the latter depth. Thus the fixed carbon dioxide did not show as great an increase as the conductance, but an increase in the quantity of iron in the lower water undoubtedly played a rôle in increasing the conductance in this stratum; the amount of iron found in the water of Anderson Lake on August 8, 1929 increased from 0.2 mg/l at the surface to 7 mg/l at 18 m.

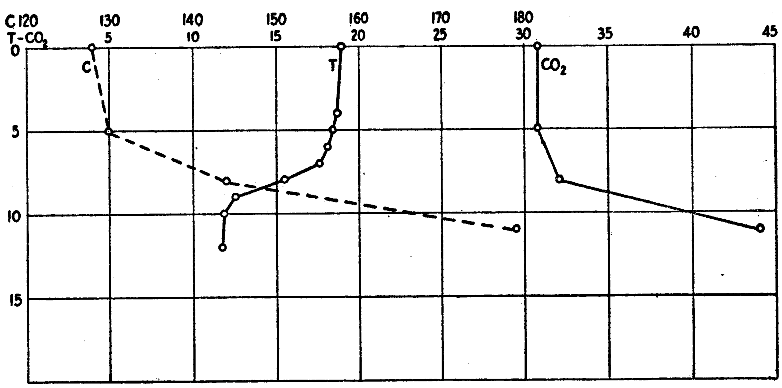


Fig. 10. Vertical distribution of temperature, specific conductance and fixed or bound carbon dioxide in Wild Cat Lake on August 24, 1926. (See Fig. 7 for further explanations).

The maximum difference of 51 reciprocal megohms noted in Wild Cat Lake on August 24, 1926 is represented in Figure 10. In this series the specific conductance rose from 128 at the surface to 179 at the bottom (11 m.); this increase in conductance was correlated with an increase in the bound carbon dioxide which ranged from 30.8 mg/l at the surface to 44.1 mg/l at the bottom.

Specific Conductances of Lake and Ground Waters

For the purpose of comparing the physical and chemical characteristics of the ground water of this lake district with those of the various lake waters, samples were obtained from 107 wells and 3 springs during the summer of 1931. These wells and springs are located on the shores of 54 lakes, except that 4 of the wells are a kilometer or two from the nearest lake. Only a single well sample was taken in the vicinity of each lake in 33 cases, while from 2 to 22 samples were taken from wells and springs on the shores of each of the other 21 lakes. The largest number of well samples, namely 22, was obtained from the shores of Trout Lake and Plum Lake was second with 8 samples. The number of well and spring samples for the other 19 lakes varied from 2 to 4.

The results obtained on some of these well and spring waters are given in Table X. In this table the wells and springs which are located on the immediate shores or in the vicinity of the various lakes follow the results given for the surface waters of the several lakes. The depths of most of the wells were ascertained and they are represented in the table; they ranged from

TABLE X

Specific conductance of lake and ground waters. The latter consist of samples of water obtained from wells and springs situated on the shores or in the vicinity of the various lakes.

Lakes and wells	Depth of wells in meters	Specific conductance in reciprocal megohms
Ballard Lake	----------	61
Rismon's House	19.5	43
Rismon's Laundry	20.7	43
Big Carr Lake	----------	12
Big Carr Resort	19.5	38
Tappawingo Resort	11.6	65
Crooked Lake	----------	16
Camp Nawakwa	7.6	65
Crawling Stone Lake	----------	58
Yeschek's Resort	8.5	27
Finley Lake	----------	13
Pinehurst	10.7	26
Fishtrap Lake	----------	70
Engel's Resort	32.0	44
Kenilworth	7.9	50
Meyer	6.7	32
Hanchett Lake	----------	12.5
Cypress Lodge	9.1	26
High Lake	----------	85
Blaisdell	8.5	49

TABLE X—Continued

Lakes and wells	Depth of wells in meters	Specific conductance in reciprocal megohms
Stevens Spring	----------	100
Horsehead Lake	----------	53
Sahlin	6.1	200
Spring	----------	160
Ike Walton Lake	----------	14
Chippewa Lodge	11.6	35
Little Bass Lake	----------	12
Cottage	11.3	180
Residence	16.5	50
Little Horsehead Lake	----------	52
Spring	----------	225
Winegar Hotel	8.5	550
Little St. Germain Lake	----------	57
Sisson's Resort	12.0	17
Lost Lake	----------	65
Baer's Resort	6.0	26
McDonald Lake	----------	13
River Forest	13.0	32
Muskellunge Lake (E. R.)	----------	47
Everett's Resort	18.3	490
Nokomis Lake	----------	39
The Pines Resort	7.0	18
North Two Lake	----------	7
Bluebird Resort	11.6	39
Oswego Lake	----------	13
Barn well	6.4	35
Plum Lake	----------	67
Camp Highlands	6.4	107
Public Camp Site	9.1	80
Ranger Station	12.2	98
Sayner's Resort	4.0	68
Sunny Crest	13.7	49
Trails End	7.6	53
Warner's Resort	8.5	175
Wolff's Cottages	6.1	33
Star Lake	----------	58
Hanson's Resort	6.1	60
Oie's Point	18.3	51
Oliver Lodge	19.8	100
Post Office well	10.7	58
State Line Lake	----------	69
Spring	----------	225
Tomahawk Lake	----------	69
Camp Minocqua	12.2	80
Gahler's well	----------	64
Hodgdon's well	22.5	76
Pottawottamie Club	9.1	50
Trout Lake	----------	70

TABLE X—Continued

Lakes and wells	Depth of wells in meters	Specific conductance in reciprocal megohms
Armour Camp	9.1	60
Blaisdell	6.7	120
Camp Franklin	3.4	68
Cardinal	7.9	73
Forestry Barn	9.1	87
Forestry House	25.3	121
Hart	13.7	62
Heinemann	————	87
Kern	6.0	22
Laboratory	4.5	72
Latimer	21.3	105
McClain	22.5	100
Meade	————	33
Murphy	7.6	40
Point Camp	4.0	60
Red Arrow Camp	5.2	150
Red Crown Lodge	————	105
Richardson	9.1	33
Rocky Reef—Driven	5.8	270
Rocky Reef—Drilled	17.4	160
Sand Beach	————	101
Smith Cottage	————	73
Wild Cat Lake	————	120
Wild Cat Inn	12.2	225
Ranger Cabin	23.2	98
Wohelo Lake	————	12
Cottage well	6.1	58

a minimum of 3.3 m. to a maximum of 45.7 m., so that they represent only the upper strata of the ground water.

The specific conductance of these well and spring waters varied from 17 to 550 reciprocal megohms. The lowest conductivity for these ground waters (17) was noted in a sample from the well of Sisson's Resort; this well is located on the shore of Little St. Germain Lake and it is 12.2 m. deep. The average conductivity of the surface water of this lake is 57 which is more than three times as great as that of the resort well. The second lowest conductance was found in a sample of water taken from a well 7 m. deep at The Pines Resort on Nokomis Lake; this well water gave a reading of 18 and that of the neighboring lake water was 39, or more than twice as large as that of the well. The third in order of low conductivity is Hart's well on the south shore of Trout Lake, with a specific conductance of 22. Next in order are three wells with readings of 26. They are the wells at Cypress Lodge on Hanchett Lake, at Pinehurst on Finley Lake and at Baer's Resort on Lost Lake; the mean conductivities of the surface waters of these three lakes are 12, 13 and 65 respectively. Thus the conductivities of the first two well waters are twice as large as those of the lakes on which they are situated, while the third one is less than half as large as that of the lake on which it is situated.

The highest specific conductance, namely 550 reciprocal megohms, was found in a sample from the hotel well in the village of Winegar; this well is 8.5 m. deep and it is about 150 m. from the edge of Little Horsehead Lake whose surface water has a conductivity of 52, or less than one-tenth as much as that of the well. The water of a small spring on the shore of this lake gave a reading of 225, while another spring about a kilometer from this one, but situated on the shore of Horsehead Lake, gave a reading of 160. The second highest conductivity was found in the water of a well 18.3 m. deep at Everett's Resort on Muskellunge Lake, which is one of the Eagle River chain of lakes; it gave a reading of 490 as compared with 47 for the surface water of the lake, which is more than a tenfold difference.

The local variations in the specific conductance of the ground water is well illustrated by the results for the 22 wells situated on the shores of Trout Lake. Seven of these wells are located on the west shore of this lake, 6 on the south shore and 9 on the east and north shores. Their depths range from 3.4 to 25.3 m. The conductivity of their waters varied from 22 to 270 reciprocal megohms. The mean conductance of the surface water of the lake is 70, so that the minimum is less than one-third as much as that of the lake and the maximum is nearly four times as large. The mean of the 22 well waters is 94 as compared with 70 for the surface water of the lake.

Marked differences in conductivity were found not only between wells that are 3 or 4 kilometers from each other, but also between wells that are less than 100 m. apart. The Meade well, on the west shore of the lake, gave a conductivity reading of 33 and the Red Arrow well, also on the west shore, about 1.5 km. from the former, a reading of 150. In 4 wells situated between these two, the conductance ranged from 40 to 105. The Blaisdell well on the east shore of the lake is a little over 3 km. from the Meade well and its water has a specific conductance of 120 and that of the McClain well on the north shore gave a reading of 100. A striking difference between wells that are near each other is shown by two at the Rocky Reef Resort on the south shore of Trout Lake. One of them is a driven well 5.8 m. deep which is located about 30 m. from the edge of the lake and the other is a drilled well which is about 120 m. from the edge of the lake and which is 17.4 m. deep. The specific conductance of the driven well was 270 and that of the drilled well was only 160, yet these two wells are only about 90 m. apart.

It is worthy of note that the Meade well and the Richardson well, both of which showed a conductivity of 33, are situated at opposite ends of Trout Lake, the former at the southwest corner of the lake and the latter at the northeast corner, so that they are about 7 km. apart.

Samples were taken from 8 wells on the shores of Plum Lake, 4 on the north and 4 on the south shore. In depth these wells ranged from 3.7 to 13.7 m.; the specific conductance of their waters varied from 33 to 175 reciprocal megohms. The wells having the minimum and maximum amount of conductance are both situated on the north shore of Plum Lake and the two wells located between them gave readings of 98 and 107. The 4 wells on the south shore ranged from 49 to 80 reciprocal megohms. The mean conductance of the surface water of Plum Lake is 67, so that the minimum reading for the wells is only half as much as that of the surface water and the maximum of the wells is a little more than two and a half times as large as that of the lake.

The conductivity of 4 wells at Star Lake ranged from 51 to 100 and that of the surface water of the lake was 58. Three well waters at Fishtrap Lake varied from 32 to 50 in comparison with 70 for the surface water of the lake. Two well waters at Ballard Lake gave conductivity readings of 43, while that of the surface water of the lake was 61.

Two well samples were taken on the shores of a lake whose water has a low conductance and one well sample from each of 11 other lakes of this type were obtained. The specific conductance of these 12 lake waters fell between 7 and 19 reciprocal megohms, while that of the wells on their respective shores varied from 26 to 180. In all cases the conductivity of the well waters was from 2 to 15 times as large as that of the corresponding lake waters. The maximum difference was noted in Little Bass Lake where the conductance of the lake water was 12 and that of the well water was 180. In the other 11 lakes the differences fell between twofold and a little more than fivefold. Big Carr, Crooked, Finley, Ike Walton, McDonald and Oswego lakes are representatives of this group.

In the lakes with higher conductivities the differences between lake and well waters are variable. In some instances the lake waters have a higher specific conductance than the corresponding well waters, in others they have a lower conductance, while in still other cases some of the well waters have a higher conductivity than the lake waters and some a lower conductance as noted in Trout and Plum lakes. The data now in hand show that there is no direct correlation between the quantity of electrolytes in the ground water and that in the lake water. These local variations in the amount of electrolytes in the ground waters are due undoubtedly to similar variations in the electrolyte content of the glacial deposits found in this region, chiefly differences in the amount of calcium and magnesium carbonates present in them.

The specific conductance of three of the Trout Lake wells was obtained again in 1932. That of the Blaisdell well was the same in 1932 as in 1931, namely, 120 reciprocal megohms. The Meade well gave a reading of 33 in 1931 and 37 in 1932, while the Point Camp well was 60 in 1931 and 66 in 1932.

Conductance and Fixed or Bound Carbon Dioxide

The relation between the specific conductance of the surface waters of the northeastern lakes and the amount of fixed or bound carbon dioxide in them is given for the various conductivity groups in Table XI. In order to indicate the range of variation in the amount of carbon dioxide found in the different groups, the minimum, maximum and mean amounts are indicated in the table. There is a rather wide range of variation in the amount of carbon dioxide in the different conductance groups, but the means obtained for the various groups show a fairly regular increase in the quantity of bound carbon dioxide correlated with the increase in conductivity. These fixed carbon dioxide means rise from 1.4 mg/l in the 5–9 conductivity group to 23.2 mg/l in the 90–99 group and to 26.2 mg/l at 100–124.

There is a little more than a threefold difference between minimum and maximum amounts of carbon dioxide in the 5–9 conductivity lakes, a nineteenfold difference at 10–14 and an eightfold one at 15–19. The difference falls to a little more than twofold in the 30–34 group and it is less than twofold in the groups which have higher conductivities and larger amounts of bound carbon dioxide. The largest actual difference between minimum and maximum amounts is found in the 75–79 and the 100–124 groups, namely 11 mg/l in each case; the smallest difference is found in the 5–9 group, namely 1.8 mg/l.

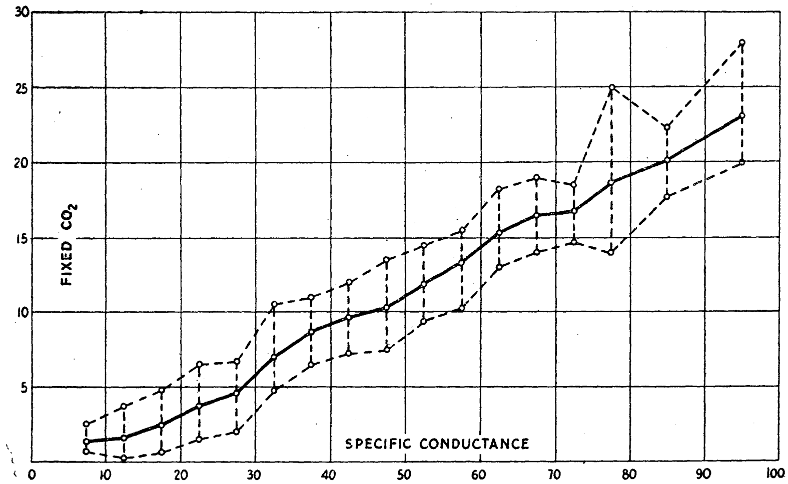


FIG. 11. This diagram shows the relation between the specific conductance of the surface waters and their fixed or bound carbon dioxide content. The upper broken line curve represents the maximum amounts of carbon dioxide in the various conductance groups and the lower one the minimum amounts; the solid line curve between them shows the mean quantities of fixed carbon dioxide in the different groups. The diagram shows the results obtained on 530 lakes. (See Table XI).

Figure 11 shows graphically the general increase of the mean quantity of fixed carbon dioxide correlated with the increase in conductivity. This diagram represents the results obtained on 523 lakes; the 7 lakes with conductivities of 100 or more cover such a wide range that they were omitted from the diagram. The curve represented by a solid line indicates the mean amounts in the various groups and it shows clearly the general rise in the amount of bound carbon dioxide corresponding to the

TABLE XI

Correlation between the specific conductance of the surface waters of the various lakes and the quantity of fixed or bound carbon dioxide. The amount of carbon dioxide is indicated in milligrams per liter of water. See Fig. 11.

Conductivity range	Number of lakes in group	Fixed or bound carbon dioxide		
		Minimum	Maximum	Mean
5—9	35	0.7	2.5	1.4
10—14	131	0.2	3.8	1.6
15—19	59	0.6	4.8	2.5
20—24	25	1.5	6.5	3.8
25—29	13	2.0	6.7	4.6
30—34	20	4.8	10.5	7.1
35—39	24	6.5	11.0	8.7
40—44	24	7.3	12.0	9.7
45—49	18	7.5	13.5	10.2
50—54	22	9.4	14.5	11.9
55—59	23	11.3	15.5	13.3
60—64	30	13.0	18.3	15.4
65—69	36	14.0	19.0	16.4
70—74	19	14.7	18.5	16.8
75—79	16	14.0	25.0	18.7
80—89	17	17.8	22.3	20.2
90—99	11	20.0	28.0	23.2
100—124	7	20.5	31.5	26.2

increase in conductivity. The upper curve, represented by a broken line, shows the maximum amounts of fixed carbon dioxide in the various groups and the lower curve consisting of a broken line shows the minimum amounts. An average of the whole series of observations included in Table XI indicates that an increase of 10 units in conductance is correlated with an increase of approximately 2.3 mg/l in the bound carbon dioxide. While the individual conductivity readings on a given lake do not always vary directly with the relatively small changes in the quantity of fixed carbon dioxide from year to year, they show a general shift in correlation with the more marked changes in the latter.

Conductance in Relation to Calcium and Magnesium

Analyses show that calcium and magnesium are the most important electrolytes in these lake waters. On the gravimetric basis calcium is generally found in somewhat larger amounts than magnesium; the average for 292 samples of surface water gives a ratio of 1.5 Ca to 1 Mg. Owing to the differences in their atomic weights and in their equivalent conductances, the two are substantially equal in importance in so far as specific conductance is concerned. That is, the differences in atomic weight and in equivalent conductance make it necessary to multiply the quantity of magnesium by the factor 1.47 in order to give it the same conductance value as the calcium and all of the magnesium results were multiplied by this factor before they were added to the calcium.

The general results for the relation between the specific conductance of the surface waters of the various lakes and the amount of calcium and magnesium in them are given in Table XII, where the minimum, maximum and mean amounts of these two substances are indicated for the different conductance groups. The results are also shown graphically in Figure 12.

Both the table and the diagram show rather wide differences between the minimum and maximum amounts of calcium and magnesium in the different conductance groups. There is al-

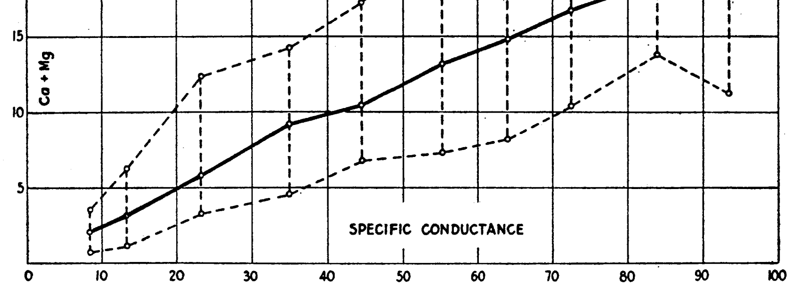


Fig. 12. Diagram showing the relation between the specific conductance of the surface waters and the amount of calcium and magnesium present in them. The upper broken curve represents the maximum amounts of calcium and magnesium and the lower one the minimum amounts in the various conductance groups; the solid line curve between them shows the mean amounts in the various conductance groups. The diagram includes the results for 292 lakes. (See Table XII).

TABLE XII

Relation between specific conductance and the quantity of calcium and magnesium present. The quantity of magnesium has been multiplied by the factor 1.47 before adding it to the calcium in order to give it a conductance value equal to that of calcium. The results are thus expressed in terms of milligrams of calcium per liter of water.

Conductance group	Number of lakes	Calcium and magnesium		
		Minimum	Maximum	Mean
0—9	11	0.64	3.60	2.06
10—19	83	1.04	6.21	3.06
20—29	21	3.34	12.37	5.92
30—39	30	4.58	14.30	9.20
40—49	25	6.74	17.22	10.36
50—59	30	7.32	21.19	13.15
60—69	42	8.14	23.46	14.81
70—79	23	10.31	25.00	16.77
80—89	11	13.86	24.59	18.81
90—99	11	11.19	30.50	19.80
100—120	5	19.63	40.85	25.94

most a sixfold difference between them in the 0–9 group and a similar difference in the 10–19 group. In the other groups the maximum is from two to four times as large as the minimum. In spite of these large variations, the means of the various groups show a general increase in the quantity of the calcium and magnesium correlated with the increase in the conductance of the waters.

The upper curve in Figure 12, consisting of a broken line, connects the points representing the maximum amounts of calcium and magnesium in the different groups; the lower broken line curve represents the minimum amounts. The means of the different groups are represented by the solid line curve between them. The surface waters of 5 lakes gave conductances of 100 to 120, but they are not included in the diagram because they differ too widely to give a fair mean. The area included between the upper and lower broken line curves gives a good idea of the greater range of variation in the maximum and minimum amounts of calcium and magnesium as the specific conductance rises; that is, the distance between these two curves increases in the higher conductivity groups. While the percentile differences between the maximum and minimum amounts of calcium and magnesium are largest in the 0–9 and 10–19 groups, the largest quantitative difference is found in the 90–99 group.

The curve in Figure 11 representing the mean amounts of bound carbon dioxide in the various conductance groups is similar to the one representing the mean amounts of calcium and magnesium in Figure 12, but the former includes 530 lakes while the latter represents only 287. The surface samples on which calcium and magnesium determinations were made, were selected as representatives of the different types of lakes and these results indicate that they are a fair average for the 530 lakes. Attention may be called to the fact that the difference between maximum and minimum amounts of bound carbon dioxide in the different conductance groups is not as large as that of the calcium and magnesium.

The causes of the wide variations in the amount of bound carbon dioxide and of calcium and magnesium in each of the various conductance groups is not known at present. These lake waters contain a great variety of organic and inorganic substances, both in solution and in suspension; some of these substances are electrolytes and others are non-electrolytes and the interactions between these two types of substances may affect the conductance of the water. Some of the electrolytes are doubtless adsorbed by the non-electrolytes and some of the former are in chemical combination with the organic compounds that are present in the water. The problem is a very complicated one and would require a detailed investigation for its solution.

SUMMARY

1. The transparency of the lake waters of northeastern Wisconsin as measured with a Secchi disc ranged from a minimum of 0.3 m. to a maximum of 13.6 m.

2. The transparency decreases with the increase of the brown color of the water and with an increase in the amount of plankton, but the color is a more important factor than the plankton in causing a decrease of transparency. (Figs. 2 and 3.)

3. There is a fairly definite correlation between the transparency of the water and its transmission of solar radiation.

4. The color of these lake waters varied from a minimum of zero to a maximum of 340 on the platinum-cobalt scale.

5. There is a definite correlation between the brown color which is derived chiefly from peat and marsh deposits and the amount of organic carbon in the surface waters. (Fig. 5.)

6. The specific conductance of the surface waters of these lakes varied from a minimum of 6 to a maximum of 132 reciprocal megohms at a temperature of 20° C.

7. The specific conductance is correlated with the quantity of fixed or bound carbon dioxide in the water. (Fig. 11.)

8. The specific conductance is also correlated with the quantity of calcium and magnesium in the surface waters. (Fig. 12.)

Literature

Bancroft, Wilder D. 1919. The Color of water. Jour. Frank. Inst. 187 : 249–271, 459–485. (Chemical News, 118. 1919).

Birge, E. A. and Juday, C. 1929. Transmission of solar radiation by the waters of inland lakes. Trans. Wis. Acad. Sci., Arts & Let. 24 : 509–580.

Birge, E. A. and Juday, C. 1931. A third report on solar radiation and inland lakes. Trans. Wis. Acad. Sci., Arts & Let. 26 : 383–425.

Birge, E. A. and Juday, C. 1932. Solar radiation and inland lakes. Fourth report. Observations of 1931. Trans. Wis. Acad. Sci., Arts & Let. 27 : 523–562.

Evershed, S. 1911. The dionic water tester. 34 pp. London.

Juday, C. and Birge, E. A. 1932. Dissolved oxygen and oxygen consumed in the lake waters of northeastern Wisconsin. Trans. Wis. Acad. Sci., Arts & Let. 27 : 415–486.

Leighton, Marshall O. 1905. Field assay of water. Water-supply and Irrigation Paper No. 151. U. S. Geol. Survey. 77 pp.

Raman, C. V. 1922. On the molecular scattering of light in water and the colour of the sea. Proc. Roy. Soc., Math.-Phys. 101 : 63–80.

Raymond, Percy E. and Stetson, H. C. 1931. A new factor in the transportation and distribution of marine sediments. Science 73 : 105–106.

Ruttner, Franz. 1914. Das elektrolytische Leitvermögen des Wassers der Lunzer Seen. Internat. Revue, Hydrog. Sup. 5 : 1–39.

Ruttner, Franz. 1921. Das elektrolytische Leitvermögen verdünnter Lösungen unter dem Einfluss submerser Gewächse. Akad. Wissensch. Wien, math.-naturw. Kl. 130 : 71–108.

Spring, W. 1897. Sur le rôle des composés ferriques et des matières humiques dans le phénomène de la coloration des eaux, et sur l'élimination de ces substances sous l' influence de la lumière solaire. Bul. Acad. Roy. des Sciences Belgique. 34 (3) : 578–600.

Whipple, George C. 1927. The microscopy of drinking water. Fourth edition. Revised by G. M. Fair and M. C. Whipple. 586 pp.

Whitson, A. R. et al. 1916. Reconnoissance soil survey of north part of north central Wisconsin. Bul. No. 1, Soil series No. 15. Wis. Geol. & Nat. Hist. Survey. 80 pp. 1 map.

ON THE STOPPAGE OF SEWER LATERALS BY ROOTS OF TREES

O. L. KOWALKE

Chemical Engineering Department
University of Wisconsin

In the autumn of 1931 there seemed to be a great many more stoppages of house sewer laterals in the Wingra Park district of Madison, Wisconsin, than in previous years, and the testimony of several plumbers indicated that similar situations could be duplicated throughout the city. Attempts were made to gather statistics relative to the matter from all the plumbers, but the attempts were unsuccessful, and only a few cooperated. The data are unfortunately incomplete. The conditions and implications suggested in the available data, however, are deemed sufficiently interesting to warrant this presentation.

Practically all stopped sewer laterals were glazed vitrified tile with "bell and spigot" connections; and portland cement mortar was usually employed to seal the joints. It is not possible to make an absolutely water tight joint with cement nor is it probable that sound conduits were laid in every instance. Any cracks in the cement seal or in the tile conduit will admit the fine root ends to moisture rich in nitrogenous food.

The stoppages occurred under a wide variety of tree and shrub conditions. Shrubbery close to the house, according to the statements of plumbers was as much to blame as the larger trees. Elms, ash, hackberry, maples hard and soft, box elder, and oaks seemed to be about equally potent in producing stoppages.

Many of the ditches observed in this section were at least 12 feet deep when the laterals were reached.

The available data indicated also that in certain districts of Madison the stoppages were more numerous than in others. The data refer largely to the district west and southwest from the Capitol; only meager data were obtained respecting the area to the east. Investigation of the soil conditions, elevation above the lake level, and of run-off pointed to rather interesting correlations with rainfall and temperatures to root growth.

The plumbing firm X supplied data covering all stoppages for the years 1928, 1929, 1930, and 1931. The data from this firm apply to the west end of Madison and are shown in Table I.

TABLE I

	1928	1929	1930	1931
Total number streets served	17	23	27	37
Total number of cases	36	43	49	83
Streets having most stoppages				
(a) Jefferson	3	5	4	5
(b) Keyes	4	0	0	3
(c) Monroe	5	3	3	6
(d) Van Buren	1	0	0	3
(e) West Lawn	3	6	6	16
Total for these five	16	14	13	33
Percent of these five of all cases..	44.4	32.5	28.9	40.7

The five streets above are in the Wingra Park residence district. The trees are predominantly elms, with some soft maple, some hard maple, some box elder, together with fewer ash and hackberry, and they are about 25 to 30 years old. They are practically all located between the curb and the cement sidewalk, with occasional plantings between the sidewalk and the house, and are spaced so that there are about two trees for a 60-foot lot. There are practically no vacant lots in this area and the streets are all paved with material impervious to water.

The top soil is a loam about two or three feet deep and this is underlain with a glacial till, sandy in character and containing boulders of various sizes.

The firm (Y) supplied data only on the actual replacements of stopped laterals, and these are judged to be incomplete. Table II of these data shows a grouping of cases as to the Uni-

TABLE II

1930	1931	
Univ. Heights	Univ. Heights	South of Chem. Bldg.
(a) Rowley Ave.	(a) Roby Road	(a) W. Dayton
(b) Univ. Ave.	(b) N. Spooner (2)	(b) N. Brooks
(c) N. Allen	(c) Univ. Ave.	(c) N. Charter
(d) Lathrop (2)	(d) Chamberlin	(d) N. Orchard
(e) Arlington		

versity Heights district and that immediately south of the Chemistry Building and Wisconsin Memorial Hospital. There were many other stoppages but in widely separated locations.

In the University Heights district the top soil is a loam about two feet thick. The sub-soil on the north slope is glacial deposit which is rather irregular in composition. One deposit may be sand and the adjacent section be clay, and another be sand and boulders. The sub-soil on the south slope on the west end is largely clay. On the slope toward the east the rock is rather close to the surface. The native trees are largely oaks and the planted ones are elms. There are houses on practically all lots and the streets have been paved for several years.

The firm (Z) furnished data only on replacements and the territory served was largely east of the Capitol. In 1930 there were six replacements and in 1931 there were nine. For every case of replacement there were over two cases where the lateral was "rodded" and the roots cut to make a temporary repair.

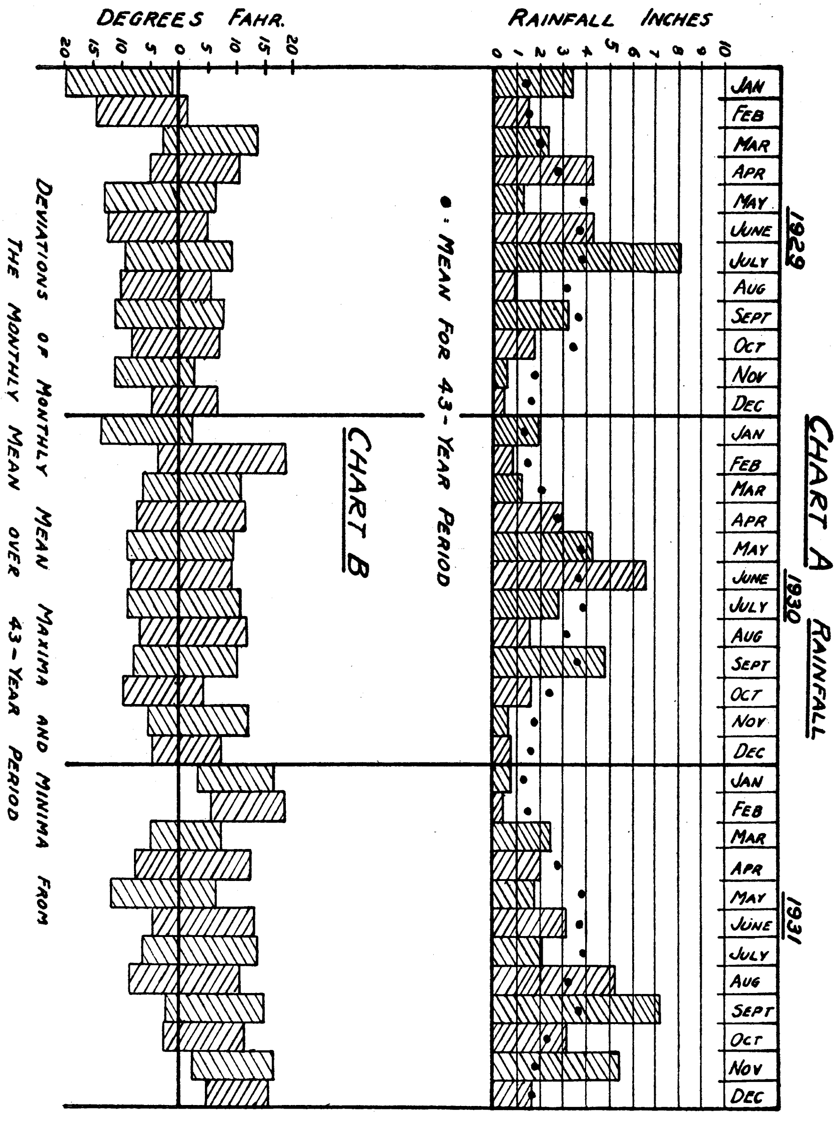
TABLE III

Cases of replacements of sewer laterals (city engineer)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1929....	0	0	4	3	2	3	0	2	5	2	4	4
1930....	2	0	1	3	2	2	3	2	2	1	5	2
1931....	1	2	3	7	3	3	2	2	4	4	2	0
Total...	3	2	8	13	7	8	5	6	11	7	11	6

Data on replacements furnished by the city engineer are given in Table III. These are all under the pavement and outside the curb. It is striking that in the month of April and in the three autumn months, September, October, and November there are the highest number of cases. While the ground is frozen, digging is usually postponed if possible; that will account for the large number of cases in April. The larger numbers of cases in the autumn may be related to the deficiency in rainfall combined with temperature and also to the chances for rainfall to penetrate to the deeper levels.

The office of the U. S. Weather Bureau at Madison furnished the data on rainfall and temperature shown in the Charts A and B. In Chart A the cross hatched areas represent the recorded rainfall in inches for the respective months. The dots represent


DEGREES FAHR.
20 15 10 5 0 5 10 15 20
RAINFALL INCHES
0 1 2 3 4 5 6 7 8 9 10
CHART A RAINFALL
CHART B
• : MEAN FOR 43-YEAR PERIOD
DEVIATIONS OF MONTHLY MEAN MAXIMA AND MINIMA FROM THE MONTHLY MEAN OVER 43-YEAR PERIOD
1929
1930
1931
JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC

the means for those months over a 43-year period. Note that, beginning with August 1929, there is a deficiency in rainfall until April 1930. Following that there is another period of scanty precipitation beginning in October 1930 and lasting through July 1931.

In Chart B are shown the deviations of the mean maxima and minima temperatures from the 43-year mean for the respective months. It is obvious that beginning with November 1930 and continuing through December 1931, the monthly mean is several degrees above the 43-year mean for the corresponding month. Evaporation from the ground may be presumed to have been greater than normal.

Precipitation as rain and snow is divisible into three portions (a) that which is run-off, (b) that caught by roots and transpired through the foliage, and (c) that which passes to the ground water supply.

Because of pavements, sidewalks, houses, and other construction, and because the trees are usually between the sidewalk and the curb, the area through which precipitation can reach the roots is limited. A greater proportion of the precipitation must run off in the cities than in the country. The City engineer when making plans for sewers for residential districts estimates that 40 per cent of the precipitation is run-off. Thus a considerable fraction of the precipitation is lost to vegetation even in wet seasons; in dry seasons with high temperatures during the growing period moisture must be transpired in larger amounts than normal. The U. S. Geological Survey in a Press Notice of February 25, 1932, states that, "As a rule there is little or no replenishment of the ground water supply during the summer and autumn because vegetation makes such heavy demands on soil moisture that the water derived from rains seldom gets beyond the root zone." A deficiency in the ground water can be brought about, (a) if during the dormant period of plants there is a deficiency in precipitation, (b) if the normal run-off is rather large due to structures and to the frozen ground, and (c) if the temperatures during the growing season are high. When the sub-soil is porous and is in elevated locations, the ground water is further depleted, and roots must follow down. Any leaks from sewer laterals into dry porous sub-soil will promote a large growth of root ends.

The data available for this discussion show that the stoppages of sewer laterals due to roots occur mostly in sandy sub-soil or glacial till which is quite apt to be deficient in nitrogen and potash; districts underlain with clay do not seem to give so much trouble.

Since the practice of laying tile sewer laterals luted with Portland Cement mortar, in porous, dry, and lean soil in the cities is quite certain to cause stoppage due to root growth, the preferred construction would be metal conduits having the joints luted with lead. The first cost of the latter might be a little higher, but the chances for stoppages are practically eliminated.

DAILY VARIATIONS IN THE FREEZING POINT OF MILK[1]

H. A. SCHUETTE AND E. O. HUEBNER

Contribution from the Laboratory of Foods and Sanitation, Department of Chemistry, University of Wisconsin.

Following close upon the suggestion of Beckman [*1*] that the freezing point be utilized as a guide in judging a suspected sample of watered milk and the announcement by Winter [*2*] that his cryometric measurements had shown that milk and blood serum are isotonic, there began to appear a literature, now voluminous, on the application of the freezing point as a physiological constant which is admirably suited for the detection of this, perhaps the oldest, form of adulteration of milk. Hortvet [*3*] has reviewed this literature and discussed the general considerations involved in the application of the fundamental principles of cryoscopy to the examination of milk. Briefly stated it appears that the osmotic pressure of milk is due chiefly to those constituents which are present in crystalloid dispersion, and that the freezing-point figure is a gauge of this pressure. The latter is not affected by the presence of the fat and whatever influence the proteins may exert is either negligible or too small for measurement by cryoscopic means. Variations in the proportion of any one of the soluble constituents must be accompanied by a change in the concentration of another constituent to the end that the proper osmotic pressure may be maintained.

Since it is quite generally accepted that the freezing point is the least variable of the so-called physical constants which are ordinarily determined in the analysis of cow's milk for regulatory purposes, it seemed worth while to investigate (1) the influence exerted upon this physiological constant by such factors as stage of lactation, day-by-day composition of the milk from individual cows, and the presence of colostrum, and (2)

[1] Presented before the Division of Agricultural and Food Chemistry at the 81st meeting of the American Chemical Society, Indianapolis, March 30–April 3, 1931, and published here by courtesy of INDUSTRIAL AND ENGINEERING CHEMISTRY.

the variation in the freezing point of milk of the herd itself of which the cows in question were members.

EXPERIMENTAL

The milk used in this investigation was supplied by well fed healthy individuals in the herd of the College of Agriculture of the University of Wisconsin. Their diet consisted of a hay-silage-grain mixture, the latter being made up of corn, oats, bran and linseed meal. Five breeds were represented among the eight cows which were chosen for this investigation. A record of the breed of each animal, its stage of lactation at the beginning of the test period, and the total lactation has been made part of Table 6. Two series of observations on composite morning and evening samples[2] were made, viz: those on the day-by-day composition of the milk of the individual cows during the thirty-two day period between November 25 and December 26, 1926; those on freezing point measurements from February 8 to May 11, 1927.

Analyses were made daily by the methods of the Association of Official Agricultural Chemists [*4*]. Protein, unless otherwise indicated, was determined "by difference." The Hortvet cryoscope [*3*] was used for making the freezing point determinations.

Freezing point determinations of the colostrum milk of Holstein cow No. 1 were made for three days following parturition and then for a period of a week thereafter during the last stages of which the milk was approaching its normal condition. Analyses were also made of the composite evening-morning milk during two days of the colostrum period and for two days about a week later.

DATA

Data are recorded in the form of complete records and, for purposes of ready comparison, of summaries. Tables I and II show the daily composition of the milk of two different breeds.

---

[2] This mode of procedure was followed for a twofold reason, (1) because of the fact that there is sometimes an appreciable, and often a conspicuous, difference in the freezing point between morning and evening milk, and (2) market milk invariably consists of a mixture of the two and it is, therefore, in this form when the occasion arises, that it would come to the analyst's attention.

TABLE I

Analysis of the milk of an individual Holstein cow at the end of her lactation period

Day	Specific gravity 15.6/15.6° C.	Total solids %	Fat %	Lactose %	Ash %	Protein %	Chloride in ash %	Freezing point °C.
1	--------	--------	--------	--------	--------	--------	--------	-0.554
2	1.0378	15.06	4.30	5.11	0.80	4.84	0.08	0.549
3	1.0376	15.09	4.40	5.04	0.80	4.85	0.07	0.542
4	1.0377	15.03	4.30	4.98	0.81	4.94	0.08	0.543
5*	1.0380	15.51	4.60	4.95	0.85	5.11	0.08	0.550
6	1.0376	15.57	4.60	5.04	0.84	5.09	0.08	0.543
7	1.0378	15.55	4.60	4.86	0.86	5.23	0.09	0.549
8	1.0380	15.53	4.50	5.13	0.85	5.05	0.08	0.551
9	1.0378	15.05	4.15	4.91	0.86	5.13	0.08	0.548
10	1.0377	15.29	4.30	4.98	0.88	5.13	0.07	0.545
11	1.0383	15.35	4.25	5.02	0.88	5.20	0.08	0.551
12*	1.0382	16.09	4.90	4.98	0.88	5.33	0.08	0.553
13	1.0380	15.39	4.40	5.13	0.83	5.03	0.07	0.547
14	1.0388	15.28	4.35	5.06	0.85	5.02	0.08	0.550
15	1.0386	16.28	4.85	5.09	0.90	5.44	0.08	0.557
16	1.0386	15.39	4.50	5.09	0.85	4.95	0.08	0.548
17	1.0385	15.81	4.70	4.84	0.88	5.39	0.09	0.550
18	1.0383	16.03	5.00	4.76	0.87	5.40	0.09	0.553
19	1.0382	16.08	4.85	4.69	0.91	5.63	0.09	0.555
20	1.0380	16.92	5.45	4.92	0.90	5.65	0.08	0.554
21	1.0393	16.56	4.95	4.84	0.93	5.85	0.07	0.559
22	1.0395	16.32	4.90	4.69	0.90	5.83	0.08	0.552
23	1.0394	16.50	5.10	4.90	0.89	5.61	0.07	0.556
24	1.0390	16.69	5.20	4.89	0.88	5.72	0.08	0.553
25	1.0386	16.34	5.05	4.60	0.87	5.82	0.08	0.548
26	1.0394	16.35	5.00	4.72	0.90	5.73	0.10	0.548
27	1.0394	16.47	5.00	4.74	0.88	5.85	0.09	0.550
28	1.0391	16.84	6.00	4.69	0.92	5.23	0.08	0.563
29	1.0401	16.53	4.90	4.69	0.93	6.01	0.09	0.563
30	1.0402	16.46	5.10	4.52	0.89	5.95	0.10	0.553
31	1.0410	16.59	4.85	4.57	0.89	6.28	0.10	0.553
32	1.0394	15.40	4.10	4.00	0.94	6.36	0.14	0.551
33	1.0383	14.68	3.45	3.71	0.97	6.55	0.15	0.555

*Evening milk

Maximum freezing point	0.542
Minimum freezing point	0.563
Average freezing point	0.551

TABLE II

Analysis of the milk of an individual Jersey cow during eleventh month of lactation period

Day	Specific gravity 15.6/15.6 °C.	Total solids %	Fat %	Lactose %	Ash %	Protein %	Chloride in ash %	Freezing point °C.
1	-------	-------	-------	-------	-------	-------	-------	-0.542
2	-------	-------	-------	-------	-------	-------	-------	0.552
3	1.0346	15.66	5.75	5.01	0.73	4.17	.039	0.551
4	1.0345	14.96	5.20	4.97	0.73	4.06	.046	0.547
5	1.0344	15.31	5.60	5.66	0.71	3.94	.035	0.549
6	1.0345	15.20	5.40	5.30	0.72	3.88	.045	0.550
7	1.0346	15.22	5.40	5.16	0.74	3.92	.046	0.547
8	1.0343	15.70	5.75	5.02	0.72	4.21	.055	0.548
9	1.0342	15.14	5.30	5.12	0.74	4.00	.049	0.548
10	1.0343	15.31	5.35	5.13	0.74	4.09	.044	0.550
11	1.0342	15.01	5.10	5.15	0.73	4.03	.037	0.551
12	1.0344	15.13	5.30	4.99	0.73	4.11	.043	0.547
13*	1.0338	15.67	5.70	5.16	0.73	4.08	.050	0.548
14	1.0346	15.06	5.00	5.15	0.73	4.18	.044	0.547
15	1.0340	15.36	5.55	5.18	0.73	3.90	.047	0.553
16	1.0344	15.15	5.25	5.00	0.73	4.17	.039	0.549
17	1.0344	15.02	5.15	5.00	0.72	4.15	.043	0.546
18	1.0345	14.98	5.00	5.03	0.75	4.10	.052	0.550
19	1.0343	15.24	5.40	5.03	0.73	4.08	.046	0.552
20	1.0345	15.32	5.50	5.06	0.74	4.02	.039	0.557
21	1.0340	15.23	5.40	5.14	0.74	3.95	.037	0.556
22	1.0330	16.92	7.20	4.98	0.71	4.03	.039	0.553
23	1.0342	15.68	5.70	5.22	0.74	4.02	.045	0.549
24	1.0346	15.68	5.80	5.15	0.71	4.02	.030	0.549
25**	1.0353	14.47	4.50	5.15	0.71	4.11	.030	0.542
26	1.0354	14.99	5.10	5.16	0.73	4.00	.046	0.550
27	1.0346	15.63	5.80	5.07	0.72	4.04	.056	0.547
28	1.0330	15.36	5.80	5.00	0.73	4.03	.054	0.543
29	1.0347	15.24	5.30	5.11	0.76	4.07	.048	0.551
30	1.0340	14.84	5.30	5.08	0.74	3.72	.049	0.547
31	1.0351	14.99	5.15	5.07	0.71	4.06	.030	0.548
32	1.0342	15.30	5.75	4.64	0.73	4.16	.056	0.546
33	1.0332	16.15	6.35	4.94	0.73	4.13	.056	0.546
34	1.0350	15.13	5.00	4.97	0.75	4.41	.054	0.551

*Morning milk	Maximum freezing point	0.542
**Evening milk	Minimum freezing point	0.557
	Average freezing point	0.549

When the data of Tables I and II are in turn subjected to analysis in terms of maxima, minima, average values, and deviations therefrom, they take the form shown in Table III.

TABLE III

Summary of analyses of milk

	Holstein Cow No. 1				Jersey Cow No. 8			
	max.	min.	ave.	dev'n	max.	min.	ave.	dev'n
Fat (per cent)	6.00	3.45	4.70	±0.36	7.20	5.00	5.46	±0.32
Lactose	5.13	3.71	4.81	0.23	5.66	4.64	6.08	0.10
Ash	0.97	0.80	0.87	0.03	0.76	0.71	0.73	0.009
Protein	6.55	4.84	5.47	0.38	4.41	3.72	4.05	0.082
Total solids	16.92	14.68	15.87	0.53	16.92	14.84	15.31	0.29
Cl in ash	0.15	0.07	0.086	0.084	0.056	0.03	0.044	0.061
Specific gravity*	1.0410	1.0376	1.0398	0.0013	1.0354	1.033	1.0342	0.004
Freezing point °C.	—0.54	—0.55	—0.55	0.003	—0.54	—0.56	—0.55	0.002

*at 15.6°/15.6°

Freezing point studies of the milk secreted by the one cow (Holstein No. 1) which was in her last month of lactation were

TABLE IV

Freezing point of the colostrum and the normal milk secreted by a Holstein cow following parturition

Day	Time	Period	Freezing Point °C.
1	P. M.	colostrum*	—0.562
2	A. M.	colostrum	—0.569
	P. M.	colostrum	—0.568
3	A. M.	colostrum	—0.562
	P. M.	colostrum	—0.555
4	A. M.	normal flow**	—0.561
	P. M.	normal flow	—0.542
5	A. M.	normal flow	—0.539
	P. M.	normal flow	—0.542
6	A. M.	normal flow	—0.538
	P. M.	normal flow	—0.541
7	A. M.	normal flow	—0.541
	P. M.	normal flow	—0.538
8	P. M.	normal flow	—0.541
9			
10	composite		—0.538
11	composite		—0.539

*average depression of freezing point —0.563°
**average depression of freezing point —0.540°

continued during the time of colostrum flow—in this instance arbitrarily designated as that produced three days after parturition—and then, the return to normal secretion having apparently again set in, for one week longer. Pertinent data are recorded in Table IV.

A composite sample was made of the evening-morning milkings of samples 2 and 3 and 3 and 4, respectively. The proximate composition of these samples, together with similar ones of the normal milk produced about a week later form the basis of Table V. Although the results are not a true criterion of the exact composition of the colostrum, yet they indicate the order of magnitude of the changes that take place in the composition of the milk following parturition, especially when compared with normal milk from the same animal.

TABLE V

Percentage composition of colostrum milk and that secreted nine days after parturition

Day	Total solids	Fat	Lactose	Protein N x 6.38	Ash	Chloride of ash
2—3	24.67	7.64	2.80	12.83	1.30	.093
3—4	25.71	12.79	2.58	8.96	1.08	.124
10	14.50	5.06	4.71	3.70	0.74	.063
11	14.13	4.74	4.74	3.51	0.73	.057

In this connection it might be well to point out that it is probably true that colostrum depresses the freezing point to a greater extent than does normal milk, but that this condition in this instance is entirely due to the effect of salts in solution is doubtful. Since protein and fat retard the rate of ice crystal formation, it seems not improbable that the high protein content of colostrum retards crystallization to such an extent that the true freezing point of the sample is not obtained. In fact, in making this test on colostrum it was observed that the rise of the mercury column in the thermometer was not as pronounced when freezing was induced as it was in the case of normal milk.

The freezing point of the milk of six other cows besides the two already mentioned (cows 1 and 8) was determined for thirty-day periods, pairs being analyzed during the months of February to May inclusive. Acidity determinations were always made in conjunction with the foregoing because of the fact that abnormal values have a disturbing effect upon them. They are not here recorded because not a single instance of high acidity was found. Pertinent freezing point data have been summarized[3] (Table VI) as before, in terms of average depression and mean deviations therefrom, as well as maxima and minima. The freezing points which were noted at the beginning and the completion of each series of tests never deviated from the grand average by more than ±0.01°C., nor was a greater difference than 0.01° noted in the individual averages for the several cows in this group.

TABLE VI

Summary of the freezing points of composite morning and evening herd milk and that of individual cows.

	Lactation period		Duration of analysis	Freezing points			
	at times of test months	total months	days	max. °C.	min. °C.	ave. °C.	mean dev'n °C.
1. Holstein	19.5	20.5	33	—0.54	—0.56	—0.55	±0.003
2. Holstein	7.5	10.5	30	—0.54	—0.55	—0.54	±0.003
3. Brown Swiss	8.5	13.5	32	—0.53	—0.54	—0.54	±0.002
4. Brown Swiss	1.0	13.5	30	—0.53	—0.55	—0.54	±0.002
5. Guernsey	5.0	15.0	31	—0.54	—0.55	—0.54	±0.003
6. Ayrshire	9.5	15.5	32	—0.53	—0.54	—0.54	±0.002
7. Ayrshire	6.5	9.0	31	—0.54	—0.55	—0.55	±0.003
8. Jersey	9.5	12.0	34	—0.54	—0.56	—0.55	±0.003
Average				—0.54	—0.55	—0.54	±0.002
Herd			90	—0.53	—0.55	—0.54	±0.002

Finally, the milk from the herd of which the eight cows in question are members was put to a similar test over a ninety-day period (February to May). The resulting data are presented (Table VI) as a summary and, like all others, have been rounded off to the second decimal place for it is in this form that they find practical application in the routine inspection of milk. The actual variation in the depression of the freezing point was found to be 0.016°C.; the average depression for the herd 0.541°. The latter value is somewhat higher than that (0.55°) adopted by the Association of Official Agricultural Chemists [4] as a basis for calculating the amount of extraneous water

[3] For the complete record of these data see E. O. Huebner, "Studies on the Cryoscopy of Milk", Master's Thesis, University of Wisconsin. 1927.

in milk, but the difference is not deemed to be disturbing for after all it represents an added water content of less than two per cent, and this is less than the probability of error (three per cent) claimed for the whole procedure in determining this form of adulteration of milk. Significant, however, is the fact that the average freezing point depression of the herd milk exactly coincides with that of the eight individuals of this group under test and that this condition is evidently independent of the stage of lactation. To be sure it does not lie beyond the realm of probability that the selection of the eight individuals was a fortuitous one and that the above noted agreement of average values is, therefore, an accident. This probability seems remote, however. Rather, since all the cows in question were stall-fed on a ration of uniform composition, it seems to point to the fact that under these conditions the animal maintains in her body an osmotic equilibrium which is practically constant. An interesting example of this will be found in Table I, for as the lactose content decreased with the approach of parturition there was a corresponding increase in the inorganic salts, particularly the chlorides of the ash. On the other hand, in Table II will be found an example of how osmotic equilibrium is maintained by a constancy of those factors that form the basis for this condition.

Conclusions

1. The freezing point of the milk secreted by an individual well fed cow does not under normal conditions vary more in a thirty-day period than does that of the herd of which she is a member.

2. This physical constant is independent of the period of lactation but is affected by the presence of colostrum in the milk.

3. The animal itself regulates the concentration of those substances with which an osmotic equilibrium is maintained within the body.

Literature Cited

1. Beckman, Ernst. *Milch-Ztg.*, 23, 703–4 (1894).
2. Winter, J. *Compt. rend.*, 121, 696–8 (1895).
3. Hortvet, J. *J. Ind. Eng. Chem.*, 13, 198–208 (1921).
4. Assoc. Official Agr. Chem., "Methods of Analysis", Washington, 1930, 3d ed., p. 214 ff.

THE OSMOTIC PERMEABILITY OF LIVING PLANT MEMBRANES

LOUIS KAHLENBERG AND RALPH N. TRAXLER

Chemical Laboratory, University of Wisconsin

In a previous paper[1] experimental results on the selective permeability of various fruit and vegetable membranes have been reported. In that investigation perfect fruits and vegetables severed from the plant were brought into contact with different solutions, and the rates of passage of the solutions through the unbroken membranes determined. In the experiments described below, various plants growing undisturbed in pot or field were irrigated with measured quantities of the various solutions, or poultices wet with the solutions were applied to leaves, stems or berries, and the entrance of the various substances into the different parts of the plant was determined by analysis. In both of these series of investigations the specific, selective permeability of plant membranes has been found to be very marked.

This investigation of the passage of substances through plant membranes is a part of the series of studies on osmosis and dialysis carried on in this laboratory in recent years. The selective action of various membranes[2] to aqueous and non-aqueous solutions have been investigated. The passage of different substances through the human skin[3] has been studied. Artificial membranes have been prepared[4] by means of which it has been possible to separate crystalloids from crystalloids. The deductions made from these investigations all lead to the conclusion that membrane permeability is a phenomenon dependent upon the chemical nature of the membrane and the solute and solvent bathing it.

Most of the following experiments were conducted at Madison between August 1 and September 20. A few were performed during July, August and early September. In every case the

[1] Kahlenberg and Traxler, Plant Physiology Vol. 2, No. 1, p. 39 (1927).
[2] Journ. Phys. Chem., *10*, 141, (1910).
[3] Journ. Biological Chem. 62, 149 (1924); also *ibid.* 79, 405 (1928).
[4] Phil. Mag., vol. i, 385 (1926).

plant and the soil around it were not disturbed unless otherwise stated, with the exception that in the field a small embankment was built up around the individual plant to prevent the solution from passing into the ground too far from the roots. The solutions were usually added between the hours of 8 A. M. and 3 P. M. The plants were subjected to the temperature and humidity existing at Madison during the months given above. The seasons were both rather below the average as far as temperature was concerned.

The salts and the boric acid used were of the best grade obtainable and were not recrystallized. Distilled water was used in preparing all the solutions. The saturated solutions of boric acid and lithium tetraborate were prepared by dissolving so much of each substance in hot water that on cooling to room temperature the excess of the solute crystallized out. This excess of the solid solute was left in the bottle in which the solutions were stored, thus assuring the maintenance of a perfectly saturated solution. The one-tenth molar solutions were prepared by dissolving weighed amounts of the respective substances in less than 1000 cc. of water and then diluting these solutions to the proper volume.

The various parts of each plant were analyzed within a very short time after removal from the soil. In the case of carrots and similar vegetables the roots were washed immediately after removal from the soil to prevent the entrance of foreign substance through lacerations caused by pulling from the ground.

Boric acid, borax and lithium tetraborate were detected by means of turmeric paper. The material was placed in a platinum crucible, covered with a small amount of sodium bicarbonate and ignited. When most of the carbon had been burned away, leaving only a small charred mass, the crucible was allowed to cool and 15 cc. of 10% hydrochloric acid added. Fresh, bright turmeric paper was placed in the crucible. The paper was left in the solution for a few moments, removed and dried on a glass plate at the temperature of boiling water. A drop of potassium hydroxide was added to the pink colored dried paper as a confirmatory test for the presence of boric acid. Standard solutions of boric acid of various strengths were used to determine the depth of pink color produced by them on turmeric paper. The turmeric strips used in all of the determinations were 8x1½ cm. By comparison of the tests obtained from the plant material, with the tests obtained from these standard solutions a quantitative estimate was made of the boron content of plant material investigated.

Lithium chloride, nitrate, sulphate and tetraborate and strontium chloride were detected in the material by placing the sample on a platinum wire and heating in a Bunsen flame. When the water had been largely expelled the flame was observed through a Krüss spectroscope.

Barium chloride was tested for by igniting in a platinum crucible with sodium bicarbonate, taking up with dilute hydrochloric acid, filtering and heating with dilute sulphuric acid. The presence or absence of barium sulphate was determined by holding the test tube up to a strong light.

Iodide was tested for by treating the plant material with fresh chlorine water and fresh starch paste.

Blank determinations for each substance were made on untreated individuals of each type of plant used.

Experiments with Japanese barberry. The bushes were growing near the chemistry building and at the time of the experiments (August 1) were covered with small red berries, averaging 2 to 3 mm. in diameter. The berries were grouped along the twigs and were quite close together. The bushes themselves were large, averaging 6 to 8 feet in total height.

(a) A group of berries selected for their apparent lack of scars and imperfections were soaked in saturated boric acid solution. The berries were *not* separated from the bush. To accomplish the immersion of the berries a cord was tied around the neck of a large-mouthed bottle containing the solution. This cord was then fastened to the stem carrying the berries so that the berries themselves (but not the stem or leaves) were held under the solution. The experiment lasted 27 hours. The twig was removed from the bush and the berries washed very thoroughly with distilled water. The berries contained a fair amount of boric acid.

(b) The same experiment was performed allowing the berries to remain in contact with the solution for only one hour. No boric acid could be detected in the berries.

(c) The same experiment was repeated using 1 per cent borax and saturated lithium tetraborate solutions on separate clusters of berries. After 30 hours of immersion in the solutions the berries contained detectable quantities of borax. No lithium from the lithium tetraborate was found in the berries, although traces of boron were present.

(d) Absorbent cotton was tied around some of the upper twigs of these bushes. The cotton only came in contact with the bark and extended for a distance of 10 centimeters. This cotton was kept moist with a saturated solution of boric acid for 4½ days. The leaves below the compress were affected *very slightly.* The leaves above the compress and close to the absorbent cotton were beginning to wilt at the end of 108 hours. The wilted leaves contained large amounts of boric acid, whereas the berries among these leaves contained only small amounts of the acid. The normal appearing leaves near the wilted ones contained fair amounts of boric acid, from which it is evident that leaves may contain a certain amount of this substance without changing their external appearance. The berries near these unwilted leaves contained no detectable quantity of boric acid.

It is evident that the boric acid is able to pass through the bark of the Japanese barberry and into the leaves and fruit. Also it is apparent that the leaves take up the acid much more rapidly than the fruit, the latter not receiving any of the boric acid until the neighboring leaves have taken up about all it is possible for them to hold.

(e) An experiment identical with (d) was performed using, however, a compress containing saturated lithium tetraborate solution. At the end of 48 hours the leaves on the upper side of the compress contained a fair amount of boric acid and a small amount of lithium. The leaves below the compress contained mere traces of boron. It is of interest that the leaves died much more rapidly in this experiment than when saturated boric acid solution was used, although the lithium tetraborate solution (because of the slight solubility of this salt) was much more dilute than the boric acid solution. In the experiments here discussed the lithium was detected by the spectroscope with which even mere traces of lithium can be recognized. Therefore, in the case where the turmeric paper test was strong and the lithium test weak, the latter element was retarded in its upper progress. The general question raised by this result is well worthy of further investigation.

(f) The same experiment was performed, using a one per cent borax solution. Leaves again gave evidence of containing more boron than the adjacent berries. It is interesting that at the end of 7 days the branches described in (c) which were exposed to lithium tetraborate were withered from the compress to their tips, whereas those in this experiment, exposed to borax solution, were to all appearances scarcely affected, although they contained just as much boron as those treated with the lithium borate. From these experiments, the toxic effect of these substances when applied to the bark or outer covering of the barberry bushes does not seem to be wholly dependent upon the rate or amounts of entrance into the plant. Lithium salt appears to be more harmful than the corresponding sodium salt.

Experiments with potted fuschias. The plant was obtained from the hot house of the University of Wisconsin. It was 50 cm. tall, with 3 main stalks (each 4 to 5 cm. in diameter). Three flowering groups were present with blossoms and unopened buds. 100 cc. of saturated boric acid solution were poured over the soil in the pot. At the end of 2 days the plant was completely withered with the leaves dry and grayish in color. The flowers and buds were the first part of the plant to be affected. In this respect the fuschia was different from the other plants studied since these parts of the organism are usually the last to be invaded and injured. Strong tests for boric acid were found in all parts of the plant.

Experiments with potted geraniums. This plant was obtained at the same time and place as the fuschia of the preceding experiment. The plant had one stalk 30 cm. high and 7 mm. in diameter at the base, and carried one flower group with blossoms and unopened buds. 100 cc. of saturated boric acid were added to the soil in which the geranium was growing. At the end of 3 days some of the lower leaves on the plant were withered. These withered leaves contained only minute amounts of the acid and the flowers and buds none at the end of 3 days. New buds were opening continuously and except for some of the older leaves at the base of the plant no injury was noticeable at a time when the fuschia exposed to the same treatment was completely dead and withered.

Experiments with Jerusalem cherry. The plants were in pots and the total height of the stalks was 23 cms. 25 cc. of saturated boric acid when added to the soil around the plants caused the leaves to turn yellow after 71 hours had elapsed. The plant had not wilted. Boron was found in abundance in all parts of the plant. A plant treated with 25 cc. of saturated lithium borate solution wilted completely in 52 hours but showed no discoloration. Traces of boron were found only in the stem. Lithium was present in every part of the plant.

Experiments with potted chrysanthemums. The total height of the plants varied from 46 to 50 cm. Leaves began to drop from the plant, watered with 40 cc. of saturated boric acid solution, at the end of 71 hours. Black spots appeared on some of the leaves. Boron was found throughout the plant, most abundantly, however, in the roots. The plant treated with 25 cc. of one-tenth molar borax solution showed some black spots on the leaves but no wilting at the end of 95 hours. Boron was found in very considerable amounts in all parts of the plant. 25 cc. of saturated lithium tetraborate caused the plant to wilt and black spots to appear in 71 hours. Both lithium and boron were found in all parts of the plant.

Experiments with potted ornamental peppers. The plant watered with 25 cc. saturated boric acid solution was 27 cm. high. At the end of 77 hours the leaves had turned yellow and wilted. Boron was found in fair amounts in all parts of the plant, except in the upper leaves where only traces were present. The plant irrigated with 25 cc. of one-tenth molar borax solution was 16 cm. high. The upper leaves were spotted with yellow but not wilted at the end of 96 hours. Boron was present in all parts of the plant. 25 cc. of saturated lithium tetraborate solution caused the upper leaves of the pepper to become wilted and spotted with yellow in 47 hours. Lithium and boron were both distributed throughout the plant.

Experiments with potted Begonias. A plant 50 cm. high was watered with 50 cc. of saturated boric acid solution. At the end of 97 hours boron was detected in considerable quantity throughout the plant. The upper leaves were spotted with yellow. 50 cc. of one-tenth molar borax solution caused a plant 50 cm. in height to wilt in 94 hours, but no spots appeared. Copious amounts of boron had entered all parts of the plant. 50 cc. of saturated lithium tetraborate were added to a begonia 26 cm. in height. At the end of 94 hours the lower leaves had died and become dry. Lithium was found throughout the plant but no detectable amount of boron.

Experiments with potted Coleus. 25 cc. of saturated boric acid added to a pot containing a plant 25 cm. high caused isolated leaves on the plant to wilt at the end of 77 hours. Boron was found in detectable quantities only in the roots and there in small amounts. A plant 35 cms. tall when treated with 25 cc. of one-tenth molar borax caused the entire plant to droop and leaves to fall in 71 hours. Boron was found throughout the plant, except in the upper leaves where no detectable amount was present. 25 cc. of saturated lithium tetraborate when added to the soil around a Coleus 23 cm. high caused the complete collapse of the plant in 31 hours. Excellent tests for boron and lithium were obtained from all parts of the plant.

Most of these potted plants were more rapidly injured by the lithium tetraborate than by the boric acid or borax. The Begonia was an exception, being equally affected by all three solutions. The boric acid and borax seemed to have about the same injurious effect on the Begonia and Coleus. On the rest of the potted plants studied the boric acid caused more rapid injury than the borax. The more rapid injury by the lithium borate is probably due to the lithium. In considering these results it should be remembered that the lithium borate solution was much weaker than the boric acid or borax solutions.

The following experiments were performed during the period from August 20 to September 1 on plants which were mature and in the flowering stage. Considerable rain fell during the time of experimentation, which since the plants were all growing in the open field, should be taken into consideration.

Experiments on Zinnia plants in the field. 150 cc. of saturated boric acid when placed on the soil around a Zinnia 35 cm. high penetrated every part of the plant after 7 days had elapsed. The leaves turned slightly yellow. 150 cc. of one-tenth molar borax solution also entered all parts of a plant 40 cm. in height at the end of 7 days. The leaves over the entire plant turned yellow. 150 cc. of saturated lithium tetraborate when added to the soil around a plant 50 cm. high caused the plant to turn yellow at the end of the 4th day. Both boron and lithium were present in all parts of the plant.

Experiments on aster plants in the field. The plants were all 50 cm. high and each was watered with 100 cc. of solution. The plants were diseased and thus the results are not those of normal plants. Saturated boric acid had not killed the plant irrigated with it at the end of 17 days. The plant watered with borax solution withered and died at the end of 7 days. Boron was found in all parts of the plant. Lithium tetraborate did not injure the plant in 5 days, although both boron and lithium were detected in all parts of the plant at the end of this period.

Experiments on dahlia plants in the field. The plants were all 100 cm. high. 300 cc. of solution were added to the soil around each plant. The leaves of the plant watered with saturated boric acid turned yellow at the end of 5 days, but very little boron was detected in any part of the plant. At the end of 10 days the dahlia irrigated with borax solution showed black spots on the leaves and detectable quantities of boron were present in all parts of the plant. 6 days after the addition of lithium tetraborate the plant was covered with black spots. The upper leaves contained neither boric acid nor lithium; the lower leaves and stem contained lithium but no boron.

Experiments on Chingma plants in the field. This Chinese fibre plant was grown in the fields of the Agricultural College, University of Wisconsin. The plants were 100 cm. tall. 500 cc. of solution was poured on the soil around each plant. Within 3 days the leaves became spotted and fell from the plant thus watered with saturated boric acid solution. Boric acid was found in all parts of the plant. Borax and lithium tetraborate caused no apparent injury in 14 days. No boron or lithium could be detected in any portion of the plants after this period of time. This resistance that chingma offers to the entrance of sodium and lithium borate, while allowing the free acid to enter, is rather unique among the plants investigated.

Experiments on ambari plants in the field. These plants were grown in the fields of the Agricultural College, University of Wisconsin. The plants were 100 cms. in height. Each plant was watered with 250 cc. of solution. The leaves on the plant watered with saturated boric acid were spotted slightly at the end of 26 days. No other injury to the plant was noted. Boric acid was found throughout the plant. The plants irrigated with borax and lithium tetraborate solution showed no injury whatever at the end of 30 days. No boric acid or lithium could be detected in any part of the plants. Here again a very marked resistance to the sodium and lithium salts of boric acid is noted, while the free acid itself passes quite readily into the plants.

Experiments on hemp plants in the field. The hemp plants used were part of the experimental plot grown in the fields of the Agricultural College, University of Wisconsin. The plants were 200 cms. high. 500 cc. of solution were placed on the soil around each plant. Within 3 days of the addition of either boric acid or borax solution the leaves on the hemp plants dried up without discoloration. Boric acid was found in all parts of the plant. The plant watered with lithium tetraborate solution was cut down by a workman 5 days after the addition of the solution. At this time no injury to the plant had become apparent. The hemp shows unusual behavior in being so sensitive to boric acid and the sodium salts, but resistant to the lithium salt. This is the opposite of the behavior exhibited by most plants.

Experiments on corn plants in the field. The corn plants used in these experiments were somewhat retarded by a late and unfavorable season and thus at the time of experiment, August 20 to September 1, the plants were just forming the ear.

(a) A hill of mature corn was irrigated with 500 cc. of potassium iodide solution, containing 16 grams of the salt. The leaves on the entire plant were dying at end of 76 hours.

(b) A hill of mature corn was treated with 500 cc. of saturated boric acid and 500 cc. of potassium iodide containing 16 grams of the salt. In 72 hours the entire plant was withered and dead. Very small amounts of boric acid were found in the upper part of the plant. Large amounts of the acid were found in the roots. The dead leaves were silvery white or grey.

(c) A corn plant 250 cm. high was watered with 500 cc. of saturated boric acid solution. At the end of 8 days grey spots had appeared on the leaves. A large amount of boric acid was found in the roots but no detectable amount was present in the upper part of the plant.

(d) 750 cc. of 5 per cent solution of borax when placed around a corn plant 200 cm. high caused yellow spots to appear on the leaves in 7 days. Boron was present in the roots in large amounts, but none could be detected in the upper parts of the plant.

(e) 200 cc. of saturated lithium tetraborate added to the soil around a corn plant 200 cm. tall caused no injury to the plant in 10 days. Lithium and boron were detected in the roots but not in the upper parts of the plants.

(f) A hole was made in a perfect stalk of corn by means of a wooden awl. The wooden awl was chosen for it allowed one to puncture the stem without actually cutting the fibres. The hole was 40 cms. from the ground and midway between two nodes. A blunt glass nozzle was inserted into this hole and the nozzle was connected by rubber tubing to a burette. A firm joint was made at the entrance to the corn by means of bandage gauze and chewing gum. The burette was filled with saturated boric acid and so adjusted that the level of the liquid was 65 cm. above the point where the solution entered the plant. 85 cc. of the boric acid were taken up by the corn stalk in 24 hours. The entire upper portion of the plant contained a large amount of the acid. Only very small amounts of boric acid could be found in the roots of the corn plant. The boric acid would go up into the plant from its point of entrance and also down until it came in contact with the ring or node just above the bracing roots where it was stopped by some structure at this point in the plant.

(g) The same experiment was performed except that the boric acid was forced into the plant below the ring marking the bracing roots. In this plant large amounts of the acid were found in the roots and section of the stalk below the bracing roots but only minute amounts were found in the upper parts of the plant. Colin and Rufz de Lanison[5] found that barium

[5] Rev. Gen. Bot., 22, 337 (1910)

nitrate does not rise past the roots in pea, corn and bean plants, whereas strontium nitrate and calcium nitrate rise into the stems. This is an interesting phase of the selective action of plants which is deserving of more study.

(h) Corn stalks were carefully dug up and the soil washed from the roots. The stem was cut off about 10 inches above the point where the bracing roots enter the stalk. The roots were trimmed off sufficiently to allow them to be placed in a two liter beaker. The stalk was held in place by iron clamps. The upper parts of the stalks were carefully hollowed out by means of a cork borer. Distilled water was placed in the beakers. Normal solution of potassium iodide, sucrose, ferric chloride, urea and boric acid were each placed in a separate corn stalk thus prepared. Potassium iodide was detected by means of chlorine water and starch paste; ferric chloride with potassium sulphocyanate; sucrose by heating with hydrochloric acid followed by Fehling's solution; urea with potassium hypobromite and boric acid with turmeric paper. The experiments were continued for 4 days. *Urea was the only substance that passed from the reservoirs in the corn stalks into the water in the beakers in this* length of time. There is good reason to believe that possibly this came from the roots of the corn and not from the solution placed in the stems.

(i) Corn was raised during the fall of 1924 in the hot house owned by the Agricultural College. This season of the year was very unfavorable for the growing of corn, but plants were obtained which grew to a height of 40 cms. in 25 days. These young corn plants were found to be very permeable to boric acid. The plants treated with the acid were saturated in their growth. The leaves became dry and grey at the tips. This appearance spread slowly and finally ended in the death of the plant.

Experiments on sorghum plants in the hot house. Small sorghum plants 30 to 50 cms. in height were watered with 30 cc. of saturated boric acid solution. Within 6 days the plants began to die and boric acid was found in large amounts in the stem and upper leaves. The death of the plants was slow and gradual, not being complete until 30 days after the solution had been added to the soil around the roots. During this time no growth took place.

Experiments on lupine beans in the hot house. When the plants were 18 days old and 13 cms. high they were watered with 30 cc. of saturated boric acid solution. The old leaves were blackened at the edges within 6 days but the plant did not collapse until after 13 days. The plants continued to grow and send out new leaves even while the old leaves were turning black. The roots of the plant were badly decayed. Boric acid was found throughout the plant except in the newly formed leaves.

Experiments on carrots in the field. Carrots grown on reclaimed marsh land owned by the University of Wisconsin were used in these experiments. The soil around each carrot was banked up slightly so that the solution would penetrate the soil immediately around the root. 250 cc. of solution were poured around each plant. Care was taken that none of the solution came in contact with the stems or leaves. The carrots were washed thoroughly in clean water immediately after being removed from the soil. The plants were analyzed immediately.

The outer membranes of the carrots were readily permeable to boric acid, borax, lithium nitrate, and lithium chloride. Strong tests for these substances were found in the tops of the carrots after 48 hours and *no* test in the heart of the carrot even after 72 hours. Lithium tetraborate and lithium sulphate penetrated the carrot membranes very slowly and sparingly. Lithium tetraborate was found in small amounts in the tops of the carrots, but only after 120 hours, although it was present in the outer membrane of the roots after 48 hours. The carrots were not noticeably permeable to potassium iodide, barium chloride or strontium chloride within 5 days. Strontium was found in spectroscopic amounts after 168 hours.

In none of the cases, even where large amounts of the substance in solution were found in the plant, was any injury to the carrots detected. *The center or heart of the root was without exception free from any trace of the substance with which the plant had been treated.* Large amounts of the boric acid and of the salts which entered the plants were found in the tips of the leaves. This indicated that the substances which entered the carrots gradually accummulated in the upper parts of their tops.

Experiments on red beets in the field. 400 cc. of solution were added to the soil around each beet. The beets were practically full grown and were located in reclaimed marsh land owned by the University of Wisconsin. Boric acid penetrated no further than the outer covering of the root within 72 hours. Lithium sulphate penetrated the beet, being found in the outer membrane and in the tops after 72 hours but *not* in the heart of the beet. Potassium iodide could not be detected in any part of the beet plant after 72 hours had elapsed.

Discussion

The most important and outstanding deduction that can be made from these experiments is that *every plant has its own characteristic selective action toward the substances it will allow to pass through its external membrane.* There is a definite and particular rate at which each membrane allows each permeable substance to pass through it. The entire phenomenon therefore appears to be essentially chemical in nature.

A plant shows different permeabilities to the same substance at different stages of its development. Young corn is much more readily penetrated by boric acid than is the mature plant. The mature corn plant shows a peculiar behavior in not allowing boric acid and some of its salts to pass in either direction past the node or ring just above the bracing roots. The experiments in this connection are unique and interesting in the implications of their results.

A plant when permeable to a toxic substance makes every effort to protect its fruit or seeds against the effects of the foreign substance. There is a tendency also to protect the younger leaves and stems. In numerous experiments on the Japanese barberry and other plants it has been found that the leaves will take up material which is harmful to the plant and keep it from the fruit. *The toxic substance enters the fruit only after the neighboring leaves have been filled to their capacity.* Corn at the earing stage of its development shows this protective action toward its seed to a very marked extent. The same action has been noted by other investigators in the case of pea and bean plants. The plants make every effort to protect the future generation from the poisonous or foreign substances.

This behavior is common and well recognized in the animal kingdom. It must be noted, however, that this protective action does not always take place. The fuschia, for example, allows boric acid to go directly to the flowers and buds, these being the first part of the plant affected.

The exceptional resistance of chingma and ambari to boric acid and borax and the susceptibility to the entrance of lithium tetraborate are of especial interest.

The experimental results obtained indicate that the individual pecularities exhibited by the various plants are dependent upon the chemical natures of the membranes through which the substances pass. Free diffusion or any sieve theory cannot explain the entrance of the various substances into the different plants. Selective action is the only explanation of the phenomenon encountered, and this selective action is no doubt chemical in character, as already stated.

Substances which are able to dissolve in the membrane material, that is enter into some sort of chemical combination with the constituents of the membrane and then leave the membrane, because of a greater attraction exerted by the substances on the inner side of the membrane are the ones which will penetrate into the organism. Consequently the chemical nature of the solution, both solvent and solute, of the membrane and of the material within the membrane determines whether substances will pass through the membrane or not. The selective permeability of various plants to the same solution is thus determined (1) by the specific chemical nature of the membrane, and (2) by that of the tissue beneath the membrane.

Summary

1. Experiments performed on Japanese barberry showed the stems, bark and berries of this plant to be permeable to boric acid, borax and lithium tetraborate solution. The foreign substances were found in the leaves before any could be detected in the adjacent berries.

2. Potted fuschias were found to be very permeable to boric acid. The flowers and buds of the plant were the first to be affected which was found to be a behavior not in harmony with experiments on other plants.

3. Potted geraniums were much more resistant to boric acid than the fuschias. The flowers and buds of the geraniums were apparently not affected by the solution, although old leaves died and wilted.

4. Jerusalem cherries, chrysanthemums, ornamental peppers, Begonias and Coleus growing in pots were watered with saturated boric acid, lithium tetraborate and one-tenth borax solution. The Begonia plants were affected to about the same degree by all three solutions. The Coleus was injured to the same extent by the boric acid and the borax solution. Most of the plants were most rapidly injured by the lithium tetraborate. The boric acid entered all the plants more rapidly and copiously than did the borax, with the exceptions noted above.

5. Experiments were performed in the field on Zinnia, aster, dahlia, chingma, ambari, and hemp plants. The hemp plants were very readily penetrated by boric acid and borax solutions, but very slowly by lithium tetraborate. Zinnia, aster and dahlia were affected by boric acid, borax and lithium tetraborate to about the same extent. The minor differences in effects are given in detail. Ambaric and chingma were slowly permeable to boric acid but impermeable to borax and lithium borate in 30 days.

6. Corn was killed by potassium iodide and injured by boric acid, borax and lithium tetraborate. Unique experiments were performed which showed that boric acid would pass in only minute amounts through the node or ring just above the roots of a mature corn plant. This phenomenon has been observed in other plants by other investigators. Young, hot house grown corn plants were very permeable to and easily killed by boric acid solution.

7. Corn roots and a short section of the stalks, which were hollowed out to form reservoirs, were used as membranes to separate solutions of potassium iodide, sucrose, ferric chloride, urea and boric acid from pure water. Urea was the only substance found in the water after four days. This may have come from the plant and not from the solution contained in the hollow stalk.

8. Experiments on hot house grown sorghum plants showed that they were permeated and gradually killed by boric acid solution.

9. Lupine beans grown in the hot house were eventually killed by boric acid. While the older parts of the plant were dying new leaves and stems contained no boric acid.

10. Carrots growing in the field were found to be readily permeable to boric acid, borax, lithium nitrate and lithium chloride. These substances were found in large amounts in the tops of the plants. Lithium sulphate and lithium tetraborate entered the plant slowly. Potassium iodide, barium chloride and strontium chloride either entered very slowly or not at all. Even when substances entered the carrots in copious amounts no injury to the plants could be detected in this case.

11. Red beets were permeable to boric acid and lithium sulphate and not permeable to potassium iodide.

THE DETERMINATION OF CALCIUM IN LAKE WATER AND LAKE WATER RESIDUES

V. W. MELOCHE AND T. SETTERQUIST

Chemical Laboratory, University of Wisconsin

In the chemical study of the water from Wisconsin Lakes, conducted for the Wisconsin Geological and Natural History Survey as a part of a general study supervised by Professor E. A. Birge and Professor C. Juday, it has been necessary to develop micro methods of analysis which would be applicable to the examination of soft waters, since the concentration of dissolved solids in the waters of some of these lakes is very low. Upon examination of the literature on the determination of calcium, the McCrudden[1] method was chosen as one most nearly satisfying the conditions encountered in our lake water analysis. It is proposed here to outline a modified procedure used in our laboratory, give some of the results obtained in the analysis of various samples, and mention parts of the procedure in which special care must be used if one is to obtain satisfactory results.

PROCEDURE

Samples of lake water residues are prepared by low temperature evaporation, 60°C, of two to four liters of water. While the early part of the evaporation is conducted in eleven inch evaporating dishes, the final evaporation is made in a four inch dish. The transfer is made when the original volume of the water has been reduced to about one hundred cubic centimeters. When the water has been completely removed, the residue is promptly removed from the dish by means of a steel spatula, transferred to a platinum crucible of two cubic centimeters capacity and after standing in a calcium chloride desiccator for some time is weighed. The record of the residue is always kept in terms of milligrams per liter. Since it is usually necessary to store the sample for some time and the residue is hygroscopic, it is always dried in a Fischer Pistol* before analysis.

[1] McCrudden, F. C., J. Biol. Chem. 7 : 83 (1909); 7 : 201 (1909); 10 : 187 (1911).

*A low temperature 60°C vacuum desiccator.

A sample of 1–10 mg. is weighed on a micro watch glass or from a micro weighing bottle, depending on whether or not the sample is hygroscopic and is transferred to a 15 cc. centrifuge tube. The sample is moistened with one drop of water and dissolved by the addition of five cubic centimeters of a 5% solution of HCl. Upon solution one drop of brom cresol purple is added and the excess of acid just neutralized with dilute ammonia (1–1). The solution is then made just acid by the addition of 5% hydrochloric acid solution. One drop of acid is added in excess and the solution is ready for the precipitation of the calcium oxalate. Two cubic centimeters of a 4% ammonium oxalate solution are added and the solution is allowed to stand 10 minutes. The solution is finally made alkaline by adding a 25% solution of sodium acetate (1–2 cc.) and allowed to stand ten minutes. The tubes are placed in the centrifuge and the machine operated at high speed (about 3000 r. p. m.) for five minutes.[2] The supernatant liquid is carefully separated from the precipitate by decantation, the tube is inverted over a filter paper and allowed to drain three or four minutes in order to increase the effectiveness of washing. The inside of the tube is carefully wiped dry by means of a clean towel, using a small glass rod to rotate the towel. At this point one must be careful not to dislodge precipitate. The sides of the tube are then washed with not more than 5 cc. of a solution containing 2% ammonia and the tube centrifuged again for three minutes. The excess liquid is separated from the precipitate by decantation and the tube inverted over a filter paper and allowed to drain. The walls of the tube are carefully dried with a clean towel and the precipitate is ready for solution and titration.

Five cubic centimeters of approximately N sulfuric acid are added and the precipitate is dislodged by means of small glass rod. The solution is transferred to a 50 cc. beaker and after heating in a water bath to about 90°C is titrated with .01 N potassium permanganate solution.

---

[2] The above procedure describes definite time intervals for the operation of the centrifuge. In order to separate a precipitate successfully by means of the centrifuge, the tube should have a sharp tip and smooth clean sides. After centrifuging the solution the precipitate should be a compact mass in the bottom of the tube, no precipitate remaining on the walls of the tube or in the meniscus of the solution. It should be possible to decant the supernatant liquid without disturbing the precipitate. If this is not possible it is necessary to operate the centrifuge for a longer period of time or at higher speed.

SOLUTIONS

0.1% solution of brom cresol purple[3]
5% solution of hydrochloric acid
25% solution of sodium acetate
2% ammonia solution
4% solution of ammonium oxalate
solution of approximately 1 N sulfuric acid
0.01 N potassium permanganate solution

RESULTS

The procedure described has been used in this laboratory for nearly three years. It has also been used successfully in the field laboratory at Trout Lake. The results expressed in Table I give some idea of the precision one may expect when this method is used.

TABLE I

The analysis of a standard solution of calcium chloride

mg. Ca taken	mg. of Ca found	deviation
.063	.057	—.006
.063	.064	+.001
.125	.128	+.003
.125	.130	+.005
.125	.131	+.006
.250	.245	—.005
.250	.253	+.003
.500	.493	—.007
1.250	1.260	+.010
2.500	2.497	—.003
2.500	2.512	+.012

In examining these data it should be remembered that the titration was made with a micro buret using 0.01 N potassium permanganate as the titrating agent. One can read the usual micro buret with a precision of .01 cc. However, one drop has a volume of about .03 cc. and this would be equivalent to .003 mg. of calcium. One may therefore reasonably expect a possible error in titration of .010 mg. of calcium.

[3] The color change of this indicator is from yellow at pH 5.2 to purple at pH 6.8.

Since relatively small amounts of iron, alumina, phosphorus, and manganese are present in our lake waters and residues it would seem unnecessary to consider the effect of these contaminants on the proposed method for the determination of calcium. However, iron in the form of ferric sulfate was added to the standard calcium chloride solution in proportions as high as 0.2 mg. iron to 0.25 mg. Ca without appreciably interfering with the determination of calcium.

The standard calcium chloride solution represents in part the situation one would face in the direct analysis of water. One limitation exists and that is the ability to measure accurate aliquots of the standard solution. In the direct analysis of natural water samples this complication completely disappears since the water samples are more dilute. In order to apply the procedure to the analysis of a standard residue, we selected a dolomitic limestone, Bureau of Standards sample number 88. Table II contains characteristic results.

TABLE II

Analysis of Bureau of Standards Sample No. 88 Theoretical—30.50%

Wt. of Sample in mg.	% CaO	Deviation from Theoretical
1.218	30.52	.02
5.687	30.46	.04
7.893	30.42	.08
16.084	30.96	.46

In the analysis of the Bureau of Standards sample more consistent results were obtained when the calcium oxalate was reprecipitated. The magnesium content of this sample was 21.5% (MgO). Reprecipitation of the calcium oxalate has not been found necessary in the analysis of the northern lake waters and their residues. Although some irregular results were obtained when small samples were used, it has been our experience that in the analysis of relatively hard waters the small sample gives more consistent results, e. g., in the above sample 1 to 5 mg. is preferred.

Table III illustrates the direct application of the method to hard water.

TABLE III

Average Ca ppm 32.66 (macro)

cc. water sample	mg. Ca found	ppm. Ca
10	.322	32.2
10	.317	31.7
6	.195	32.4
6	.198	32.9
4	.130	32.4
4	.128	32.0
2	.067	33.3

The results given in Tables IV and V show the agreement obtained by the application of the procedure to lake water samples and residues.

TABLE IV

Analysis of Water Samples

	cc. water sample	mg. Ca found	ppm. Ca
Boulder Lake	100	.818	8.1
	100	.797	7.9
	10	.075	7.5
Silver Lake	100	.878	8.7
	10	.086	8.6
Wolf Lake	100	1.664	16.6
	10	.159	15.9
Wild Cat	100	2.085	20.8
	10	.201	20.1
Clear Crooked	100	.520	5.2
	10	.053	5.3
Forestry Bog	100	.100	1.0

In using 100 cc. samples, evaporation was made in small porcelain evaporating dishes having a capacity of 25 cc. The evaporation was continued until the bulk of the sample was reduced to about 5 cc. and the sample was then transferred to a centrifuge tube and the procedure used as described. It is necessary to use hydrochloric acid in order to transfer the concentrated solution completely from the evaporating dish to the centrifuge tube since a slight residue is usually formed during evaporation.

An examination of the results expressed in the tables clearly indicates that the factor used to convert milligrams of calcium to parts per million is small for the large sample and large for the small sample. Errors in the determination of calcium in small aliquots of water are correspondingly magnified in the conversion from *mg.Ca.* to *p.p.m.*

TABLE V
Analysis of Lake Water Residues

Lake	% Ca		Parts Per Million	
	I	II	I	II
Wingra	16.2	16.1	49.9	49.5
Devils Lake	9.4	9.8	41.9	
Trout Lake	18.7	18.9	14.1	14.2
Big Lake	19.2	18.5	15.0	14.4
Blue Lake	6.4	6.4	3.8	3.8

In many instances in the study of Wisconsin lake waters, it has been convenient to evaporate known quantities of water according to the procedure already given and save the weighed residues for later examination. Since a considerable quantity of organic matter is sometimes present, it is desirable to weigh the sample for the determination of calcium in a small platinum dish and carefully ignite the sample for one minute before transferring to the centrifuge tube.

Judging from our experiences during the last three years, we believe the procedure described to be applicable to the determination of calcium in lake waters and their residues. The method is particularly convenient and rapid for the study of calcium variations in *soft* waters. In his work on calcium, Shohl[4] has emphasized the fact that the separation of pure calcium oxalate depends largely on a careful adjustment of hydrogen ion concentration. Each new type of sample must be carefully studied before the method can be successfully applied.

The waters which we have examined have varied in hardness and organic content and in general had a low concentration of iron and phosphorus. Under these conditions when the procedure is carefully followed, a reasonably accurate result will be obtained.

[4] Shohl, J. Biol. Chem., 50 : 527, (1922)

SHAFTESBURY AND THE DOCTRINE OF OPTIMISM IN THE EIGHTEENTH CENTURY

WILLIAM E. ALDERMAN

It would indeed have been strange had not Shaftesbury's theories of universal harmony, both physical and moral, led him to his theory of optimism. In this he was running counter to the orthodoxy which taught that this world was a corrupt place and gave promise of a more salutary habitation in the hereafter. "What therefore can be worse done in the cause of a Deity than to magnify disorder, and exaggerate (as some zealous people do) the misfortunes of virtue, so far as to render it an unhappy choice with respect to this world. They err widely who propose to turn men to the thoughts of a better world by making them think less of this."[1]

If it is admitted that there is a system of all things and a universal nature, it follows that "there can be no particular being or system which is not either good or ill in that general one of the universe."[2] If any particular part is really ill, the whole is ill and imperfect. When, however, an apparent ill is for the good of the whole, the ill is not a real one in itself. If there were such a thing as ill in the universe, it must have come by knowledge (design) or chance. To admit the former would be to make the designing principle corrupt; to grant the latter would be to ascribe to it impotency or ill-will. Both of these were repulsive to the "perfect Theist," who stoutly preached that "everything is governed, ordered, or regulated for the best, by a designing principle or mind, necessarily good and permanent."[3] If "the whole itself is thought to want perfection, and to be only a vast and infinite deformity," then would a person be little disposed to love any particular subordinate beauty.[4]

But there are no blemishes in Nature. "'Tis good which is predominant."[5] It is impossible "that Heaven should have acted

[1] *The Moralists*, Pt. II, sect. iii.
[2] *Inquiry concerning Virtue*, Bk. I, Pt. II, sect. i.
[3] *Inquiry concerning Virtue*, Bk. I, Pt. I, sect. ii.
[4] *Inquiry concerning Virtue*, Bk. I, Pt. III, sect. ii.
[5] *The Moralists*, Pt. I, sect. iii.

otherwise than for the best." Nature has suited form, shape, and even affections to each other: "All managed for the best, with perfect frugality and just reserve; profuse to none, but bountiful to all."[6] "Whatever the order of the world produces is in the main both just and good."[7]

The optimist was not blind to the fact that there was suffering and hardship in the world any more than was the cynical Mandeville or the sensible Dr. Johnson. Looking at the totality of things, however, he came to the same conclusion time and time again. "But I deny she (Nature) errs: and when she seems most ignorant or perverse in her productions, I assert her even then as wise and provident as in her goodliest works."[8] Cold, inquiring Philocles soon comes to see that "there may be no real ill in things, but all may be perfectly concurrent to one interest, the interest of that universal One."[9]

The apparent ill is so only because of our limited insights. "For nothing beside what is infinite can see infinite conceptions."[10] More elaborately stated we have elsewhere the same explanation that "in an infinity of things thus relative, a mind which sees not infinitely can see nothing fully; and since each particular has relation to all in general, it can know no perfect or true relation of any thing in a world not perfectly and fully known."[11] Thus the optimistic conclusion is not invalidated. Count upon it, the ill is actually excluded. The "jarring motions of intelligent beings" are made to "contribute to the good and perfection of the universe."[12] Everything is for "the good of all in general; and what is for the good of all in general is just and good."[13]

That there was herein any clash between the optimist and the moralist seems not to have occurred in any disconcerting way to Shaftesbury or his followers. At any rate, the Third Earl would have been the last person to have remained supinely silent and inactive in the face of discord and spiritual imperfection. His theistic tenets would not allow him to escape from optimism on

---

[6] *The Moralists,* Pt. II, sect. iv.
[7] *Inquiry concerning Virtue,* Bk. I, Pt. III, sect. iii.
[8] *The Moralists,* Pt. I, sect. iii.
[9] *The Moralists,* Pt. III, sect. i.
[10] *The Moralists,* Pt. III, sect. i.
[11] *The Moralists,* Pt. II, sect. iv.
[12] *The Moralists,* Pt. III, sect. i.
[13] *Ibid.*

the one hand, and drove him to seek harmony on the other. Strangely enough the contradiction was so little felt that optimistic beliefs took vigorous root in the English mind and flourished across the channel.

The mention of the continent recalls such figures as Leibnitz and Voltaire, so prominent in the history of speculation, and these in turn require certain explanations to set them in their proper relation to Shaftesbury and to the optimistic philosophy which they shared with him. Warton points out that the doctrine was originally inculcated "by Plato and the Stoics, but more amply and particularly by the later Platonists, and by Antoninus and Simplicius."[14] That Liebnitz was not a pioneer in the field is evident from the fact that his *Theodicée* did not appear until the year following the publication of *The Moralists,* and from his remark that he found the greater part of Shaftesbury's philosophy in his own written, but unpublished treatise. The remark of Warton that Pope owed a debt to Leibnitz,[15] is discounted by the fact that Pope denied having ever read a single line of the *Theodicée,*[16] by the statement of Warburton to the effect that those passages in the *Essay on Man* that resembled Leibnitz came from Shaftesbury,[17] and by the slighting remarks directed against the foreign philosopher by Bolingbroke in a letter to Pope.[18] Voltaire knew the writings of Pope and Shaftesbury intimately, and made the former dependent upon the latter.[19] Early in his life he adopted the optimistic philosophy wholeheartedly. Later, when he had had a change of heart, it was only his Pangloss, tutor to Candide, who insisted that "all is for the best in this best possible of worlds." Voltaire continued to point out, however, that it was Shaftesbury who brought optimism into fashion.[20]

---

[14] *Essay on the Genius and Writings of Pope,* London, 1806. Vol. II, p. 58.

[15] *Ibid.* See *Did Leibnitz Influence Pope's Essay* by Moore, Journal of English and Germanic Philology, Vol. XVI, pp. 84–102.

[16] *Letter to Warburton,* Feb. 2, 1739.

[17] Warburton, in a letter to Dr. Birch, said: "As to the passages of Mr. Pope that correspond with Leibnitz, you know he took them from Shaftesbury".

[18] *Letter to Mr. Pope* in volume with *Letter* to Wyndham, 1753, p. 476.

[19] "L'Essai sur l'Homme de Pope me parait le plus beau poeme didactique, le plus utile, le plus sublime qu'on ait jamais fait dans acune langue. Il est vrai que le fond s'en trouve tout entier dans les *Charactèristiques* du lord Shaftesbury; et je ne sais pourquoi M. Pope en fait uniquement honneur à M. de Bolingbroke, sans dire un mot du célèbre Shaftesbury, élève de Locke." *Lettres sur Anglais.*

[20] "Those who exclaim that all is good are charlatans. Shaftesbury, who brought the fable into fashion, was a very unhappy man. I have seen Bolingbroke

It is not to be understood that the doctrine of "Whatever is, is right" made headway without opposition. On the one hand it seemed to engender a supine complacency and a contentment with things as they were; and on the other to be a flat denial of disease, poverty, and those kindred miseries that constantly harassed mankind. Although to conceive it thus was to misrepresent it,[21] and although the optimists were also the most ardent of the benevolists, yet the theory had its detractors among those devoted to common-sense and reason. Dr. Johnson concludes some remarks on the necessity of patience with these words: "A settled conviction of the tendency of everything to our good, and of the possibility of turning miseries into happiness, by receiving them rightly, will incline us to *bless the name of the Lord, whether he gives or takes away.*"[22] But the melancholy, disappointment, gloom, and suffering of the world are to him so actual and ubiquitous that he inclines not at all to the more cheerful philosophy of life. The relatively conservative opposition of such men as Johnson and Swift supposedly gave courage to orthodoxy; whereas the more radical distrust of Mandeville bred a dangerous distrust in the order of the moral world and, consequently, in a designer back of it all. Some used Shaftesbury's own weapon, raillery, in attempting to give the theory its quietus, and others attempted a *reductio ad absurdum.* Sly thrusts at the doctrine in the most unexpected places give proof of its popularity. It will be remembered that Jolter, hearing of Peregrine Pickle's love for Emily and his conduct at Windsor, rode to him and attempted, by a mathematical demonstration, to convince him of the error of his ways. After Pergrine had listened to his teacher for some time, he "could contain himself no longer, but interrupted the investigation with a loud laugh and told him, that his *postulata* put him in mind of a certain learned and ingenious gentleman, who undertook to disprove the existence of natural evil, and asked no

---

devoured with chagrin and rage, and Pope, whom he induced to put the mockery into verse, was as much to be pitied as any man I have every known—deformed in body, unequal in temper, always ill, a burthen to himself, and harrassed by a hundred enemies in his dying hour." Cited from *OEuvres,* tom, xlvii, p. 98, by Elwin, *Works of Pope,* Vol. II, p. 299.

[21] For an interpretation of the doctrine of the philosophical optimists of the eighteenth century see Arthur O. Lovejoy, *Optimism and Romanticism,* P. M. L. A. Vol. XLII, pp. 921–945.

[22] *Rambler,* 32, July 7, 1750.

other *datum* on which to found his demonstration, but an acknowledgement that *everything that is is right.*"[23] At the very end of the century the *Anti-Jacobin* makes grim sport of those votaries of sensibility who could look upon all horrors of the revolution—cities drenched in blood, foul crimes that blot the age, subverted altars and thrones, and all the rage of madness—"and hope, that all is for the best."[24]

That stagnant contentment which some feared would be the result of applied optimism appears but rarely in the literature of the century. John Byrom's happy workman, in *Contentment,* however, is just such a self-satisfied product. He lives in a cottage, works all day, is not troubled with politics, envies the rich not at all, and concludes:

> "In short, my condition, whatever it be,
> 'Tis God that appoints it, as far as I see,
> And I'm sure I can never do better than He."

But the state of mind of this happy-go-lucky artisan is the result of a lackadaisical trust, spiritually soporific, rather than of an impelling belief in the ultimate justice of all that transpires.

What, on the surface of things, may appear to be but a half-hearted acceptance of the hopeful views of Shaftesbury and Pope is that of Brooke in *Universal Beauty.* Although he accepts the theory of Universal Harmony, he denies the goodness of man.

> Ay, there's the task, the labour of our song—
> To prove that all is right, though man be wrong.[25]

The disagreement is apparent, however, rather than real. All is right *despite* the fact that man is wrong. But it is civilized man who is wrong, not natural man. A return to simpler ways of living, a closer conformity to the original order of things, would restore original goodness; and this, it will be remembered, is in accord with deistic philosophy. It is hard for us to refrain from being captious in the face of seeming contradiction between the optimist and the moralist. This, however, is because we apply too meticulously and too immediately a theory whose truth depends upon a more universal application. Neither

[23] Smollett, *Peregrine Pickle,* Ch. XXIV.
[24] *New Morality* in *Anti Jacobin* XXXVI, July 9, 1798.
[25] Bk. III, ll. 90–91.

Shaftesbury nor any of his followers was so purblind as to fail to see the existence of personal and social blemishes, nor so besotted as to deny the need and means of remedy.

The optimist is ready with an answer to the scoffer who insists that all is not right because there is in evidence so much that is wrong.

> Let no presuming impious railer tax
> Creative Wisdom, as if aught was formed
> In vain, or not for admirable ends—
> Shall little haughty ignorance pronounce
> His works unwise, of which the smallest part
> Exceeds the narrow vision of her mind?
> As if upon a full proportioned dome,
> On swelling columns heaved, the pride of art,
> A critic fly, whose feeble ray scarce spreads
> An inch around, with blind presumption bold,
> Should dare to tax the structure of the whole.[26]

So speaks Thomson to those who are bold to criticize, and Akenside is one with him in spirit. Mortal man, says he, has not sufficient insight to warrant his aspiring to judge "the Lord of Nature and his works, or to lift his voice against anything that the All-wise one has decreed to be good and lovely.[27] As Pope sees it,[28] only the one who is capable of infinite perception can

---

[26] *Summer*, ll. 318–328.

[27] Thou, alas!
Dost thou aspire to judge between the Lord
Of Nature and his works? to lift thy voice
Against the sovereign order he decreed,
All good and lovely? to blaspheme the bonds
Of tenderness innate, and social love,
Holiest of things! by which the general orb
Of being, as by adamantine links,
Was drawn to perfect union, and sustained
From everlasting?
Pleasures of the Imagination, Bk. II, ll. 245–254.

[28] The purposes of this article do not necessitate an elaboration or defense of the statement, often repeated, that Pope owed a verbal and intellectual debt to Shaftesbury. Herder says that "ohne die Moralisten haette Pope die besten Verse seines Essay on Man schwerlich geschrieben" (See Vater, *Pope und Shaftesbury*, Halle, 1897, p. 22). See footnote 19 *supra* for one of Voltaire's many references. Parallels between Shaftesbury's *Characteristics* and Pope's *Essay on Man* can easily be found. The following short list of references will suffice here. Robertson's edition of *Characteristics*, London, 1900, Vol. I, pp. xxv–xxvi; Fowler, *Shaftesbury and Hutcheson*, New York, 1883, p. 152; Warton *Essay on the Genius and Writings of Pope*, London, 1806, Vol. II, pp. 91–94; Pattison, *Essay on Man*, p. 9 *et seq.;* Elwin, *Works of Pope*, Vol. II, p. 37; Lyons, *Shaftesbury's Ethical Principles of Adaptation to Universal Harmony*, New York, 1909, p. 23–25.

see and explain all things.[29] Heaven hides from us all that is written in the book of fate and reveals it only in the ever recurring present.[30] Not until the dull ox comes to know just why he is what he is, will man comprehend all the mysteries of his life. In other words, finite man will never possess omniscience; but this does not render him imperfect, for he is as perfect as he needs to be for his present state and place.[31] What, therefore, appears to be physical or moral ill may not be so at all. Indeed God does not send ill at all; partial ill, if rightly understood, is universal good.[32]

With this steadying philosophy, Mallet, in *The Excursion* (1728), could look upon the inexplicable phenomena of nature with a firm faith that they were for the best. Reason is subdued and confused in the face of a city swallowed up by an earthquake,[33] and the accompanying sacrifice of the guilty and the

---

[29] He, who through vast immensity can pierce,
See worlds on worlds compose the universe,
Observe how system into system runs,
What other planets circle other suns,
What vary'd being peoples every star,
May tell why heav'n has made us as we are.
Essay on Man, Ep. I. ll. 23–28.

[30] Heav'n from all creatures hides the book of fate,
All but the page prescrib'd their present state.
Essay on Man, Ep. I, ll. 76–77.

[31] When the proud steed shall know why man restrains
His fiery course, or drives him o'er the plains;
When the dull ox, why now he breaks the clod,
Is now a victim, and now AEgypt's god:
Then shall man's pride and dullness comprehend
His actions', passions', being's, use and end;
Why doing, suff'ring check'd, impell'd; and why
This hour a slave, the next a deity.
Then say not man's imperfect, heav'n in fault;
Say, rather, man's as perfect as he ought:
His knowledge measur'd to his state and place;
His time a moment, and a point his space.
Essay on Man, Ep. I, ll. 61–72.

[32] What makes all physical or moral ill?
There deviates nature, and here wanders will.
God sends not ill; if rightly understood,
Or partial ill is universal good.
Essay on Man, Ep. IV, ll. 111–114.

[33] The reaction of the disillusioned Voltaire after the Lisbon disaster is interesting by way of contrast. See *The Lisbon Earthquake,* especially pp. 8–10, 14, *Works* of Voltaire, Du Mont edition, 1901, Vol. X, pt. 2.

Horrors on horrors, griefs on griefs, must show,
That man's the victim of unceasing woe,
And lamentations which inspire my strain,
Prove that philosophy is false and vain.
* * * * *

just alike, and yet it acknowledges the divine will to be "unerring, wisest, justest, best!"[34] Having described morning, noon, and night, a thunderstorm, the northland and the southland, the deserts of Tartary and an Italian city destroyed by the unresistable forces of nature, he concludes Canto I with these lines:

> Thus roaming with adventurous wing the globe,
> From scene to scene excursive, I behold
> In all her workings, beauteous, great, or new,
> Fair Nature, and in all with wonder trace
> The sovereign Maker, first, supreme, and best,
> Who actuates the whole; at whose command,
> Obedient fire and flood tremendous rise,
> His ministers of vengeance, to reprove,
> And scourge the nations. Holy are his ways,
> His works unnumber'd, and to all proclaim
> Unfathom'd wisdom, goodness unconfin'd.

To the true optimist the partial ills are but a means to an end—the general good. The individual dissonances unite with other dissonances and harmonies to make a symphonic whole. This point of view finds elaborate support. To Thomson, all in the moral world is fitted and impelled by the hand of wisdom and issues "in general good."[35] To Akenside, even the "dates of being," "the field of motion," and "the hour of rest" are so fixed

---

> All's right, you answer, the eternal cause
> Rules not by partial but by general laws.
> Say what advantage can result to all,
> From wretched Lisbon's lamentable fall?
> * * * * *
> Oh worthless bliss! In injured reason's sight,
> With faltering voice you cry, "What is, is right"?
> The universe confutes your boasting vain,
> Your heart retracts the error you maintain,
> Men, beasts, and elements know no repose
> From dire contention; earth's the seat of woes:
> We strive in vain its secret source to find.

[34] How greatly terrible, how dark and deep
The purposes of Heaven! At once o'erthrown,
White age and youth, the guilty and the just,
O, seemingly severe, promiscuous fall.
Reason, whose daring eye alone explores
The fearful providence, confus'd, subdued
To silence and amazement, with due praise
Acknowledges th' Almighty, and adores
His will unerring, wisest, justest, best!
The Excursion, Canto I.

[35] *Winter,* ll. 583–587.

as to further the "universal good."[36] Pope, likewise, has all tending toward one end,[37] and the impartial man of Melmoth, in *Of Active and Retired Life* (1735),

> "Sees different turns to gen'ral good conspire."

Thus are we constantly led back to that conclusion, aphoristically put by Pope and closely echoed by others,[38] to the effect that "Whatever is, is right."[39] Both the way of reasoning and the manner of phrasing are so similar to the logic and wording of Shaftesbury that he who runs may read.[40] A passage quoted above from *The Moralists* forcefully recalls the resemblances and, therefore, furnishes a fitting close. Everything is for "the good of all in general; and what is for the good of all in general is just and good."

BELOIT COLLEGE

---

[36] *Pleasures of the Imagination,* Bk. II, ll. 304–343.

[37] *Essay on Man,* Ep. III, ll. 1–2.

[38] O let thy soul
Remember, what the will of Heaven ordains
Is ever good for all; and if for all,
Then good for thee.

Pleasures of the Imagination, Bk. II, ll. 548–551.

[39] All nature is but art, unknown to thee;
All chance, direction, which thou canst not see;
All discord, harmony, not understood;
All partial evil, universal good.
And, spite of pride, in erring reason's spite,
One truth is clear, 'Whatever is, is right'.

Essay on Man, Ep. I, ll. 289–294.

The very best will variously incline,
And what rewards your virtue, punish mine.
Whatever is, is right.

Essay on Man, Ep. IV, ll. 143–145.

Show'd erring pride, whatever is, is right.

Essay on Man, Ep. IV, ll. 394.

[40] The reader who cares to look further into the general influence of Shaftesbury on the thought of his century is referred to the following: ***Shaftesbury and the Ethical Poets,*** by C. A. Moore, P. M. L. A., Vol. XXXI, pp. 264–325; and these articles by the present writer: ***The Significance of Shaftesbury in English Speculation,*** P. M. L. A., Vol. XXXVIII, pp. 175–195; ***The Style of Shaftesbury,*** M. L. N., Vol. XXXVIII, pp. 209–215; ***Bibliographical Evidence of the Vogue of Shaftesbury in the Eighteenth Century,*** Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, Vol. XXI, pp. 57–70; ***Shaftesbury and the Doctrine of Benevolence in the Eighteenth Century,*** Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, Vol. XXVI, pp. 137–159; ***Shaftesbury and the Doctrine of Moral Sense in the Eighteenth Century,*** P. M. L. A., Vol. XLVI, pp. 1087–1094.

THOMAS PAINE'S THEORIES OF RHETORIC

HARRY HAYDEN CLARK

Thomas Paine has long been recognized as foremost among those who brought the rationalism of the eighteenth century home to the plain people and, in revolting against throne and altar, encouraged them to strive for democracy and the religion of humanity. If authorities on the history of political theory are agreed that in spite of his vast influence "Paine cannot be classed as a great political thinker" since "his theories of the state of nature, the rights of man, the social contract, representative government—in fact, all the great features of his system [—] had been marked out before and better by others," if the "source of his power is found in his rare faculty for popular statement," if "few political writers have had a more perfect mastery of the art of popular persuasion,"[1] it should be of interest to ascertain as far as possible the literary theories which helped to make the great republican the "prince of pamphleteers."[2] Of course, being neither a literary critic nor an aesthete, being concerned not with "pure" but with "applied" literature, Paine had relatively little to say regarding abstract literary theories. Nevertheless, if the criterion of the success of applied literature is its acceptance by those in whose cause it is applied, the fact that the demand for *Common Sense* and the *Rights of Man* ran to half a million copies of each[3] suggests that, the same ideas being available in other forms, their style embodied a congruency to the human mind and heart which is after all the badge of a valid literary theory and which gives what Paine does have to say of his literary theory a rather unusual claim to our attention.

---

[1] C. E. Merriam, "The Political Theories of Thomas Paine," *Political Science Quarterly,* XIV, 402. See also C. B. R. Kent, *English Radicals,* London, 1899, 115. As regards *The Age of Reason,* I. W. Riley concludes, "there is not an idea in it which cannot be matched in the writings of the English free-thinkers of the Georgian era." (*American Philosophy. The Early Schools,* New York, 1907, 299).

[2] *The Cambridge History of English Literature,* XI, 53.

[3] M. D. Conway, *The Life of Thomas Paine,* New York, 1892, I, 69, and *The Writings of Thomas Paine* (hereafter referred to as *Writings*), edited by Conway, New York, 1894–96, III, 382.

I

Before coming directly to a consideration of this theory, however, it may be well to remind ourselves that the contemporary effectiveness of Paine's work was due in part to other factors than the intrinsic merit of its style. Applied writing depends in no small measure for its success upon the condition of the point of application, and probably at no time in history had economic distress and political inefficiency done so much to make acceptable Paine's mordant criticism of monarchy and his ardent advocacy of humanitarian reform.[4] He himself remarks in *Common Sense,* which is often credited with having single-handed caused a somersault in opinion as to the American Revolution, that he found "the disposition of the people such, that they might have been led by a thread and governed by a reed,"[5] a situation which does not suggest the need of any very violent power to overcome inertia. And it has been plausibly argued that Paine was not so much the creator as the voice of popular opinion,[6] moulded by an infinite variety of other factors. In England "the chief activities [of the Society for Constitutional Information] were confined to spreading the writings of Thomas Paine in cheap editions, printing 'Proclamations' and letters advocating their principles, and attempting to cooperate in these measures with various similar organizations."[7] Unfortunately, all writers cannot rely upon such an organization for distributing their work!

Furthermore, Paine's literary effectiveness may depend upon intangible factors, in part, integral with his general outlook and character. "What I write," he said, "is pure nature, and my

---

[4] See W. P. Hall, *British Radicalism,* 1791–97, New York, 1912, especially the earlier part.

[5] *Writings,* I, 275.

[6] R. G. Adams, *Political Ideas of the American Revolution,* Durham, North Carolina, 1922, p. 112, and Sir George O. Trevelyan, *The American Revolution,* London, 1903, I, 162. One should remember that Paine was only one of a vast number of propagandists. See P. Q. Davidson, Jr., "Revolutionary Propaganda in New England, New York, and Pennsylvania, 1763–76." *University of Chicago Abstracts of Theses,* Humanistic Series, VII, pp. 239–42.

[7] *The Life of Thomas Holcroft,* (ed. by Colby), London, 1925, II, 34. According to C. B. R. Kent (*The English Radicals,* p. 111), "In the end it [the second part of the *Rights of Man*] was adopted by the Constitutional Society as a kind of democratic Magna Charta, and sent by them to all the Corresponding Societies in England, France, and Scotland." See also Julius West, *A History of the Chartist Movement,* London, 1920, p. 22.

pen and my soul have ever gone together."[8] It is probably true, as I hope to demonstrate in detail elsewhere, that Paine wrote in the light of an all-embracing central principle, essentially religious,[9] and such a principle, regardless of its intrinsic validity, helps to give a man's writing focus and unity and driving power, as well as the sort of effectiveness which comes from hitting the reader repeatedly on the same nerve. No doubt Paine's devotion to geometry and to scientific methods essentially deductive tended to give his work syllogistic convincingness and the air of dogmatic assurance which springs from the absence of a tedious inductive approach and a distracting regard for qualifications and exceptions. His general programme of returning to the simplicity of nature and his ostensible contempt for book-learning as opposed to the universal and sufficient light of nature[10] tended, furthermore, to free his style from pedantic literary allusions which so often clogged earlier American style, as for example that of Cotton Mather's *Magnalia.* If the rank and file of robust men are attracted by a good fight, Paine handled words as the pugilist handles his gloves; he delights in verbal knock-outs. Witness the way in which this so-called Quaker apostle of humanitarian brotherhood salutes an opponent: "Remember thou hast thrown me the glove, Cato, and either thee or I must tire. I fear not the field of fair debate, but thou hast stepped aside and made it personal. Thou hast tauntingly called on me by name; and if I cease to hunt thee from every lane and lurking hole of mischief, and bring thee not a trembling culprit before the public bar, then brand me with reproach, by naming me in the list of your confederates."[11] At the period of the birth of the nation the Fathers were outspoken, believing in free speech as a means of "conveying *heat* and *light,*" (especially heat!) as Paine's friend Benjamin Rush said, "to every individual in the Federal Commonwealth."[12] After an age when opponents of monarchy and ec-

[8] Conway, *Life of Paine,* I, 88.

[9] This is also asserted by E. Halévy, *The Growth of Philosophic Radicalism,* London, 1928, pp. 188–89.

[10] *Writings,* IV, 339–40. "Man must go back to Nature for information" (*ibid.,* II, 402). "Perfection consists in Simplicity."

[11] *Writings,* I, 133.

[12] H. Niles, *Principles and Acts of the Revolution in America,* 235. The Continental Congress, according to its *Journal* (edition of 1904, I, 108), stood for freedom of the press "whereby oppressive officials are *shamed or intimidated* into

clesiasticism, living at their mercy, had been obliged to take refuge in sinuous methods and guarded analogies, many vigorous spirits no doubt found Paine's outspoken bluntness refreshing, if not contagious. Finally, if, as Emerson remarks, a man can excel in nothing who does not believe that what he is doing is at the moment the most important thing in the world, Paine's solemn conviction that he was a messiah sent to liberate mankind from "the tributary bondage of the ages" to throne and altar, to usher in "the birthday of a new world,"[13] steeled him with self-confidence, economic and political history having given him a sympathetic audience, which inspired his pen in its consecration to a noble cause with a fervour apostolic. His spirit was dampened by no paralyzing surrender to determinisms, economic or mechanistic, or by any misgivings as to the efficacy of his tools: he was enraptured by the magic witchery of words, confident that if mankind were to be regenerated, it would be through the mighty power of the pen. A perfectibilian dedicated to the current faith that conduct is the mere externalization of opinion, he regarded "one philosopher though a heathen" as of "more use" than "all the heathen conquerors that ever existed," the French Revolution being literally truth clad in hell-fire, "no more than the consequence of a mental revolution priorily existing in France"[14] engendered by "the writings of the French philosophers." "There is nothing which obtains so great an influence over the manners and morals of a people as the Press."[15] "Letters, the tongue of the world," represent the fighting wedge of progress, the writer commanding "a scene as vast as the world. . . . Jesus Christ and his apostles could not do this."[16]

II

If such general factors, integral with Paine's general outlook, help in part to explain his power, it must also be borne in mind that his mastery of his art was conditioned, in no small measure, by a knowledge of the achievements and methods of other writers and thinkers. It has been conventional to take

---

more honourable or just modes of conducting affairs." See T. Schroeder's "Intellectual Liberty and Literary Style," *Open Court*, XXXIV, 275 ff.

[13] *Writings*, I, 119.

[14] *Ibid*, II, 333.

[15] *Ibid.*, I, 16.

[16] *Ibid.*, II, 102–3; IV, 287.

him at his word—"I neither read books, nor studied other people's opinion"[17]—notwithstanding the fact that he contradicted this assertion repeatedly in word and act; it has been conventional to assume as axiomatic that he was distinguished by an "immense ignorance of history and literature."[18] Ignorant he no doubt was, if one uses the learning of a Coleridge or an Arnold as a standard; but such a view of Paine's knowledge of books, which has never been thoroughly investigated, would seem rather naively to neglect certain somewhat unique considerations. If, as in the case of Franklin, his formal schooling ended at an early age, he was aflame with an insatiable curiosity, and he had most unusual opportunities for satisfying it. "I seldom passed five minutes of my life however circumstanced," he confides, "in which I did not acquire some knowledge."[19] To begin with, contemporary doggerel records that as a result of his repeated triumps in debate at the "White Hart Evening Club" his fellow-townsmen at Lewes crowned "Immortal Paine ... General of the Headstrong War," his ability being such that the excisemen of England finally appointed him to plead with Parliament on behalf of "The Case of the Officers of the Excise," 1772. He had served as a school-teacher, and Franklin, who sponsored his coming to America, supposed he would continue that calling there. There, however, as editor of *The Pennsylvania Magazine,* he received and commented upon current publications in America, England, and France. It appears that before 1775 he had "received much pleasure from perusing" such English magazines as *The Gentleman's,* the *London,* the *Universal,* the *Town and Country,* the *Covent-Garden,* and the *Westminster.*[20] The Continental Congress regarded him as competent to serve as "secretary for foreign affairs almost two years,"[21] a position in which he read and wrote a vast number of important letters. These opportunities for securing information, however, are trivial compared with

[17] *Writings,* II, 463.

[18] *Cambridge History of English Literature,* XI, 53.

[19] Quoted by his friend, T. C. Rickman, *The Life of Thomas Paine,* London, 1819. "As to the learning that any person gains from school education, it serves only, like a small capital, to put him in the way of beginning learning for himself afterwards. Every person of learning is finally his own teacher . . .". *Writings* IV, 64.

[20] *Writings,* I, 15.

[21] *Ibid.,* I, 413.

his immense opportunities as a result of his multitudinous contacts, in Franklin's circle in America, Godwin's circle in England, and Condorcet's circle in France.[22] What could he not have learned regarding ideas, perhaps from books whose names were unmentioned, from listening to the conservation not only of the men mentioned but of such men as Jefferson, Barlow, Dr. Rush, John Adams, Horne Tooke, Holcroft, Burke (whose earlier work Paine admired), Brissot, Lafayette, and countless others who were Paine's frequent companions and his hosts?

The fact that Paine seldom refers to other writers may not be inconsistent with a knowledge of their ideas, especially when one takes into account the indirect conversational sources suggested above and the considerations which follow. First, as a perfectibilian condemning the past and gazing hopefully into the future, as a sworn enemy of a socially mediated tradition, Paine was generally too much of a logician to cite that tradition as support for an attack upon it. Second, as a naturalistic opponent of philosophies and religions dependent upon books which were for him rooted in traditional imposture and national and temporal idiosyncrasies, Paine advocated, through the scientific quest for universal and immutable natural law, the study not of books but of nature, which was supposed to be everywhere, to all times and peoples, a uniform and universal revelation of a wisdom and benevolence divine; consequently, he could not logically appear to depend himself upon books. Indeed, contemporary critics taunted him upon the inconsistency of himself condemning a book-religion by means of a book and offering a book as a remedy.[23] Third, it was part of the established campaign strategy of the Godwinian circle, which saw to the details of publishing the *Rights of Man* in England, to cite "no authori-

[22] See Conway's *Life of Paine,* I, 225; M. C. Tyler's *Literary History of the Revolution,* New York, 1897, I, 455–56; John Adams, *Works,* Boston, 1850–56, II, 507.

[23] *Writings,* IV, 83. See William Cobbett (*Observations on Paine's Age of Reason,* p. 1–2): "You offer wonders of inconsistency for our digestion. We are to believe you on your word, that we, infallible men of reason, having the Bible of Creation (as you call it) daily before our noses, are not withstanding, in imminent danger of losing sight even of morality, humanity, and theology—that a *work,* a *written book on Religion,* is not only *necessary,* but even *exceedingly* necessary for our preservation; that our Creator has not provided for such a work, but has abandoned mankind to the pernicious effects of seduction and immorality; that he is surpassed in benevolence by you; and that he has left the production of a work *exceedingly necessary, in a moral point of view,* to the care of *poor, silly* Tom Paine . . ."

ties."[24] Fourth, Citizen Egotism, as Paine was called, posing as an original genius, was not anxious to share the glory of having "a range in political writing beyond, perhaps, what any man ever possessed in any country,"[25] of having "arrived at an eminence in political literature the most difficult of all lines to succeed and excel in, which aristocracy with all its aids has not been able to reach or to rival,"[26] of having by his pen equalled the power of Washington's sword, his book which liberated America having "the greatest sale that any performance ever had since the use of letters."[27]

Fifth, considering that Paine was the spokesman of the unschooled and the illiterate, priding himself upon his ability to resolve imposing sophistry to its simple elements, to avoid the artificiality of an aristocratic culture, it would be unlikely that Paine would strain toward literary allusions. And finally, it was an effective part of his strategy in *The Age of Reason,* as Richard Watson scrupulously noted,[28] to disclaim all learned appeals to other books, and "to undertake to prove, from the Bible itself, that it is unworthy of credit." How Paine revels in demonstrating, as he thinks, that the Bible is "book of lies, wickedness, and blasphemy"[29] without going for proof beyond what was regarded as the sacred Word of God![30] Considering such a confessed controversial strategy, it would seem rather obvious that the paucity of other books cited could not be taken as valid evidence of the author's "immense ignorance." This, however, is but one of many instances of inadequate interpretations of Paine as a result of a failure to read individual passages in the light of both the contemporary climate of opinion and the man's central philosophical outlook. I would not imply

[24] Witness Godwin's advice to Thelwall: "Amass as much knowledge as you please, but no authorities. To quote authorities is a vulgar business; every soulless hypocrite can do that. To quote authorities is a cold business; it excites no responsive sentiments and produces no heart-felt conviction . . . Appeal to that eternal law which the heart of every man of common-sense recognizes immediately. Make your justification as palpable to the unlearned as the studious. Strip it of all superfluous appendages; banish from it all useless complexity." (Quoted by C. Cestre, *John Thelwell,* London, 1906, 202).

[25] *Writings,* II, 463.

[26] *Writings,* II, 462–3.

[27] *Ibid,* IV, 431.

[28] *An Apology for the Bible, in a series of Letters Addressed to Thomas Paine* . . . Cork, 1796, p. 96.

[29] *Writings,* IV, 103.

[30] *Ibid.,* IV, 105.

that Paine was in any sense a prodigy of learning, but I do think that he had a decent knowledge of contemporary currents of opinion and literary methods. With the six considerations just suggested in mind, it would seem that what references Paine does make directly to other writers might be taken at somewhat more than their customary face-value, since such references conflicted with his whole philosophy and his controversial method, inviting taunts, painful to a logician and moralist, of an inability to follow his own precepts. Elsewhere[31] I hope to discuss Paine's references to more than an hundred such figures as the following, and to show his knowledge, in varying degrees, of their work; these are: Homer, Xenophon, Aesop, Herodotus, Thucydides, Plato, Aristotle, Zoroaster, Confucius, Cicero, Virgil, Pliny, Tacitus, Scaliger, Dragonetti, Augustine, Maimonides, Origen, Spinoza, Luther, Cervantes, Shakespeare, Ben Jonson, Barclay, Milton, Bunyan, Tillotson, Locke, Sydney, Henry Lord, Descartes, Newton, 'Hudibras' Butler, Grotius, Denham, Dryden, Defoe, Swift, Pope, Smollett, Thomson, Allan Ramsay, Chatterton, James Ferguson, Benjamin Martin, Conyers Middleton, Churchill, Robertson, Chesterfield, Wilkes, Blackstone, 'Junius', George Lewis Scott, Samuel Rogers, Fox, Burke, Johnson, Shelburne, Robert Merry, Blake, Sampson Perry, Godwin, Mary Wollstonecraft, Holcroft, Priestly, Cobbett, Rapin, Burgh, Price, David Levi, Ferguson, Sir William Jones, Whiston, 'Peter Pindar', Adam Smith, David Williams, Franklin, Jefferson, Barlow, John Adams, James Wilson, Samuel Adams, Christie, Edward Fitzgerald, Towers, Mackintosh, Washington, Gouverneur Morris, Monroe, Palmer, Montesquieu, Voltaire, Rousseau, Turgot, Quesnay, Raynal, Helvétius, Boulauger, Brissot, Lafayette, and Condorcet. But could the 'rebellious staymaker' read critically and digest the ideas of such authors? His diabolically acute analysis of the Holy Scriptures suggests that he could. At least he should have been able to profit by the theory and practice of these authors

[31] I have begun this task in a study of "Thomas Paine's Relation to Voltaire and Rousseau," which will be found in the *Revue Anglo-Américaine,* April and June, 1932. Two quotations from Rousseau, unnoted there, have since come to my attention; see *Writings,* III, 104, (80–81) and I, 150. F. J. C. Hearnshaw (*Development of Political Ideas,* 1927, pp. 56–57) says Paine "disseminated Rousseau's doctrines."

in formulating his own literary theories, which are for the most part in close accord with those of his age.[32]

III

Having now considered extra-literary factors which aided Paine and having suggested that he was not quite so ignorant of literary tradition as generally supposed, let us turn directly to a presentation of what he himself has to say regarding literary theory and the art of writing controversial prose. What were his avowed aims?

First among these aims is candour, simplicity, and clarity. He would "rid our ideas of all superfluous words, and consider them in their natural bareness and simplicity."[33] "I speak a language full and intelligible," he remarks in summing up his writing on "every subject." "I deal not in hints and intimations. I have several reasons for this: First, that I may be clearly understood. Secondly, that it may be seen I am in earnest; and, thirdly, because it is an affront to truth to treat falsehood with complaisance."[34] He describes the *Rights of Man* as "a book calmly and rationally written, . . . in a fair, open, and manly manner,"[35] and he tells us elsewhere that he forbade himself "the use of equivocal expression or mere ceremony."[36] When Americans were reluctant on account of sentimental ties to break the bond which bound them to the Fatherland, he exclaimed impatiently, "I bring reason to your ears, and in language as plain as A, B, C, hold up truth to your eyes."[37] No doubt John Adams came as near hating Paine as any man, and as a Federalist he increasingly abominated his anti-traditional[38] and equalitarian principles, yet he was honest enough to recog-

---

[32] Unfortunately, little study has been devoted to the literary theories underlying the applied literature of Americans such as Franklin, Jefferson, Adams, Barlow and Hamilton. If the birth of the nation was in no small measure rendered possible by the literary efforts of these men, it would seem that the theories underlying these efforts deserve presentation and analysis. Most critics who have approached them from the literary point of view have been content with registering their merely subjective likes and dislikes.

[33] *Writings,* II, 238.

[34] *Ibid.,* IV, 406.

[35] *Writings,* III, 54–55.

[36] *Ibid.,* III, 115. "Plain language may perhaps sound uncouthly to an ear vitiated by courtly refinements, but words were made for use." *Ibid.,* I, 182.

[37] *Writings,* I, 178. "I offer nothing more than simple facts, plain arguments, and common sense." (*Ibid.,* I, 84).

[38] See *Writings,* III, 61.

nize that he himself "could not have written anything in so manly and striking a style [as *Common Sense*]," and that it contained "a great deal of good sense delivered in clear, simple, concise, and nervous style."[39] This first ideal of Paine's was of course in line with that of eighteenth-century prose writers from Defoe to his beloved patron Franklin, although Paine was conspicuously lacking in Franklin's inoffensive Socratic approach and his skill in winning assent without antagonizing. As Franklin wrote Hume, who had pronounced him the first man-of-letters of the New World, "certainly in writings intended for persuasion and for general information, one can not be too clear; and every expression in the least obscure is a fault . . . The introducing new words, where we are already possessed of old ones sufficiently expressive, I confess must be generally wrong."[40] Moreover, Paine's mastery of his familiar friend's ideal in this respect is attested by the fact, as Jefferson remarked,[41] that *Common Sense*, which Paine submitted to Franklin for criticism, was first attributed to Franklin.

One may designate *boldness* Paine's second ideal, one, unfortunately, as it seems to me, which not seldom carried him, as he confessed, beyond the "common track of civil language."[42] It is, he says, "curious to observe how soon this spell [of sentimental attachment to monarchy] can be dissolved. A single expression, boldly conceived and uttered, will sometimes put a whole company into their proper feelings: and whole nations are acted on in the same manner."[43] In transferring this lit-

---

[39] *Works,* I, 205.

[40] From Franklin's letter quoted by W. C. Bruce, *Benjamin Franklin Self-Revealed,* New York, 1917, II, 439. Franklin summed up his own conception of what constitutes a good piece of writing as follows: "To be good it ought to have a tendency to benefit the reader, by improving his virtue or his knowledge. But, not regarding the intention of the author, the method should be just; that is, it should proceed regularly from things known to things unknown, distinctly and clearly without confusion. The words used should be the most expressive that the language affords, provided that they are the most generally understood. Nothing should be expressed in two words that can be as well expressed in one; that is, no synonymes should be used, or very rarely, but the whole should be as short as possible, consistent with clearness; the words should be so placed as to be agreeable to the ear in reading; summarily it should be smooth, clear and short, for the contrary qualities are displeasing." (Quoted by W. C. Bruce, *Franklin Self-Revealed,* II, 440).

[41] *Works* (ed. Ford), New York, 1904–5, X, 183.

[42] *Writings,* I, 140.

[43] *Ibid.,* II, 481. See also the passage (*ibid.*, I, 133–134) where Paine tries to rationalize his delight in abusiveness, arguing that "personality is concerned in any political debate."

erary method acquired in the rough-and-tumble of politics to religion, Paine was conscious of pioneering in "a style of thinking and expression different to what had been customary in England."[44] As he wrote Elihu Palmer, whose "Principles of Nature" carried on Paine's tradition in America, "The hinting and intimidating manner of writing that was formerly used on subjects of this kind, produced skepticism, but not conviction. It is necessary to be bold. Some people can be reasoned into sense, and others must be shocked into it. Say a bold thing that will stagger them, and they will begin to think.[45] And in speaking of the agitation caused by the boldness of the first part of *The Age of Reason,* he concludes, "I have but one way to be secure in my next work, which is, to go further than in my first. I see that *great rogues* escape by the excess of their crimes, and, perhaps, it may be the same in honest cases."[46] I do not choose to stain these pages by quoting examples of the scarlet and profane Billingsgate and the coarse innuendoes which Paine unworthily employed as an attack upon Christianity in his illiberal and intolerant endeavour to prove that "the only true religion is deism."[47] If Franklin was an agnostic, he was also tolerant of most religions and rich in the benign wisdom of silence. Where the master feared to tread, the disciple rushed in, with the result that whereas Franklin died the venerated Citizen of the World, beloved of mankind, Paine literally became an object of fear and pity, spending his last years in a vain endeavour to patch together the floating fragments of a wrecked renown. We cannot digress from our restricted purpose here to discuss the vast problems involved in Paine's deism. One observation might be ventured, however. Just as Paine's view that the dead have no authority over the living, that one generation can renounce its obligation to its predecessor, has been undermined by modern doctrines of the inexorable continuity of evolution, so his religious view that one must "vindicate the moral justice of God against the calumnies of the Bible,"[48] in which God is presented as cruel, by forsaking the

---

[44] *Writings,* II, 394. Thomas Seccombe (The Age of Johnson, London, 1900, p. 115–16) says that Paine's manner, as applied to Christianity, was "of a rather different kind to any that had preceded it in England."

[45] Conway, *Life of Paine,* II, 298. See also *Writings,* III, 404.

[46] *Ibid.*

[47] *Writings,* IV, 167. See also IV, 190.

[48] *Writings,* IV, 96.

Bible for nature, has likewise been undermined by the modern evolutionists' demonstration that nature is more cruel than the God of the Old Testament in her indifference to the struggle for existence and the survival of the fittest. Evolution has reinforced, unexpectedly, the famous nature-argument of Butler's *Analogy* (1736), against the earlier deists, who were sure that nature was all benevolence, an argument which Richard Watson tellingly used against Paine in 1796.[49]

If, as a political thinker, his chief weakness lay in his blindness to the unconscious and historical element in human association, the recognition of which constitutes "Burke's supreme claim to greatness,"[50] as a religious thinker this handicap is much more pronounced, since as a rationalist Paine sees but one path to truth, discounting insight, faith, illusion, and the religious imagination, which have guided such seers as Plato and Dante, as mere obscurantism. And this defect is furthermore aggravated by the fact that, with one or two exceptions, he was totally unfitted, by his external, mechanistic concept of God as a watchmaker and by his doctrine that worship consists only in external humanitarian service, to "be a Columbus to whole continents and worlds within," which has constituted the central objective of the American transcendentalists and of most distinctively religious people. Thus does the iniquity of oblivion, at the behest of time, scatter her poppy, and in rendering the boldest affirmations untenable instruct us in the wisdom of philosophic humility and the avoidance of unseemly dogmatism and violence of expression.

Of course Paine's boldness of phrase is merely the outward garment of the perfectibilian's black-and-white philosophy, according to which all rulers of the past were devils[51] while all rulers of the future will be saints. "The present state of civilization is as odious as it is unjust. It is absolutely the opposite

---

[49] *Apology*, 8–9. See Joseph Butler's *The Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature*, ed. Halifax, Oxford, 1844, p. 5 and p. 11; and see W. Grisenthwaite, *A Refutation of . . . Thomas Paine, etc.*, Wells, 1822, pp. 10–11.

[50] C. P. Gooch, *Cambridge Modern History*, VIII, 756–57.

[51] "What scenes of horror, what perfection of iniquity, present themselves in contemplating the character and reviewing the history of such governments! If we would delineate human nature with a baseness of heart and hypocrisy of countenance that reflexion would shudder at and humanity disown, it is Kings, courts and cabinets that must sit for the portrait". (*Writings*, II, 413; see also, *ibid.*, IV, 256).

of what it should be."[52] "The politics of Britain, so far as respects America, were originally conceived in idiotism and acted in madness."[53] He is forever the implacable enemy of "mixed governments," middle courses, and gradual methods; nothing will do but "a total reformation."[54] To this apostle of the religion of humanity his former sovereign, afflicted with mental infirmity, is his "Madjesty,"[55] otherwise a "Royal Wretch,"[56] a "Royal Criminal,"[57] or "a sceptred savage."[58] The long struggles of the English people for a "freedom slowly broadening down from precedent to precedent" are to him nothing; in the background he sees not Magna Charta but William of Normandy, to him the "son of a prostitute and the plunderer of the English nation." His universal ascription of dark motives to men of the past would better become a believer in total depravity than a believer in liberalism and natural goodness. Indeed, his brutality toward his opponents accords oddly with his professed monopoly on virtues humanitarian. If Paine's ideal of boldness must be pronounced one of the regrettable weaknesses of his literary theory, we should recall that it was a weakness he shared with his contemporaries, whose ungentle ways, it must be admitted, were not conducive to temperate expression. William Cobbett, for example, whose later affection for Paine caused him to bring his remains back to his native land, called him "a profane fool," a "blockhead," a "bloodhound," "an ass," and "red-nosed Tom, . . . the impostor, the liar, and the disturber of mankind." "Men will learn to express all that is *base, malignant, treacherous, unnatural,* and blasphemous, by the single monosyllable Paine."[59] And Paine's good friend Samuel Adams, who argued that "the natural liberty of man is to be free from any superior power on earth, and not to be under the will or legislative authority of man, but only to have the law of nature for his rule,[60] was addressed by American opponents as

[52] *Writings,* III, 337.

[53] *Ibid.,* II, 122. "Everything in the English government appears to me the reverse of what it ought to be, and of what it is said to be," (*ibid,* II, 315).

[54] *Ibid.,*II, 120.

[55] Conway's *Life,* II, 31.

[56] *Writings,* I, 123.

[57] *Ibid.,* I, 161.

[58] *Ibid.,* I, 132.

[59] *Observations on Paine's Age of Reason,* pp. 1, 3, 4, 6, 7, 8.

[60] As quoted in J. T. Adam's *The Epic of America,* 83. See the correspondence between Samuel Adams and Paine, *Writings,* IV, 200–8. As examples of Samuel

"the foulest, subtlest, and most venomous serpent ever issued from the egg of sedition." And in England, of course Paine's boldness was in accord with that of such writers as Junius, "the favorite model of political writers,"[61] whose "brilliant pen . . . enraptured" Paine, who said that "in the plenitude of its rage it might be said to give elegance to bitterness."[62] "No writer of the time came so near to the style of Junius," it had been said, "as Paine."[63]

Somewhat akin to Paine's ideal of boldness was his third ideal, that of *wit*. "Wit," he explained, "is naturally a volunteer, delights in action, and under proper discipline is capable of great execution. 'Tis a perfect master in the art of bush-fighting; and though it attacks with more subtility than science, has often defeated a whole regiment of heavy artillery . . . 'Tis a qualification which, like the passions, has a natural wildness, that requires governing. Left to itself, it soon overflows its banks, mixes with common filth, and brings disrepute on the fountain. We have many valuable springs of it in America, which at present run purer streams, than the generality of it in other countries."[64] He may have been thinking of the wit of Franklin, rising to the surface of his work like sparkling bubbles in wine, or the wit of Freneau, or of Barlow and the Hartford Wits. Occasionally Paine gives us a mild cerebral tickle as when, in speaking of peace terms unpopular with the democrats, he remarked, "this is what the tories call making their peace, 'a peace which passeth all understanding' indeed."[65] Often, however, as Romilly said, he is "flat where he attempts

---

Adams's boldness of language see *Writings of Samuel Adams*, ed. Cushing, New York, 1904–8, II, 313–21. ("Vindex" in *Boston Gazette*, April 20, 1772) and II, 332–37. ("Valerius Poplicola" in *Boston Gazette*, Oct. 5, 1772). R. V. Harlow (*Samuel Adams*, New York, 1923, p. 183) says "There are pages upon pages of this sort of thing in Adams's extant works."

[61] J. B. Daly, *The Dawn of Radicalism*, London, 1886, 105.

[62] *Writings*, II, 198.

[63] W. H. Burr, *Paine, Was He Junius?* 1890, p. 14. The argument that Paine was Junius seems to me inconclusive; but might not the "three hundred parallels of character, conduct, opinion, style, sentiment, and language" suggest that Junius, whom Paine read, influenced him?

[64] *Writings*, 1, 16. Paine wrote elsewhere (ibid., IV, 342), anonymously, "With respect to morality, the writings of Thomas Paine are remarkable for purity and benevolence; and though he often enlivens them with wit and humour, he never loses sight of the real solemnity of his subject."

[65] *Writings*, I, 177.

wit,"[66] as when he described the traitor Arnold boarding "the *Vulture* sloop of war lying in the North River; on which it may be truly said, that one vulture was receiving another." And often his wit is winged with a desire to pain. John Adams, who had been a target for Paine, attributed the Federalists' defeat in part to a failure to guard themselves against "that scoffing, scorning wit, and that caustic malignity of soul, which appeared so remarkably in all the writings of Thomas Paine."[67] Certainly in respect to his wit, and his deficiency in humour, Paine was a true citizen of that rationalistic century which produced such wits as Swift, Defoe, Bolingbroke, Pope, Churchill, Peter Pindar, Wilkes, and Junius, all of whom Paine read and admired.

Paine's fourth ideal—perhaps unexpected in one who was essentially a rationalist otherwise—may be described as an *appeal to feeling* and a regard for those niceties of composition, such as connotation, antithesis, balance, and cadence, which are productive of emotional or poetic pleasure. This aspect of Paine's work has been, I think, little noticed, and yet I venture to think it has stood him in good stead in his conflict with oblivion. "I had some turn," he confessed, reminiscently, "and I believe some talent for poetry; but this I rather repressed than

---

[66] Sir Samuel Romilly, *Memoirs*, etc., I, 415–16. "There have been several answers to Burke since you left us, but none that have much merit except one by Paine . . . It is written in his own wild but forcible style; inaccurate in point of grammar [for an exhaustive list of such errors see F. Oldys, *Life of Paine*, London, 1792, pp. 46, 67, 88, 98 ff.] flat where he attempts wit, and often ridiculous when he indulges himself in metaphors; but, with all that, full of spirit and energy, and likely to produce a very great effect. It has done that, indeed, already; in the course of a fortnight, it has gone through three editions; and, what I own has a good deal surprised me, has made converts of many persons who were before enemies to the [French] Revolution." See also *Tom Paine's Jests: Being an entirely new and select collection of Patriotic Bon Mots, Repartees, Anecdotes, Epigrams, Observations, &c. on Political Subjects*, By Thomas Paine and other supporters of the Rights of Man . . . London, 1794. (A copy of this rare volume, of 56 pages, sold at sixpence, will be found in the British Museum, No. 8135. a. 65).

[67] John Adams, *Works*, IX, 278. In arranging terms of a debate with the Abbe Siéyes on monarchy, Paine promised to "treat the subject seriously and sincerely," but held himself "at liberty to ridicule, as they deserve, Monarchical obsurdities, whensoever the occasion shall present itself." His so-called wit directed at the Virgin Mary and Mary Magdalene is of course especially painful. Richard Watson censured him for introducing "railing for reasoning, vulgar and illiberal sarcasm in the room of argument," (*Apology*, 14) and the anonymous author of *Christianity the Only True Theology; as an answer to Mr. Paine's Age of Reason*, (London, n. d.), censures Paine's neglect of "a serious and impartial examination of truth" for "illiberal satyr, and impertinent witticism," for "the lighter weapons of ludicrous description and impudent buffoonry". (pp. 7, 58–59).

encouraged, as leading too much into the field of imagination."[68] Nevertheless, this repressed feeling for the poetic is seldom far beneath the surface, fertilizing his art, giving it at times, as even his enemies admitted, an elevation which was not without beauty. At first, although I think it is not generally known, this hard-headed rationalist was much given to wandering in fairy lands of fancy, as one will note who reads his early papers in *The Pennsylvania Magazine* for the year 1775 on such topics as "Cupid and Hymen." Enchanted with his new-found home, Paine wandered fancifully in "the groves of Arcadia," charmed with the "lovely appearance," the "air of pleasantness," every shepherdess being "decorated with a profusion of flowers," while amidst the "little cottages" and the "jessamine and myrtle" "the sound of labour was not heard" but only "a sweet confusion of voices mingled with instrumental music."[69] It is

[68] *Writings,* IV, 63. This attitude toward poetry was in accord with that of Paine's contemporaries. Witness Franklin's advice to Ralph: "I approved the amusing one's self with poetry now and then, so far as to improve one's language but no farther." *Writings,* I, 270. Madison argued that "something more substantial, more durable, more profitable [than poetry] befits our riper age." See H. H. Clark, *Poems of Freneau,* New York, 1928, especially pp. xlvii–lviii, for a consideration of Deism as related to the genesis of American poetry. On Paine's editorship in relation to early American journalism and its literary ideals see Lyon N. Richardson, *A History of Early American Magazines,* 1741–1789, New York, 1931, and A. H. Smyth. *The Philadelphia Magazines and Their Contributors 1741–1850,* Philadelphia, 1892.

[69] *Writings,* I, 36. As further examples of this sort of style, see *Writings,* I, 26–27, where he delights, in a "pleasant kind of melancholy," when even "the trees seemed to sleep," in crossing the Styx to the "Plutonian world" in quest of Alexander the Great, marvelling at a chariot "drawn by eight horses in golden harness" and all the splendour which "shined so luminously". The tendencies here suggested are found elaborated in the work of Paine's contemporary and admirer, Philip Freneau. (See H. H. Clark, "What Made Freneau the Father of American Prose?" (*Wisconsin Academy of Sciences, Arts, and Letters.* XXV, May 1930, pp. 39–50). And see the purple patch (*Writings,* I, 22–23) which suggests that the deist's delight in nature was not so exclusively cold-blooded and scientific as might be imagined: "Tho' nature is gay, polite, and generous abroad, she is sullen, rude, and niggardly at home: Return the visit, and she admits you with all the suspicion of a miser, and all the reluctance of an antiquated beauty retired to replenish her charms. Bred up in antediluvian notions, she has not yet acquired the European taste of receiving visitants in her dressing-room: she locks and bolts up her private recesses with extraordinary care, as if not only resolved to preserve her hoards, but to conceal her age, and hide the remains of a face that was young and lovely in the days of Adam. He that would view nature in her undress and partake of her internal treasurers, must proceed with the resolution of a robber, if not of a ravisher. She gives no invitation to follow her to the cavern. The external earth makes no proclamation of the interior stores, but leaves to chance and industry, the discovery of the whole. In such gifts as nature can annually re-create, she is noble and profuse, and entertains the whole world with the interest of her fortunes; but watches over the capital with the care of a miser. Her gold and jewels

in this scene that Cupid rescues the beauteous Ruralinda from Gothic, Lord of the Manor, and returns her to her shepherd swain with whom she lives happily ever after. No wonder Paine, who is popularly pictured in this period as a sort of fire-eater, wrote Franklin, "I thought it very hard to have the Country set on fire about my Ears almost the moment I got into it."[70] Nevertheless, he was summoned forth from this Arcadian fairyland to publish *Common Sense,* the call to arms, January 10, 1776, which presages his matured prose style embodied fifteen years later in the *Rights of Man.* As I have suggested, his style in 1775 was, for the most part, ornate, involved, artificial, rich in languorous emotional overtones which caress the sentimental fancies of an Arcadian; his style in 1791 is essentially bare, terse, swift, metallic, and epigrammatic, not without an echo, here and there, of stately eloquence. What accounts for this interesting stylistic evolution?[71] It cannot be attributed entirely to the outgrowing of youthful sentimentalism, for Paine was thirty-eight when he wrote the passages just quoted. No doubt, as in the case of Sidney Lanier later, the author's personal experience in the war had something to do with helping him to view things realistically and to give his words the ring of sincerity. For Paine was an aide to General Greene, and took part in an engagement which involved rowing "in an open boat to Fort Mifflin during the cannonade," a "*very* gallant act," as a contemporary said, "that shows what a fearless man Mr. Paine was."[72] Such an experience in the teeth of a cannonade has a way of making a man think less about Cupids and shepherdesses and fairies and Necromancers' cells. No wonder he poured out "The Crisis" in "a passion of patriotism,"[73] writing,

---

lie concealed in the earth, in caves of utter darkness; and hoards of wealth, heaps upon heaps, mould in the chests, like the riches of a Necromancer's cell." One would hardly suspect that this passage constitutes a good share of a so-called "useful" essay on ways and means of mining! For evidence regarding Paine's authorship of these and other early articles, see Frank Smith, "New Light on Thomas Paine's First Year in America," *American Literature,* I, 347–371.

[70] *Writings,* I, 393.

[71] It should be borne in mind, of course, that between Paine's early work in 1775 and the *Rights of Man* in 1791 and 1792, there was a general reaction in America against stilted and grandiloquent language, which was satirized, for example, by the Hartford Wits' *Echo.* See the ridiculous examples of contemporary high-flown artificiality quoted at length by C. B. Todd, *Life and Letters of Joel Barlow,* New York, 1886, pp. 52–53.

[72] Conway, *Life of Paine,* I, 99.

[73] *Writings,* IV, 431.

it is said, on the head of a drum in the light of flickering campfires while the wornout army slumbered. More important, however, was the intellectual influence of associating on intimate terms, as Secretary of Foreign Affairs, fellow-author, or guest, with the leaders of Revolutionary thought such as Jefferson and Franklin, and the natural tendency to assimilate not only their thought[74] but their ideals as regards the art of writing, which were in the direction of sobriety, clarity, precision, ease, vigour and purposeful didacticism. He confessed that, while he formerly had no interest in politics,[75] "it was the American revolution that made me an author,"[76] and that as regards his later work such as the *Rights of Man* "the principles . . . . were the same as those in *"Common Sense,"*[77] learned in America. Henceforth, the ever-growing faith in the natural man and Utopian progress, which throbbed and pounded and exulted through his work, was in his mind given philosophic sanction by what he took to be the concrete and successful embodiment of it in the history of America. In such an interpretation, however, it is manifest that he, like other naturalists of the French Revolutionary era, failed to perceive the extent to which the American "order and decorum,"[78] which Paine expected in vain in the French Revolution, and which he attributed to natural goodness, were the inherited habitude of a Puritan liberalism, mindful of the dark impulses of the human heart, which strove not to make men masterless but self-mastered.[79] Such an entrancing vision of being instrumental in "regenerating the Old World by the principles of the New,"[80] by merely modifying the external machinery of government, in conjunction with the stylistic ideals of such intimate friends as Franklin and Jefferson,[81] made him impatient not only of fanciful writing but even

[74] See M. R. Eiselen, *Franklin's Political Theories,* New York, 1928; and G. Chinard, *Thomas Jefferson,* Boston, 1929.

[75] *Writings,* IV, 63 ff.

[76] *Ibid.,* III, 402.

[77] *Ibid.,* III, 382.

[78] *Writings,* II, 463.

[79] See J. W. Thornton, *The Pulpit of the American Revolution,* Boston, 1860; and Alice M. Baldwin, *The New England Clergy and the American Revolution,* Durham, North Carolina, 1928.

[80] *Writings,* III, 98.

[81] Jefferson (*Works,* ed. Ford, VIII, 65) wrote, in 1801, regarding poetry: "In earlier life I was fond of it, and easily pleased. But as age and cares advanced, the powers of fancy have declined . . . So much has my relish for poetry deserted me that, at present, I cannot read even Virgil with pleasure . . . The

of non-didactic or non-historical writing such as the drama. "Mr. Burke should recollect," he says, "that he is writing history and not *plays;* and that his readers will expect truth, and not the spouting to rant of high-toned exclamation."[82] Jefferson, in the interest of "reason and fact, plain and unadored," had condemned the undidactic novel for its "poison" of "fancy."

As I have suggested, however, Paine's early delight in the poetic did not desert him, but, being repressed, indirectly fertilized his style, giving it, at its best, colour, connotation, and cadence, enabling him to hold in thrall not only the reader's head but his heart. For the "prince of pamphleteers" knew that "the mind of a *living* public . . . feels first and reasons afterwards."[83] Everyone, of course, is familiar with his picturesque retort to Burke, who in the French Revolution pitied the rich but forgot the poor. As Paine remarked, "He is not affected by the reality of distress touching his heart, but by the showy resemblance of it striking his imagination. *He pities the plumage, but forgets the dying bird.*"[84] In metaphors of such haunting beauty Paine often succeeds in pointedly compressing his argument, rendering it strikingly memorable and quotable. "The palaces of kings are founded on the bowers of paradise." "Government, like dress, is the badge of lost innocence." "Cannons are the barristers of kings." If "there is in Paine's style none of the organ's roll which hushes Burke's

---

very feelings to which it [poetry] is addressed are among those I have lost." Although as a young man Jefferson did not object to novels provided they were sufficiently didactic and morally "useful" (*Works,* Ford, ed. I, 396), in general he considered them fanciful, and hence objectionable: "A great obstacle to good education is the inordinate passion prevalent for novels, and the time lost in that reading which should be instructively employed. When this poison infects the mind, it destroys its tone and revolts it against wholesome reading. Reason and fact, plain and unadorned, are rejected. Nothing can engage attention unless dressed in all the figments of fancy, and nothing so bedecked comes amiss. The result is a sickly judgment, and disgust towards all the real business of life." (*Works,* ed. Ford, X, 104). It should be remembered, also, that Benjamin Martin, the Newtonian popularizer whose lectures impressed Paine at the age of twenty (Writings, IV, 63), proclaimed "As to Poetry, it is so far from being the Source of any Learning, that, on the contrary, it has, for its subject, *pure Fiction,* which is quite its Opposite: If *Wit* and *Fancy* be your *Taste,* read Poetry; if *Wisdom* and Learning, attend on [natural] Philosophy". (*A Panegyrick,* p. 54).

[82] *Writings,* II, 286–87. "I consider Mr. Burke's book in scarcely any other light than a dramatic performance; and he must, I think, have considered it in the same light himself, by the poetical liberties he has taken of omitting some facts, distorting others, and making the whole machinery bend to produce a stage effect." (*Ibid.,* II, 297).

[83] *Writings,* I, p. 395.

[84] *Ibid.,* II, 288.

listeners into a state of veneration and awe,"[85] a statement to which there are many exceptions, he is a master of epigrams, clothed often in homely phrases, which "became catchwords; household proverbs; verbal banners to flaunt before the astonished vision of a comfortable aristocracy and a contented conservatism."[86] This facility in the art of epigrams stems, no doubt, partly from the neo-classical delight in the general rather than the particular, partly from Paine's delight in logical abstraction as opposed to historic relativism, and partly from the fact that his delight in the university of natural law led to a delight in framing major premises in terms universal. I venture to think, however, that Paine's writing derives no small measure of its vibrating power from his ability, as a retentive student of the English Bible, to clothe his thought in the moving diction and haunting cadences of that masterpiece of beauty which has left its authentic stamp upon most of what is great in English letters. For Paine did not condemn all the Bible, even in content. He never tires of praising the Book of Job, especially for its style. "As a composition, it is sublime, beautiful, and scientific: full of sentiment, and abounding in grand metaphorical description . . . In the last act, where the Almighty is introduced as speaking from the whirlwind, to decide the controversy between Job and his friends, it is an idea as grand as poetic imagination can conceive."[87] And it will be found, I think, that usually wherever Paine attains a dignity and impressiveness of style, an earnest and lofty eloquence, and a telling incisiveness of phrase, there are subtle echoes of the book he condemned. "The vanity and presumption of governing beyond the grave is the most ridiculous and insolent of all tyrannies. Man has no property in man; neither has any generation a property in the generations which are to follow."[68] "The farce of monarchy in all countries is following that of chivalry, and Mr. Burke is dressing for the funeral. Let it then pass gently to the tomb of all other follies and the mourners be comforted." "It is [quoting] authority against authority all the way, till we come to the divine origin

[85] Seccombe, *op. cit.*, 86–87.
[86] W. P. Hall, *op. cit.*, 87.
[87] *Writings*, IV, 276. See also his appreciation of the nineteenth Psalm (*ibid.*, IV, 337).
[88] *Ibid.*, II, 278.

of the rights of man at the creation. Here our enquiries find a resting place and our reason finds a home."[89] And in the following sentence, notice not only the biblical echoes in this attack on the Bible, but the balance and antithesis, and the stately cadence: ". . . the terrors and inquisitorial fury of the Church, like what they tell us of the flaming sword that turned every way, stood sentry over the New Testament; and time, which brings everything to light, has served to thicken the darkness that guards it from detection."[90] Paine's nice regard for rythmical units and for the music of the spoken word are obvious, and this regard must have been effectively advanced by his manner of composing, which was also, incidentally, not unlike that of Emerson. "His manner of composing, as I have heard persons who have heard him relate," writes Hogg, "was thus. He walked backwards and forwards about a room until he had completed a sentence to his satisfaction; he then wrote it down entire and perfect and never to be amended. When the weather was fair, if there was a garden, a field, a courtyard at hand, he walked about out of doors for a while, and then came in and put down the sentence which he had arranged mentally, and went out again and walked until he was ready to be delivered of another."[91] No wonder he could make his words, terrible but beautiful, march like soldiers with trumpets; no wonder he could make his words vibrate with the indignation of a Hebrew prophet foretelling the destruction of "Sodom and Gormorrah."[92] In praising his timely appeal to feeling, however, I have in mind not so much his war propaganda, a type of work with which we are all unpleasantly familiar, as that portion of his writing inspired by passion social and humanitarian. For the bitterness with which he hated the oppressors was of course merely the reverse side of the tenderness with which he pitied the oppressed. "I defend," he said, " the cause of the poor, . . . of all those on whom the real burden of the taxes fall—but above all, I defend the cause of humanity." "I speak an open and disinterested language, dictated by no passion but that of humanity . . . my country is the world, and my religion is to do

[89] *Writings,* II, 304.
[90] *Ibid,* IV, 405.
[91] Hogg, *Life of Shelley,* ed. Dowden, 517.
[92] *Writings,* I, 208.

good."[93] If Paine was blind to most of what the historic majesty of the past has to teach, and if his idyllic prophecies of a New Jerusalem come on earth were belied by the events of the future, if few can accept today either his religion or political doctrines, which subsume a benevolence in nature and the natural man which realistic observation and evolution has tended to disprove, it may turn out that his most important contribution was the impetus which he gave toward a wider recognition of social evils and a quest for concrete remedies. A contemporary and reader of humanitarians such as Thomson, Cowper, Blake, Mary Wollstonecraft, Franklin, Jefferson, Voltaire, Rousseau, Raynal, Brissot and Condorcet, it is no wonder that, in elaborating his many practical suggestions[94] for the relief of social suffering, whereby life's blessings were to be more equally distributed, his words throb with a contagious sympathy[95] which brought hope to the unfortunate, the poor, and the oppressed. For, much as he tempered his earlier addiction to the sentimental, he never forgot that "the mind of a living public . . . feels first, and reasons afterwards." In this respect, Paine approaches, for a moment, the view of Burke, whose essay on "The Sublime and the Beautiful" (1756) he evidently read, who held that an ideal sentence should involve first, a thought, second, an image, and, third, a sentiment.

If the rationalist Paine was not unmindful of an appeal to the reader's feelings, if he aimed "to make the reader feel, fancy, and understand justly at the same time,"[96] his practice had the support of a typically neo-classic theory of a desired balance between Memory, Judgment and Imagination, a balance which may be said to constitute his *fifth* literary ideal. It is interesting to note, incidentally, that the literary effectiveness of his defence of liberty is in no small measure dependent upon an allegiance to a principal of control. His statement of his theory is so important that I must beg leave to quote it in full, long as it is:

---

[93] *Writings,* II, 472.

[94] Among Paine's humanitarian interests were abolition of slavery, arbitration schemes to avoid war, land reforms, income taxes, old age pensions, more practical and universal education, remedies for yellow fever, copyright laws, and many inventions for saving time and life.

[95] See, for example, the moving passage (*Writings,* II, 493) which conclude's Paine's presentation of his fourteen concrete suggestions, in the second part of the *Rights of Man,* for alleviating suffering.

[96] *Ibid,* II, 69–70.

"The three great faculties of the mind", he wrote, much as did Sir William Jones, whom Paine read,[97] "are *Imagination, Judgment* and *Memory*. Every action of the mind comes under one or the other of these faculties . . . [The mind being like a watch,[98]] the main spring which puts all in motion corresponds to the imagination; the pendulum which corrects and regulates that motion, corresponds to the judgment; and the hand and dial, like the memory, record the operation. . . . if the judgment sleeps whilst the imagination keeps awake . . . the master of the school is gone out and the boys are in an uproar."[99]

". . . How very few men there are in any country," he remarks in censuring Raynal, "who can at once, and without the aid of reflection and revisal, combine warm passions with a cool temper, and the full expansion of the imagination with the natural and necessary gravity of judgment, so as to be rightly balanced within themselves, and to make a reader feel, fancy, and understand justly at the same time. To call three powers of the mind into action at once, in a manner that neither shall interrupt, and that each shall aid and invigorate the other, is a talent very rarely possessed. It often happens that the weight of an argument is lost by the wit of setting it off; or the judgment disordered by an intemperate irritation of the passions: yet a certain degree of animation must be felt by the writer, and raised in the reader, in order to interest the attention; and a sufficient scope given to the imagination, to enable it to create in the mind a sight of the persons, characters and circumstances, of the subject: for without these, the judgment will feel little or no excitement to office, and its determinations will be cold, sluggish, and imperfect. But if either or both of the two former are raised too high, or heated too much, the judgment will be jostled from its seat, and the whole matter, however, important in

[97] Paine seems to have drawn some of his knowledge of Eastern religions from Sir William Jones's *Asiatic Researches* (*Writings*, IV, 330); and Jones's *Principles of Government* (1782), which ran to five editions by 1818, is strikingly paralleled by passages in Paine's later political writing. In "A Discourse on the Institution of a Society," etc., p. 8, Jones writes: "Human knowledge has been elegantly analysed according to the three great faculties of the mind, *Memory, Reason,* and *Imagination;* which we constantly find employed in arranging and retaining, comparing and distinguishing, combining and diversifying the idea, which we receive through our senses, or acquire by reflection."

[98] In 1804, after Paley's works were published, Paine wrote: "When we see a watch, we have as positive evidence of the existence of a watchmaker as if we saw him; and in the same manner the creation is evidence to our reason and our senses of the existence of a Creator." (*Writings*, IV, 317) If Paine may have borrowed this mechanical figure from Paley, Paley's political philosophy of natural rights has interesting resemblances to Paine's, elaborated in print before most of Paley's works had appeared.

[99] *Writings*, IV, 360–62.

> itself, will diminish into a pantomine of the mind, in which we create images that promote no other purpose than amusement."[100]

It is often erroneously supposed that the neo-classicists and the radical rationalists were implacably hostile to the imagination. It is true, as we have seen, that Paine repressed his interest in poetry as "leading too much into the field of imagination";[101] his hostility toward what he calls "the vapours of the imagination",[102] however, refers only to the unbalanced and undisciplined use of that faculty. For to Paine, as to many of his contemporaries, the imagination, as he described it above, is the "main-spring" of the mind. We should notice carefully, however, exactly what he means by imagination. To Paine it not so much an Aristotelian faculty, essentially moral, whereby ethical universals are envisaged on the basis of particulars purged of what is accidental or idiosyncratic, a conception held by such men as Burke, Sir Joshua Reynolds, and the mature James Russell Lowell,[103] as it was a creative arranger of images furnished by memory and controlled by judgment. If we recall how exuberant were Paine's early flights of fancy, how strongly he leaned toward the over-ornate and the Arcadian, we will understand how difficult, and necessary, in his case was self-discipline, and we will perhaps be more charitable toward his frequent and deplorable inability to bring his writing, often done under stress of emergencies which forbade revision, into complete harmony with his ideal of a fruitful and purposeful balance between the Memory, the Judgment and the Imagination. With regard to this ideal, as with others, he was in accord with the main current of his age. For, as Professor F. B. Kaye

[100] *Writings,* II, 69–70.

[101] *Ibid.,* IV, 63.

[102] *Ibid.,* I, 178. "But priests, preachers, and fanatics, put imagination in the place of faith, and it is the nature of the imagination to believe without evidence." *Ibid.,* IV, 422.

[103] See Norman Foerster, *American Criticism,* Boston, 1928, on Lowell's imagination; H. H. Clark, "Lowell's Criticism of Romantic Literature," *Publications of the Modern Language Association,* XLI, 209–228, and also "Lowell-Humanitarian, Nationalist, or Humanist?" *Studies in Philology,* XXVII, 411–441 (July, 1930). Paine, of course, had little in common with the contemporary heralds of original genius who used the imagination mainly as a means of escape, or a means of creating what was idiosyncratic or unique. In a paper on "The Romanticism of Edward Young" (*Wisconsin Academy of Sciences, Arts and Letters,* XXIV) I have discussed the neo-classical as contrasted with the classical imagination, although I should have given more stress to the idea that the neo-classicists were not hostile to the sort of imagination just described.

reminded us, "The neo-classicist distrusted only the undisciplined use of the faculty [imagination]; the disciplined imagination he required. The following is a typical neo-classic statement: 'In a good poem, whether it be *epic* or *dramatic;* as also in *sonnets, epigrams,* and other pieces, both judgment and fancy are required . . .'[104] This was a doctrine preached by Pope and Addison [whom Paine read, admired and quoted]. That the neo-classicists could hardly help respecting the imagination is shown by their conceptions of the creative art. The central psychological theory was that of Hobbes and Locke, according to which the judgment separates the impressions stored in the memory by the senses and the imagination joins and relates them. Imagination, therefore, was as necessary to controlled thinking as judgment, and shared its good repute."[105]

Sixth, having advocated this difficult balance of facuties necessary to the writer, Paine aimed to adjust language to thought with such exquisite precision as to create exactly the impression he wished to produce and no other. The ex-soldier knew that ammunition is not more necessary than infallible aiming. As he himself sums the matter up. "To fit the powers of thinking and the turn of language to the subject, so as to bring out a clear conclusion that shall hit the point in question and nothing else, is the true criterion of writing."[106] Conscious of his own earlier weaknesses, he is aware that the means should be always subordinated to the end, the part to the whole, that writing may fail "through an excess of graces", if as in Raynal's case, "the coloring is too high for the original", even though "the conception is lofty and the expression elegant".[107] As he boasted later, reviewing, no doubt, his own struggles for literary self-control and for artistic integrity, "All the world knows, for it cannot help knowing, that to judge *rightly,* and to write *clearly,* and that upon all sorts of subjects, to be able to command thought

[104] Hobbes, *Of Man,* Pt. I, sect. 8.

[105] In the *Philological Quarterly,* VII, 178. See also, Charles Gildon, *The Complete Art of Poetry,* 1718, I, 125; "For Fancy and Judgment must join in every great Poet, as Courage and Judgement in every great General; for where either is wanting, the other is useless, or of small Value. Fancy is what we generally call *Nature,* or a *Genius, Judgment* is what we mean by Art, the union of which in one Man makes a complete Poet."

[106] *Writings,* II, 110.

[107] *Writings,* II, 110.

and as it were to play with it at pleasure, and be always master of one's temper in writing, is the faculty only of a serene mind, and the attribute of a happy and philosophical temperament."[108]

Like Milton, whose work he read,[109] Paine recognized that literary success depends upon far more than verbal carpentry and astute craftsmanship, important as these are; he recognized, like the greater and more profound radical, the organic relation between character and literary creation, the fact that the life of a poet must itself be a genuine and living poem. The deist, grossly libelled as an atheist or infidel, who spent his life ringing the changes on his master-theme that "It is only in the Creation [nature] that all our ideas and conceptions of a *word of God* can unite,"[110] was not slow to grasp the parallel idea that the literary creation of man is a revelation of its human creator, noble or ignoble in proportion as the deeper springs of his character are in fruitful harmony with what Emerson, like Paine in this respect, called "the law alive and beautiful",[111] the Oversoul. And if Paine's writing is not flawless, if he wanders far at times from the high-road he charted, it is perhaps not unrelated to the fact that he never completely achieved the "happy and philosophical" self-command he sought,[112] that he did not escape what

---

[108] *Ibid.*, III, 402.

[109] *Ibid.*, I, 91. John Adams, Works, II, 508, records that Paine came "to my lodgings and spent an evening with me," and in discussing the portion of *Common Sense* dealing with monarchy, he "said he had taken his ideas in that part from Milton".

[110] *Writings,* IV, 46. He was the champion, unlike Rousseau, of representative government (*Ibid.*, II, 414–429) and he was among the first to see that "the union of America is the foundation-stone of her independence; the rock on which it is built . . ." (*Ibid.*, I, 340; see all of *Crisis,* XIII).

[111] Emerson, *Complete Works* (Centenary Edition), III, 283. See H. H. Clark, "Emerson and Science", *Philological Quarterly,* X, 225–260, where evidence is presented to show that on one side Emerson's thought had a strong kinship with that of the deists.

[112] Of course Paine has been unpardonably libelled as regards his personal character, especially by such biographers as Cheetham. His sympathetic champion, however, M. D. Conway, was obliged to accept the fact that he was dismissed from the excise for a violation of his trust, and his best friends have reluctantly admitted that in later life he "gave in to the too frequent indulgence of drinking, neglected his appearance, and retired, mortified and disgusted, from an ill-judging, unkind, unjust world, into coarse obscurity, and the association of characters in inferior life." This is the testimony of Rickman, (*Life of Paine,* London, 1819, p. 11), and it is substantiated by other friends such as Barlow (C. B. Todd, *Life and Letters of Joel Barlow,* New York, 1886, see Barlow's long letter on Paine quoted pp. 236–39). See also C. Wilmont, *An Irish Peer on the Continent* (1801–3), pp. 26–27. James Monroe, who had Paine released from prison and who nursed him back to health in his own ambassadorial residence, was grieved that Paine "would commit such a breach of confidence as well as of gratitude", as that

his defender, Shelley,[113] called the "contagion of the world's slow stain". On the other hand, it should be borne in mind that this ultimate stress upon self-discipline in literary art is in the last analysis the inevitable result, in literary terms, of the contemporary outlook of religious radicals, or deists, culminating with Bolingbroke and Pope, whom Paine admired as "Free-thinkers".[114] For, as I hope to show elsewhere, the views of such religious radicals as Paine represents have been somewhat misunderstood, and important political, humanitarian, and literary results of such views largely ignored. Paine was anything but an atheist or an anarchist. If he advocated, like Pope, following nature, the concept "nature" must be interpreted in the light of the contemporary climate of opinion. He did not mean by following nature to return to the actual physical life of a savage in a wilderness. For to Paine, as to most of the deists, nature had a special meaning, confirmed by Newtonion science: as Paine expressly says, "nature is of divine origin. It is the laws by which the universe is governed";[115] nature "is no other than the laws the Creator has prescribed to matter", laws operating in "unerring order and universal harmony",[116] and perceptible through the study of science by means of "the divine gift of reason".[117] *Nature is law, eternal, immutable, universal.*[118] Now, whatever were the facts of the personal life of Paine, philosophically, far from preaching lustful license or do-as-you-please, the ultimate virtue to him, as his deist contemporaries in England, was living in harmony with this law which is nature, a conformity involving no little discipline, as has been

---

involved in publishing from his host's home pamphlets which compromised his host, the United States' ambassador, and according to B. Fay, "Paine shattered his work", (*The Revolutionary Spirit in France and America,* New York, 1927, trans. by R. Guthrie, pp. 379–380; *Writings of James Monroe,* New York, 1898–1903, II, 440–42; III, 20–21; III, 27).

[113] *The Shelley Correspondence in the Bodleian Library,* ed. R. H. Hill, Oxford, 1926, p. 21 ff., Letter XXVI, "Shelley to J. H. Hunt, 3 November, 1819, on the conviction of Richard Carlile for Publishing Paine's 'Age of Reason'." (The first and third sheets only of this letter had been printed, as in editions by Forman and Ingpen).

[114] *Writings,* IV 391–93 and 342.

[115] *Ibid.,* IV, 311.

[116] *Writings,* IV, 339.

[117] *Ibid.,* IV, 315–16, and 322.

[118] In another study, "Newtonianism and Thomas Paine", I have endeavoured to define and outline Paine's central assumptions in the light of contemporary thought, especially that of Newtonians such as James Ferguson and Benjamin Martin, who were Paine's teachers.

demonstrated in the case of Shaftesbury.[119] Thus, to indicate Paine's accord with the spirit of the age, in this matter of a disciplined precision, "the true criterion of writing", we may recall that to Pope, as to Paine, "prayerbooks are the toys of age",[120] while God is revealed in nature, in "the stupendous whole" harmony of nature's laws, which are universal—"still the same". Thus, unlike the "original genius" naturalists such as Edward Young, whose cult of following nature led to a literary diversitarianism, a quest of the eccentric, of nonconformity, Pope and Paine urge us to "first follow nature, which is still the same",[121] a quest of the concentric or the universal, an ideal, in Pope's case, if less faithfully in practice in Paine's, which involved the most intense literary self-discipline as regards craftsmanship in the interest of finality of expression, of what was "ne'er so well expressed". The crowning stress, then, which Paine lays upon harmonizing a writer's powers by allegiance to a judgment which "corrects and regulates", and upon being able "to command thought and as it were to play with it at pleasure", to hit the point in question and nothing else", this crowning stress upon control in writing was but a reflection of the central philosophy of that day, wherein man found his salvation by a self-disciplined conformity to nature's law, the "unerring order and universal harmony", and it can be only inadequately, if not falsely, interpreted when divorced from that philosophic background of deism and Newtonian law.[122]

---

[119] Esther Tiffany, "Shaftesbury as Stoic", *Publications of the Modern Language Association,* XXXVIII (1923), 642–84.

[120] "Essay on Man" (1734).

[121] "Essay on Criticism". Mary Segar has recently argued, inconclusively, as it seems to me, that Pope's deism may be reconciled with his nominal Catholicism. ("Some Notes on Pope's Religion", *Dublin Review,* No. 381, April, 1932).

[122] This vastly important subject of the relation between literary ideals and Newtonian deism awaits, so far as I am aware, thorough investigation, both in England and America. A suggestive but very brief tabulation of meanings of the term "nature" in criticism of the seventeenth and eighteenth century will be found in a paper on "'Nature' as Aesthetic Norm" by A. O. Lovejoy (*Modern Language Notes,* XLII, 1927, pp. 444–50). As regards America, Carl Becker has admirably shown how important were widespread Newtonian naturalism and deism in moulding political theory and history; he does not mention Paine, but it should be evident that if Paine imbibed Newtonianism earlier in England through indirect sources, he must have had his faith reinforced by breathing its prevailing atmosphere in America. (*The Declaration of Independence. A Study in the History of Political Ideas,* New York, 1922, Ch. II). And see B. F. Wright, Jr., "American Interpretations of Natural Law", *American Political Science Review,* XX, (1926), 524–47; and A. O. Lovejoy (*Modern Philology,* XXIX, Feb. 1932,

Having satisfied himself as to the perfection of the units of his composition, striving, as we have seen, for candour, simplicity, and clarity, for boldness, for wit, for an appeal not only to reason but to feeling, for a balance between judgement and imagination, and for a purposeful and precise adjustment between language and ideas with reference to a definite audience, Paine strove, finally, to arrange his units, his carefully constructed sentences, in an architectonic pattern designed to give them their maximum effectiveness. He worshipped order in everything, but especially in literary composition, and as a critic he is especially sensitive to faults in order and method. His friend Rickman testifies that "he used to speak highly of the sentimental parts of Raynal's History",[123] and he acknowledged that the Frenchman who cloaked humanitarianism under history "displays great powers of genius, and is a master of style and language".[124] Yet as an apostle of orderly method in the development of an argument, he cannot overlook the fact that "the greater part of the abbé's writings, (if he will pardon me the remark) appear to me uncentral, and burdened with variety. They represent a beautiful wilderness without paths; in which the eye is diverted by everything, without being particularly directed to anything . . ."[125] The same fault loomed large to him in the writing of "Cato", whose attack on *Common Sense* called forth Paine's Forester papers: "Cato's manner of writing has as much order in it as the motion of a squirrel. He frequently writes as if he knew not what to write next, just as the other jumps about, only because it cannot stand still".[126] And especially, in answering Burke's *Reflections,* he lamented the difficulty of imposing an orderly pattern upon the *Rights of Man,* since, as he remarked in one of his happy phrases, he had to tread "a

pp. 281–299) "The Parallel of Deism and Classicism". A. Bosker, *Literary Criticism in the Age of Johnson* (The Hague, 1930), surveys his subject in the light of the stock interpretations and romantic assumptions.

[123] Rickman, *Life of Paine,* 136. See also p. 32: "Distinctness and arrangement are the peculiar characteristics of his writings: this reflection brings to mind an observation once made to him by an American girl, that his head was like an orange—it had a separate apartment for every thing it contained."

[124] *Writings,* II, 79.

[125] *Writings,* II, 110. See also *ibid,* IV, 379: "Isaiah is, upon the whole, a wild disorderly writer, preserving in general no clear chain of perception in the arrangement of his ideas, and consequently producing no definite conclusions from them."

[126] *Ibid,* I, 138.

pathless widerness of rhapsodies".[127] In common with the main figures of his era, devoted to the beauty of symmetry and the progressive unfolding of a rationalistic argument, Paine exclaims, "I love method, because I see and am convinced of its beauty and advantage. It is that which makes all business easy and understood, and without which, everything becomes embarrassed and difficult."[128] For "it is only by reducing complicated things to method and orderly connexion that they can be understood with advantage, or pursued with success."[129] Paine's own practice of this theory is, as everyone knows, imperfect. He never succeeded in bringing his compositions into that faultless harmony with geometrical method illustrated so finely by the structure of Godwin's *Political Justice*. Nevertheless, as he remarks regarding one subject, he "endeavoured to give it as systematical an investigation as the short time allowed."[130] His manner of lighting the way through his compositions is simple: in general, at his best, he follows the old playwright's advice of telling us what he is going to do, of telling us he is doing it, and then telling us he has done it. Thus we find him making use, regularly, of what one may call "signpost" sentences,[131] and "flash-backs" such as the "Recapitulation" at the end of Part I of *The Age of Reason*.[132] Such a method of securing method, added to his "damnable iteration" of his master-ideas, made it practically impossible for even the most unliterary reader to miss his meaning, so clear did he make it. Thus we are eventually come full circle, his last ideal of method serving to make possible his first ideal of clear simplicity. Just as the first is ultimately grounded on his deistic faith that "man must go back to nature for information", since "perfection consists in simplicity", so his last ideal, that of order, is also grounded on his deistic faith that the test of the revelation even of God himself is that "harmonious, magnificent order that reigns throughout the visible universe," an order

---

[127] *Ibid,* II, 302.

[128] *Writings,* I.

[129] *Ibid,* I.

[130] *Ibid,* II, 24. Watson (*Apology,* p. 8) taxes *The Age of Reason,* Part II, with "much repetition, and a defect of proper arrangement," a criticism also made by T. Meek, *Sophistry Detected, or, a Refutation of T. Paine's Age of Reason,* Newcastle, *MDCCXCV,* p. 28.

[131] Such as, "Having done A, we will now turn to B," etc. See especially, for examples, *Writings* II, 520; II, 83–4; III, 331; IV, 62; I, 290; I, 329.

[132] *Ibid.,* IV, 83–84.

which is "the standard to which everything must be brought."[133] Like his theories political, economic, humanitarian, and educational, his theories of rhetoric ultimately stem from and are fully explainable only in the light of Newtonian science and deism. *The pivot round which his thought revolved was scientific deism.* As I have suggested, in espousing orderly method in writing Paine was in full accord with his contemporaries; witness his idol, Franklin, giving typically prosaic and practical suggestions whereby his friend Benjamin Vaughan could overcome his want of "perspicuity" which Franklin traced "principally to a neglect of method".[134] If there are splendours and glooms of the human soul which the eighteenth century seldom cared to explore, if in general, as compared with the Age of Wordsworth, the Age of Pope is inferior in moral and imaginative sublimity, it is well to remember that the latter is preeminent in its regard for form and for exquisiteness of literary order. Deism, with its belief in God, man, and nature as sharply distinct, its belief in what Paine called divinely "unerring order", is parallelled in literature and art and landscape gardening by order;[135] whereas pantheism, with its belief in unity, or the fusion of God, man, and nature, is parallelled in these same fields, by comparative disorder. "Order," said Pope, "is Heav'n's first law." The apotheosis of order, and this is the point I would stress, whether or not a result of deism, was characteristic of Paine's age. Loving "unerring order" and

[133] *Writings,* IV, 339–40.

[134] "What I would therefore recommend to you is, that, before you sit down to write on any subject, you would spend some days in considering it, putting down at the same time, in short hints, every thought which occurs to you as proper to make a part of your intended piece. When you have thus obtained a collection of the thoughts, examine them carefully with this view, to find which of them is properest to be presented *first* to the mind of the reader that he, being possessed of that, may the more easily understand it, and be better disposed to receive what you intend for the second; and thus I would have you put a figure before each thought, to mark its future place in your composition. For so, every preceding proposition preparing the mind for that which is to follow, and the reader often anticipating it, he proceeds with ease, and pleasure, and approbation, as seemingly continually to meet with his own thoughts. In this mode you have a better chance for a perfect production; because the mind attending first to the sentiments alone, next to the method alone, each part is likely to be better performed, and I think too in less time." Quoted by W. C. Bruce, *Franklin Self-Revealed,* II, 441. It is interesting to observe that Franklin, who read "Shaftesbury and Collins", was the friend of Henry Pemberton, author of *A View of Sir Isaac Newton's Philosophy,* (London, 1729), and who confessed that he "became a thorough deist", placed high among his cardinal virtues the virtue of order.

[135] See Myra Reynolds, *The Treatment of Nature in English Poetry,* Chicago, 1919, p. 327 ff.

finding it sublimely present in the "eternal harmony" of the stars, symbols of light and law, Paine said that "my belief in the perfection of the Deity will not permit me to believe that a book [the Bible] so manifestly obscure, disorderly, and contradictory can be his work",[136] but Thomas Burnet in 1759 deplored the "disorder", even of the stars, because they did not conform to the neo-classic demand for a symmetrical pattern:

> "They lie carelessly scattered as if they had been sown in the heaven like seed, by handfuls, and not by a skilful hand neither. What a beautiful hemisphere they would have made if they had been placed in rank and order; if they had all been disposed into regular figures, and the little ones set with due regard to the greater, and then all finished and made up into one fair piece or great composition according to the rules of art and symmetry!"[137]

Could a passion for order go beyond this?

If Paine suffered many disappointments, was the object of much public and private malice, and was ultimately disillusioned with the French Revolution, and obliged to "despair of seeing the great object of European liberty accomplished,"[138] Jefferson, his great idol, the father of democracy, recognized the precious services of his pen:

> "No writer", Jefferson wrote, "has exceeded Paine in ease and familiarity of style, in perspicuity of expression, happiness in elucidation, and in simple and unassuming language. In this he may be compared with Dr. Franklin; and indeed his Common Sense was, for a while, believed to have been written by Dr. Franklin."[139]

> And as he wrote Paine himself, "You must not be too much elated and set up when I tell you my belief that you are the only writer in America who can write better than your obliged and obedient servant—Thomas Jefferson."[140]

> "I am in hopes," he wrote Paine in 1801, "you will find us returned generally to sentiments worthy of former times. In these it will be your glory to have steadily laboured and with as much effect as any man living."[141]

---

[136] *Writings,* IV, 222 and 216.

[137] Thomas Burnet, *The Sacred Theory of the Earth,* London, 1759. See the chapter entitled "Stars".

[138] *Writings,* III, 135.

[139] Jefferson's *Works,* ed. Ford, X, 183.

[140] Quoted in D. E. Wheller's *Life and Writings of Thomas Paine,* I, 327.

[141] Jefferson's *Works,* VIII, 19, and proudly quoted by Paine himself, *Writings,* III, 428.

And in the attainment of this superlative "glory", Paine was guided by literary theories which, if by no means ideal, at least bore the test of practice. For he commanded the attention of half a million readers, vigorously stirring them to contemplate the political, religious, and social doctrines which helped to call into being the American and French Revolutions as well as many humanitarian movements of later days, doctrines forcefully and clearly presented in a style which served as a trusty tool and was occasionally not without elements of beauty.

THE IDEA OF PROGRESS IN *LOCKSLEY HALL*

ROBERT K. RICHARDSON

Beloit College

Since Tennyson published his *Locksley Hall* in 1842, its popularity has paralleled the vogue of its dominant concept, the 'idea of progress,' and may, in large measure, be ascribed to the poem's reflection of that vogue.[1] So familiar have its lines become as almost to require apology for their quotation. Yet, even in the face of the face of the publication by the late Professor Bury, some eleven years gone by, of *The Idea of Progress, an Inquiry Into Its Origin and Growth*,[2] it is probable that few readers of the poem realize the degree in which its remarkable stanzas, directly, or by easy implication, are the legitimate and authentic product of the entire historical evolution of the factors essential to the idea; embody in a way possible only to verse that emotional element which would appear also a prerequisite of the idea; and suggest, by their presentation of the necessary components of the concept, its adequate definition.

---

[1] Tennyson was accustomed deliberately to adapt his art to its age. *Cf.* Elizabeth Luther Cary: *Tennyson: His Homes, His Friends, and His Work*, 47–48: "Mr. Pater......wrote in his essay on *'Style'*: 'English, for a quarter of a century past, has been assimilating the phraseology of pictorial art; for half a century, the phraseology of the great German metaphysical movement of eighty years ago; in part, also, the language of mystical theology: and none but pedants will regret a great consequent increase of its resources. For many years to come its enterprise may well lie in the naturalization of the vocabulary of science, so only it be under the eye of a sensitive scholarship—a liberal naturalization of the ideas of science too, for, after all, the chief stimulus of good style is to possess a full, rich, complex material to grapple with.'

Tennyson did precisely this, bending his nineteenth-century intellect to the task of naturalizing scientific and metaphysical ideas and their phraseology, in a most unprecedented fashion. This adaptation of his art to his age constituted, perhaps, his chief claim to originality. His mind was not, like Browning's, a quarry of native marble; it was rather a mint, receiving and giving current value to ore of a thousand mines. He anticipated, in his dreams and visions, subjects that were presently to be chief interests with the public, with much of the instinct that serves the true journalist who makes an art of his profession."

Cf. Thomas R. Lounsbury, *The Life and Times of Tennyson* [*From 1809—1850*], ft. 439–445.

[2] J. B. Bury, *op. cit.*, London, 1921.

HISTORICAL EVOLUTION OF THE IDEA OF PROGRESS

And, first, for the evolution and integration of the component elements of the idea.

The notion of progress, in Tennyson or elsewhere, owes relatively little to classical antiquity. Both the thought and feeling of the ancients were unfavorable to the rise of such an idea. A philosophy of progress is a philosophy of flux and, despite notable exceptions, the tendency of antiquity was to view changelessness and stability as superior to their opposites. Philosophy, law, and religion were in this accordant. "Inasmuch as philosophers only are able to grasp the eternal and unchangeable," asserts the Platonic Socrates, "and those who wander in the region of the many and variable are not philosophers, I must ask you which of the two classes should be the rulers of our State?"[3] "As laid down in the Institutes of Justinian," writes Dean Pound, "the precepts of law are three: to live honorably, not to injure another, to give to everyone his due. What the interests of another are which one is not to injure, what constitutes anyone's due which is to be given him, are questions left to the traditional and authoritative social organization."[4] And a famous text of St. Paul, not now much preached upon, is "for I have learned, in whatsoever state I am, therewith to be content."[5]

Other features of the thought and life of antiquity adverse to the rise of a theory of human progress were classical notions as to repetitive cycles of existence, personal or cosmic;[6] contempt for commerce and labor as baunistic;[7] absence of thrill-evoking invention; the ascetic resignation of Roman imperial times; and emphasis on necessity and fate. The rational and

[3] *The Republic,* VI, 484, B (Jowett's tr.), *Cf.* Marcus Aurelius, *Thoughts,* V, 2: "How easy it is to repel and to wipe away every impression which is troublesome or unsuitable, and immediately to be in all tranquility." (Long's tr., 2nd ed., 106.) *Cf.* Plotinus on the "eternal peace" of the "Intellect" or, as Dean Inge translates, the "Spiritual World" (*Plotini Enneades,* ed. Creuzer and Moser, Paris, 1855, V, Bk. 1, iv, p. 301, col. 1, ll. 4–6).

[4] Roscoe Pound, *The Spirit of the Common Law,* 86.

[5] Phil., IV, 11, and *cf.* I Tim., VI. Augustine, *De Civitate Dei,* I, Pref., "Gloriosissimam civitatem Dei sive in hoc temporum cursu, ... sive in illa stabilitate sedis aeternae" (ed. Dombart, Leipzig, 1863, I, 3: and *passim,* indefinitely). *Vid.,* also, Lewis Mumford, *The Story of Utopias,* New York, 1922.

[6] *Cf.* Plato, *Republic,* X; Augustine, *De Civ, Dei,* ed. cit., XII, 11, 13, 17; Virgil, *Ecloga* IV, ll. 5–7, 34–36. But for an opposite use of this material to Virgil's, *cf.* Shelley, final chorus of the *Hellas.*

[7] *Cf.* Plato, *Republic,* II, 371, C; III, 415, A.

emotional appreciation of enormous times and spaces, so agreeable to the development of a sense of progress, was also foreign to the classic mind. The Greek temple is

> The one thing finished in this hasty world,
> Forever finished,

soliloquizes Lowell in *The Cathedral* and, as Spengler points out, its architecture is entirely one which draws the interest of the spectator to its inner point, the confining *cella*,—not one which, like Gothic, lures the worshipper from the within to the without and from the below to the above. Greek mathematics are as timeless as Greek architecture. Whereas "We conceive of things as they *become* and *behave*, as *function*" and have thus arrived, says Spengler, at "dynamics, analytical geometry" and finally "to the Differential Calculus," "in Greek mathematics time figures not at all."[8] "Classical man formed no image of a world in progress."[9]

Antiquity did, on the other hand, make one important contribution to the idea of progress: it conceived and to a notable degree embodied the unity of man. Such an idea was acceptable alike to the Stoic philosopher, the Christian missionary, and the Roman official:[10] and it is an idea needful to the rise of a notion of progress as implying the cooperation of all peoples in the task of advancement incident to a blending of their respective contributions. The unity of man appears in such lines of *Locksley Hall* as:

> (1) Saw the *vision of the world*, and all the wonder that would be. [*bis*]
>
> (2) *Men, my brothers*, men the workers.
>
> (3) In the *Parliament of man, the Federation of the World.*

Tennyson was to strike the note more clearly, if possible, in the

[8] Oswald Spengler, *Decline of the West*, tr., I, 15; 15, n. 1; and *passim*.

[9] *Ibid.*, I, 15, *Cf.* I, 14–15; 134, n. 1; 254; 133. The conception of infinity, helpful to the idea of progress, was to the Greek abhorrent: *cf.* Plato and Plotinus, *passim*.

[10] *Cf.* W. Windelband, *Hist. of Philosophy*, tr., 2nd, ed., 176–178; Bryce, *Studies in History and Jurisprudence*, Essay XI, *The Law of Nature*, 570 ff. *Annals of Tacitus*, ed. Furneaux, Bk. XI, 23, 24, and Appendix I (Claudius on the enlargement of the Senate). Aeneid, Bk. VI, ll. 847–853. *Ephesians*, II, 11–III, 7.

It ought, perhaps, to be added that Pythagorean and Platonic mathematical emphasis was not without influence in the Copernican and Cartesian revolutions: *vid.* J. H. Randall, *The Making of the Modern Mind*, 227 ff.

Ode Sung at the Opening of the International Exhibition of 1862,[11] but it is very plainly in *Lockley Hall* none the less.

The Middle Ages, like Antiquity, brought to completeness but one element needed for the final and classic form[12] of the idea of progress: a sense of the continuity of history. This element appears in the following lines of *Locksley Hall:*

(1) nourishing a youth sublime
With the fairy tales of science and *the long result of time;*
When the centuries behind me like a peacful land reposed.[13]
(2) *Science moves,* but slowly, slowly, *creeping on from point to point.*
(3) Yet I doubt not *thro' the ages one increasing purpose runs,*
And *the thoughts of men are widen'd with the process of the suns.*
(4) *I the heir of all the ages,* in the foremost *files of time.*

Most influential in laying the foundations of the notion of historic continuity was Augustine of Hippo. In most regards the Fathers and their successors stood for ideas quite as op-

---

[11] "Uplift a thousand voices full and sweet,
"In this wide hall with earth's invention stored,
"And praise the invisible universal Lord,
"Who lets once more in peace the nations meet,
"Where Science, Art, and Labour have outpour'd
"Their myriad horns of plenty at our feet.
....
"O ye, the wise who think, the wise who reign,
"From growing commerce loose her latest chain,
....
"Till each man find his own in all men's good,
"And all men work in noble brotherhood,
"Breaking their mailed fleets and armed towers,
"And ruling by obeying Nature's powers,
"And gathering all the fruits of earth and crown'd with all her flowers."

With this should be compared the excerpt from the speech of the Prince Consort at the Exhibition of 1851, given by Bury, *op. cit.*, 330: "that great end to which indeed all history points—the realization of the unity of mankind."

[12] This, in effect, means the French form of the doctrine as distinguished from various German variations. *Vid.* Bury, *op. cit.*, ch. XIII.

[13] The attitude of the typical Englishman toward change, supported by a vast amount of English historical precedent, is shared by Tennyson and must have helped him the more easily to face such a difficulty in the way of a doctrine of continuity as was offered by the problem of "the Dark Ages." *Cf.* the poems *You ask me, why, tho' ill at ease* (*ca.* 1833, and published 1842) and *Love thou thy land, with love far-brought* (*ca.* 1833, published 1842). In the latter poem, for example, is the significant verse:

"So let the change which comes be free
"To ingroove itself with that which flies,
"And work, a joint of state, that plies
"Its office, moved with sympathy."

Tennyson is one who watches "what main-currents draw the years" (*ibid.*).

posed to any thought of progress as had been the classical ideas just mentioned: for an other-worldly interpretation of reality and of the goals of living, for a catastrophic world's end, for supernatural interventions, for a gospel of original sin.[14] On the other hand, Augustine attacks the doctrines of cycles; and history, in connection with the drama of salvation, the strife of the two Cities, is accorded meaning, wholeness, and continuity.[15] It was not less advantageous for the rise of an idea of progress that the mediaeval view of the nature of history was necessarily connected, through Church and Holy Roman Empire, with the previous, and almost as essential, doctrine of the unity of man.

In the *Methodus ad Facilem Historiarum Cognitionem* of Bodin (1566) the classical and mediaeval contributions have combined into a doctrine whereby history falls into three stages, during which, respectively, the peoples of the South-East contribute religion to the common fund, those of the Mediterranean gifts of practical sagacity, and those of the North aptitude in war and inventive skill.[16] By the middle of the eighteenth century so thoroughly adopted is the conception of continuity that Montesquieu, Voltaire, and Turgot are seeking the laws determining its course: from which point the path is short to the sociological theories of Saint-Simon, August-Comte. and Karl Marx.[17]

---

[14] *De Civ. Dei,* ed. Dombart, 1863, VII, Pref.: Multum magna res agitur, cum verá et vere sancta divinitas, quamvis ab ea nobis etiam huic, quam nunc gerimus, fragilitati necessaria subsidia praebeantur, non tamen propter mortalis vitae transitorium vaporem, sed propter vitam beatam, quae non nisi aeterna est quaerenda et colenda praedicatur. *Cf.,* also, IX, 15 and Bk. XIX, which is particularly pessimistic, *passim, Cf.,* also, the Prologue of the eighth book of Otto of Freising's chronicle of *The Two Cities* (tr. C. C. Mierow, ed. Evans and Knapp, 1928), and Introduction, 75 ff.

[15] *Cf.* Augustine, *op. cit.,* XII, 11, 13, 17, 20: as, also, Otto of Freising.

[16] Bury, *op, cit.,* 38.

[17] *Ibid.,* 144–146, 151–152, 153–158. On Montesquieu and Voltaire, *cf.* Eduard Fueter, *Geschichte der Neueren Historiographie* (1911), 384: "Es war erstens nicht von geringerer Bedeutung, dass Montesquieu viele Neuerungen im Sinne der Aufklärung, die Voltaire in die Geschichtschreibung einführte, mit dem Gewichte seines Namens unterstützte. So die Erweiterung des Geschichtskreises über die ganze Erde hin, so vor allem die Ablehnung der theologischen Geschichtsbetrachtung in jeder Form. Montesquieu und Voltaire wichen oft voreinander ab; aber darin waren sie beide einig, dass sie historische Vorgänge ausschliesslich aus natürlichen Ursachen erklärten." Of Voltaire Fueter remarks (*op. cit.,* 354): "Sein Jahrhundert [*i. e.,* Louis XIV's] ist das erste Werk, das die annalistische Gliederung, ja die äusserlich chronologische Einreihung überhaupt aufgibt. Zum ersten Male werden die geschichtlichen Ereignisse nach ihrem inneren Zusammenhange, nicht bloss nach der Gleichzeitigkeit zu ordnen versucht. Zum ersten Male wird der *gesamte* Leben eines Staates dargestellt." The very table of contents of *l'Esprit des Lois* exudes the notion of natural law underlying historical

The other essential components of the idea of progress, whatever their remoter origins, mature this side of the Middle Ages. They are six in number and, like their predecessors, are represented in *Locksley Hall.*

1. An ethically accepted this-worldliness.
2. Confidence in human reason.
3. Development and acceptance of scientific aim and method.
4. Increase of inventions.
5. Acceptance as available for human advancement of a vast and indefinite future, the movement tending to be conceived as accelerative.
6. Inclusion within the term "progress" of political and social ameliorations as well as of enhancement of knowledge and technique.

By an ethically accepted this-worldliness is meant a this-worldliness so firmly held, and almost so unconsciously, as to be taken for granted and unsubject to serious ethical or theological criticism. It is represented in *Locksley Hall,* not only by a plot in which the disappointed lover seeks to drown his grief in life's practical business rather than in any ascetic or transcendental fashion, but by the following specific lines:

(1) *When I clung to all the present* for the promise that it closed:
When I dipt into the future far as human eye could see;
Saw the vision of the world, and all the wonder that would be.

(2) Men, my brothers, *men the workers*..........:
That which they have done but earnest of the things that they shall do.

(3) *Let the great world spin forever down the ringing grooves of change.*

This last a line, it is fair to say, which would have found small favor with Plato!

The origins of this friendly attitude toward the Here-and-Now are, of course, and properly, associated with the Renaissance. One instinctively thinks of the circles of Lorenzo and of Florence, of the egoisms and worse of Benvenuto, of the experimentations and surmises of Leonardo, of the tales of Boccaccio, and of Petrarch's love of fame and Laura. But Dante, too, had

process, and notably the life and nature of the state: note particularly Bks. 14, 15, 16, 18, 20.

vowed his beloved fame, and kept the vow; and before Dante, even back in the twelfth century, students had been singing songs beside which "Here's to good old Yale" were a gospel-hymn.[18] In view of many considerations, of *fabliaux,* of *chansons d'aventure,* and of early classical revivals, one hardly knows to-day whether to ask: "Was there a Renaissance?" or "Was there a Middle Age?"

In reality, however, the basic source of the overthrow of the dominance of other-worldliness would appear to have been the revival of the foreign commerce of western Europe incident to the growing stability of the tenth and eleventh centuries, the unbroken mercantile connections of Venice with Constantinople, the revival of the Flanders trade through the new mart of Bruges in the tenth and eleventh centuries, and the rise—probably based on sheer surplusage of servile population—of a professional mercantile class throughout central western Europe in the tenth century. Members of this class, of servile origin but, *de facto,* free by reason of sheer untraceability, might settle, for example, outside the fortified "burg," in their *forisburgus,* their *faubourg,* which soon became *the* bourg, and thus create a bourgeois class. As a type of this new "third estate" Pirenne mentions the mercantile period of the life of St. Godric of Finchale, of the late eleventh and early twelfth centuries.[19]

Curiously enough, this mercantile movement, eyed askance by the Church, so this-worldly in all its associations and consequences, received its final impetus precisely from the Crusades which, in their ultimate motivations were among the most perfect examples of mediaeval renunciation and transcendentalism! It remained, however, for the rationalistic and mathematically minded revolutions of the seventeenth and eighteenth centuries to administer the *coup de grace* to the dominance of any other-

[18] *Cf.* Boris I. Jarcho: *Die Vorläufer des Golias,* in *Speculum,* III, no. 4, Oct. 1928, 523 ff., as also Prof. Rand's note, *ibid.,* 595. Examples of verse, in Haskins, *The Renaissance of the Twelfth Century,* 181 ff. *Cf.,* also, James Westfall Thompson, *The Last Pagan,* stanza XXXI, p. 49 (*Presidential Address Before the Chicago Literary Club, Forty-Third Year, Oct. 9th, 1916.* Chicago Literary Club, 1917). The poem translated by Prof. Thompson is that of a 13th century admirer of Lucretius. *Ibid.,* 18, 24–26.

[19] Pirenne, *Medieval Cities, Their Origins and the Revival of Trade,* 120 ff. Of Godric the author remarks: "The quest of profit guided all his actions and in him can be easily recognized that famous 'capitalistic spirit' (*spiritus capitalisticus*) which some would have us believe dates only from the Renaissance . . . . It is not employing too modern an expression to say that the profits he realized were put to work as fast as possible to augment his revolving capital."

worldliness, either of the traditional Catholic or of the Protestant type.[20]

The second post-mediaeval factor in the idea of progress is confidence in the human reason. This item may not be specifically mentioned in *Locksley Hall,* but it is implicit in its emotional expression and is clearly apparent through such a line as *"Science moves, but slowly slowly, creeping on from point to point."*[21]

The mediaevalist thinks at once of the *Sic et Non* of twelfth century Abelard, or of the *Concordantia Discordantium Canonum* of the same epoch, or of the analytical and synthetical *Summa* of Aquinas.[22] These, after all, are in the main critical treatments of previous authorities: and though these, and other monuments of scholastic thought, doubtless trained and sharpened the human mind and led to the rationalistic freedom of a Valla and an Erasmus, even such freedom was soon threatened by a new authority, antiquity itself. Against this new foe Bodin protested in his above mentioned *Methodus.* In behalf of the rationalistic powers of the moderns he appealed alike to the light thrown by them upon phenomena inadequately explained by the ancients, and to such discoveries as the compass, gunpowder and the printing press. Bodin found a supporter in Le Roy.[23] Particularly hostile to undue reverence for antiquity was Lord Bacon. In the very preface of *The Great Instauration* he writes of the wisdom derivable from the Greeks that "it can talk, but it cannot generate; for it is fruitful of controversies but barren of works."[24]

But of the seventeenth century, the critical and decisive century for the rise of the idea of progress, Descartes is, with respect to that idea, the central figure: and of the Cartesian viewpoint the supremacy of the human reason is the very key. The conception appears in the first sentences of the *Discourse on*

---

[20] *Cf.* Randall, *op. cit.,* chs. IX, *et seq.*

[21] *Cf,* too, such a protest as the line: *"Cursed be the sickly forms that err from honest Nature's rule!"* wherein *"Nature"* seems equivalent to Reason as in Pope's *"True wit is nature to advantage dress'd."* On the other hand it may be romantically used, or be merely ambiguous.

[22] *Cf.,* also, such a writer as Dante. At the beginning of the *De Monarchia* he tells us that he is striving "to establish truths unattempted by others," (*op. cit.,* tr. Aurelia Henry, I, 1); but his dependence on Aristotle is constant, and it remains for Marsiglio and Machiavelli really to get a new standpoint.

[23] Bury, *op. cit.,* 40–41, 44–49.

[24] *The Works of Francis Bacon,* ed. Spedding, Ellis and Heath, IV (1883), 14.

Method (1637): "Good sense is, of all things among men, the most equally distributed; for every one thinks himself so abundantly provided with it, that those even who are the most difficult to satisfy in everything else, do not usually desire a larger measure of this quality than they already possess. And in this it is not likely that all are mistaken: the conviction is rather to be held as testifying that the power of judging aright and of distinguishing truth from error, which is properly what is called good sense or reason, is by nature equal in all men; and that the diversity of our opinions, consequently, does not arise from some being endowed with a larger share of reason than others, but solely from this, that we conduct our thoughts along different ways, and do not fix our attention on the same objects. For to be possessed of a vigorous mind is not enough; the prime requisite is rightly to apply it."[25] In the fourth book of the *Discourse* the idea is epigrammatically summarized: "For, in fine, whether awake or asleep, we ought never to allow ourselves to be persuaded of the truth of anything unless on the evidence of our reason."[26] The mindedness of Descartes was enthroned throughout the eighteenth century, and by 1789 it had, with a daring unknown to the master, optimistically and light-heartedly brought all institutions to the bar of reason and produced the French Revolution, of which we so largely are the children, even a Tennyson.

The next two constituants of the progress-idea as above enumerated are the development of scientific aim and method, and the increase of inventions—thrilling inventions, we should perhaps have added! Each of these factors is inextricably associated with the other, and both are cradled in the rising confidence in human reason. The lines involving these two matters in the poem are as follows:

(1) Nourishing a youth *sublime*
With the fairy tales of science.

(2) Men the workers, *ever reaping something new:*
That which they have done but earnest of the things that they shall do."

(3) For I dipt into the future, far as human eye could see,
Saw the Vision of the world, and *all the wonder that would be;*
Saw the heavens fill with commerce, argosies of magic sails.

[25] Descartes, *op. cit.,* Everyman ed., 3.
[26] *Ibid.,* 32; *cf.,* also, 22–24.

Pilots of the purple twilight, dropping down with costly bales;
Heard the heavens fill with shouting, and there rain'd a ghastly dew
From *the nations' airy navies grappling in the central blue;*
Far along the world-wide whisper of the south-wind rushing warm,
With the standards of the peoples plunging thro' the thunder-storm.

(4) Let the great world spin forever down *the ringing grooves of change.*

—this last quotation in view of the circumstances of its writing which were those of Tennyson's first railroad ride.[27]

Space and common sense forbid discussion of the rise of theoretical and applied science in the seventeenth and eighteenth centuries: but it is clear that in the above excerpts are involved the aims and methodology of Bacon and Descartes: of Galileo and Kepler and Newton: the utilitarianism of the *Novum Organon,*[28] and its application in the Industrial Revolution. Anything dreamed of in Bacon's *New Atlantis* or contemplated in the cogitations of the Royal Society of 1660 had been far surpassed by 1842. And only the following year *Punch* was to publish a cartoon entitled *The Aerial Steam Carriage,* with an explanatory text prophesying a first line to India, "the carriages leaving the top of the Monument, Fish Street Hill, every morn-

[27] Notes to Macmillan edition., 1920, p. 901, note to p. 100, line 22: "When I went by the first train from Liverpool to Manchester (1830), I thought that the wheels ran in a groove. It was a black night, and there was such a vast crowd at the station that we could not see the wheels. Then I made this line."

[28] Passages indicated by Bury are as follows: *Aphorisms Concerning the Interpretation of Nature and the Kingdom of Man,* Bk. I, lxxxi (in *Novum Organon*): this includes the passage: "And if by chance there be one who seeks after truth in earnest, yet even he will propose to himself such a kind of truth as shall yield satisfaction to the mind and understanding in rendering causes for things long since discovered, and not the truth which shall lead to new assurance of works and new lights of axiums." (*Works of Francis Bacon,* ed. Spedding, *etc.,* IV [1883], 79–80.) Also, *ibid.,* Bk. I, iii, p. 47. To these may be added ciii, p. 96.

Bury also indicates the highly basic passage of the *De Augmentis Scientiarum,* VII, 1: "Ego certe......et in iis quae nunc edo et in iis quae in posterum meditor dignitatem ingenii et nominis mei (si qua sit) saepius sciens et volens projicio, dum commodis humanis inserviam..."(*ibid.,* I [1879], 714.)

The same period which was to witness the triumph of utilitarianism as illustrated in the Great Exposition of 1851 and as connected with the triumph of *laissez-faire* and Free Trade, saw a combination between the utilitarianism of Free Trade and the international peace movement of the time. The combination in *Locksley Hall* of emphases on science and invention on the one side, and on peace and international movements on the other, is thoroughly typical of the period. *Vid.* Bury, *op. cit.,* 330, and A. C. F. Beales, *The History of Peace,* 1931, 69–70.

ing, and taking five minutes at the summit of the Great Pyramid, for refreshments, and to allow the passengers a short time to stretch their legs." This picture was to be reproduced in the same magazine toward the close of 1931, incident to the establishment of Air Mail Service to the Cape.[29]

Necessary to the rise of a general presumption of progress is not only a series of notable applications of science to human advantage, but the acceptance as available for human improvement of a vast and indefinite future: and if the process come to be deemed accelerative, so much the better. *Locksley Hall* assumes such an indefinite future, though its suggestion of acceleration seems but slight. The lines noted are as follows:

(1) That which they have done *but earnest of the things that they shall do:*
For I dipt into the future, far as human eye could see,
Saw the vision of the world and *all the wonder that would be.*
(2) Yet I doubt not *thro' the ages one increasing purpose runs,*
And the *thoughts of men are widen'd with the process of the suns.*
(3) Not in vain *the distance beacons. Forward, forward let us range,*
Let the great world spin forever down the ringing grooves of change.

In this connection, also, may properly be cited the lines in the poem entitled *The Day Dream,* in a part of the poem published in 1842:

For we are Ancients of the earth,
And in the morning of the times.

The first of these two lines might well be a direct translation of the Eighty-fourth Aphorism of the First Book of the *Novum Organon: Mundi enim senium et grandaevitas pro antiquitate vere habenda sunt; quae temporibus nostris tribui debent, non juniori aetati mundi, qualis apud antiquos fuit.*[30] It is to be

[29] Punch, Dec. 16, 1931. The appearance of the contraptions pictured is highly similar to that of the modern aeroplane. Service to the Cape was established Dec. 9, 1931.

[30] *Works of Francis Bacon. ed. cit.,* I, 190. *Cf.,* also, *The Making of Man,* written late in Tennyson's life and published in 1892.

"Where is one that born of woman, altogether can escape
"From the lower world within him, moods of tiger, or of ape?
"Man as yet is being made, and ere the crowning Age of ages,
"Shall not aeon after aeon pass and touch him into shape?
"All about him shadow still, but, while the races flower and fade

noted, however, that whereas Bacon means that we are "ancients" because we have had the real experience conferred by lapse of time, Tennyson, as shown by the unquoted context, holds that we are "ancients" because, like the men of old, we too are standing only at the portals of an indefinite future, and of great change and progress.

For the most part the pioneers of what was to crystallize into a doctrine of progress and human perfectibility were still too much under the influence of eschatological considerations to lay great stress on a future;[31] but forty-eight years after the *Novum Organon,* Glanville, in a book defending the Royal Society and glorifying its scientific achievement since Bacon's time, declares that its utilitarian mission must be attained by 'insensible degrees,' and that "we must seek and gather, observe and examine, and lay up in bank for the ages that come after." Glanville, therefore, assumes a vast futurity.[32] Twenty years

[32] *Ibid.,* 94. Material in single quotation marks, Bury's: in double, Glanville's as quoted by Bury, from *Plus Ultra.*

this side of Glanville, Fontenelle, in his *Digression on the Ancients and Moderns* (1688), first lays down in its completeness what was to become the general doctrine of the fathers of the French Revolution: that mankind will never degenerate nor enter a second childhood and that progress and knowledge develop independently of the follies or misfortunes of particular individuals.[33] With 1770 begins the still augmenting series of

---

"Prophet-eyes may catch a glory slowly gaining on the shade,
"Till the peoples all are one, and all their voices blend in choric
"Hallelujah to the Maker 'It is finish'd. Man is made.' "

Cf., also, *The Dawn,* similarly written and published (2nd verse):

"Red of the Dawn!
"Godless fury of peoples, and Christless frolic of kings,
"And the bolt of war dashing down upon
cities and blazing farms,
"For Babylon was a child new-born, and
Rome was a babe in arms,
"And London and Paris and all the rest
are as yet but in leading strings."

For a very general treatment, *vid.* William Clark Gordon, *The Social Ideals of Alfred Tennyson as Related to his Time,* Un. of Chicago Press, 1906. In addition to the two above poems, Mr. Gordon calls attention to the four stages of history in *The Holy Grail,* represented in the sculpture at Camelot:

"In the lowest beasts are slaying men,
"And in the second men are slaying beasts,
"And on the third are warriors, perfect men,
"And on the fourth are men with growing wings."

[31] Bury, *op. cit.,* 57–59, 90, 94, 97.

[33] Bury, *op. cit.,* 109–110, 162–163. Fontenelle was, however, devoid of a theory of evolution, held that most men would always be fools, and had no dreams of social improvement (*ibid.,* 110–111).

Utopias, fictitious or attempted, not confined like Plato's or Bacon's to contemporary space, near or remote, but frequently imagined in the future.[34] That of Bellamy may serve as a type. Among English poets perfectibility's choicest product is Shelley, in whom are blended the Platonism of antiquity, the chivalry of the Middle Ages, and the humanitarianism of the Revolution.

Tennyson's doctrine of the "one increasing purpose" and the widening of men's thoughts "with the process of the suns" may, to some, suggest the accelerative character of progress. If Tennyson did have this in mind he was presenting a doctrine laid down by Turgot in an unrealized plan for a treatment of universal history[35] and by Condorcet who, in his *Sketch of a Historical Picture of the Progress of the Human Mind,* had indicated that the study of history enables man both to determine and to accelerate his progress.[36]

Lastly, so far as regards the intellectual factors logically essential to the evolution of the idea of progress, *Locksley Hall* includes, not only the conception of enlargements of knowledge and improvements of technique, but also the tenet of an indefinite amelioration of political and social conditions. Pertinent lines are as follows:

(1) *Cursed be the social wants that sin against the strength of youth!*
Cursed be the social lies that warp us from the living truth!
(2) *Saw the heavens fill with commerce.*
(3) *Till the war-drum throbb'd no longer, and the battle flags were furl'd*
In the Parliament of man, the Federation of the world.
There the common sense of most shall hold a fretful realm in awe,
And the kindly earth shall slumber, lapt in universal law.

The topics specifically mentioned are harmful social conventions, international trade ("free trade"), international organization for peace, and the rule of politically competent majority opinion. These few topics may be held to stand for the many,

---

[34] *Ibid.,* ch. X. *Cf.* Mumford, *Story of Utopias.*

[35] Bury, *op. cit.,* 157.

[36] Bury, *op. cit.,* 211, using the 1795 edition. *Cf.* the translation: *"Outlines of an Historical View of the Progress of the Human Mind,"* Philadelphia, 1796, 11: "From these observations on what man has heretofore been, and what he is at present, we shall be led to the means of securing and of accelerating the still further progress, of which, from his nature, we may indulge the hope."

and what is explicit in the second *Locksley Hall* may be deemed implicit in the first.

In all these matters Tennyson represents tendencies long developing. Bury points out that it was an Englishman, George Hakewill, who, in a pedantic and now long forgotten folio, of 1627, introduced into the "Quarrel of the Ancients and Moderns" and thus indirectly into the idea of progress the matters of moral and social amelioration:[37] but that it remained for the humanitarian Abbé de Saint-Pierre to make "progress towards social perfection" a definitive and integral part of the theory of unlimited progress.[38] The abbé was a typically cheerful Cartesian, eternally propounding programs of reform, in short, a kind of French, seventeenth century, for the time-being less influential, Jeremy Bentham. In his *Project of Henry the Great to Render Peace Perpetual, Explained by the Abbé de Saint-Pierre* he was a notable forerunner of current internationalism,[39] and, in general, marked the transition from mere Cartesion rationalism to Encyclopaedic and Revolutionary humanitarianism.[40] The influence of Rousseau counted heavily, of course, on the same side of the balance. Supremely typical, however, of the programs of the humanitarian progressivists is that of Condorcet in the work above noted. It is reserved for treatment in connection with the definition of the idea of progress.

In England Tennyson had been preceded by such representatives of this phase of the general movement as Priestly, Godwin, Shelley, and others,—not including Bentham, who, for all his humanitarianism and utilitarianism, took small stock in the French school of rights and perfectibility.[41] Later the doctrine of improvement by legislation, shared by Bentham with the illuminationists generally, passed into the various schools of English and Continental socialism represented by such names as Owen, Saint-Simon and Comte. The *Communist Manifesto* was not to be written and published till early in 1848 and no

---

[37] Bury, *op. cit.*, 88–89.

[38] *Ibid.*, 128.

[39] Bury, *op. cit.*, ch. VI, *in toto.* A. V. Dicey, *Lectures on the Relation Between Law and Public Opinion in England During the Nineteenth Century,* 2nd ed., Lectures VI. *Cf. Memoirs of Maximilian de Bethune, Duke of Sully,* V (London, 1778, tr.), Bk XXX, containing the plan of Henry IV.

[40] Bury, *ut sup.*

[41] *Id., op. cit.,* 230. Dicey, *ut sup.*

English translation of the *Manifesto* appeared before 1850.[42] Saint-Simon died in 1825, but not till after he had revived the Abbé de Saint-Pierre's idea of the abolition of war through the creation of what was practically a United States of Europe. "Here," remarks Bury, "is the germ of the idea of a 'Parliament of Man.' "[43]

Placed in respect to the pacifistic and internationalistic movements of the nineteenth and twentieth centuries, *Locksley Hall* was published after the great British and American Peace Societies had been founded in 1816 and 1828, respectively—the American society, however, representing the amalgamation of societies the earliest of which slightly antedated any British society;[44] one year after the death of the notable American peace promoter William Ladd;[45] and at the beginning of that definite cooperation between the peace and free trade propagandas, reflected in the poem, and historically embodied in the joint councils and labors of Bright, Cobden, and Richard.[46] Ladd's masterpiece, *Essay on a Congress of Nations,* appeared the same year.[47] The series of international Peace Congresses was to begin the following year and to terminate in 1851.[48] It was not till 1849 that Victor Hugo, another great poet of peace and progress, was to preside at the Paris Peace Congress;[49] in which year, too, Cobden was to introduce into the House of Commons his memorable motion "that the time was ripe for the government to enter into communications with foreign governments for the establishment of a system of arbitration throughout the world."[50]

Such are the chief components of the idea of progress as they have historically evolved and as they have found expression in *Locksley Hall.* Quite a list of ancillary and subordinate concepts might be formulated, as also of counter currents and attitudes.[51] Such a list would, for example, include sundry German meta-

---

[42] *Historical Readings in Nineteenth Century Thought,* ed. Hall and Beller, 92.
[43] Bury, *op. cit.,* 285.
[44] A. C. F. Beales, *The History of Peace* (1931), 46, 53.
[45] *Ibid.,* 64, Ladd died April 9, 1841.
[46] *Ibid.,* 57, and *passim. Vid.* n. 28, *sup.,* at end.
[47] *Ibid.,* 62.
[48] *Ibid.,* ch. IV.
[49] *Ibid.,* 78–80.
[50] *Ibid.,* 77–78.
[51] For example, the regressiveness of Rousseau's *Discours sur l'Origine de l'Inégalité Parmi les Hommes.*

physical theories.[52] None the less, Tennyson has, consciously or unconsciously, grasped all the absolutely essential features of the idea of progress as that has been dynamic in the behaviour of the European and the American, and has combined them within the span of a comparatively short poem.

LOCKSLEY HALL AND THE EMOTIONAL ELEMENTS CONNECTED WITH THE IDEA OF PROGRESS

The idea of progress belongs to that order of ideas which, like patriotism, or humanitarianism, or utilitarianism, or Christianity, is so suffused with feeling as to produce life-long dedications and even martyrdom. The lines of *Locksley Hall* are correspondingly emotional: they are full of "wild pulsation," "yearning for the large excitement," and 'leapings' of the spirit. Tennyson was conscious of this for in *Locksley Hall Sixty Years After* (1886), he selects for deprecating quotation the

> Forward, forward let us range,
> Let the great world spin forever down the ringing grooves of change,

—only, this time, the lines read:

> Gone the cry of 'Forward, Forward,' lost within a growing gloom;
> Lost, or only heard in silence from the silence of a tomb.

But emotions have roots as well as have ideas. Sometimes they go deeper than ideas. And by emotions is meant not only thrills but whole mental atmospheres, characteristic of long periods of time, the common temperaments of untold numbers of people. Such are nationalism, or socialism, or legalism (as applied to Rome), or aestheticism (as in the case of Greek devotion to the ideal of *meden agan*, or chivalry (as applied to the respective middle ages of Western Europe or Japan). Thus it may well be that the emotion connected with the idea of progress is a very cause of the idea, and that this emotion is itself a large part of some mindedness, some ethos, some *Anschauung*, some unconscious, destiny-shaping mental force characteristic of those western stocks whose seventeenth and eighteenth centuries indubitably gave birth to progress as idea.

---

[52] The following are matters of the auxiliary types suggested: providence and progress; freedom of the will and progress; the views of Leibnitz, Herder, Kant, Hegel, and others; progress and happiness; spiral progress; astronomy and progress; standards for measuring progress; is human welfare the prime consideration in a theory of progress; *etc. etc. Cf.* Bury, *op. cit.*, ch. XIII.

It has already been suggested, following Spengler, that the ethos of classical man was the spirit of the confined, the finite, and the present: it is now suggested, in agreement with Spengler, that the *esprit* and point of view of the peoples who took the torch from Greek and Roman, were those of time, the infinite, and the soul. "Save us from the tyranny of the near and the little" was the burden of a recent pastoral prayer,[53] and perhaps the pastor prayed like a true barbarian!

James Russell Lowell catches the antithesis in *The Cathedral.* After the lines in part above quoted:

> The Grecian gluts me with its perfectness,
> Unanswerable as Euclid, self-contained,
> The one thing finished in this hasty world,

there follows a rhapsody on the old cathedral, which happened to be Chartres, but which might have been any of a hundred others:

> But ah! this other, *this that never ends,*
> *Still climbing, luring fancy still to climb,*
> *As full of morals half-divined as life,*
> Graceful, *grotesque, with ever new surprise.*
> ....
> I looked, *and owned myself a happy Goth.*
> ....
> ...."*No Grecian drop*
> *Rebukes these veins that leap with kindred thrill,*
> After long exile, *to the mother-tongue.*"

The Cambridge poet recognizes his kinship with the "happy Goth" whose works spoke the same "mother-tongue" of fancy, aspiration, and of what Glanville calls *plus ultra.*[54]

For Spengler this same imaginative, longing, adventurous, beyond-seeking life of the Middle Ages[55] is the life that still pulsates in modern western man. Even the product of the Renaissance, in literature, painting, sculpture and architecture, is at bottom the output of the same spirit, warped and pseudomorphosed by a revived and trammeling classicism. The lines underscored in a college student's copy of George Herbert Palmer's *The Glory of the Imperfect* speak this same 'mother-

---

[53] First Congregational Church, Beloit, Wis., Dec. 30, 1928.

[54] The "mother-tongue" is a playful reference to a preceding scene at the inn. For this matter of ethos, *vid.* Spengler, *op. cit., passim.* And *cf.* Goethe's "prime phenomenon" (Bielchowsky, *The Life of Goethe,* tr. Wm. Cooper, III [1908], ch. III, *re* the Urpflanze, *etc.,* and 377, n. 16).

[55] This is not to deny the place of custom in mediaeval life.

tongue:' "For in the lives of us all *there should be a divine discontent,—not devilish discontent, but divine discontent,—a consciousness that life may be larger than we have yet attained, that we are to press beyond what we have reached, that joy lies in the future, in that which has not been found, rather than in the realized present.*"

If then, in the seventeenth and eighteenth centuries, the new astronomy, the new mathematics, and the new utilitarian and experimental science, gave lethal blows—as they did—to the mediaeval schema of life and salvation, leaving man isolated in, and from, the universe on his tiny globe, what more natural, granting this spirit of infinitude within the western peoples, than that it should seek outlet in the indefinite improvement of human conditions, no longer within the flowery meads of Paradise,[56] but within the garden of the Here-and-Now, of the only world left to it by unaided, utilitarian, skeptical reason?

It is suggested, therefore, that the emotion of progress, tellingly embodied in *Locksley Hall,* is Tennyson's expression of the age-long and destiny-fixing, though sub-conscious urge of the western stocks, deflected from orthodox Catholic and Protestant other-worldliness of outlet, to expression through rationalism, scientific utilitarianism, and humanitarianism.[57]

LOCKSLEY HALL AND THE DEFINITION OF PROGRESS

Locksley Hall contains no formal or explicit definition of the idea of progress: but such a definition is there for any reader who will be at the pains to resynthesize the component elements of the idea as embodied in the poem. Such a definition would be something like the following: *the idea of progress is the recently arisen, and emotionally colored and facilitated, belief that mankind, of necessity, has slowly moved, is moving, and will continue to move, for a period of exceeding great and indefinite duration, to a condition of general welfare.*[58]

---

[56] *Cf La Chanson de Roland,* ll. 1854–1856, 2196–2197 (ed. T. A. Jenkins, 1924).

[57] Amiel's *Journal* (tr. Mrs. Humphrey Ward) is full of this thought of *daemon, fatum,* destiny, providence, nature and time, appointed phases, unfathomable substance, life, inner genius, mission, primitive disposition. *Vid.* I, 94–95; 111; 102; 129; 98. (2nd ed.)

A vast emotional urge becomes associated with the idea of progress on the humanitarian side from Jesus and the Hebrew prophets: but this is an auxiliary and ancillary emotionalism, not to be confused with the hypothetical type of progress-urge described in the text. *Cf.* such English humanitarians as Southey and Kingsley.

[58] *Cf.* Bury, *op. cit.,* 2–5.

The question reasonably remains: what are the sorts of goods implied by the definition as conducive to "general welfare?"

The Courts of the United States are said occasionally to arrive at the true sense of a statute by noting the debates incident to its enactment; and perhaps the above definition may be elucidated from the expressed programs of those ultimately responsible for its formulation, notably the thinkers and reformers whose labors caught the attention and aroused the emotional interest of the poet. Let Condorcet serve as spokesman.

Jean Antoine Nicolas de Caritat, Marquis de Condorcet, wrote his already mentioned work on the *Progress of the Human Mind* while hiding from Robespierre in 1793—a fact in itself illustrative of the emotional dynamic of the idea. The following is a general list of the improvements appointed for his tenth, and last, historical epoch, the Future.

The first group relates to the abolition of inequality between nations. Attainment of this aim includes or involves: the end of the slave trade; the dedication of the more enlightened nations to the welfare of the backward ones (as, in principle, in our "mandates"); free trade and the abolition of chartered, monopolistic trading companies (with reference to the Dutch spice trade, or, more generally, to what we call "economic imperialism"); the ending of war; the creation of leagues of nations; the elimination of what, to him, was superstitious missionary work; and the collapse of the religions of the Orient. He expresses himself as encouraged with regard to this program by the hold already gained by the ideas of the Revolution upon enlightened Europe!

Condorcet's second group of betterments deals with the progress of equality within the nations severally. He anticipates, so far as natural causes allow, the relative extinction of inequalities of wealth, of education, and of those incident to the difference in circumstance between those whose security rests on permanent capital and those whose incomes end at death—the salaried man and wage-earner. All these matters he discusses in the spirit of our own time. Various interesting auxiliary topics are treated in this general connection: mass-education; life-insurance; acceleration of scientific development incident to increasing power of generalization; labor-saving machinery; intensive agriculture; increase of leisure; restriction of population; a more exact political and ethical terminology; extension of morality by sound legislation; equality of the sexes; a universal scientific language—programs familiar to us all.

The third group of reforms pertains to the improvement of the human organism itself. In this connection are discussed diminution of extremes of poverty and wealth; improved medical practice, especially in the treatment of contagious disease; diatetics; increase of longevity; eugenics.[59]

How close was Condorcet's thinking to our own is amply illustrated by an article in the Winter Number of *The Yale Review*, 1929, entitled *Medicine in Our Changing World.*[60] This article indicates that "the advancement of society" "depends on six important factors," enumerated as follows:

> "The securing of new knowledge by discovery, invention, and research."
> "Unification of knowledge and the understanding of the interrelation of its parts."
> "The development of adequate means for establishing continuity in knowledge."
> "The physical and mental effectiveness of the individual."
> "Continued betterment of economic and political organisation."
> "Enlargement of the fundamental or basic capacity of the individual."

In this short passage are the souls, not only of Condorcet, but of Bacon, of Descartes, and of all the illuminists and humanitarians of the generations finally condensed into the French Revolution. "Have these things," says the idea of progress, as defined, "and you shall have welfare!"

The implications of the definition, the question of the relation between progress and happiness,[61] and the problem of what may have been Tennyson's subsequent attitude toward the idea, do not fall within the scope of this paper. Whatever might be said in these regards, it may fairly, at least, be claimed for *Locksley Hall* that it is a magnificent embodiment of the factors his-

[59] For criticism of Condorcet's program, *vid.* Amiel's *Journal, ut cit.*, I, 92–93.

[60] *The Yale Review*, vol. XVIII, No. 2, 344 (art. by Morris Fishbein, quoting and paraphrasing Dr. John C. Merriam of the Carnegie Institution).

[61] Bury's definition is as follows: "This idea means that civilization has moved, is moving, and will move in a desireable direction." (*Op. cit.*, 2.)

torically and logically inherent in the idea of progress; of the emotional and mental atmosphere so vitally connected with the idea; and, by implication and inference, of the definition of the idea as producible by a generalization based on its several components.

SHAKESPEARE'S USE OF ENGLISH AND FOREIGN ELEMENTS IN THE SETTING OF *MUCH ADO ABOUT NOTHING*

JULIA GRACE WALES

I

INTRODUCTION

We find in the critics[1] three main views of Shakespeare's use of Italy: that it is to convey a real sense of Italy, that it is to serve as a mere vague romantic background favorable to all kinds of adventure, that it is only a disguise for an English setting. Which of these views, if any, applies to Shakespeare's use of elements of setting in *Much Ado?*[2]

The story is Italian in origin. It is found in Bandello's novel of Don Timbreo di Cardona and Fenicia, daughter of Lionato di Lionati; a variant occurs in the story told by Dalinda in Harington's translation of Ariosto's *Orlando Furioso.* These are easily accessible[3] and have been many times analyzed. It is not necessary to review them here.

---

[1] For example in Sarrazin, Miss Janet Spens, Sir A. T. Quiller-Couch, T. F. Ordish, etc.

[2] As I have elsewhere tried to show (see "Shakespeare's Use of English and Foreign Elements in the Setting of *The Two Gentlemen of Verona*", *Wisconsin Academy,* vol. 27 (1932), pp. 85–126), it is the second of these views that best applies to *The Two Gentlemen of Verona.* The background of *Romeo and Juliet* is the Italy of an old poem, seen in the light not only of the far away but of the long ago. The Italy of *The Merchant of Venice,* on the other hand, though seen romantically in a blaze of Renaissance splendor, is a contemporary foreign land of which the returned traveller has much to tell. That of *Othello* is a place and a condition wherein terrible crimes could happen and monstrous types of character could develop; the scene presenting not only high lights but deep shadows—the sinister side of a sophisticated civilization.

[3] See H. H. Furness, *Variorum,* pp. 295 ff. The window episode is of course a more or less stock situation. Winifred Smith (*The Commedia dell'Arte,* New York, 1912, p. 12) notes that the Zanni would sometimes "dress himself in a gown exactly like that of the heroine or her maid and so cause either terror or confusion". Compare on this general influence of Italian comedy two very important studies by Professor O. J. Campbell: "*Love's Labour's Lost* Restudied" and "*The Two Gentlemen of Verona* and Italian Comedy", in *Studies in Shakespeare, Milton, and Donne,* by members of the English Department of the University of Michigan, New York, 1925. See further, Kathleen M. Lea: "The Bibliography of the Commedia dell' Arte: The Miscellanies of the Comici and Virtuosi." *The Library,* June, 1930.

The possibility of another Italian source has been shown, by Miss M. A. Scott,[4] in the fact that there are at least very striking parallels in idea and expression between many of the Benedick-Beatrice passages in the play and certain passages in Castiglione's *Book of the Courtier,* first published in English in the year 1561. To Miss Scott's valuable article we shall return in our discussion of the characters.

It is held by some critics that a lost play probably intervened between *Much Ado* and the original sources.[5] On this intermediate form of the story we can only speculate; but the evidence that it existed is strong enough to prevent us from drawing any hard and fast conclusions about Shakespeare's adaptation of his raw material. It seems probable, however, that Shakespeare did himself have the task of combining the Hero and the Beatrice material into one play and that he added a comedy of low life of his own invention. Hence, so far as our present knowledge extends, the problem of fusion and the mode of solving that problem are essentially Shakespeare's. Nor can it be out of place to note the parallels between these earlier sources that we have and the play as it stands, whenever these parallels serve to set in relief any aspects of Shakespeare's treatment of background.

The material, whatever its immediate source, is of several kinds: comedy of high life, comedy of low life, and something almost approaching tragedy. The given characters and the given story present refractory elements, not easy to render truly dramatic. Shakespeare, according to his usual method, develops the characters within the given action, and by realizing a setting, attempts to lend harmony of tone to the piece as a whole.

II

Difficult Elements in Character and Action

In order to see what the difficulties are, let us first turn briefly to those scenes in which the consistency of all four characters

[4] M. A. Scott, *"The Book of the Courtyer*: A Possible Source of Benedick and Beatrice", *P. M. L. A.* XVI (1901), p. 491 ff.

[5] Furness feels sure there was a play modeled on Bandello. He thinks it fairly certain that Shakespeare did not know Bandello or Belleforest (Preface to the Variorum edition, p. xxi). See also his discussion of Ayrer's *Die Schoene Phaenicia* and the extracts from Ayrer which he gives, *Variorum,* pp. 329–337. It has been pointed out that Ayrer introduces a comedy of low life. The resemblances to Shakespeare, however, are most general and slight.

having prototypes in Bandello's story—Hero, Claudio, Don Pedro, and Lionato—can be most clearly tested.

In Act III, Scene ii, Don John comes to Claudio and Don Pedro with his slanderous story. Claudio's suspicion is first roused in this scene but not until near the end of it. His first questions "Who, Hero?" . . . . . "Disloyal?" are not suspicious, merely sharp and alert. He shows no emotion but listens attentively. "May this be so?" is wondering rather than dismayed. "If I see any thing tonight why I should not marry her tomorrow, in the congregation, where I should wed, there will I shame her." This does not mean that he is already believing the slander. On the contrary a moment's reflection has assured him that it is false. He speaks indignantly, though not so much at the insult to Hero as at the insult to himself. He is thinking of himself throughout the scene. "O mischief strangely thwarting", his last speech in the scene, is the only one that need be read as showing incipient doubt.

Don Pedro doubts from the beginning not Hero, but his brother. The Arden Edition (Boston, 1902) gives this comment: "This is the only scene in which Don Pedro speaks to his brother. The curtness of his replies is in marked contrast to the Bastard's clumsy assumption of civility." The words "You know he does" interrupting Don John's question to Claudio "Means your lordship to be married tomorrow?" show Don Pedro's doubt of his brother's motive. When Claudio exclaims "May this be so?" Don Pedro says quickly and firmly, having arrived at conviction by rapid thought, "I will not think it." When Claudio threatens vengeance if the unbelievable thing be true, Don Pedro adds, "And as I wooed for thee to obtain her, I will join with thee to disgrace her." But by this he may mean to imply only that no proof will be found. Further, the concluding exclamation "O day untowardly turned" necessarily implies not the slightest doubt but only dismay that the harmony of the occasion has been thus broken in upon. But even with all care taken in the acting to slow the psychological movement, Claudio's change of mind is swift enough to tax our credulity.

The church scene arouses mingled feelings in the critics, who are torn between a sense on the one hand of its all but tragic power in isolation, and on the other of its improbability and the difficulty of harmonizing it with the tone of the play as a whole. Professor Stoll's view here seems on the whole the most tenable, that the story is here unrealized because essentially unrealizable,[6] that the demand for a good theatrical scene at this point has been allowed to over-ride any interest in character. As I have elsewhere tried to show,[7] we need not conclude, however, that, because at such junctures Shakespeare often fails in consistency of character, he was therefore not greatly interested in character. From the body of his plays as a whole, we have at least as much reason to infer that, despite the theatrical demands under which he worked as a playwright, Shakespeare was intensely interested in character. In the present play his characters have already become too real for his plot. Had they been less real we could have accepted this extravagant action without incredulity; as it is, we tend to check, not by conventions of melodrama, but by life; and hence a sense of discrepancy. Even on the theory of a colossal and vindictive egotism could Claudio have brought himself to perpetrate the church scene? Would not his egotism have been better served by a less conspicuous mode of annulling his betrothal? In view of the marriage customs assumed in the play, his consequently slight knowledge of his betrothed, and his restive egotism, Claudio's loss of faith in Hero seems less strange than that he should have chosen so public a way to get free of the entanglement.

The modern reader is even more scandalized at Leonato's swift desertion of his daughter's cause. But here again the unlikelihood does not seem so great as it would in a modern play. Moreover, Leonato is fussy, half in his dotage, egotistical, quite ignorant of his daughter's character, easily suspicious, highly suggestible, and concerned chiefly for his own dignity and that of his house. He succumbs promptly to Claudio's accusation, the testimony of the Prince, and the absurd evidence of Don John. Doubt having once entered his mind, the failure of a somewhat belated attempt to establish an alibi seems to him final proof. He betrays the hope that Hero is dead, the one escape for her and her family from imminent disgrace. The friar's question "Yea, wherefore should she not?" brings out a flood of egotism and self-pity, which shows, though some previous pride in Hero, little affection for her. Just as easily, Leonato swings to

---

[6] E. E. Stoll, *Shakespearean Studies, Historical and Comparative in Method,* New York, 1927, p. 109.

[7] "Character and Action in Shakespeare: A Consideration of some Skeptical Views", *University of Wisconsin Studies, No. 18,* 1923.

the opposite state of mind under the reassuring suggestions of the friar. He is ready to avenge Hero. Then he yields entirely to the friar's direction:

> Being that I flow in grief,
> The smallest twine may lead me.

Don Pedro's part in the church scene is very slight. He says as little as he can. He is merciless, it is true, but keenly regretful. And he does not share Claudio's self-righteous harshness. "The grieved count" does Claudio far more than justice. Don Pedro believes the slander and feels to blame for having pushed the match. In the readiness of Don Pedro to be deceived and in the readiness of Claudio to denounce publicly are the chief improbabilities of the scene. That Leonato and Claudio are easy victims is, in view of their temperaments, less surprising.[8] The fact is that the reality of the church scene lies chiefly in the reality of the character of Beatrice.[9] It is Beatrice who instantly apprehends it in its every aspect, and in whom its pathos is transmuted into the motive of strenuous action.

The first scene of Act V presents almost as many difficulties. Leonato is indulging violently in grief. Antonio, who can hardly find opportunity to get in a word, is counselling self-control and concentration on practical expedients. Leonato objects to any philosophy that urges patience:

> I will be flesh and blood;
> For there was never yet philosopher
> That could endure the toothache patiently,
> However they have writ the style of gods
> And made a push at chance and sufferance.

This presentation of Leonato is a clever device to keep the action in the realm of comedy. We are not allowed to have too much sympathy with him. His grief—but not his cause of

[8] *The Adventures of Don Sebastian, King of Portugal,* printed at London, 1603, contains the names of Sebastian, Prospero, Alonso, Don Pedro, Antonio, Don John. It contains also a story of a shoemaker whose daughter bore a son to Don John, natural son to the King of Portugal. The daughter (Ines) lived chaste the rest of her life, but her father who had "reviled her with most opprobrious words and beat her out of his doors openly" never forgave her and did not allow her to be buried in the family vault. Leonato's rage with Hero had no doubt plenty of parallels, despite the fact that in the story of Fenicia (Bandello) the father of the accused girl takes a kindly attitude to his daughter and does not doubt her innocence. See Harleian Miscellany (1808), vol. II, p. 386.

[9] See *Variorum,* p. 390, the account of Helen Faucit's Beatrice, especially her "kill Claudio"; also Ellen Terry's, p. 392.

grief—is given a certain absurdity. Moreover, as Benedick and Beatrice at the end of the church scene amused us but were not amused themselves and hence kept an aspect of seriousness before our minds, so the scene of Leonato and Antonio is meant to be at once funny and grave. When Claudio and Don Pedro enter, our sympathies remain with the old men. The scene is not always played to permit this, but it should be so played. This is evident from Don Pedro's words:

> Nay, do not quarrel with us, good old man.

Leonato's excitability is not wholly comic to the Prince. Nor is it wholly comic to Claudio.[10] Claudio is on the defensive, however, because not at ease in his own mind. "Who wrongs him?" he brusquely demands, unconsciously laying his hand on his sword. This movement Leonato notices.

> Nay, never lay thy hand upon thy sword.
> I fear thee not.

Claudio is smitten with a compunction that does him credit and at once apologizes:

> Marry, beshrew my hand
> If it should give your age such cause of fear.
> In faith, my hand meant nothing to my sword.

Leonato, quite unjustly, interprets the speech as a jeer at his own age and weakness, and replies with a challenge to fight, concluding his arraignment with the words:

> I say thou hast belied mine innocent child;
> Thy slander hath gone through and through her heart,
> And she lies buried with her ancestors;
> O, in a tomb where never scandal slept,
> Save this of hers, framed by thy villainy!

[10] Andrew Lang says of this scene: "He [Claudio] is, perhaps, more absolutely intolerable when he fleers and jests at the anger of Leonato than even when he denounces Hero, making her a sacrifice to the vanity of his jealousy." *Variorum*, p. 362.

Wetz, however, takes a somewhat different view: "And, after all, Claudio is not so merry as his detractors would have it appear. Neither he nor Don Pedro is easy in mind when he sees the consequences of his conduct, and the suffering of the two old men. Yet, since they believe themselves to have acted rightly, they do not yield to their uneasiness, but try to laugh it off. Their jests do not come from their hearts, as is hinted in the words with which Claudio greets Benedick: 'We have been up and down to seek thee; for we are high-proof melancholy and would fain have it beaten away. Wilt thou not use thy wit?' " *Variorum*, p. 383.

"My villainy?" cries Claudio, exasperated, and Don Pedro intervenes,

> You say not right, old man.

But Leonato is thereby stung to new threats, in which he is joined with equal violence by Antonio. Their helpless senile rage with the younger men is given a comic aspect and was no doubt meant to amuse the audience. But that it was not, even to a contemporary audience, wholly comic is clear from Don Pedro's dignified interposition.

> Gentlemen both, we will not wake your patience.
> My heart is sorry for your daughter's death:
> But, on my honour, she was charged with nothing
> But what was true and very full of proof.

The brief scene with Benedick which immediately follows is also at once serious and comic. Claudio, still uncomfortable, begins by blustering,

> We had like to have had our noses snapped off
> by two old men without teeth.

Don Pedro's words may be read as slightly apologetic for Claudio's. "Had we fought, I doubt we should have been too young for them." Benedick agrees: "In a false quarrel there is no true valour." Claudio is sincere when he says, "We are high-proof melancholy and would fain have it beaten away."

Benedick is in no mood for even a pretence of jesting. He is in fact pale with anger. Claudio's bravado is curtly thrust aside. Don Pedro, set upon avoiding further unpleasantness for Claudio, does his best to distract Benedick's attention with jesting about Beatrice. But the old gibes have lost their power, and Benedick, having thrown down his challenge, sternly repeats his accusation:

> You have among you killed a sweet and innocent lady.

The most incredible words in the scene are spoken by Don Pedro, in a humorous context, "The old man's daughter told us all." But at least he avoids the name of Hero, and the speech has somewhat the effect of a gruesome slip of memory such as may in real life momentarily befall one who is trying to bring about a return to the commonplace after some tragic disaster. Probably, however, they are an oversight on the part of Shakespeare, who, with the audience, knows, though Don Pedro does not, that Hero is alive, and that the whole situation is less tragic than it appears.[11]

"He is in earnest," says Don Pedro gravely to Claudio as Benedick goes out.

They attribute the challenge to the influence of Beatrice and will not take it seriously; but, as Wetz has pointed out,[12] their hearts are not necessarily in their jesting. In the next scene, when the facts come out, Don Pedro's words are grave enough:

> Runs not this speech like iron through your blood?

And Claudio answers,

> I have drunk poison whiles he utter'd it.

Thus it is important to observe that a serious note runs through the first scene of Act V. To play it as wholly comic, to make Don Pedro and Claudio merely lighthearted, is to render the scene intolerably jarring. It is primarily comedy—true. But it is largely genuine drama as well. There is a very definite and by no means wholly unsuccessful attempt at motivation and unification. The task of the actors is not easy, but neither is it impossible. They must emphasize not only wit combat and comic irony but also the real rage and mortification of the old men, the real indignation of Benedick, the real discomfort of Claudio (mingled of compunction and caddish self-defense), and the real pity and uneasiness of Don Pedro, whose instincts are always kindly.

Let us now turn to the characters that Shakespeare has added (whether from his own invention or some other source) to those given in Bandello.

Of the comic reality of the watch much has been written and we need not dwell on it here. As we shall see, this reality presents its own difficulties when we try to form a unified impression of locality. But on another count the comic reality of this group has added incalculably to the unity of the piece. For it has helped to make the villains ridiculous. In fact the villains are throughout essentially comic characters. In the source the friend is the treacherous foe; the motive is jealousy; villainy is a serious instead of a comic element. In *Much Ado About Noth-*

---

[11] Here we may compare the scene of the musicians in *Romeo and Juliet*, which as Professor J. F. A. Pyre has pointed out, serves to remind us that Juliet is not dead.

[12] Cf. note 10.

ing the absurdity of the villains is increased by the motiveless nature of the crime. Don John is actuated only by the desire to make others as uncomfortable as himself, and to feed his egotism by a sense of power over the destinies of those whom he unpleasantly perceives to be better and happier than he. J. C. Smith says on this point:

> At the root of Don John's misanthropy lies the consciousness of the stain on his birth, of which he still is perversely proud. He has no social equals; he herds with his inferiors....[13] Don John, like Iago, is ready to give himself reasons for his malice.[14]

True, Shakespeare had never heard of an "inferiority complex". Neither, perhaps, had his critic at the time of writing. The latter, however, calls in contemporary evidence of some such spring of human action, in Bacon's *Essay IX*, "Of Envy". The passage is also quoted by Furness:[15] "For he that cannot possibly mend his owne case, will doe what he can to impaire anothers."

The motive in Spenser's version is similar:

> He either enuying my toward good,
> Or of himselfe to treason ill disposd.[16]

Thus, in this play, the familiar *motif* of melancholy is brought out not in the hero or the hero's friend, but in the person of the chief villain. Don John is "out of measure sad". His words are lofty, sententious, and sour. He fancies himself in the rôle of one enveloped in gloom, and more than Jaques, is wholeheartedly a poseur. Conrade admires him as Verges admires Dogberry, and plays up to his humor. Borachio's roguery is less mixed with pose. He is lively, active, ingenious, conscienceless, full of a relatively innocent joy of life and action. He even enters with a certain enthusiasm into the business of repentance at the end.

> *Bora.* If you would know your wronger, look on me.
>
> *Leon.* Art thou the slave that with thy breath hast kill'd
> Mine innocent child?
>
> *Bora.* Yea, even I alone.

---

[13] Arden Edition, Boston, 1902, p. 86.
[14] *Ibid.*, p. 87.
[15] *Variorum*, p. 18.
[16] *Variorum*, p. 308. Bandello uses the phrase, not of Girondo, but of his accomplice, "a young courtier, a man of little account, to whom evil was more pleasing than good." *Variorum*, p. 313.

In the second act, Beatrice has noticed with amusement the sombre air of Don John:

> *Beatrice.* How tartly that gentleman looks! I never can see him but I am heart-burned an hour after.
>
> *Hero.* He is of a very melancholy disposition.
>
> *Beatrice.* He were an excellent man that were made just in the midway between him and Benedick: the one is too like an image, and says nothing; and the other too like my lady's eldest son, evermore tattling.

The truth is that we are not to fear these villains, nor even, exactly, to loathe them; but chiefly to be amused at the comic discrepancy between their absurdities and the seriousness with which they admire their own villainy. "You are both sure and will assist me?" asks Don John darkly; to which Conrade and Borachio reply with zest, "To the death, my lord."

I first gathered this impression of Don John from an amateur performance of the play given by students of Westfield College, the University of London. The student who acted the part of Don John had shortly before taken the part of the villain in a mock tragedy. She employed the same general method with great effect in playing Don John. The laugh raised by her first lines, "I thank you, I am not of many words, but I thank you," recognized Don John the egotist, taking himself so seriously that he cannot be taken seriously by any one else. Kreyssig says: "Compound of envy as he is, Don John amuses us more than·he terrifies us, for Shakespeare has denied him the one characteristic that could produce the latter effect. He cannot possibly feign."[17] It is not his envy that is amusing in Don John, however, but the sense of superiority with which he "compensates" for it by enjoying his own gloom. Most of the critics appear to take him seriously. He was acted as "complex", "plausible", and "sinister" in the performance described in the *Variorum,* pp. 391-2. Obviously to make the villains comic is partly to dissolve the difficulty of the incongruous tragic element.

On the character of Beatrice and Benedick we shall make no attempt to offer fresh observations or to review the critical material as a whole. It is enough to note one contrast in critical view that is significant for our purpose. There has been a

[17] *Variorum,* p. 49.

tendency to find Beatrice and Benedick characteristically English types. Brander Matthews says:

> Shakespeare has also laid the scene of a story in an alleged Sicily, but his Beatrice and his Benedick are quite as English as his Dogberry and Verges. Shakespere and Molière both of them reproduced character they knew at first hand, and made no vain effort after local color; neither of them fatigued himself in an idle endeavour to step off his own shadow.[18]

The essentially English note, if it is here, may very well have crept in without Shakespeare's conscious knowledge and hence in itself proves nothing as to whether he meant to make the characters English or Italian. Nor does the fact that they are serious at heart prove them English. Seriousness and morality existed and were known to exist in Italy as well as in England. Perhaps, however, we discern an English national characteristic not shared in the same degree or at least in the same form by other races, in the deliberate masking of sentiment behind wit, in the almost morbid fear of being caught taking oneself seriously, in the self-conscious dislike of seeming self-conscious which characterize Benedick and Beatrice and which cause the comic clash between them.

On the other hand, one critic finds their origin and inspiration essentially Italian. Professor M. A. Scott has, as we have already noted, worked out a careful parallel between the wit combats of Beatrice and Benedick and those of Signor Gaspare Pallavicino and the Lady Emilia Pia:

> Leaving Lyly's artificial style out of account it is no disparagement of Shakespere and not overpraise of Castiglione, to say, that up to the time of *Much Ado* Shakespere had done nothing in dialogue that can be compared to the freedom and ease and grace of the *conversazioni* of *Il Cortegiano*. The Italians, taking the dialogue as a literary form from the ancients, had cultivated it until they were masters of dramatic colloquy, not indeed in their plays, but precisely in such courtly conversations as "Castilion's Courtier and Guazzo his dialogues".[19]

Among the most suggestive passages from *The Courtyer* cited in the article are the following:

---

[18] *Molière, His Life and Times,* London, 1910, p. 186.

[19] M. A. Scott, "*The Book of the Courtyer*: A Possible Source of Benedick and Beatrice", *P. M. L. A. XVI* (1901), p. 491.

> And as they were now passing out at the great chambre dorre, the Lord Generall tourned hym to the Dutches, and said: Madam, to take up the variance beetweene the Lord Gaspar and the Lord Julian, (as to whether women could attain to the heavenly love or not,) we will assemble this night with the judge sooner than we did yesterdaye.
>
> The Lady Emilia answered: Upon condicion, that in case my Lord Gaspar wyll accuse women, and geve them, as his wont is, some false reporte, he wil also put us in suretye to stand to triall, for I recken him a waveringe starter. (365)[20]

> Nowe the Lord Gaspar Pallavicino answered here smilinge: You to confirme your judgement with reason, alleage unto me women's doinges, which for the most part are voide of al reason....
>
> Here manie began and in maner all, to speake againste the Lord Gaspar, but the Dutchesse made them all to houlde their peace. Afterward she said smilinge: If the yll which you speake of women were not so farr wide from the truth, that in speakinge it, it hurteth and shameth rather the speaker than them, I would suffer you to be answered. (144)[21]

> Women neede no defendoure againste an accuser of so small authoritie. Therefore let the Lord Gaspar alone in this his froward opinion, risen more because he could never finde woman that was willynge to loke upon him, then for anye want that is in women. (179)[22]

Many other similarities are noted in the article, for instance:

> Among other parallelisms of thought, I would recall that the Lord Gaspare's subject for the dialogue is the ideal woman, what virtues she must have, and what faults may be overlooked in her. Benedick (II.3) actually enumerates the graces a woman must have to come into his grace.[23]

Miss Scott thus sums up her conclusions:[24]

> First, that Benedick and Beatrice are plainly of Italian origin; in Italian literature the Lady Emilia is first seen in the Lady Pampinea of the *Decamerone.*

---

[20] *Ibid.,* pp. 492–3. (The pages given above refer to *The Book of the Courtier,* London, 1900, The Tudor Translations). To be compared of course, as Miss Scott points out, with *Much Ado,* I. i. 167: "Do you question me, as an honest man should do", etc.

[21] *Ibid.,* p. 493.

[22] *Ibid.,* p. 493. To be compared, as Miss Scott points out, with *Much Ado,* I. i. 121: "Is it possible Disdain should die", etc.

[23] *Ibid.,* p. 498.

[24] *Ibid.,* pp. 501–2.

Second, that they do not belong to Hero's story in Bandello, and fit into it loosely in Shakespere, precisely as if they did not belong to any story.

Third, that in *Much Ado* they are both detached persons, they have just "growed", precisely as the Lord Gaspare and the Lady Emilia appear in the *Courtyer.*

Fourth, that a comparison between the play and the dialogue shows remarkable coincidences in character, in action, in environment, in thought, and in language.

Fifth, that the very vividness of the representation is due to the fact that Benedick and Beatrice were originally real persons, the Lord Gaspare Pallavicino and the Lady Emilia Pia, of *Il Cortegiano.*

The fifth conclusion seems to me weak. They are in this respect twice removed from reality. Shakespeare probably had other real people more or less in mind. We are perhaps within safe limits in saying that Beatrice and Benedick represent an essentially English version of what was once an Italian ideal.

In relation to our main problem of the welding of English and Italian elements, one more character must be mentioned, the friar. As has often been pointed out, the friar is typical of Shakespeare's ecclesiastics, benevolent, ingenious, managing, not too scrupulous about the facts. His advice,

Maintain a mourning ostentation;
And on your family's old monument
Hang mournful epitaphs and do all rites
That appertain unto a burial,

takes us back at once, away from gay country houses in England or elsewhere, to the atmosphere of old Italian cities, to sombre pageants and monuments, imprisoned ladies, broken hearts. Hero is to be spirited away, to

some reclusive and religious life,
Out of all eyes, tongues, minds, and injuries.

It is with this change in the music that the spell of Italy is again suddenly cast over us. The friar's words have woven it. And he is a very astute psychologist (whether or not the modern critic will allow Shakespeare to be one), for he foretells to a nicety the waning of Claudio's anger and the beginning of a softer frame of mind.

So will it fare with Claudio:
When he shall hear she died upon his words,

> The idea of her life shall sweetly creep
> Into his study of imagination,
> And every lovely organ of her life
> Shall come apparell'd in more precious habit,
> More moving-delicate and full of life,
> Into the eye and prospect of his soul,
> Than when she lived indeed.

To the problem of English and Italian elements in relation to character we shall return in our discussion of the setting.

III

The Setting

From the foregoing analysis it is evident that this play is constructed of very diverse elements, that action and dialogue are often difficult to realize dramatically, and that the problem of unity of effect is unusually great. Do what we will with the more incongruous aspects, improbabilities remain. We must bear in mind the fact repeatedly stressed by Mr. Stoll that the Elizabethans were satisfied to apprehend the action scene by scene with much less care than have we for the logical connection of the whole. On the other hand let us not forget that the desire for an illusion and a sustained illusion is essentially the same in the human mind of all time, however varying in the modes of its satisfaction. Probably Elizabethan play-goers differed from ourselves not in that they cared less for a sustained illusion, but in that they sustained their illusion more easily than we, with less effort to test by reference to actuality. Yet even they were not wholly irresponsible to fact, and even the Elizabethan playwright must assimilate his materials as far as he can and make them credible to the common imagination. Hence, for the present play, the paramount importance of setting and atmosphere as a solvent.

Before we examine the details of setting, let us return to Bandello, to see what actual suggestions of place his version of the story has to offer.

Don Timbreo is advised to ambush himself "in the ruins over against the garden". A bit of description follows:

> Now there abutted upon these ruins a face of Messer Lionato's house, wherein there was an old saloon, whose windows stood open day and night, and there Fenicia was bytimes used to show herself, for that from that quarter the

> beauty of the garden was better to be enjoyed; but Messer Lionato and his family abode in the other part of the palace, which was ancient and very great and might have sufficed for a prince's court, not to say a gentlemen's household.[25]

The window scene is not without vividness:

> Half an hour before the appointed time he [Don Timbreo] went to hide himself in that ruined place, on such wise that he might very well see whoso passed there, himseeming yet impossible that Fencia should have yielded herself unto another....
>
> The night was not very dark but execeeding still, and presently he heard the noise of coming feet and eke some broken word or two. By and by he saw the three pass and recognized the youth who had that morning advertised him, but could not recall the faces of the other twain. As they passed before him, he heard the perfumed one, him who played the lover, say to him who bore the ladder, "Look thou set the ladder featly to the window, so it make no noise, for, when we were last here, my lady Fenicia told me that thou lettest it fall over-heavily. Do all adroitly and quietly"....
>
> The three, then, coming under Messer Lionato's windows, on the side aforesaid, set the ladder very softly against the balcony, and he who played the lover climbed up by it and entered the house, as if he had intelligence within.

When Don Timbreo's envoy arrives to break off the match, he finds Lionato "walking in the saloon, against dinner should be ready",[26] the ladies of the household being seated at their embroidery. After the supposed death of Fenicia, there is mention of a village three miles from Messina, where Lionato and the two young men hear mass at the church. We then have a hint of another interior. They betake themselves into a saloon "magnificently arrayed with Alexandrian arras and carpets".[27]

The story itself is sombre. A political background is suggested with elements of war and violence. Nevertheless the action is framed in with festivities.

> King Pedro held his court many days in Palermo on right royal and magnificent wise and made high festival for the acquisition of the island.

King Charles comes by sea, and a sea battle takes place.

[25] *Variorum*, p. 314.
[26] *Variorum*, p. 315.
[27] *Ibid.*, p. 323.

> In the end King Pedro defeated King Charles...after which ...he removed with his whole court to Messina.[28]

Here "he held a right royal court and all was joy and gladness for the gotten victory, joustings being made and balls holden daily. . ."

At the end of the story "when the joyous company returned from the country house to Messina to celebrate the nuptials, they were met on the way by all the gentlemen and gentlewomen of the city . . . . and an innumerable company of knights and gentlemen led by the King's son; at the entrance to the city the King himself with the Queen met them, and rode to the royal palace, the King between Messer Lionato and Don Timbreo, the Queen between Fenicia and Belfiore. 'There they dined sumptuously and after dinner, Don Timbreo . . . recounted . . . the whole history of his loves; which done, they fell to dancing and the King kept open court all that week.' "[29]

In Harington's Ariosto[30] the hints of setting are of the slightest. Though the scene is in Scotland, the climate suggests Italy. The princess has changed her bedroom because of the heat:

> Who us'd to other chambers to resort
> In summer time, and this for heat to leave.

There are a few other details of setting.

> ...this window standeth out of sight,
> Where none do come by day nor yet by night....
> Some ruin'd houses stood oppos'd direct
> Against the window where he doth ascend.

There is a northern forest near at hand, a remote castle toward which Dalinda is dispatched, and a nunnery to which she ultimately goes.

Such are the meagre suggestions of locality in the antecedent material so far as we know it. The play, in contrast, offers a wealth of realistic details. How far are these English? How far Italian? How far common to England and Italy?

---

[28] *Variorum,* p. 311.
[29] *Variorum,* p. 326.
[30] See *Variorum,* pp. 296–307, for the significant passages.

The names have been studied by Elze, Sullivan, and others.[31] Furness notes the changes in names from the novel. To abandon the "pretty and suitable" name of Fenicia seems to him evidence that Shakespeare did not know Bandello. The coloring afforded by the names of people in the play is indistinct, though in the main Italian.[32] Place names add little help; for the specific allusions to place are notably few. Claudio is a young Florentine. He has an uncle "here in Messina".[33] Signior Benedick is "of Padua". He is doomed to matrimony "if cupid have not spend all his quiver in Venice".[34] He is "the only man of Italy" . . . and "goes foremost in report through Italy".[35]

---

[31] Of Borachio Elze says, "Whether or not it be derived from *bora* a kind of snake or *borra* loquacity or *boraccia,* a canteen, it bears a bad sense, as its termination *accio* indicates; and Shakespeare uses it with a full knowledge of that meaning just as he uses Trinculo, in the Tempest." *Jahrbuch,* XV, 255, quoted in *Variorum,* p. 2. Cf. Edward Sullivan, "Shakespeare in Italy", *The Nineteenth Century,* Vol. LXXXIII, p. 323: "*The Dramatis Personae,* with one exception, show no great effort on Shakespeare's part to distinguish their nationality, although the source of the plot is believed to be Italian. The exception referred to is Borachio, which I fancy was taken from Pettie's Guazzo, where we find—'give it to Cavallero Bottazzo to fill his Boracho withall.' The nearest approach to actual Italian is the reference of Beatrice to Benedick under the name of 'Signor Montanto' (I. i), but montanto was 'a fencing term, or a big two-handed sword suggesting a braggart', and so does not carry us very far. There are other distinct recollections here and there of *The Civil Conversation,* and also, as Professor Mary Scott suggests, of Hoby's *Cortegiano,* both English works. And so, tried by the test of Italian knowledge disclosed in the play, it looks as if *Much Ado* should go back to an earlier date than 1600, and should really come before both *The Merchant* and *Romeo.*" [Not, it seems to me, a necessary inference. J. G. W.]

A footnote on this passage is as follows: "*Civil Conversation,* Bk. IV. 188. The word means 'drinking cup'. Note the addition of an i for the purpose of making it a name, as in other cases in Shakespeare. Some other names of Italian formation, suggesting peculiarity of character, as in the case of Borachio, in other plays, are Gratiano (*Merchant*) translated by Florio as 'a self-conceited fellow in a play or comedie'; Gobbo, 'hunch-back'; Festé, 'Merryman', and Trinculo, 'tipler', from Italian trincare."

[32] The Arden editor observes that "the names of the gentlefolk as usual are (or might be) Italian; the maids and the constables are plain English." [We might conclude from this fact that the scenes of low life are to be imagined in England, the scenes of high life in Italy. But such a formula is, as we shall see, too simple. J. G. W.]

[33] I. i. 18.

[34] I. i. 274. See Clare Howard, *English Travellers of the Renaissance,* 1914, pp. 54–55. "Then, too, the scholar diversified his labours by excursions to Venice, in one of those passenger boats which plied daily from Padua, of which was said 'that the boat shall bee drowned, when it carries neither Monke, nor Student, nor Curtesan...the passengers being for the most part of these kinds.' [Quoted from Fynes Moryson, *An Itinerary,* etc., Glasgow ed. 1907, i. 159.]....In the outlandish mixture of nations swarming at Venice, a student could spend all day watching mountebanks, and bloody street fights, and processions."

[35] III. i. 92, 97.

Don Pedro is of Arragon and is to "go toward Arragon" after Claudio's marriage.[36] Hero's gown is worth ten of the Duchess of Milan's.[37]

On the other hand, even fewer details are unmistakably English.

Allusions to climate are, if anything, northern in color.

> *Leonato.* You will never run mad, niece.
> *Beatrice.* No, not till a hot January.[38]

And, in the same scene:

> There's her cousin, an she were not possessed with a fury, exceeds her as much in beauty as the first of May doth the last of December.[39]

Benedick accuses Beatrice of saying that he is "duller than a great thaw".[40]

There are religious references some of which suggest a partly Puritanized England rather than Catholic Italy, some of which reflect the older faith. If Beatrice does not marry, some gentleman will "scape a predestinate scratched face".[41] Benedick was "ever an obstinate heretic in the despite of beauty". He will die in his opinion "at the stake".[42] We hear of the devil, the door-keeper of hell;[43] and Saint Peter directing well-behaved maids and bachelors to their seats in heaven;[44] of the clerk's responses in church.[45] The married man must "sigh away Sundays".[46] Benedick would not marry Beatrice though she "were endowed with all that Adam had left him before he transgressed."[47] He finds her "the infernal Ate in good apparel. I would to God some scholar would conjure her; for certainly while she is here, a man may live as quiet in hell as in a sanctuary; and people sin upon purpose because they would go thither."[48]

---

[36] III. ii. 2.
[37] III. iv. 23.
[38] I. i. 93, 94.
[39] I. i. 192–5.
[40] II. i. 251.
[41] I. i. 135.
[42] I. i. 235–7.
[43] II. i. 44.
[44] II. i. 50.
[45] II. i. 110–114.
[46] I. i. 204.
[47] II. i. 258–9.
[48] II. i. 263–267.

The scenes in which appear Dogberry and Verges and the Watch, afford not only English names but English details of setting. Here we have familiarly to do with Hugh Oatcake,[49] George Seacoal—who can read and write—and his pen and ink-horn,[50] the Watch with their bills and lanterns,[51] the alehouses,[52] streets, and gaol,[53] drunken loiterers,[54] thieves,[55] the penthouse sheltering the intriguers from the drizzling rain;[56] the church-bench where the watch sit dozing until two o'clock, when they can go home to bed;[57] the sexton and his stool and cushion;[58] and we are reminded of other sights and sounds of every day—baaing lambs,[59] bleating calves,[60] crying children,[61] "Pharoah's soldiers in the reechy painting", "the god Bel's priests in the old church window", "the shaven Hercules in the smirched worm-eaten tapestry."[62]

There are a number of allusions to sports and pastimes most of them English in suggestion, when considered separately, though a few reflect customs naturalized from the Continent. Beatrice says of Benedick, "He set up his bills here in Messina and challenged cupid at the flight; and my uncle's fool, reading the challenge, subscribed for cupid, and challenged him at the bird-bolt."[63] We hear later that Cupid is a hare-finder.[64] Claudio is as melancholy as a "lodge in a warren".[65] He calls Benedick the kid fox.[66] Beatrice would rather hear her dog bark at a crow than a man swear he loves her.[67] Benedick would that his horse had the speed of Beatrice's tongue "and so good

---

[49] III. iii. 11. See the extensive annotations on these passages, in the *Variorum*, largely quoted from Grace Latham's study "The Petty Constable: his Duties and Difficulties in Shakespeare's Day", *Jahrbuch* XXXII, pp. 133–148.

[50] III. iii. 12; III. v. 63.

[51] III. iii. 25, 44, 191.

[52] III. iii. 45.

[53] III. v. 64.

[54] III. iii. 45–51.

[55] III. iii. 53–6.

[56] III. iii. 110.

[57] III. iii. 95–96.

[58] IV. ii. 2.

[59] III. iii. 75.

[60] III. iii. 76.

[61] III. iii. 69–74.

[62] III. iii. 142–146.

[63] I. i. 39–42.

[64] I. i. 186.

[65] II. i. 221.

[66] II. iii. 45.

[67] I. i. 132.

a continuer".[68] Beatrice retorts, "You always end with a jade's trick. I know you of old."[69] Mention is made of bugle and baldrick,[70] the recheat or blast for calling the hounds when the hunt was over.[71] The successful archer, after shooting at a cat in a basket, is clapped on the shoulder and called Adam.[72] Beatrice "runs like a lapwing . . . . close by the ground;"[73] her spirits are "as coy and wild as haggerds of the rock."[74] She is "limed" (caught with bird-lime).[75] Her resolve to yield to Benedick's suit carries on the same figure, "taming my wild heart to thy loving hand".[76] "Stalk on," says one of the conspirators, "the fowl sits." And again, "Bait the hook well; this fish will bite."[77]

Besides archery, riding, and hunting, we have mention of tennis balls, fencer's foils, dice, music, the lute, the drum and the fife, the tabor and the pipe, dancing, the Scotch jig, the measure, and the cinque pace.[78] Most of these enter by way of allusion only. One pastime, the masque, appears as an element of the action. The scene is the hall after supper. Leonato, Beatrice, Antonio, and Hero have been talking together: the revellers enter, and "all put on their masques".[79] From the dialogues that follow, however, it is not clear that any of the ladies are masked. Hence the frolic is probably of the nature of a masque proper, rather than a masked ball in which all are disguised.

Dr. J. W. Cunliffe has shown that masques, though somewhat similar to the English "disguises", were of Italian origin, and were in the sixteenth century associated with Italy. He defines the masque thus:

> The masque was an evening entertainment in which the chief performers were masked courtiers, accompanied by torchbearers, all in costumes appropriate to the device presented: the elements of song and dialogue were developed

[68] I. i. 143.
[69] I. i. 144.
[70] I. i. 245.
[71] I. i. 243.
[72] I. i. 259–61.
[73] III. i. 24–25.
[74] III. i. 35–36.
[75] III. i. 104.
[76] III. i. 112.
[77] II. iii. 95, 114.
[78] II. i. 73–81.
[79] II, i.

later, the original nucleus being dances and conversation with spectators selected by the masquers.[80]

He cites examples of the use of the masque in Italy in the fourteenth, fifteenth and sixteenth centuries.

T. F. Crane[81] notes in Whetstone's *Heptameron of Civil Discourses,* " 'The device of the second night's Mask' ". "After supper five of the gentlemen withdrew, and about 9 o'clock reentered in disguise, a concert preceding them. The dresses of the musicians, the torch-bearers, and the maskers are fully described."

Many current ideas and interests come in by the way. Beatrice has—or rather implies that she has not—some of her good wit out of *The Hundred Merry Tales.*[82] She was born under a dancing star. A classical allusion is given a homely turn: "She would have made Hercules have turned spit, yea, and have cleft his club to make the fire too. Come, talk not of her; you shall find her the infernal Ate in good apparel."[83] The current interest in the Antipodes comes out here, as in many other plays of the time. Benedick will "fetch you a tooth-picker now from the furthest inch of Asia; bring you the length of Prester John's foot; fetch you a hair off the great Cham's beard; do you any embassage to the Pigmies, rather than hold three words' conference with this harpy."[84] Such allusions may very well be associated with a characteristically British interest in non-European lands such as crops up in English literature since the days when knights were glad for the sake of their ladies to

Go hoodles to the drye see,
And come hoom by the Carrenare.

It is no more English than Italian in spirit, however. Marco Polo's adventures belong to Venice, and were translated into English by Frampton in 1579.[85] And the many books of travel

---

[80] "The Prototypes of the Masque and Dumb Show", *P. M. L. A.,* 1907, p. 146.

[81] *Italian Social Customs of the Sixteenth Century* (1920), p. 514.

[82] II. i. 135.

[83] II. i. 261–3.

[84] II. i. 273–280.

[85] The actual source of the reference matters for our purpose less than its connotation. The footnote in the New Hudson edition reads thus: "In the Maundeville cycle of legend Prester (Presbyter, Priest) John was a mythical Christian ruler of the Far East. In later stories he was of Abyssinia, 'from the red sea almost to the Aethiopike Occean'. 'The great Cham' (or Caan of Cathaya, the Khan of Tartary) also belongs to the Maundeville legendary matter. Near his realms was the 'land of Pigmie', where are men 'of little stature, for they are but three spans long'.—*Voiage and Travaile of Syr John Maundeville.*"

and geography which fascinated the Elizabethans were, so far as the Orient is concerned, largely of Italian origin. M. A. Scott[86] describes some eighteen books of voyages and discovery translated from Italian into English between the years 1555 and 1607.[87]

The lines of the play abound in miscellaneous pictures of every-day life and affairs: the canker rose in the hedge,[88] the lover wearing willow,[89] the usurer's chain,[90] the lieutenant's scarf,[91] the ballad-maker's pen,[92] the prince's jester,[93] the pestilence,[94] the "young squarer" that will "make a voyage to the devil",[95] the honest drover selling bullocks,[96] the blind man beating the post because the boy stole his meat,[97] "the hurt fowl creeping into sedges",[98] "the school-boy who, being overjoyed with finding a bird's nest, shows it to his companion and he steals it",[99] an oak with one green leaf,[100] a great thaw,[101] a wild creature "trusted with a muzzle and enfranchised with a clog".[102]

Many are the allusions to dress and fashion. Benedick (according to Beatrice) "wears his faith but as the fashion of his hat; it ever changes with the next block."[103] Don Pedro says teasingly of Benedick,

---

[86] *English Translations from the Italian,* New York, 1916.

[87] Compare the material in Botero: A long account of the Great Cham, comprising war between Great Cham, and Prester John, extent of empire of Great Cham, descriptions of his palace at Xaindu, revenue, forces, government, description of the appearance of the people: pp. 142–150. A separate account of Prester John, pp. 212–220: his territory, character of people, government, revenue, relations with neighboring states. See Giovanni Botero, *The Travellers Breviat, or An historicall description of the most famous Kingdomes in the World.* Translated into English. London, 1601.

[88] I. iii. 28.

[89] II. i. 194.

[90] II. i. 197.

[91] II. i. 198.

[92] I. i. 254.

[93] II. i. 251.

[94] II. iii. 85.

[95] I. i. 82–3.

[96] II. i. 202.

[97] II. i. 205–7.

[98] II. i. 209.

[99] II. i. 229–31.

[100] II. i. 247.

[101] II. i. 251.

[102] I. iii. 34.

[103] I. i. 76.

> There is no appearance of fancy in him, unless it be a fancy that he hath to strange disguises; as, to be a Dutchman today, a Frenchman tomorrow, or in the shape of two countries at once, as a German from the waist downwards, all slops, and a Spaniard from the hip upward, no doublet.[104]

We hear also that he brushes his hat "a mornings", and "looks younger that he did, by the loss of a beard", "the old ornament of his cheek" having already "stuffed tennis balls". He has even taken to cosmetics.[105] Benedick draws a figure of speech from the tailor: "The body of your discourse is sometime guarded with fragments, and the guards are but slightly basted on neither." [106]

In Act III, scene iv, Margaret and Hero, in Hero's apartment, discuss clothes with zest:

> *Margaret.* Troth, I think your other rabato were better.
> *Hero.* No, pray thee, good Meg, I'll wear this....
> *Margaret.* I like the new tire within excellently, if the hair were a thought browner; and your gown's a most rare fashion, i' faith. I saw the Duchess of Milan's gown that they praise so.
> *Hero.* O, that exceeds, they say.
> *Margaret.* By my troth, 's but a night-gown in respect of yours: cloth o' gold, down sleeves, side sleeves, and skirts, round underborne with a bluish tinsel: but for a fine, quaint, graceful and excellent fashion, yours is worth ten on't.

Boulting quotes Bandello:[107]

> What shall we say of the magnificence of the ladies of Milan, their dresses covered with wrought gold, so many trimmings, embroideries, laces and precious jewels, so that when a dame goes forth from her door it reminds one of the 'Ascension' at Venice?

The scene of *Much Ado* is given reality by references to the house and grounds[108] and the outward business of hospitality.

---

[104] III. ii. I have not undertaken extensive annotations on the subject of dress. Ample materials are, of course, available. See *Shakespeare's England,* II, xix, and bibliography. English fashions were extensively borrowed from the Continent; hence the subject has little significance for the present purpose.

[105] III. ii. 45–51.

[106] I. i. 287–291.

[107] I. Nov. 9. See *Woman in Italy* (1910), p. 219.

[108] See *Shakespeare's England* (1916), II, XVII (Architecture) and II, XX (The Home), with Bibliographies. See also Bacon's Essay *Of Building.* He gives an account of a palace as it should be, hall, chapel, kitchens, butteries, panteries, towers, and stairways; outer and inner courts, galleries, rooms for summer and winter, "imbowed windows", cloisters and arches, grotto, fountain, terraces and garden.

A perfumer, smoking a musty room, whips behind the arras as he hears voices approaching.[109] We hear of a great supper, first in preparation, than in progress. A note in the Arden Edition calls attention to the second scene of Act I as a "short bustling scene" to be compared with the fifth scene of Act I in *Romeo and Juliet.* The two old men, Leonato and Antonio are gossiping for a moment about hospitable arrangements. Antonio's son is providing the music. Leonato is glad to have Antonio's help "this busy time". The scene suggests the manifold activities of a large household engaged in providing comfort for many guests, all of whom are bent on pleasure and absorbed in their own interests and intrigues. Apparently Leonato and Antonio have adjoining estates. In Antonio's orchard Claudio and Don Pedro have been overheard talking in a "thick-pleached alley".

Ordish, in his chapter on "Nature and London"[110] has presented much interesting material on the gardens of London derived from Stow's *Survey* (1598) and from Gerard's *Herball* (1597):

> The garden of the Elizabethan London house contributed largely to the garniture of the living rooms within. In place of carpets and of some accessories which to us appear to be indispensable, the floors were strewn with rushes, with branches, and with flowers; nosegays filled the corners which are occupied with various ornaments in modern chambers. Herbs, sprays, and branches were carefully preserved for winter use; in summer flowers were the chief ornament, and on ceremonial occasions the chambers were strewn with them.

We may compare Bacon, *Of Gardens:*

> For the side grounds, you are to fill them with variety of alleys, private, to give a full shade, some of them, wheresoever the sun be. You are to frame some of them likewise for shelter, that when the wind blows sharp you may walk as in a gallery: and those alleys must be likewise hedged at both ends, to keep out the wind; and these closer alleys must be ever finely gravelled, and no grass, because of going wet.

In Leonato's orchard after supper we find Benedick sauntering. He sends back his boy to get a book left in his chamber

[109] I. iii.

[110] *Shakespeare's London* (1904), Chapter III, pp. 93-4.

window.[111] Hearing Claudio and Don Pedro approaching, he conceals himself in the arbor. The schemers are attended by a musician who sings and withdraws. Claudio, Don Pedro, and Leonato, walking up and down the garden path, then work their will upon the unsuspecting Benedick. The same setting, elaborated in description, is used for the deception of Beatrice.

Hero's words to Margaret convey the very spirit of gardens:

> ......bid her steal into the pleached bower
> Where honey-suckles, ripen'd by the sun,
> Forbid the sun to enter; like favourites,
> Made proud by princes, that advance their pride
> Against that power that bred it. Then will she hide her,
> To listen to our purpose.

Margaret runs to the house on her mission.

> Now, Ursula, when Beatrice doth come,
> As we do trace the alley up and down,
> Our talk must only be of Benedick.
> ....Now begin;
> For look where Beatrice, like a lapwing, runs
> Close by the ground, to hear our conference.

Ursula's reply is in the same strain.

> The pleasant'st angling is to see the fish
> Cut with her golden oars the silver stream,
> And greedily devour the treacherous bait:
> So angle we for Beatrice; who even now
> Is couched in the woodbine coverture.[112]

IV

The Use of the Elements of Setting in Relation to the Total Effect

The mass of detail which we have examined cannot be called either distinctly English or distinctly Italian; and whether its

---

[111] II. iii. 3. Aymer Vallance in *Art in England during the Elizabethan and Stuart Periods* (1908), pp. 66, 68, gives a description of windows in Elizabethan houses. The windows had small lead-set panes, and not much stained glass. "... for the medieval art consecrated as it was primarily to the service of the church, received for all intents and purposes its death-warrant in the Reformation. Thenceforward, although there might be occasional demand still for armorial subjects for domestic purposes, no such magnificent series of heraldic glass as the Perpendicular windows at Ockwells, in Berkshire, was ever produced....Much ingenuity...was exercised in devising different designs in ornamental lead glazing with plain glass." [Through such a window, perhaps, the light fell on Benedick's book before he left it open on the window seat. J. G. W.]

[112] III. i. 7–11, 15–17, 24–26, 26–30.

effect is predominantly one or the other depends largely on its associations and hence on the outline which it is used to fill in.

Now, are the relatively few foreign allusions in the play meant to direct the imagination to some region abroad, or are they only a flimsy disguise? Is the real direction in the English associations of hospitality and the homely activities of the watch? The question cannot be answered dogmatically. Yet it seems probable that the imagination of the Elizabethan spectator would be less impeded by thinking in the main of a distant city than by thinking in the main of England; and for this reason—that the unfamiliar element is the more consciously arresting to the imagination, and the familiar is more easily taken for granted.

On either hypothesis, most of the detail merely makes for *reality,* not in the narrow sense of local realism, but in the larger sense of having solidity and tangibility to the imagination. The editor of the Arden edition has already been quoted on the usefulness of the "short bustling scenes" in creating an illusion of real life. In other connections he emphasizes the same effect of "depth" and the method of producing it.

> This trait of his [Shakespeare's] has been called "epic". He likes, so far as the conditions of his art allow, to set out his action on a background. We seem to have known his characters a long time. Here, for instance [Act I, Scene i], we gather that Benedick has been in Messina before, and has crossed swords with Beatrice.[113]

Again, on the incorrect versions given by Antonio and Borachio of Claudio's confidences to the Prince he says:

> Shakespeare had noted that no two reports of an occurrence are, as a rule, precisely the same, unless by collusion. Cf. *Othello,* i.3.5—
> "But though they jump not on a just account,
> As in these cases, where the aim reports,
> 'Tis oft with difference...."
> These little discrepancies, like the two views in a stereoscope, help to create that sense of solidity of which Shakespeare is the greatest master.[114]

---

[113] Arden Edition, Boston, 1901, p. 75. It is fair to note, however, that other critics have attributed this passage to the out-cropping of an older version of the play.

[114] *Ibid.,* p. 84.

The whole episode of Dogberry and Verges contributes to the effect of reality and "diffuses an air of settled English security in which tragedy cannot breathe".[115]

Much has been written on the English color of these episodes.

Ordish says, "The humours of the watch are wholly Elizabethan, possibly a burlesque on the Statutes of the Streets, imprinted 1595. There is a tradition that the prototype of Dogberry was a citizen of Cornhill. . . . . If the original of Dogberry were actually associated with Cornhill, it was probably in connection with the 'Tun upon Cornhill'—the city prison for 'night-walkers and other suspicious persons', in the words of Stow."[116] He cites a letter of Lord Burghley from the Domestic State Papers, 1586, showing that "the watch had, in fact, become a byword for pompous stupidity".[117]

C. A. Brown, on the other hand, declares almost passionately:

> The scene of *Much ado about Nothing* is at Messina. If Dogberry and Verges should be pronounced nothing else than the constables of the night in London, before the new police was established, I can assert that I have seen those very officers in Italy, France and Russia; and doubtless they are to be found at Constantinople,—unless among the Turks there are no petty dogs in office, at once self-sufficient, pompous, and ignorant. Nothing in this Sicilian comedy is of a contradictory nature.[118]

Thus we see that even these scenes, in isolation more readily thought of as English, are capable of being imagined as part of a foreign picture by one who approaches them with the thought of Messina strongly in mind. The fact remains that most of the critics see them as English. The question is of course not how we can see them now but how Shakespeare and his audience saw them. In visualizing a scene as in accepting persons and incidents the Elizabethan was no doubt more uncritically open to suggestion than we and better able to do imaginatively as he was told. And no doubt he cared comparatively little where he found himself so that the story went forward. No doubt if he was in London at one moment, he could almost as easily be in Messina the next. Hence even if the low comedy

[115] Arden Edition, p. xviii.
[116] *Shakespeare's London,* p. 189.
[117] *Ibid.,* pp. 190–191. Cf. p. 30 above, note.
[118] *Shakespeare's Autobiographical Poems,* London, 1838, p. 111.

characters with their English names do somewhat come out of the picture, any argument for the localizing of the main action in a foreign setting remains practically unchanged.

Still as we have pointed out in relation to character and action, even for the Elizabethan the more unity of effect the better. One way of patching and mending, of putting new cloth on old garments and weaving a darn until it looks like embroidery is to use lyrical elements. We have already noticed in the church scene the value of the friar's words, which wove a spell over us as of an incantation. In the last act the scene before the monument is perhaps meant to perform the same office. It is suggested by the source.[119]

> At eventide Messer Lionato and his wife and kinsfolk, clad all in black, escorted the coffin to the church, making such a show of extreme grief as if they had in very deed followed their daughter's body to the tomb....The coffin was accordingly interred, with general mourning of the whole city, and thereover was set a monument of stone, emblazoned with the ensigns of the Lionati....

The epitaph is in verse. The later scene in which the young men visit the church contains little description.

> The two gentlemen, then, alone entered the church, where they found no one, and Girando carried Timbreo to the chapel where was the pretended tomb. There he fell on his knees before the tomb and unsheathing a poniard, etc.

The scene in the play is in the spirit of the novel, remote and romantic. It concludes with a transition from torch-light to daylight.

> Good morrow, master; put your torches out.
>   The wolves have prey'd; and look, the gentle day,
> Before the wheels of Phoebus, round about
>   Dapples the drowsy east with spots of grey.

No doubt these transitions were more effective for the Elizabethan than for us. We are more susceptible to the influence of the garden scenes, which together with the manifold suggestions of the hospitality of a country house, already dealt with, contribute more than does any other device to an enveloping atmosphere and to the fusion of the diverse elements of the action.

---

[119] See *Variorum*, pp. 318–320.

Instead of this very general setting, Shakespeare, had he chosen could perhaps have given us a more realistic picture of Messina, although the following accounts of Sicily were not available in print at the time the play was written.

Hoby says of Messina:

> There is in this towne on of the fairest portes in Europe, standing as well for the Levant and all those quarters as for the Ponent. The towne standethe sumwhat upon the side of a hill, betwext the hill and the port. Upon the hill there are two or three faire castles, kept by Spaniardes. Yt is more in lengthe than in breadethe. The cheffest thing for antiquitie I sawe there, were the heades of Scipio and Hannibal when they were yong menn, in stone....These remaine straightlie kept in the towne house of Messina, and not to bee seene, withowt yt be for friendshippe, to straungers. For a new worke and that not finisshed at my being there, I saw a fountaine of verie white marble graven with the storie of Acteon and suche other, by on Giovan Angelo, a florentine, which to my eyes is on of the fairest peece of worke that ever I sawe. This fountain was appointed to be sett uppe before the hige churche where there is on old on alreadie. Here is an old palaice belonging unto the Kings of Sicilia, and now most part of it is built a new from the groound.[120]

In his description of Sicily Hoby contrives to produce an atmosphere of clear air, shining sea and pleasant havens, marshes, plains, castles, snow-capped mountains, gushing streams, ancient ruins,—not unlike the atmosphere of the *Winter's Tale.*

George Sandys[121] enumerates the striking features of Messina: It lies between a bay and hills, "strongly walled, and fortified about with bulwarks". He mentions the strong citadel, the castle of Gonsage, beautiful buildings, statues, fountains of fresh water, the ruins of an old aqueduct, the viceroy's palace "surrounded with delightful gardens and orchards", the admirable haven, the "High Lanterne", etc. "The better sort are *Spanish* in attire, and the meanest artificers wife is clothed in silke: whereof an infinite quantity is made by the worme, and

[120] *A Booke of the Travaile and Lief of Thomas Hoby,* The Camden Miscellany, Vol. x. p. 44. Written 1547–64. First published 1902. See also pp. 45–49. As has often been pointed out, the main action of the *Winter's Tale* is by Shakespeare moved from Bohemia to Sicily (he reverses the two scenes as given in *Pandosto*), though the pastoral scene of Act IV has therefore to be placed in Bohemia.

[121] *A relation of a Journey begun An. Dom. 1610 containing a description of... the Remote Parts of Italy,* London, 1615. Book IV, pp. 245, 246.

a part thereof wrought into stuffes (but rudely) by the workman." Thieves are very common. "In their private revenges, no night doth passe without murder." The following vivid scene could hardly have been described to Shakespeare without inspiring some allusion in a drama of his having Messina for a background.

> Every evening they solace themselves along the Marine (a place left throughout between the Citie wall and the haven) the men on horsebacke, and the women in large Carosses, being drawne with the slowest procession. There is to be seene the pride and beauties of the Citie. There have they their playhouses, where the parts of women are acted by women, and too naturally passionated: which they forbeare not to frequent upon Sundays. The Duke of Osuna their new Vice-roy was here daily expected; for whom a sumptuous landing place was made, and that but to continue for a day.

Even if such information was to be had, by word of mouth or otherwise, when Shakespeare was writing *Much Ado,* it may very well have been inconvenient to collect it at the moment. In any case Messina was a less familiar hunting ground to the popular imagination than the cities of Northern Italy, and nothing would be gained by trying to present it in detail. Shakespeare chooses to avoid suggesting any background of city life. By presenting a great house that might be a country house, hints of what might be village life, an atmosphere of hospitality,[122] of festivities and pleasure gardens, he is able to absorb a tragic situation into what is as a whole one of the most cheerful of his plays.

Nor is this enveloping atmosphere entirely a matter of place. It is contributed to by the characters. J. S. Smith says of the witty talk of Beatrice in the first scene of the second act, "every line breathes that atmosphere of gaiety which emanates especially from Beatrice, and in which the play moves for the next

[122] For the use of hospitality and the setting of a country house, compare the scenes laid in Gloucestershire in *Henry IV.* Madden has utilized these in combination with the Induction of *The Taming of The Shrew* to inspire his charming picture of Elizabethan country life in the historical fantasy *The Diary of Master William Silence.* For details more objectively given of what these Elizabethan houses were like, see *Shakespeare's England,* II, Chapters XVII, XX. See also Greene's *History of the English People,* New York, Illustrated edition of 1895, II. pp. 790–797. The literature of the period abounds in pictures and suggestions of this life. Compare for example Sidney's *Arcadia,* edited by Feuillerat, Cambridge, 1912, p. 12.

two acts."[123] And here is, perhaps, the chief value of Miss Scott's study of *Much Ado About Nothing* in relation to *Il Cortegiano*. One passage presented in this study seems to give the very spirit of Beatrice and her surroundings.

> In introducing her [The Lady Emilia Pia], it is said that she had such a lively wit and judgment that she "seemed the maistresse and ringe leader of all the companye, and that everye manne at her receyed understandinge and courage. There was then to be hearde pleasaunte communication and merye conceytes, and in every mannes countenance a manne myght perceyve peyncted a lovynge jocundenesse. So that thys house truelye might well be called the verye mansion place of Myrth and Joye.[124]

Thus it is not only in detailed parallels that the significance of this resemblance is found. What it shows is an interest, in England, in witty, urbane, and sophisticated society, and the association of its ideals with an Italian setting. Nor, as Miss Scott has herself briefly indicated,[125] is it to Castiglione alone that we may look for the inspiration in England of this kind of interest. In her invaluable *English Translations from the Italian*,[126] Miss Scott gives an account of some twenty books on manners and morals translated from Italian into English between 1561 and 1607.

In his very full study of these and other books of the kind, T. F. Crane[127] summarizes their characteristics and tendencies and their influence in Europe in the sixteenth and seventeenth centuries.

An interesting feature of the material presented by Crane is the relation of the various elements, story, setting, dialogue, social ideals. Crane shows how the debate or *tenzon* is presently related to the frame stories, little tales being told to illustrate a point. In the Italian frame stories, the setting is usually a garden; in Castiglione it is a palace. In Castiglione and the subsequent books on manners and morals, the frame and the ideas

---

[123] Arden Edition, p. 87.

[124] M. A. Scott, "*The Book of the Courtyer*: A Possible Source of Benedick and Beatrice", *P. M. L. A. XVI* (1901), p. 499.

[125] *P. M. L. A.* XVI (1901), p. 475.

[126] Boston, 1916, pp. 445–482.

[127] Thomas Frederick Crane, *Italian Social Customs of the Sixteenth Century*, Yale U. Press, 1920. Cf. Edward Sullivan, "A Forgotten Volume in Shakespeare's Library" [Pettie's trans. of Guazzo], *Nineteenth Century*, vol. 55, Feb. 1904, pp. 267–277.

expand and become the main consideration. In these books of manners and morals three things are stressed, sprightly and cultivated conversation, a suitable setting, highly conscious social ideals.

Crane gives a chapter on the influence of such books in England. Of Robert Greene he says:[128]

> When one who is familiar with this branch of Italian literature reads Greene he seems to be perusing a translation from the Italian, but when he seeks the original he can discover no single work that Greene has used. Like the other Elizabethan writer [writers?] he has so fully assimilated his material that his works have an original worth.

Crane quotes Koeppel on Whetstone's *Heptameron of Civil Discourses.*

> Koeppel's concluding remarks (*Studien zur Geschichte der Italienischen Novelle,* p. 34.) on this work [Whetstone's] are worthy of quotation...."We see in the spirit of Whetstone, whom we can regard as the typical representative of a numerous class of Elizabethan writers, the confluence of different streams of culture. Evident is the influence of the Italian *Decameron* and the French *Heptameron,* but Whetstone's work differs in an important manner from these two novels with frames. In them the picture in the frame predominates, in Whetstone the frame itself. He has, like Tilney, and very probably influenced by Tilney, taken as his model the *Courtier* of Castiglione, which he mentions among the books of his Philoxenus: 'for Government and Civil behaviours he read Plutarches *Moralles;* Guevaraes *Dial of Princes;* the *Courtier* of Count Baldazar Castillio.' Whetstone brings his circle before us not in the open air as Boccaccio and the Queen of Navarre, but in a splendid palace, like Castiglione. From Castiglione, who offers moral-didactic conversations with brief illustrative stories, Whetstone learned the introduction of the extensive frame. Whetstone also took as the models of his individual characters the figures of the Italian company: as in Castiglione the wife of the master of the house, the Duchess of Urbino, so in Whetstone Aurelia, the sister of the host, is the centre of the circle. Doctor Mossenigo has inherited the woman-hating disposition of Signior Gaspare Palavicino and the English author's ladies have been to school to the ready Signora Emilia Pia. As in Castiglione, at the end of the second and the beginning of the third book,

---

[128] Chapter XI, p. 528.

so in Whetstone on the fourth day, the question whether woman is as perfect a being as man is fully discussed."[129]

Characteristic of the independence of the English treatment of this kind of frame story is Lodowick Bryskett's version[130] of Cinthio's Three Dialogues; he sets his version in a dialogue among friends of his own, introducing Spenser among others.

For our purpose, the settings of these books are interesting. In Greene's *Morando* the setting is in part in a garden.[131] In *Farewell to Folly* it is "a graunge place by scituation melancholie, as seated in the middest of a thicket."[132] In Tilney's *Flower of Friendshippe*, the scene is a garden. There is a direct reference to Italian associations: Don Pedro

> "remembered how Boccace and Countie Baltizar with others recounted many proper deuises for exercise," which "were used in the courts of Italie, and some much like them are practised at this day in the English court, wherein is not only delectable, but pleasure ioyned with profite and exercise of the wyt."

They discuss the virtues of the matrimonial estate.

> ...after dinner they went into an arbour in the garden—"it might be called a terrestrial Paradise"; the benches "were trimly set with camamile and dasies".[133]

Whetstone's setting is a country house in winter:

> The author relates that in the "dead season", winter, his affairs sent him into a country far from home and unknown to him; having travelled on Christmas eve through a forest, and gone astray, he came to a stately palace where everyone was feasting indoors. A servant with his lord's welcome invited him to alight and walk in, which after some excuses he did. An interesting description of the screen of the great hall, and of another great chamber is given. The lord (he was brought up in the French court and was a Protestant) met him in the hall and led him into "a faire great chamber", where he found many gentlemen and ladies. Declaring himself an Englishman, the lord broke out into a eulogy of the "Mayden Queene" and begged him to stay. He was led to a

---

129 Crane, footnote, pp. 520–521.

130 See Miss Scott's description of this book (no. 390 in her list of English translations from the Italian), pp. 476–478.

131 See Crane, p. 525.

132 Crane, p. 526.

133 Crane, p. 507.

> bed-chamber and afterwards to supper, where many other foreigners were present. After supper, a cake being cut and distributed to select a king or queen, the lot fell to Madame Aurelia, sister to the lord of the palace, to be queen of the Christmas pleasures.[134]

This remote influence of the Italian frame story, an influence quite possibly unconscious to the playwright, if it exists at all—may also throw light on the structure of *Much Ado* and the relation of the two stories. Miss Scott does not—so far as I can find—note that we have here not so much two stories interwoven as one story set back within the other on a somewhat "different plane of reality".[135] There has been some difference of opinion among the critics as to which is main plot in this play and which underplot. Brander Matthews finds the story of Benedick and Beatrice the main plot:

> It is for this direct appeal [Beatrice's "Kill Claudio"] to Benedick's affection for Beatrice that the carefully compounded plot has been built up. The vulnerable elements of the play are all in the Hero-Claudio episodes.[136]

Crane has noted the variety of emphasis in the Italian works which he presents. Sometimes the frame is frame merely and the stories are all-important. Sometimes the stories are mere illustrations. Half way between these extremes we can imagine a type in which although the two are not on the same plane of reality, they might get something like equal emphasis. And this, we may say, approaches the situation in *Much Ado About Nothing.*

Thus the most important foreign elements of *Much Ado* may be of a vague and elusive kind; and may be in the association of a romantic Italian story, a merry war of wits, gaiety of atmosphere, and charm of setting. We do not wish to press the point too far. The influence of the Italian social ideal was too diffused in England to be a matter of deliberate imitation on Shake-

---

[134] Crane, p. 512.

[135] A phrase given me by a friend to whom I was talking of this theory in relation to *A Midsummer Night's Dream.* This conception of planes of reality—little plays written within plays varying in technique, to be compared, perhaps, to remote and close-up views in the cinema—seems to me to have an important bearing on several plays, notably *A Midsummer Night's Dream* and *The Taming of the Shrew.* In a study of these two plays I hope to develop the idea further.

[136] Brander Matthews, *Shakespeare as a Playwright,* New York, 1913, p. 154.

speare's part. Moreover he has, as usual, recreated his materials, giving them both a national and an individual quality.

Sir Arthur Quiller-Couch, on the other hand, has this to say of the Italianate quality of *Much Ado:*

> Actually it is the most Italianate play in the canon, and actually the closest to the spirit of the Renaissance. Nay, that spirit—so peculiar in essence and so volatile—permeates the whole piece and exhales from it. The characters can all speak 'by the book'.

He quotes from A. R. Walkley (*Playhouse Impressions,* 1892) the comment

> But life and letters do not sum up the Renaissance; they must be completed by a touch of the lurid—Benvenuto must cut Pompeo's throat as well as carve in silver—and so we get our third impression. This is an impression of somber melodrama, Italian treachery, the intrusion of Mephistopheles into the *Kermesse,* which the dramatist has provided for us in the intrigue of Don John and Borachio. . . . Can I register a fourth impression? Yes; in the strange manner of Claudio's wooing—behind a mask, and in the person of his prince—I like to fancy a premonition of the theater of Hugo and Musset. And when Claudio consents to wed a veiled lady whom he has never seen, he is the direct ancestor of Don César de Bazan. Thus here are the Elizabethan and the romantic epoch brought together. One might go on to a fifthly or fifteenthly—all merging at last into one composite picture of the multifarious, seething, fermenting life, the polychromatic phantasmagoria of the Renaissance. Like some quaint book of the time, with a quaint title, some *Hypnerotomachia Poliphili,* or like some vast crowded canvas of the time—the great marriage piece, say, of Veronese in the Salon Carré of the Louvre—*Much Ado About Nothing* is an Inn of Strange Meetings.[137]

Leonato's house is not the gorgeous and remote palace of the Italian frame story. It is more homely and more real, furnished with familiar objects. And the wit of Beatrice and Benedick is not conventionalized but has the energy and buoyant high spirits of a comparatively young and happy people.[138] Yet this setting is adequate—more than adequate. Like a deep, ornate

[137] Quoted by Sir Arthur Quiller-Couch in his Introduction to the play (1923). C. U. Press. pp. xxiv–v.

[138] In this comment I am influenced by a lecture of Professor R. E. N. Dodge of the University of Wisconsin.

frame for a very small picture, it has distracted our attention from the central incident itself. It is not for Hero's story, but for the diversified human interest of Leonato's house party that we read *Much Ado About Nothing.*

Thus the emphasis is upon the house as a great house, the garden as a garden, upon hospitality, gaiety, wit, conversation. This place is primarily "neither of England nor of Italy". For it is of England and Italy. It is "of civilization".[139] But it is still called Messina—thought of and imagined as Messina. Only by a gradual shifting of values, leaving out of the unintelligible, filling in of the congruous, similar to the whole rejection, acceptance, recreation of the foreign ideal, has the scene perhaps come unconsciously to be domesticated nearer home. We are told that the place is Messina and we believe it, since there is nothing definite in the play to turn back the original direction given to our fancy. Yet, on the other hand, as Elizabethan spectators, we know little of Messina to conflict with another tendency of the imagination, to weave the fabric of the unknown out of threads of the known. A house of Messina shall be built—unless we are told otherwise—of English stone and mortar and belong nonetheless in a distant land. In the homelier comedy scenes, perhaps, we forget for a moment that we are not at home; the characters come out among us and are of ourselves. For the rest, all is in the picture, at its distance, fairly well in focus and of a piece, foreign for all we know to the contrary. And yet, the modern reader, with his own history and geography duly pigeon-holed, has to acknowledge that, despite its Italian sources, and irrespective perhaps of Shakespeare's intention and the consciousness of his spectators, the piece as a whole, in character, setting, atmosphere, and general tone, is far more English than it is Italian.

[139] I am indebted to a lecture of Professor J. F. A. Pyre, of the University of Wisconsin, for this idea, applied by him in general to the diffusion of Italian culture in England. Compare the words of Erasmus, quoted by Einstein (*The Italian Renaissance in England,* p. 44): "Mihi Italus est quisque probe doctus est etiamsi fit apud Juvernos natus."

PROCEEDINGS OF THE ACADEMY

SIXTY-SECOND ANNUAL MEETING, 1932

The sixty-second annual meeting of the Wisconsin Academy of Sciences, Arts and Letters was held, in joint session with the Wisconsin Archeological Society and the Midwest Museums Conference, at the Public Museum, Milwaukee, Wisconsin, on Friday and Saturday, April 8 and 9, 1932. The following papers were presented:

Friday morning. S. A. Barrett: Address of welcome; Stephen Kliman: The use of sodium silicate as a mounting medium; J. K. Conklin: Some museum photographic methods; John B. MacHarg: Museum bulletin boards; Alton K. Fischer: The museum as a public utility; J. G. Gregory: Museum origins in Milwaukee; C. E. Brown: The George Washington exhibit of the State Historical Museum; Mrs. Ruth J. Shuttleworth: "Little George and his Hatchet" (a Madison poem, 1854); R. P. Gray: Folk songs and ballads; H. R. Rich: Aquatic leaf-cutting beetles of Wisconsin; T. E. B. Pope: An unusual occurrence of the alder fly; H. W. Mossman: What is a red squirrel; H. W. Mossman: Prenatal and postnatal development of the thirteen-striped spermophile; L. J. Cole: The effects of light periodicity on the reproductive cycle of the mourning dove; J. A. Bradley and H. W. Mossman: The behavior of captive spermophiles in the presence of a bull snake; J. A. Bradley and H. W. Mossman: Accidentally induced color changes in chipmunks; O. L. Kowalke: On the stoppage of sewer laterals by roots; Louis Kahlenberg and R. N. Traxler: The osmotic permeability of living plant membranes; N. C. Fassett: Notes on some plants of Wisconsin.

Friday afternoon. J. B. MacHarg: Locating Lincoln's haunts at New Salem; R. K. Richardson: Tennyson as an exponent of the idea of progress; T. T. Brown: Sieur Charles de Langlade, bravest of the brave; Ernst Voss: Dutch colonies in northern Germany during the Middle Ages, (by title); Lorraine C. Brown: Wisconsin hobby riders; Anton Sohrweide: The origin and distribution of copper artifacts; George Overton: What a season may bring forth; C. E. Brown: A sheet copper bird effigy ornament; E. L. Miloslavich: Arrow-head injuries of the spinal column in American Indians; L. F. Graber: An environmental study of the injury of grasses by white grubs in southern Wisconsin; S. C. Wadmond: The Quercus ellipsoidalis—Quercus coccinea complex; L. R. Wilson: The classification of North American Lycopodiums on spore characters; H. V. Truman: Some fossil pollens from the Gibraltar Bluff peat bog; Albert M. Fuller: The occurrence of natural hybrids in our native orchids; M. L. Clikeman: The classification of Gymnosperms according to their pollen grains; G. H. Conant: Butyl alcohol as a fixative in plant histology; J. F. Groves: Demonstration material for teaching botany; E. R. Miller: The snowfall of Wisconsin.

Special lectures on Friday: Rev. O. W. Smith: High Mountains; Dr. R. Bagg: Yesterday and Today in South America.

Saturday morning: E. J. Dornfeld: Variability in Haploa; H. R. Rich: Modernizing mollusk exhibits; T. E. B. Pope: Value of an economic fishery exhibit; E. G. Wolff: Fire-arms and museums; Charlotte Partridge: Children's classes at the Layton Art Gallery; Eugene Boardman: Engraved ostrich egg-shell of North Africa; E. L. Miloslavich: Anomalies of the epistropheus in two Indian skeletons; Ira Edwards: Creating an outdoor museum; Gilbert Raasch: Special problems of a university museum; H. D. Squires: Strike slip faulting in the Acadian Appalachians; Rachel Mary Campbell: Wisconsin Biographies.

A tea for the members of the three societies was held at Milwaukee-Downer College on Saturday afternoon in the Greene Memorial Museum.

The annual business meeting of the Academy was held in the Lecture Hall of the Public Museum at 5:30 Friday afternoon, April 8. The secretary presented the following report on membership, as of April 6, 1932: honorary members, 3; life members, 14; corresponding members, 12; active members, 342; total, 371. Membership losses during the year: deceased, 7; resigned, 24; dropped for non-payment, 12; dropped for loss of address, 8. The names of fourteen new members were presented and unanimously elected. This, added to the 54 new members elected during the year by council action, brought the total of new members for the year to 68. The complete list follows: Rudolph J. Allgeier, Elda Anderson, Ira L. Baldwin, Glenn J. Baker, A. L. Barker, E. F. Barta, Dorothy Bauch, Harry Beckman, Joseph C. Bock, E. L. Bolender, P. N. Butler, J. O. Carbys, W. J. Carson, Frank H. Coleman, Frances E. Colien, R. E. Davies, Dolores Dohr, E. J. Dornfeld, Lucile Evans, M. Fernan-Nunez, Amelia C. Ford, Oscar Gram, Wallace B. Grange, E. J. Graul, Alvin Grether, John Grill, Ella Hanawalt, Ralph Hile, Earl A. Helgeson, George Klak, H. O. Lathrop, Huber A. Ludwig, Kenneth L. Mahony, M. J. McKeough, G. D. McLaughlin, E. J. Menge, Otto Mortenson, Merna Miller, R. G. Mills, Sobey Okuyama, Carroll W. Osgood, Henry Otterson, Aleida J. Peters, Mary Edith Pinney, F. W. Ray, August C. Rehwaldt, Chapman Reynolds, Lillian Scheuber, E. M. Searls, Alfred Senn, Elmer L. Sevringhaus, R. G. Shands, Robert R. Shrock, Theodore L. Squier, H. D. Squires, Marian E. Stark, George Town, Julia Grace Wales, Ruth Wallerstein, R. G. Washburn, Mrs. George Wettengel, Russell Whitaker, Helen C. White, Wallace L. Wilgus, A. D. Winspear, Harold R. Wolfe, Richard Woltereck, Agnes Zeimet. The following members were elected to corresponding membership: E. F. Chandler, Milton R. Gutsch, S. J. Holmes, W. S. Naylor, and O. B. Zimmerman. The treasurer's report, as of March 31, 1932, was presented as follows:

RECEIPTS

Balance in State Treasury, April 9, 1931	$1955.08
State appropriation for the year 1931–32	1000.00
Dues received from members	439.55
Annual allowance from A. A. A. S.	109.00
Reprints sold to authors	108.32
Publications sold to public	44.36
Total receipts	$3656.31

DISBURSEMENTS

Printing of Vol. 26 of Transactions	$1028.17
Reprints for Vol. 26 of Transactions	370.87
Engraving for Vol. 27 of Transactions	418.72
Other printing (programs, announcements, etc.)	64.13
Secretary's salary for the year	200.00
Postage	76.00
Express	2.08
Refund to R. H. Whitbeck on reprints	17.95
Total disbursements	$2177.92
Balance on deposit, March 31, 1932	1478.39
Total	$3656.31

ENDOWMENT FUND

Trust agreement, Central Wisconsin Trust Co.	$1000.00
City of Madison bonds	1000.00
Chapman block bonds (Madison)	400.00
Commonwealth Telephone Co. bonds	400.00
Wisconsin Power and Light Co. bonds	200.00
Capitol Square Realty Co. bonds (Madison)	200.00
Cash on hand	62.10
Total assets	$3262.10

The auditing committee, consisting of Professor Chancey Juday and Dr. T. E. B. Pope, reported that it had examined the accounts of the treasurer and found them to be correct. The annual dinner of the Academy was held at the Hotel Schroeder, with about forty-five people in attendance.

The following are the members of the Academy who have died during the past year:

David Starr Jordan, Sept. 17, 1931.
George B. Merrick, April 21. 1931.
Charles E. Monroe, May 12, 1931.
M. V. O'Shea, Jan. 14, 1932.
E. T. Owen, Nov. 9, 1931.
L. H. Pammel, Mar. 23, 1931.
F. J. Turner, Mar. 15, 1932.

LOWELL E. NOLAND,
Secretary-Treasurer.