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WALTER F. PETERSON

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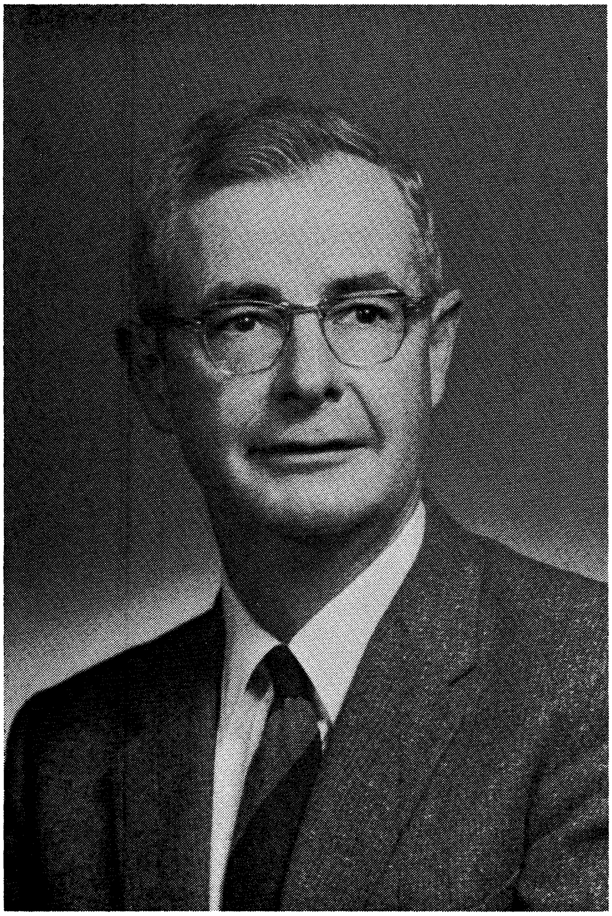

JOHN W. THOMSON

47th President of the

WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

GREEN POWER: THE INFLUENCE OF PLANTS ON CIVILIZATION

John W. Thomson

When considering the possibilities for this address tonight there was a strong temptation to entitle it "Flower Power". But, such a topic presented by a professor from the University of Wisconsin might perhaps be unappreciated by many of our citizens who comment upon daily life on our campus.

As a professional botanist my own field of research and teaching involves the science or art of classification and the naming of plants, a field known to the professional as plant taxonomy. In actual practise a plant taxonomist studies many aspects of the life of plants: their physiology, chemistry, ecology, cytology, uses, and many other things. Perhaps more than for any other botanist his tracing the history of the names of the plants leads him into an awareness of significant historical events which resulted from the intertwining of the life of man and the plants of his environment.

The current geologist will point out a fact based upon his solid evidence that in the earlier days of its founding, the earth was surrounded by a different mixture of gases than that with which we are familiar: The abundant volcanoes produced an atmosphere with a higher content of carbon dioxide than the 0.03% of today and less than the 20% of oxygen which sustains our life. The evolution of plants which used this high concentration of carbon dioxide gas in their photosynthetic activity, giving off oxygen as a byproduct, altered the atmosphere to the more liveable atmosphere on which we are so dependent today. The algae in the waters of the earth can take their carbon dioxide from the dissolved bicarbonates, precipitating the unused portion as carbonates, usually lime carbonates. The thousands of feet thick of limestone deposits have locked up in them the carbonates from which the ancient algae released the oxygen in their life processes. The enormous coal deposits of the world also represent such an alteration of the atmosphere in which the carbon dioxide of the air was taken out and changed into organic materials which were fossilized and the byproduct oxygen enriched the air.

For some people, the earliest relationship of man and plants was perhaps that described in the delightful tale of the use of the apple by Eve in the Garden of Eden as related in Genesis.

Studies of anthropologists tell us that man evolved as a predator, a hunter. His early weapons, his art, the artifacts of his civilization, attest to this. He had little to do with plants except when game grew scarce. Then he would gather nuts, berries, and roots of the plants which he found around him. He became a gatherer of plants as well. Probably his earliest use of plants on a consistent basis was as fuel for his fires. The early development of hand axes perhaps reflects the possibility of such use and yet these were mainly weapons. The use of fire dates back only some 20,000 to 30,000 years ago (Baker, 1965). Man may also have used plants in the making of shelters of wattle or of reeds and barks. Probably the grasses were early harvested in the wild as wild rice is still harvested in northern Wisconsin and Minnesota, or as small grains in the Sudan.

At this point I should like to bring to your attention two possible routes of the evolution or development of civilizations based upon plants. The tropics are large areas where a civilization based upon fruits and roots evolved, including products as breadfruit, the tubers of tara (corms) and "yams" of the banana type fruits or of *Dioscorea* (tubers). These are perishable foodstuffs. Furthermore their collection requires much hand labor. They cannot be laid up against starvation periods or crop failures, nor are they easily transported. A civilization based upon such foods as these is subject to periods of feasting or famine. How different is a civilization such as ours based upon the grains of grasses. The grass stores its food in a non-perishable easily handled package. Its stored food is on stems which are easily cut and processed and it lends itself to mass treatment, especially by machinery. Its product can be stored, protected from the depredations of insects for many years, circumventing the old cycle of inevitable feast and famine periods. Its ease of culture and of transport has led to a situation in which over 30 people may be supported in cities by one on a farm. This proportion, still increasing today, has made possible a civilization of immense cities in cold climates. It makes possible the feeding of one part of the world by the production in another. An equitable sharing of the products of the earth is more possible with the grains of this family of plants than with the products of any other plant family except possibly the legumes.

The story of the rise of this allegiance of man to the grasses is a long story, perhaps of three chapters achieved quite independently in three parts of the world; one based upon wheat and originating in Asia minor, one based upon corn and originating in the new world, and the third based upon rice originating in the orient.

Agriculture, according to Baker, had its inception in the Mesolithic or Middle Stone Age, a period when the glaciers were melting away in Europe. Around the communities of the "hunter-gatherers" were undoubtedly disturbed soils, midden heaps, areas rich in nitrogenous wastes. Some of the weeds may likely have developed there. They would have been derived from plants of disturbed habitats such as rock slides, cliff faces, sea shores, sand bars, cattle wallows, etc. Among these ancient weeds were species of *Triticum,* the wild wheats, three species of which are known from remains of a 7th millennium village in the Tigris–Euphrates valley. These grains were probably parched to assist in removing the husk and prepared in a gruel, as bread-making is a comparatively recent art. In any case these weedy plants became crossed with other weeds in the genus *Aegilops* and the chromosomes multiplied to give us the hexaploid bread wheats of today. The best of the progenies of these weeds were probably unconsciously selected and fell near the homes of our ancestors. Somehow, somewhere, some genius among these ancestors decided that rather than to rely on finding the grains, a better way would be to scratch the soil and thereby promote their growth. Thus agriculture and the dependence of man on a sedentary life was born.

A similar story can be told for the independent origin of indian corn or maize, in the new world. Its origin is less well known than that of wheat. It does appear to be related to teosinte *(Euchlaena mexicana)* but to also have characters derived from a weedy species of *Tripsacum.*

One of the fascinating developments of such weeds into plants upon which we depend is the series of crops which European man developed from a nondescript weed of the chalk cliffs of England and France, a mustard, *Brassica oleracea.* From this unimposing start have been derived cabbage by developing the terminal bud, brussell sprouts by developing the lateral buds, cauliflower and broccoli by developing the flower buds, and kale by developing the leaves. Would that some genius among us find such promise in the pigweeds of our garden!

One other food plant should be mentioned with respect to its influence upon our history. The potato originated in the high Andes where many varieties are grown. The conquerors of Peru introduced it to Spain during the 16th century and from there it spread to all of northern Europe. It has become one of the world's most important crops. In Britain and Ireland it was the main crop fed to the peasantry with perhaps a pig or two per family per year allowed as a source of protein by the landlords who owned the land. Such dependence upon a single crop was dangerous and when the late blight fungus (a plant of course) hit the fields of Europe during 1845–1847 millions of the peasants across northern Europe starved to death. Many others, especially from hard-hit Ireland, migrated to North America, contributing to the large populations of Irish along the eastern seaboard and affecting the destiny of the United States. A very important development of this period was the repeal of the "infamous" corn-laws of England which protected the small grain grower of Britain from competition of grains from the United States and Canada. John Peel (well known in a song) was influential in the British Parliament in securing this repeal. The increased import of grain from abroad made it necessary to secure ocean travel against privateers and pirates who then operated with "permits" from the nations, and Britain promulgated the doctrine of the freedom of the seas to all trade, and built the tremendous navy necessary to enforce this doctrine. For many decades this navy was the guarantor of the freedom of the seas, and Britain was the world's greatest seapower until the period of World War II. We must admit that this doctrine of the freedom of the seas has profoundly influenced the course of history, and the potato and potato blight initiated it.

From one of our fiber plants, cotton, we have inherited some of the most serious issues of today. Let me tell you some of its background. Cotton originated from wild plants, some of Asiatic, and some of North American origin. In India it has been cultivated for several millenia. The Asiatic strains were undoubtedly known in biblical times. The New World varieties had to await the discovery of the Americas for their introduction.

In Europe, prior to the use of cotton, the main fiber used was wool. It was a warm fiber suited for use in a cool moist climate. Its original production was largely a home cottage industry, the sheep being sheared, the wool spun by the housewife and the thread woven either by the housewife or the itinerant weaver. Cotton altered this picture of domestic tranquility. The new methods of manufacture made possible a cheaper product. The cotton gin invented by Eli Whitney made it possible to get large quantities of the fiber separated from the seed easily and the spinning machines of Richard Arkwright (1768) and enormous weaving machines made mass production possible. The Industrial Revolution had begun with all its ills and abuses. It was a revolution which altered the whole way of life of man, taking him far from the land, putting him in cities and developing the immense urbanization of whole nations. It was with the fiber of cotton that all of this began.

A further enormous sin may be laid to cotton. In the southern part of the United States a plantation system based on the production of dye indigo had evolved. An important blue dye was obtained from this plant. The system was faltering in competition with the dye indigo obtained from India where labor was even cheaper than that of the slaves the planters of the south were importing from Africa. The rise of the mills of cotton manufacturies made the demand for cotton so great that a rapid shift to cotton and tremendous expansion of the plantation system in the south occurred.

The importation of the negro slaves from Africa and their use as labor for the plantation has led to a multitude of problems for our country. We can blame the Civil War upon cotton, the exhaustion of the lateritic soils of the south, the social ills of the south, and the riots of today upon cotton. Truly this plant opened to us a Pandora's Box containing much evil.

From time immemorial the spices have been articles of trade, sometimes of use only to the wealthy as a status symbol of greater value than any commodity even the precious metals. Cloves, pepper, and cinnamon found their way from the Orient during the Middle Ages via long voyages, camel trains and arduous journeys. They were prized for their flavors, yes, but in addition for the promotion of perspiration, for aid to digestive processes, for preservatives, and because of lack of refrigeration, to cover up the flavor of partially rotting meat, and were even used as deodorants by people who believed that baths were dangerous and unhealthy. To avoid the inevitable losses and tribute attrition of profits caused by the long overland trade routes, the great voyages from Spain, Portugal and Italy were undertaken. These may have commenced with Marco Polo's epic 24 year journey in the mid 13th century and continued with those dates which every school child can recite for you: Columbus 1492, Vasco da Gama 1497, and Magellan 1519–22. Many were the wars and naval engagements fought in our history to secure monopolies of the spice trade. Portugal, Spain, England, and Holland fought for and sometimes won, sometimes lost, colonial empires whose products were the fragrant and profitable spices. Let anyone think that we have not inherited a legacy of problems from these plants and we shall let the names of Oriental and south seas trouble spots roll from the tongue—Indonesia, Macao, Ceylon, Malaysia, Hong Kong, to name a few.

The development of the overseas routes discovered during the great period of exploration led to the need for navies to keep open the routes and protect the trading vessels from piracy. That was the day of wooden vessels, for it was not until the battle of Hampton Roads in 1862 when the Monitor met the Merrimac that the era of wooden ships began to end. The need for forests of oak for the ships and of conifers for spars led to many problems as the forests of Europe became exhausted. Naval operations around the Baltic sea were necessary to insure Britain a supply of masts and spars. Naturally this type of operation became objectionable. Finally during the latter part of the 17th century North America became a source of naval timbers and supplies. During the Napoleonic Wars of the 19th century it was possible for Britain to win the victories of Aboukir Bay and Trafalgar only because she had access to the timbers of Canada for naval construction.

Lest we think that the movement of armies and navies caused by plant resources is a phenomenon of only the past, something which ended in the Victorian Period, let me hasten to call to your attention some of the strategies of World War II. These were determined in the Pacific Theatre of Operation in large part by plants. In central America and on the Amazonian slopes of the Andes and the Amazonian slopes of Colombia and Venezuela are trees from which rubber is obtained. This product remained mainly a curiosity until 1839 when Charles Goodyear discovered the process of vulcanization. This discovery makes it possible to use rubber in the manufacture of tires for vehicles including those on which our vast and mobile civilizations and armies are now completely dependent. The rubber trees were eventually imported to Ceylon, Malaya, and Indonesia where the principal plantations of the world are located.

A second plant genus of the same region of northern South America, *Cinchona,* supplies the world with quinine, the drug necessary to control malaria. Its introduction to the East Indies led to the source of 90% of the world's supplies being the plantations of Java. Without quinine, no army can effectively operate in the tropics. Without the wheels to roll upon, and quinine to protect against the scourge of malaria, our great armies would have been impotent. The strategies of Japan in the Pacific were to cut us from these vital supplies coming from the far reaches of the Pacific. Our strategies had to include campaigns to regain control of these vital plantations.

The quest for plant materials to treat the ailments of man is an old one. Probably our ancestors in testing the edibility of plants when they were in transition from hunters to hunters and gatherers sampled everything in their environment and in some cases found surprising effects; laxative, emetic, hallucinatory, soporific etc. The body of lore they accumulated was passed on as an oral tradition by their medicine men; later the first books on plants dealt mainly with their medicinal values. This traditional background of botany still finds use today although many drugs of today are now synthesized rather than extracted.

For the alleviation of pain we still may use cocaine from the leaves of the cocoa tree and morphine from the latex of poppies. Digitalin from the foxglove is important in the treatment of certain heart diseases; atropine from belladonna finds many important medicinal uses; precursors of cortisone are obtained from yams of the genus *Dioscorea;* and *Rauvolfia* yields reserpine which has proven so effective in the treatment of mental ailments. The tremendous effects on world health by the antibiotics obtained from the mold fungi such as *Penicillium* must also be recognized. Some of the extracts from plants contain addictive alkaloids as morphine or its derivative heroin in the latex of the opium poppy or nicotine in the tobacco plant. What have been the effects of such plant products on man? It is not necessary here to do more than remind one of the tremendous economic and social effects of these addictions. It is an ironic twist of events that the addiction of the nicotine user is the chief source of funds for the Outdoor Recreation Act of Wisconsin, or that a major source of revenues for the government is this same addiction. Many of us also certainly are habituated, if not addicted to the milder alkaloid caffeine contained in coffee. Sometimes too, we may be enlivened by the alcohol produced by the yeast plants when carrying on anaerobic fermentation in obtaining their energy for life processes. There are not many other plant products, or even animal products, that have not been utilized by man in seeking to harness the yeasts to his desired aims.

Tonight I have spoken of but a few of the examples of the power of plants in influencing man's course of action. I could have spoken of many more, of cacao and coffee, of tea, and of the forests and the influence of paper, other foods and fibers, things to chew, an amazing array of plants from far corners of the earth. But, I should like to conclude with some thoughts concerning our future relationships with plants. In the newspaper this past weekend was a discussion of a vast project which was proposed for South America. A dam would form an inland sea as large as western Europe. The newswriter with remarkable insight commented that he wondered what the significance could be of removing so much of an area of trees from the oxygen regeneration system of the world. This is part and parcel of the same problem in which we use the fossil fuels of the earth, coal and petroleum, taking oxygen from the atmosphere and releasing carbon dioxide by the millions of tons, a process which Prof. Reid Bryson, one of our academy members and a climatologist will tell us portends serious alterations in the climate of the earth. This too, Prof. Bryson tells us, is correlated with problems caused by the removal of the vegetation of large areas of the earth by man and his domesticated animals, especially the goat, leading to atmospheric dust pollution which causes greater reflection of the radiant energy of the sun, in turn thus cooling the earth and its climate. Continuation of this process will certainly force man to alter much of his way of life in the northern hemisphere. To reverse this process and to revegetate the large areas of the world which once were green and supported huge cities as those of the Mycenians and the Sumerians in the region of Asia Minor seems well nigh impossible. The evidence seems incontrovertible that the loss of the vegetation of these regions caused the decline of great civilizations.

A hitherto unsuspected influence of plants is only now making itself felt. Henry Thoreau's statement of it was borrowed for the title of a recent publication of the Sierra Club "In Wildness Is The Preservation Of The World". Perhaps we can say that this is an influence upon the soul of man! Man was a creature of the edge of the forest, perhaps of a savannah-like landscape. He feared the deep forest, he feared the open prairie. Does he not cut down the forest around his home to open it to sunlight? When travelling in the Dakotas does he not seek a tree under which to picnic? Can he bear the solid expanse of concrete and asphalt of the urban horrors which have arisen today? Certainly he is never happy in them, he escapes to the greener expanses of suburbia when he can and is happiest when camping in what he can call the "wilds". He has come a full circle. From a native home in a world clothed in plants, he came to a utilization of plants which led to vast cities in which man scarcely felt any relationship to plants, so far was he from the land. And now he has returned to a realization that plants are necessary not just for economic values but merely because he feels he needs them and is unhappy without them. This is the age when the pressures upon the plants are so severe that the conscience of man feels the need to grant the plants sanctuaries, when the Nature Conservancy and the Sierra Club become inner needs felt by so many people. They are an expression of the power of plants upon people, a green power whose influence will continue to be needed no matter how far we progress in achievement. When we reach for the stars, plants will ride with us, exchanging oxygen for the carbon dioxide produced by the astronauts, a cycle with which we started our thoughts tonight, the green power which is indispensable to man.

THE RELATION OF HENRY JAMES'S ART CRITICISM TO HIS LITERARY STANDARDS

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Henry James's use of the representational arts as material for fiction extends from the early "A Landscape Painter" of 1866 to *The Outcry* of 1911. In the Preface to *The Tragic Muse* he speaks of the fascination of the artist-life as "a human complication and a social stumbling-block," the conflict between the claims of art and of society being, he feels, one of "the half-dozen great primary motives."[1] He exploits this subject also in *Roderick Hudson* and in many of the short stories. Although in fiction he treats problems of the painter, the actor, and the sculptor, his art criticism and his discussions of the problems of representation deal most frequently with painting. The terms of painting enter into his criticism of literature, a great deal of metaphor is drawn from this art, and he alludes frequently to specific canvasses.

But as art critic James is an amateur, a lover of painting who could never become the rigorous professional he made himself in his proper field. Mr. John Sweeney, who has collected much of the art criticism, emphasizes James's reliance on personal impressions in his role of an attentive spectator interested in questions of representation. He delighted in "shows," and he made his investment of time and interest yield a return for his developing critical sense. As Mr. Sweeney points out, he never concealed the fact that he found literary as well as plastic values in pictures, and "*read* pictures with an eye for their possible lurking donnée."[2]

James's criticism of painting is to be found in art reviews and accounts of travel. The reviews appeared from 1868 to about 1882 and again, briefly, in 1897; the travel accounts which deal with painting were written in the early 1870's. Mr. Sweeney has collected the bulk of the reviews, and *Transatlantic Sketches* includes most of James discussion of painting in his travel writings. The great difference is that the travel accounts record personal, imme-

[1] *The Art of the Novel* (New York, 1934), p. 79.

[2] Henry James, *The Painter's Eye*, ed. John L. Sweeney (Cambridge, Mass., 1956), p. 12.

diate responses and discoveries which enriched James's visits to new places. The reviews are more reserved, but without being impersonal.

All the accounts of painting are best seen in relation to James's criticism in general. In his career James is at first more the reviewer and the critic than the writer of fiction, and the art reviewing begins some years later than the book reviewing. One notable difference follows: Where the reviewing of books gives place to extended critical essays in which James eventually speaks with the authority of "a man of the craft," as he later styles himself, the art notices remain always the appreciations of an intelligent observer, and eventually cease.

James disclaims interest in technical criticism of painting; this is a matter which is to be left to others.

> There is a certain sort of talk which should be confined to manuals and notebooks and studio records; there is something impertinent in pretending to work it into literary form. . . . It is narrow and unimaginative not to understand that a very deep and intelligent enjoyment of pictures is consistent with a lively indifference to this "inside view" of them. It has too much in common with the reverse of a tapestry.[3]

The "inside view" is precisely what makes James's later literary criticism uniquely valuable, yet the record of his enjoyment of pictures has its own interest, for his views on painting are related to his inseparable concerns for the role of the critic and his assessment of the imagination of the producer in all artistic performance.

In his earliest literary criticism, which antedates any of the art criticism, James takes the position that the critic must be opposed to his author, bound to consider the work within the limitations of subject imposed on him, without reference to extraneous theory or critical dogma. He distinguishes between "great" criticism, which touches on philosophy in the fashion of Goethe, and the practice of Sainte-Beuve, which at this time he considers productive of "small" criticism. It is, he maintains, the duty of the critic to "compare a work with itself, with its own concrete standard of truth," and to rely on his reason rather than his feelings.[4] He makes a Coleridgean distinction between imagination and fancy. Imagination enables the writer to present recognizably living figures, to whom the imaginative reader can respond; the merely fanciful writer seeks cheap and easy effects because he recognizes no stand-

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[3] Review of Eugène Fromentin's *Les Maîtres d'Autrefois: Belgique–Hollande, Nation,* 23 (13 July 1876), p. 48.

[4] *Notes and Review by Henry James,* ed. Pierre de Chaignon la Rose (Cambridge, Mass., 1921), p. 102f,

ard of truth or accuracy. "As in the writing of fiction there is no grander instrument than a potent imagination," James declares, "so there is no more pernicious dependence than an unbridled fancy."[5] Fancy alone may convey the impression of physical surroundings; the reconstruction of feelings and ideas requires imagination.

Within a very few years James modifies this stand and takes a sterner view of the function of the imagination, which he now maintains should "hold itself responsible to certain uncompromising realities."[6] Beyond this respect for fact, the imagination, by sympathetic penetration of its subject, can convey the very color of reality. He shortly adds that the working of the imagination is connected with questions of both realism and morality; analytic imagination, presenting a scene with "hard material integrity," can leave behind a certain moral deposit.[7]

At the same time he softens the tone of critical authority and calls now for justness of characterization. The day of critical dogmatism, he holds, is over, and with it the ancient infallibility and tyranny of the critic. It now seems to him his duty as critic to detach from a work under discussion "ideas and principles appreciable and available to the cultivated public judgment."[8] At this point James begins his discussions of painting, and it is at once clear that the principles he has formulated for literature are to be applied also to painting; justness of characterization of a canvas requires, quite as much as does analysis of a novel, an estimate of the imaginative force behind its creation.

The bases of James's responses to painting and painters are: A distinction between imagination and fancy; a concern for reality; a search for justness of characterization; a fondness for the narrative or literary aspects of a canvas; and a demand for morality and taste. They all appear in one of the earliest of his reviews of an exhibition of paintings in which he begins a discussion of Alexandre Decamps by naming this painter as representative of the gifted class of artists who pursue effect without direct reference to truth whether it be in literature, music, drama, or painting. Yet he goes on to acknowledge Decamps' "penetrating imagination" as warrant for a background much resembling, so far as it relates to reality, "some first-rate descriptive titbit of Edgar Poe or Charles Baudelaire." And then James finds that, in default of reality, the somewhat arbitrary and ambiguous air of grandeur and lustre is

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[5] *Ibid.*, p. 32.

[6] "Novels by the author of *Mary Powell*," *Nation*, 5 (15 August 1867), p. 126.

[7] Review of Gustave Droz' *Around a Spring*, *Atlantic*, 28 (August, 1871), p. 251.

[8] Review of Rebecca H. Davis' *Dallas Galbraith*, *Nation*, 7 (22 October 1868), p. 330.

the conception, rather, of "a supremely vivid fancy." In comparison, the juxtaposed canvasses of Eugène Delacroix reveal "a generous fallibility which is the penalty of his generous imagination . . . he is a painter whose imaginative impulse begins where that of most painters ends." It is not that Delacroix selects grotesque or exceptional subjects, but that he sees them rather in "a ray of that light that never was on land or sea—which is simply the light of the mind." James goes on to describe a picture of men around a campfire, and he finds great fault with the drawing; but in the picture, he feels, Delacroix has shown an eye for the *"mystery"* of a scene which fuses expression and details into the harmony of poetry. And when it comes to morality and taste, James can describe a Daubiguy canvas as "a little blank and thin; but . . . indefinably *honnête,*" in the fashion of one of George Sand's rural novels.[9]

With variations this is the pattern of the early art reviewing, in which James respects the definitions and discriminations he has already made clear in his general critical effort. He deplores, in a picture admittedly painted with precision and skill, the total lack of what may be called "moral atmosphere."[10] He notes that Foxcroft Cole's pictures have rather less of "an imaginative or reflective germ" than suits his taste and finds it a pity that a painter should ever produce anything without suggesting its associations, its human uses, and its general "sentimental value." He discovers that art is thoroughness and intelligent choice, and that beauty is sincerity; that the artist who would avoid superficiality must deal with the simple and the familiar; that superficiality is the only vulgarity; and that to be broadly *real* is to be interesting.[11] Returning to Decamps, he finds that his work is rich in "skill . . . invention . . . force . . . apprehension of color . . . and *insincerity,*" since his prime warrant is his fancy.[12] He feels that Winslow Homer "not only has no imagination, but he contrives to elevate this rather blighting negative into a blooming and honorable positive. He is almost barbarously simple, and, to our eye, he is horribly ugly; but there is nevertheless something one likes about him."[13] He finds an extraordinary impression of "imagination, vigor, and facility," in the work of Gustave Doré.[14]

A comparison of the art reviews with the reviews of books and the criticism of authors which James was multiplying at the same

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[9] "French Pictures in Boston," *Atlantic,* 29 (January, 1872), p. 115–118.
[10] "Pictures by William Morris Hunt, Gérôme, and Others," *Atlantic,* 29 (February, 1872), p. 246.
[11] "Art," *Atlantic,* 29 (March, 1872), p. 372 f.
[12] "The Wallace Collection in Bethnal Green," *Atlantic,* 31 (January, 1873), p. 72 f.
[13] "On Some Pictures Lately Exhibited," *Galaxy,* 20 (July, 1875), p. 93.
[14] "London Sights," *Nation,* 21 (16 December 1875), p. 387.

time shows how closely connected are his theories of criticism and of the imagination in all fields. By 1872 he expresses a preference for the method of Sainte-Beuve, whom he once slighted as a "small" critic, over the supposedly scientific method of Hippolyte Taine. While Taine attempts to knock loose chunks of truth with a blow of his critical hammer, Sainte-Beuve rather disengages its diffused and imponderable essence by patient chemistry, by dissolving his attention in the sea of circumstances. James now considers Sainte-Beuve's provisional empiricism more truly scientific than the premature philosophy of M. Taine.[15] He begins to revise his own critical practice, and the sympathetic essay on Turgenev of 1874 reveals something of the critical empiricism he praises in the French critic. He finds Turgenev a searching observer, but even more a man of imagination, universally sensitive, who surpasses the French realists in appreciation of sensuous impressions and at the same time appreciates impulses outside the realists' scope. He discusses Turgenev's imagination, which he cannot praise too highly for its "intensity and fecundity." No novelist seems to James to have created a greater number of living figures, to have had so masterly a touch in portraiture, or to have mingled so much ideal beauty with so much unsparing reality.[16]

Thus it is hardly surprising that at very nearly the same time he can note Winslow Homer's "perfect realism" while remarking that although Homer is a genuine painter it is not his practice to think, imagine, select, refine, or compose. He goes on in the same review to say of another painter that he lacks intellectual charm, a thing which James finds precious even to its being the only thing of deep value in a work of art, since imagination or intellectual elevation cannot be studied or acquired, whereas everything else can.[17] And just as he expresses fatigue that his self-respect requires his being analytical in observing pictures, he experiences revulsion from literary criticism as he has practiced it. Examination of paintings in Italy has persuaded him that the whole history of art is the conscious expression of a single mysterious spirit. He has worked off his juvenile impulse to partisanship, and he now perceives a certain human solidarity in all cultivated effort. "There comes a time," he confesses in 1874, "when points of difference with friends and foes and authors dwindle, and points of contact expand. We have a vision of the vanity of remonstrance and of the idleness of criticism."[18] Within the year he speaks of criticism as "deep appreciation."

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[15] Review of Taine's *English Literature, Atlantic,* 29 (April, 1872), p. 469.
[16] *French Poets and Novelists* (London, 1878), pp. 275, 318.
[17] "On Some Pictures Lately Exhibited," *Galaxy,* 20 (July, 1875), pp. 91, 93.
[18] Review of Victor Hugo's *Quatrevingt-trieze, Nation,* 18 (9 April 1874), p. 238.

During this same time he enlarges his conception of the imagination, and of the imaginative force behind artistic construction. Flaubert in *Madame Bovary* reveals what the imagination can accomplish under a powerful impulse to mirror the unmitigated realities of life.[19] Emile Montegut's "cultivated imagination" gives out in his work "a kind of constant murmur of appreciation—a tremor of perception and reflection."[20] The "true imaginative force" enables Howells to give his readers not only the mechanical structure of a dramatic situation, but also its atmosphere, meaning, and poetry.[21] James cites also such negative examples as Charles Kingsley, whose imagination died a natural death when Kingsley turned didactic historian,[22] and Bayard Taylor's, which was so cold it could not kindle the reader's.[23] When in 1875 he discusses Balzac extensively for the first time his chief concern is the quality of Balzac's imagination, and in later essays he returns to it again and again. It becomes for James the great explanatory fact behind Balzac's reality, his vividness, and his systematizing of the *Comedie Humaine*. Its deficiences explain Balzac's failures of portrayal whenever he attempts to touch the moral life.[24]

This discussion of literary matters, which deliberately departs from James's concern with painting, serves two ends: It shows the inseparable connection of his changing conceptions of the critic's role in his responses to both books and pictures, and it underscores his developing sense of the crucial role of the imagination in all artistic production. And since it deals with the formulations which are most explicit in his writings of 1872 and 1875 it encloses, as in a parenthesis, the bulk of the travel accounts subsequently collected as *Transatlantic Sketches*. It is no way surprising that these accounts reflect also, with the intensity of vivid, immediate experience, perceptions and responses to pictures which James had learned elsewhere. The travels reinforce one's inescapable sense of *connection* in everything James wrote.

He rhapsodized in 1873 on Tintoretto, before whose work he feels old doubts and dilemmas to evaporate and the conflict of idealism and realism to be practically solved. That earlier sense which led him to declare that a scene presented with hard material integrity could leave behind a certain moral deposit now makes

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[19] Review of Gustave Flaubert's *Temptation of St. Anthony, Nation,* 18 (4 June 1874), p. 365.

[20] Review of Emile Montegut's *Souvenirs de Bourgogne, Nation* 19 (23 July 1894), p. 62.

[21] Review of William Dean Howells' *A Foregone Conclusion, Nation,* 20 (7 January 1875), p. 12.

[22] "Charles Kingsley," Nation, 20 (28 January 1875), p. 61.

[23] Review of Bayard Taylor's *The Prophet: A Tragedy, North American Review,* 120 (January, 1875), p. 193.

[24] *French Poets and Novelists,* p. 114.

him speak of Tintoretto as "the most *interesting* of painters," whose indefatigable hand never drew a line that was not "a moral line." Tintoretto's great merit, to James's mind, is his unequalled distinctness of vision: "When once he had conceived the germ of a scene, it defined itself to his imagination with an intensity, an amplitude, an individuality of expression, which makes one's observation of his picture seem less an operation of the mind than a kind of supplementary experience of life." Veronese and Titian, by comparison, seem to James to be content with much looser specification, so that to place them against Tintoretto is to measure the difference between observation and imagination. Tintoretto grasped the whole scene in his great dramatic compositions, and his work conveys the impression that "he *felt*, pictorially, the great, beautiful, terrible spectacle of human life very much as Shakespeare felt it poetically."[25]

The justness of characterization which James demands in literary criticism is again, in his observations on painters and painting, satisfied only with an account of the artist's imagination. He proceeds even by negative example with Domenichino, to him a supreme example of "effort detached from inspiration . . . school-merit divorced from spontaneity" for the production of examples of how the artist must *never* paint. The intensity of James's feeling is apparent in his introduction, into a travel account, of a fictional character, the head-master of a drawing academy who sadly leads his pupils to the disheartening examples of this painter's work and explains,

> "Domenichino had great talent, and here and there he is an excellent model; he was devoted, conscientious, observant, industrious; but . . . his imagination was cold. It loved nothing, it lost itself in nothing, its efforts never gave it the heart-ache. It went about trying this and that, concocting cold pictures after cold receipts, dealing in the second-hand and the ready-made, and putting into its performances a little of everything but itself."[26]

The same type of discrimination appears in James's discussion of Sandro Botticelli, whom he finds, in a certain way, the most interesting of the Florentine painters. Although he acknowledges indebtedness to Walter Pater he resolutely puts aside all that he considers recondite in Pater's interpretation of Botticelli and proceeds in typical fashion to conclude, "A rigidly sufficient account of his genius is that his own imagination was active, that his fancy was audacious and adventurous. Alone among the painters

[25] *Transatlantic Sketches* (Boston, 1875), p. 90 ff.
[26] *Ibid.*, p. 177.

of his time, he seems to me to possess *invention.*" Where the glow of expanding observation sent Botticelli's contemporaries to their easels, Botticelli possessed a faculty which loved to play tricks with the actual, to sport, wander, and explore on its own account.[27]

James's individual judgments of painters or canvasses, of both which numerous critics can give more just accounts, are less interesting than the bases of his judgments and their relations to his literary criticism. Early and late examples in both fields show his conviction that the quality of imagination in a work of art is all-important. It is the power, he now feels, to conceive greatly and to feel greatly, to organize irreproachably the work of art of whatever kind, and to make it a kind of supplementary experience of life. Of literature James speaks with an authority that is wanting in his criticism of painting, for in dealing with books he can make the kind of technical analysis he eschews in his reports of painters and their work. He can thus, in 1877, condemn Whistler's work as unprofitable and uninteresting, and at the same time praise the work of Edward Burne–Jones as having, for all its faults, "an amount of imaginative force the mere overflow of which would set up in trade a thousand of the painters who are more generally accepted by the public."[28] Again, in the same year he can declare that "a picture should have some relation to live as well as to painting. Mr. Whistler's experiments have no relation whatever to life; they have only a relation to painting," while he praises the art of Burne–Jones as the art of culture, reflection, intellectual luxury, and aesthetic refinement, the art, in short, "of people who look at the world and at life not directly . . . and in all its accidental reality, but in the reflection and ornamental portrait of it furnished by art itself in other manifestations; furnished by literature, by poetry, by history, by erudition."[29]

James much later confessed to Charles Eliot Norton that he had come to find the work of Burne–Jones uninteresting,[30] but the changed view is of less significance than that James's insistence on relations in art leads eventually to his conceptlon of criticism as in part the study of connections. Guided himself by the practice of Sainte-Beuve, in 1880 he praised the Frenchman's sense of his role: "The critic, in his conception, was not the narrow lawgiver or the rigid censor that he is often assumed to be; he was the student, the inquirer, the observer, the interpreter, the active, indefatigable commentator, whose constant aim was to arrive at just-

[27] *Ibid.*, p. 300.

[28] "The Grosvenor Gallery and the Royal Academy," *Nation*, 24 (31 May 1877), p. 320.

[29] "The Picture Season in London," *Galaxy*, 24 (August, 1877), p. 156f.

[30] *Letters*, ed. Percy Lubbock (London, 1920), I, 341.

ness of characterization."[31] Four years later he says, "The measure of my enjoyment of a critic is the degree to which he resembles Sainte-Beuve."[32]

James's experience as writer inevitably affected his criticism; he more and more cited his own authority. One such authoritative pronouncement is "The Art of Fiction," of 1884, which characterizes the novel as a direct impression of life, the value of which depends upon the intensity of the impression. The writer must work from reality and experience, but reality has myriad forms, and experience is never complete. "It is an immense sensibility . . . it is the very atmosphere of the mind; and when the mind is imaginative . . . it converts the very pulses of the air into revelations." "Imagination assisting," the artist can deal with anything, for experience is practically constituted of the gifts which are designated as imagination: "The power to guess the unseen from the seen, to trace the implications of things, to judge the whole piece by the pattern, the condition of feeling life in general so completely that you are well on your way to knowing any particular corner of it."[33]

This declaration explains why in James's criticism in all fields the imagination is so emphasized, why it is the ground of so many of his discriminations, and why he insists upon a description of the artist's imagination as part of the discussion of his work. With his enlarging view of criticism as practiced by Sainte-Beuve, James is shortly to remark that works of art grow more interesting as one studies their connections, this study being a function of intelligent criticism.[34] He goes on to insist that everything depends on the qualifications of the critic. "Curiosity and sympathy" form his equipment.

> To lend himself, to project himself and steep himself, to feel and feel till he understands and to understand so well that he can say, to have perception at the pitch and passion and expression as embracing as the air, to be infinitely curious and incorrigibly patient, and yet plastic and inflammable and determinable . . . these are fine chances for an active mind.[35]

He characterizes himself when he speaks of the critic who has no *a priori* rule but that a production shall have genuine life.[36]

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31 "Sainte-Beuve," *North American Review,* 130 (January, 1880), p. 56.

32 "Matthew Arnold," *English Illustrated Magazine,* 1 (January, 1884), p. 242.

33 *Partial Portraits* (London, 1888), pp. 387, 389.

34 *Essays in London* (London, 1893), p. 160.

35 *Ibid.,* p. 276.

36 *Views and Reviews* (Boston, 1908), p. 227.

James is well known to have remarked rather testily, "Nothing is ever my last word about anything," but for a variety of reasons he gave over the criticism of painting, and one of his last words has an almost valedictory note. It is his mature expression of the importance which through his life he attached to art, the embalmer, the magician whom we can never speak too fair or whose importance overstate. For art "prolongs, it preserves, it consecrates, it raises from the dead. It conciliates, charms, bribes posterity; and it murmurs to mortals, as the old French poet sang to his mistress, 'You will be fair only so far as I have said so.' "[37]

This may belong to the realm of deep appreciation, but it is no longer criticism. Aside from the stresses of James's desperate preoccupation with the stage between 1890 and 1895, his return from defeat there to the magic of his "*own* old pen," and his disgust with all journalistic practices and activities, is there not also a partial explanation of James's ceasing to write on painting in his inability to conduct the kind of analysis which, with novelists, he increasingly made a part of his criticism, and with no one so much as himself? All the last critical essays bear a family resemblance, and the artistic problem is always the general subject, as it is in the Prefaces for the collective New York edition of James's own work.

A final illuminating statement of the office and the effect of criticism completes the perspective of James's changing views and implies his neglect, in the late criticism, of painting. Painting had been one of the great resources of his imaginative life, but he could not write of it as he could of literature, the field in which he spoke with the authority of the high title he gave himself as "a man of the craft."

> The effect, if not the prime office, of criticism, is to make our absorption and our enjoyment of the things that feed the mind as aware of itself as possible, since that awareness quickens the mental demand, which thus in turn wanders further and further for pasture. This action on the part of the mind practically amounts to a reaching out for the reasons of its interest, as only by its so ascertaining them can the interest grow more various. This is the very education of our imaginative life . . . we cease to be instinctive and at the mercy of chance."[38]

In its scope and development James's criticism reveals the growth of an artistic mind of high quality, and the evolution of his standards explains the changing estimates he made of painters and

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[37] *Picture and Text* (New York, 1893), p. 134 f.
[38] *Notes on Novelists* (New York, 1914), p. 315.

writers. This itself is sufficient ground of interest, his views of the painter's art forming a long and interesting chapter in the whole volume. The early advocate of science and logic turns from judgment to justness of characterization and at last to deep appreciation, with his final word a demand that criticism promote the education of the imaginative life itself. A good deal of James's artistic education came from pictures, and he was deeply responsive; but as critic he was authoritative only in his own productive field.

VIOLENCE AND SURVIVAL IN THE NOVELS OF IRIS MURDOCH

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Iris Murdoch is a contemporary Anglo–Irish novelist and philosopher who besides writing a monograph on Jean-Paul Sartre (1953) continues to lecture and to produce papers in both her professional fields since her resignation from Oxford. Beginning in 1954 she has published eleven novels, none of which can properly be termed a philosophical novel though each is related to the problems of contemporary philosophy and to Miss Murdoch's own developing thought. She is an artist who believes that men are social creatures who confront the intractibility of a contingent world in which their concerns are not abstractions but personal relationships and the confusing, unpredictable "stuff" of human life. She writes in full awareness of the state of fictional art, with an inexhaustible inventiveness, humor, irony, and compassion; and she has a high regard for the 19th century novel of character and plot although she has attempted it less frequently than the patterned novel which tends to abstraction and symbolism.

The novel is one of the contemporary modes of philosophy, and Sartre has gone so far as to declare it a chief mode of expression for his brand of existentialism. As a form it reaches an audience indifferent to other statements, and whether existentialist or not has a persuasiveness more powerful than discursive exposition. It expresses more sensitively than other forms the motives and assumptions of men in action or, in some of its guises, the convictions, amounting to assessments of the culture of their times, of its authors. The novel is one of the chief cultural documents of the age, and Miss Murdoch considers it "a picture of, and a comment upon, the human condition."

She regularly directs her attention to the principal strategies of the novel in our time. In her criticism and her practice she distinguishes four chief modes: the journalistic novel of thin characterization and abundant detail; the realistic novel of character which is closely related to the great 19th century examples of, say, George

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Eliot or Tolstoy; the symbolist, almost allegorical novel of the type of William Golding's *The Spire,* which she terms a "crystalline" form; and the fantasy-myth which she herself produced brilliantly in her first novel, *Under the Net* (1954). Although much of the best modern work has been done in the symbolist novel, she regards the form with misgivings prompted by her conviction that interest in issues rather than people is inappropriate in the novel. To her thinking the novelist proper is "a sort of phenomenologist . . . a describer rather than an explainer," whose eye should be fixed on what we do rather than on what we ought to do. She thus insists on "the stubborn irreducibility of persons" and the contingency of experience, and finds Sartre's impatience with the "stuff" of human life crippling to his work.

Miss Murdoch is herself victim of the paradox which confronts every novelist. On the one hand there is the bumbling confusion of human personalities and relationships, on the other the demands of the novel for some degree of formal coherence. The form has swung between the wonderful, lifelike record of contingency which made Henry James refer to the 19th century English novel as "the paradise of the loose end," and the contemporary tight, structured form which results in what Miss Murdoch terms "dryness". Against such dryness she argues that the novelist must portray individuals who are independent of their author and are not puppets to exteriorize some psychological conflict of his own. As she also says, "A novel must be a house fit for free characters to live in; and to combine form with respect for reality with all its odd contingent ways is the highest art of prose." She demands respect for contingency, yet she writes novels which have sometimes prompted her critics to draw diagrams. In practice she has resolved the paradox of composition with varying degrees of success in fictions which tend to be well-structured although her characters are believably unpredictable and her own sense of the ridiculous conveys a lively sense of their contingent world.

Some further preliminaries must be dealt with: Miss Murdoch's philosophical ballast; the relations between her work and that of others; and her own development as a novelist. As an unreformed academic she naturally draws upon her professional knowledge of philosophy when she works as a novelist. In an excellent study, *Degrees of Freedom,* Mrs. A. S. Byatt documents Miss Murdoch's indebtedness, sometimes in opposition, to Sartre. Wittgenstein's net of concepts furnishes the dramatic metaphor of the hero's predicament as well as the title of the first novel. Simone Weil's life and work illuminate, for example, the portrayals of suffering in *The Flight from the Enchanter* (1956) and *The Unicorn* (1963).

There are allusions to Kant and Hegel, and to the religious concepts possible to a novelist who terms herself a Protestant "Christian fellow-traveller." Yet Miss Murdoch says there is little connection between her books and her academic thinking despite the fact that their shape and moral bases owe something to philosophy.

When she published her earliest novels she was bracketed by critics with such Young Angries of the 50's as John Wain and Kingsley Amis, and her third novel, *The Sandcastle* (1957), disappointed those who expected her to continue in a single vein. *A Severed Head* (1961) was a further surprise which had even some success of scandal—How far could she go?—and was likened by critics to the Restoration drama of Congreve. *An Unofficial Rose* (1962), in which she made an ambitious attempt to regain the advantages of the 19th century novel of character led to her being categorized as a "lady novelist," a term which was repeated with all its denigrative connotations for *The Nice and the Good* (1968), whatever it may mean.

Iris Murdoch is well read in her profession of novelist as in her profession of philosopher, and awareness of the art affects her work much as does her knowledge of philosophy—there is only partial connection between the work she does and what, as critic, she approves, yet the shape of her novels owes much to her critical understanding of the art and of the developments which have brought it to its present state. She began with two novels best described as fantasy-myths, the first concerned with freedom for the individual caught in the conceptual net, the second with the meanings of power in the modern world. Both are social novels, both owe something to existentialist thinking, and both maintain a brisk pace in which respect for contingency leads at times to portrayal of wild and hilarious improbabilities. Since then Miss Murdoch has chosen to deal more frequently with inter-personal relations, an emphasis which recalls that of Henry James. Her most successful novel, *The Bell* (1958), has the solid life which Miss Murdoch praises in the great 19th century novels, for it best displays the "real apprehension of persons other than the author as having a right to exist and to have a separate mode of being which is important and interesting to themselves." Other novels of this type are *The Sandcastle* (1957), *An Unofficial Rose* (1962), *The Red and the Green* (1965), and *The Nice and the Good* (1968). *A Severed Head* (1961) is strikingly different from the other novels in style and plot, and is an apparent attempt of Miss Murdoch's to make a comic substitution of the "hard idea of truth" for the "facile idea of sincerity" with which, to her mind, both Freud and Sartre are associated; and *The Italian Girl* (1964) is a feebler example. There is one further division within the work: *The Uni-*

corn (1963) is a return from the realistic complexity of *The Bell* type of novel to the patterned, mythic novel, no longer fantastic in the fashion of the earliest novels, but stripped and contrived, as is *The Time of the Angels* (1966).

Mrs. Byatt has found the central concern of Miss Murdoch's novels in the question of freedom, and it is an illuminating approach; but other themes deserve analysis, among them violence and survival. Four exemplary novels will serve: *Under the Net, The Bell, An Unofficial Rose,* and *The Time of the Angels.* They happen to have appeared at precise four year intervals since 1954, but they are not strikingly better than others for illustrative purposes. They might equally be used to define such other recurrent themes as the nature of love; the relation between love and morality; the recognition of reality, especially the reality of other persons; or the conflict between reality and illusion.

Outward violence in Miss Murdoch's work ranges from simple theft to murder or suicide on the scale of action, from impulse to premeditation on the scale of intention, from accident to catastrophe within the workings of nature; but the inward violence of aggression, subjugation, and enslavement is frequently far more interesting than any outward event, as is the inward struggle for freedom. The terms of survival encompass the degrees between the unthinking safety of self-chosen ignorance, the achievement of stoic endurance, and the liberation of self-awareness. But for Miss Murdoch's characters survival is not always possible nor even, sometimes, desired.

Under the Net is the earliest of the three novels Miss Murdoch has attempted in the first person, and from a male point of view. It is a lively romp, wildly improbable at times, which conveys an encompassing sense of London and, in a different way, of Paris. Jake Donaghue is the ideal narrator for a piece filled with action and ideas, for the substance of his life is the private conversation with himself of a man who sees too much ever to give a straight answer. Besides, in his half-outsider fashion he is as much a philosopher as Iris Murdoch. Beneath the tumultuous action there is a seriousness which makes Jake's final grasp of a direction for his life meaningful and convincing, but there is none of the grimness of final choices apparent in some later novels, none of the sense of harried individuals pushed to intolerable limits. There is even a good-natured quality about the violence, which occurs in great variety. Why shouldn't a sensible man carry a pick-lock and take over his friends' apartments when locked out of his room for nonpayment? Why shouldn't he, when his manuscript has been stolen, steal a valuable dog which the thief has kidnapped? Or help his friend break out of a hospital? Or escape from a riot in a film studio by blowing a hole in the set? Or use a powerful detonator of the type conveniently at hand in well-furnished apartments, to blow open a wall safe? Jake's sense of the passing of time, however, at last turns him to other courses.

> All work and all love, the search for wealth and fame, the search for truth, life itself, are made up of moments which pass and become nothing. Yet through this shaft of nothings we drive onwards with that miraculous vitality that creates our precarious habitations in the past and the future. So we live—a spirit that broods and hovers over the continual death of time, the lost meaning, the unrecaptured moment, the unremembered face, until the final chop-chop that ends all our moments and plunges that spirit back into the void from which it came.

Jake turns from the hand-to-mouth survival of his first thirty years to the possibility of writing well, from the "ragged, inglorious, and apparently purposeless" life he has known to the possibility of doing better work than in his first book, with a strength and joy which make the moment "the morning of the first day." His survival is not endurance but a plunge into a life made new by being newly understood. And he achieves the understanding for himself.

Another novel filled with the odd contingencies of life followed *Under the Net,* though more sombre in tone. Miss Murdoch then turned to a less highly charged picture of domestic life and personal relations, thence to *The Bell,* her best piece thus far. The action of *The Bell* centers about an Anglican lay community and the disruptive events which lead to its closing after a public scandal. It is far too rich a novel for easy summary, but the violence of much of it indicates the direction which Miss Murdoch is taking: From the casual, almost merry violence of the first novel she has turned to more consequential acts, not because suicide is more desperate an act than safe-cracking but because all the violence is seen more meaningfully in relation to the values of religion and philosophy. There is more depth to this novel than to the first, and the study of violence in still later novels will show a progression already apparent here. Yet the two principal characters are far less intelligent than Jake Donaghue. Dora Greenfield is neither talented as an artist nor gifted with common sense even in ordinary affairs; and Michael Meade is a weak, homosexual ex-schoolteacher who fails in all relationships through fumbling attempts at tender-minded goodness. It is Miss Murdoch who is intelligent in this novel, though with that respect for her characters as having lives of their own which she considers typical of the great novelists.

Besides suicide, attempted suicide, adultery, and self-righteous bullying there is the more subtle violence, increasingly apparent in Miss Murdoch's work, of the sins against love: indifference, failure of feeling, and calculated betrayal. It is these which are destructive; the violence is their product. And the terms of survival have changed. For Dora and Michael there is no sudden life-enhancing vision such as Jake Donaghue experienced; instead, there is a slow progress and adjustment to their changed lives. Michael observes that the events at Imber Court increase Dora's substance; there is simply "more of her" after the dreadful events have passed. Michael himself, in anguish over the death of a man he might have saved, defeats thoughts of suicide by perfecting his suffering through responsibility for the dead man's half-mad sister. At last he, like Dora, turns to the hope of life when he can "experience again, responding with his heart, that indefinitely extended requirement that one human being makes upon another."

After *The Bell* Miss Murdoch produced a witty, brilliant study of sexuality in *A Severed Head,* but with *An Unofficial Rose* she returned to what she terms "the novel proper," and here there is far less of the strangeness, amounting at times to the effect of enchantment, elsewhere cast about her characters. Miss Murdoch's characters are never ordinary but they are sometimes fantastic; the figures of *An Unofficial Rose* are believable without being commonplace. More of this novel is related to the linked problems of violence and survival than any other, yet the surface is comparatively placid. There is one tumultuous scene and at least two symbolic murders, but with her shift of interest from social to personal relations Miss Murdoch here subdues violence to those crimes only possible between persons who have loved or, what is worse, have failed of love. There is Hugh Peronett, who is willing to sell a precious picture to finance his son Randall in an adultery the like of which Hugh was never bold enough to attempt. The selfishness of Randall includes a self-justifying and coldly rationalized hatred of his wife Ann, at the same time that his acceptance of Hugh's money is a joyful symbolic murder of his father. The daughter of Ann and Randall destroys her mother's possibility of happiness by ruthless deception which prevents Ann from ever enjoying the love of a good man who has waited until Randall deserted her. Even Hugh's mistress of long ago manipulates Hugh, Randall, and Randall's new mistress with devilish skill. Yet they are not monstrous, however they may seem, and they survive in their varied fashions beyond such difficulties as are always, one character remarks, solved by violence. For some there is simple forgetfulness—the young will find other interests. For Hugh and his failing mistress there is the anticipation of an early extinction which leaves Hugh thinking only that a brief interval remains: "Perhaps he had been confused, perhaps he had understood nothing, but he had certainly survived. He was free. *O spare me a little that I may recover my strength; before I go hence and be no more seen.*" Randall is simply left in a besotted state with the mistress whom he may decide, when sober, to leave. For Ann there is endurance in her ignorance of those she has never known. "She had not known them. She did not know herself. It was not possible, it was not necessary, it was perhaps not even proper. . . . Tasks lay ahead, one after one after one, and the gradual return to an old simplicity. She would never know, and that would be her way of surviving."

In her next novel, *The Unicorn,* Miss Murdoch turned more directly to the problems of suffering and endurance, but in a form radically different and equally exemplified later in *The Time of the Angels.* It has been noted that her thought can be related to that of other philosophers and her fictions to those of other novelists. *The Unicorn* suggests the strangeness of Sheridan Le Fanu while its subject is related to the anatomy of suffering diagrammed by Simone Weil. Both influences are apparent in *The Time of the Angels,* set in London but a corner of London isolated amidst bombed-out acres, and fog-shrouded into a remoteness as strange as that of any Irish coast. These two novels are departures from the realism to which Miss Murdoch feels the novel must return to recover its vitality. It is as though the modern fascination with myth-making, abstraction, and the creation of patterned fictions has some sort of irresistible appeal. Or possibly Miss Murdoch finds realism in some ways inadequate and unsatisfying and seeks somehow to get more directly to the core of reality by rejecting commonplace actuality, "a world in which people play cricket, cook cakes, make simple decisions, remember their childhood and go to the circus; not the world in which they commit sins, fall in love, say prayers, or join the Communist Party." She has moved, as has been seen, from Jake Donaghue's tumultuous social world to the portrayal of personal relationships, thence to ever-tighter sets of relationships in progressively restricted groupings of characters. This has been accompanied by a deepening of meaning as she has neglected the everyday world in which people play cricket and cook cakes for the more intense world in which, if they do not pray, they are concerned with God, man, suffering, and evil. And violence has become ever more closely identified with evil, while suffering has acquired an ultimate redemptive power. It is only fair to note that the latest novel, *The Nice and the Good* (1968), returns, with some modifications, to the realistic mode.

The Time of the Angels actually contrasts the commonplace world with the enclosed, fantastic rectory dominated by the mad atheist priest Carel Fisher, for into it intrude Carel's younger brother Marcus and the one-time mistress of Carel's older brother Julian, who committed suicide after Carel had seduced Julian's wife. The weird household includes Muriel, Carel's daughter by his deceased wife; Elizabeth, the daughter of that adultery, with whom Carel commits incest; and Pattie O'Driscoll, Carel's mulatto mistress and housekeeper. Other servants are a father and son, a refugee pair, of whom the son is the more interesting because he is a pathological liar. All is not the grimness of American Southern Gothic with which in subject matter this novel surely could compete; there are scenes and encounters as funny as some in Faulkner, if sometimes equally macabre. Much of the violence is in the past, and if theft, incest, and suicide are in the foreground, the meaning of violence has changed. Carel Fisher is a Dostoevskyan character sunk in debasement and at the same time a religious seeker for whom God is dead. Not even evil is real to him any longer. "There is only power and the marvel of power, there is only chance and the terror of chance." Carel's most significant act of violence is a blow to his brother's face, for he is persuaded now that only infliction of pain can prove the existence of others. When his daughters discover the truth of their relationship and when Pattie cannot remain with Carel, though she loves him, he kills himself. And now it is not a question of survival so much as of suffering. Pattie's love is to be her own torment only. Muriel, watching her father die, realizes she is "condemned to be divided forever from the world of simple innocent things, thoughtless affections and free happy laughter and dogs passing in the street." She is bound to Elizabeth, and they will be each other's damnation.

The ultimate violence and perversity of both *The Unicorn* and *The Time of the Angels* belong to the literature of extremity, the very thing which Miss Murdoch had avoided in her earlier work. She has already gone on to another portrayal of a more easily recognizable world in *The Nice and the Good,* but it is a world in which, as before, violence is a fact to which survival or destruction are alternatives. These themes will surely recur in the further work of this endlessly inventive and interesting novelist. They are centrally related to her conception of the human condition, and despite her respect for a contingent world and irreducible persons Miss Murdoch seems increasingly drawn to the symbolic novel in which emphasis on violence and suffering is greater than in portrayals in the realistic mode.

LIFE AGAINST DEATH IN ENGLISH POETRY: A METHOD OF STYLISTIC DEFINITION*

Karl Kroeber
with Alfred L. Kroeber and
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Our purpose in this paper is to illustrate a method of defining configurations of literary style through the study of word-choice patterns in poetry. Refined and extended, this method should make possible more meaningful analyses of poetic movements and counter-movements both within and across the conventional classifications of stylistic periods—neo-classic, romantic, modern, and the like.

We began by counting words sure to have significance in poetry, words such as *nature, soul, spirit,* and words referring to the emotions, the seasons, and so forth. We soon found ourselves overwhelmed by a wealth of possible directions and significances, so we settled on a pattern of life and death words as a starting point, examining four life words and four death words in thirty-five poets, both British and American, beginning with Chaucer and concluding with James Dickey, for a time span of nearly six hundred years.

Our technique is to determine the frequency of the same set of words in (where feasible) the total work of each poet. This sort of survey of course turns for its data to the standard concordances, whose value has too often been underestimated. A mass of extracted and ordered stylistic information lies shallowly buried in every concordance, and this information may be illuminating and significant in many diverse ways. For instance, Housman has much to say of the *soul,* which he mentions thirty-four times in his serious verse as against twelve mentions of *flesh.* But his concordance also shows that he does not once use either the word *spirit* or the word *body*—a fact that might easily escape the most devoted student's observation. Yet this "negative fact" is essential to our

* The work reported on in this article was begun by my father, the late Alfred L. Kroeber. Always interested in literature, he became especially intrigued during his later years with problems of describing literary styles. This essay represents one of the last scholarly investigations he initiated. Recent developments in techniques for using computers to compile concordances make it feasible now to carry out systematically the extensive stylistic analyses my father first envisaged nearly a decade ago.
Karl Kroeber

understanding of the function of *soul* and *flesh* in Housman's poetry.

There are as yet, unfortunately, no concordances for some major poets and still very few for minor poets. We are reluctant to base findings on a sample which will someday be superseded by a concordance: the latter is not only complete but also far more reliable. We did, however, make some counts of life and death words to give broader representation to our list. Except for Swinburne, our samples are probably adequate, covering approximately a moiety of each poet's work. But these results are strictly provisional, both because they are not based on total output, and because a running tally is almost surely less accurate than a formal concordance count.

Even these provisional findings, however, are adequate to illustrate the nature of our method and (we hope) to encourage others to undertake analogous studies. In work of this kind results are in large measure additive. Indeed, it is our premise that only through the accumulation of many investigators' findings will such quantitative discriminations lead to deeper understanding of the qualities of literary style.

We counted the nouns *death* and *life,* including of course their plurals and possessives; the verbs *die* and *live,* including conjugational forms such as *dies, dieth, died;* the participles *dying* and *living;* and the adjectives *dead* and *alive.* These eight have the merits of being simple and unescapable Anglo–Saxon, and the four of each set derive from one root. This last is not always the case—thus in German, *death* is *Tod,* but the verb for *die* shifts to *sterben,* the *Tod*-derived verb *töten* being used for *kill.*

Some features of our limitation to these four pairs are admittedly arbitrary, but we have made the limitation in the interest of avoiding complications. Thus *live* as an adjective may have been used more frequently by some poets than *alive,* but some concordances do not distinguish parts of speech, even mechanically grouping the verb *lives* with the plural noun *lives.* Too many re-orderings of concordance listings would have introduced a high degree of error into work where at best mistakes are easy. *Quick* as a synonym might also have come into consideration, especially in earlier poets. *Deadly* would perhaps have been desirable to include, but its counterpart *lively* has moved out of the range of the corresponding meaning. *Mortal* might well have been significant, and one could argue plausibly that the contrast of *birth* to *death* would be at least as meaningful as that of *life* to *death.* The terms we chose are certainly not exhaustive, but one step at a time seemed wisest as a beginning, with consideration for consistency and for equal pairing on the life and on the death side. The final goal of this method is the creation of a series of something like "semantic fields" upon which to base stylistic judgments. Our eight words, then, should be regarded as the first segment of such a field.

The results of our count of the concordances plus our sample counts are given in Table 1. Fourteen of the poets show an excess of life words, twenty of death words. Collins, whose volume is tiny, splits evenly. The general division, then, is not a half and half one, and it is not random. Before 1815, and especially from Milton on, most poets give preference to life; after 1815 death takes the lead. Although clusterings seem most significant, the inevitable individual exceptions are interesting.

The results of our counts have throughout been converted into percentages to make them comparable. The absolute numbers in the last three columns of the table are the totals of our counts, included as indication of the reliability of the percentage figures. We cannot invest with much significance the grand total. About all that can be ventured from our absolute figures is that, for the six centuries, life and death words are in approximate equality, and that the total number of poets favoring one or the other may be expected to be more or less in balance when it shall have become possible to make a complete count of all of them. The significance of variability in our count lies in periods and in individuals, not in grand totals. We have not yet attempted the other obvious "totaling" test—determining how large a part life and death words play in the total vocabulary of each poet.

The series begins with Chaucer, our only Middle-English poet. The concordance included but we excluded from his count the *Boethius* and the *Parson's Tale* as being in prose and *The Romaunt of the Rose* as being an outright translation. Their inclusion, as a matter of fact, would not very materially change his proportions—by two percent only—but it would be inconsistent with the method of our other counts. In Chaucer we discover a reasonable balance between life and death, the death words being weighted over the life ones by the small percentage of fifty-four to forty-six. Such a balance sems proper to Chaucer, robust and sanguine of temperament as he was but nonetheless a poet not yet out of the Middle Ages and their preoccupation with the after life, and writing a scant century before the addiction of popular North European art to the macabre Dance of Death, the carrying off of the damned, and their torments in hell. Chaucer's life and death word preferences lie near the presumable English poetical mean, to judge by our other counts: small but pleasantly corroboratory evidence for the view that Chaucer was already within the generic

TABLE 1

Poet	Percent Life					Percent Death					Number of Occurrences		
	Life	Alive	Live	Living	Total	Death	Dead	Die	Dying	Total	Life	Death	Total
Chaucer, 1340	30	1	13	2	46	18	14	22	0	54	586	681	1267
Wyatt, 1503	33	5	20	2	60	23	4	13	0	40	161	109	270
Spenser, 1552	28	4	13	11	56	17	11	13	3	44	992	766	1758
Shakespeare, 1564, Sonnet	18	2	33	6	59	16	12	12	1	41	74	52	126
Narrative	20	2	15	3	40	24	14	18	4	60	70	103	173
Drama	23	2	18	3	46	25	11	17	1	54	1654	1914	3568
Donne, 1573	15	2	14	2	33	26	16	23	2	67	159	316	475
Herrick, 1591	17	0	35	2	54	11	15	19	1	46	287	240	527
Herbert, 1593	27	1	19	0	47	23	9	19	2	53	117	130	247
Milton, 1608	27	0	19	8	54	31	4	9	2	46	266	223	489
Dryden, 1631*	25	2	18	6	51	22	7	16	4	49	573	568	1141
Pope, 1688	29	2	16	6	53	13	9	21	4	47	225	203	428
Gray, 1716	21	0	17	8	46	21	8	23	2	54	28	33	61
Collins, 1721	32	0	18	0	50	14	18	16	2	50	22	22	44
Goldsmith, 1728	44	4	11	1	60	13	7	19	1	40	50	34	84
Cowper, 1731	44	2	17	2	65	13	4	15	3	35	295	161	456
Burns, 1759	42	0	16	2	60	20	6	11	3	40	229	150	379
Wordsworth, 1770	30	3	17	11	61	14	11	12	2	39	983	617	1600
Coleridge, 1772, Poetry	33	2	15	6	56	17	9	15	3	44	368	288	656
Plays	31	3	22	5	61	12	13	12	2	39	257	167	424
Byron, 1788	30	1	15	5	51	18	12	15	4	49	1175	1125	2300
Shelley, 1792	22	1	11	7	41	28	15	12	4	59	781	1106	1887
Keats, 1795	23	0	14	2	39	23	13	20	5	61	185	284	469
Emerson, 1803	40	5	20	6	71	8	6	14	1	29	137	57	194
Poe, 1809	28	1	11	5	45	14	15	21	5	55	68	84	152
Tennyson, Poetry	29	1	14	5	49	16	13	20	2	51	896	942	1838
Plays	24	1	14	4	43	18	19	17	3	57	266	354	620
Browning, 1812	43	2	14	2	61	13	9	15	2	39	2832	1774	4606
Whitman, 1819	31	3	6	7	47	29	15	5	4	53	310	347	657
Arnold, 1822	31	2	17	4	54	16	15	12	3	46	483	411	894
Dickinson, 1830	26	3	13	2	44	23	8	18	7	56	293	366	659
Swinburne, 1837	25	1	9	4	39	28	18	13	2	61	125	199	324
Lanier, 1840	29	1	9	4	43	24	15	14	4	57	122	162	284
Housman, 1859	12	4	10	3	29	10	20	37	4	71	45	112	157
Kipling, 1865	15	2	12	4	33	14	15	33	5	67	70	143	213
Yeats, 1865	15	2	16	6	39	14	20	24	3	61	295	457	752
Eliot, 1888	30	5	6	5	46	26	16	4	8	54	60	71	131
Thomas, 1914	4	3	1	3	11	40	21	17	11	89	19	143	162
Dickey, 1923	26	5	9	6	46	10	33	8	3	54	83	100	183

*Figures for Dryden illustrate the slight inconsistencies produced by cumulative "rounding off." These, however, seem a small price to pay for relative legibility' stream of preoccupation characteristic of subsequent English poetry.

Spenser, the earliest Elizabethan for whom we have a full count, shows a definite life preference, fifty-six percent life words, forty-four percent death words (it is perhaps significant that our count for Wyatt suggests his even heavier life preference). This orientation makes one think of Spenser's inclination to the charming and the pleasing and makes one recall that many early Elizabethans shared these inclinations, at least in tolerance for the pastoral, the decorative, and the allegorical in their literature, a toleration which sometimes vanishes from sight under the full flood of the tragedy and realism of the Shakespearean drama.

With Shakespeare one must decide which Shakespeare. His sonnets lie within the Spenserian life-preference with fifty-nine percent life words. But the sonnets constitute too small a part of his work to have an over-all representativeness for him. Nor are the 126 life–death words numerous enough for a surely valid statistical sample, a matter of importance because Shakespeare's sonnets show as high a bias for life as the work of any other early poet in our list, and are surpassed only in the eighteenth century by Goldsmith, Cowper, and Burns, and in the nineteenth by Wordsworth, Emerson, and Browning. This weighting toward life might be reduced by other lyrical verse of Shakespeare's which we omitted from our count, mainly because of the contested authorship of some of the poems. Shakespeare's two narrative poems, with their fatal and lamentative themes, are weighted toward death in the proportion of three to two.

The bulk of the plays is so great and so much in excess of all his other poetry that their death–life ratio, fifty-four to forty-six, must, we believe, be regarded as the ultimately significant one. There are surely some interesting differences between tragedies, histories, and comedies buried in the gross total of life and death words, but these differences we do not pursue here, since our primary problem is the trend as it finds expression in successive poets, not the variability due to theme and genre within one poet's work.

With Shakespeare's drama we enter a more "modern" world, the full Renaissance in England, attended apparently with a weighting toward death which continues until Milton, although Herricks' life-preference may not be an idiosyncratic phenomenon. Our count for Donne, a decade later than Shakespeare, shows an impressive sixty-seven percent death preference; for Herbert, two decades after Donne, the death preference drops to fifty-three percent, close to the count for Shakespeare's dramas. Not to put too fine a point on it, these ratios suggest that a sort of climax of the death-orientation was expressed in Donne, which by the time of Herbert and Herrick was lessening toward balance, evolving, finally, to the definite life-preference initiated by Milton. Donne's is a considerable body of verse and his ratio of sixty-seven percent death words is the highest for any poet until we come to the turn of the nineteenth into the twentieth century. It may well be that Donne's preoccupation with death, which is accompanied of course by remarkable intellectual sophistication, accounts at least in part for the revival of Donne's popularity in the twentieth century.

We now discover, as we go down the list, a swing back to a life preference, beginning with Milton and persisting until the full weight of the romantic impetus started a long return swing to death. During these one hundred and fifty years, Gray provides the only exception to be found amongst the English poets for whom there are complete concordances. It is indeed fitting that the author of the "Elegy" and the traditional precursor of romanticism should lean to the death side, but the total number of words, sixty-one life and death words all told, is so small as to leave the preference without much solid significance. And this block of a century and a half of life-preference is impressive. The climate of mood, the set of the culture, something beyond individual idiosyncrasy must be part of the explanation of this long preference, for the poets of this period could not have been more different in personal orientation, temperament, even in choice of subject-matter and of poetic forms.

In the second half of the eighteenth century and the first decade of the nineteenth, the life ratios run up into the sixties. Byron, born a decade and a half after Wordsworth, shows, however, the beginning of a counter-trend which fully manifests itself in Shelley and Keats according to our table. We find, beginning with Shelley and continuing as far as we go into the twentieth century, death words to be in excess of life words. This is a period already approaching in length the preceding one hundred and fifty years of excess of life words over death words. The second period, however, is not so consistently patterned as its predecessor: Emerson, Arnold, and Browning, particularly the last, are notable exceptions. Browning uses the abstract noun *life* alone oftener than all four death words together, and his total life-percentage is sixty-one, matching Wordsworth's high. It should be observed that Tennyson's death-preference is relatively slight, only the plays tilt him strongly toward death. Since the dramas belong to the latter part of his career they may be associated with the death slope that gets steeper at the end of the nineteenth century and through the first decade of the twentieth. Housman marks a trough, surely to be connected with the negativistic culmination of *fin-de-siècle* development. At any rate, the three great Victorian poets do not advance the trend initiated by Shelley and Keats, nor do they link up closely with the later nineteenth-century poets.

Housman's contemporaries and successors on our list, Kipling, Yeats, Eliot, might seem to mark a movement back toward a balance between life and death. But our sampling of Thomas, by far the most death-oriented of the poets tested, and of Dickey raises doubts as to whether that balance has been achieved in our century. Of course in the lower portion of our list a new factor enters. Our limited figures, particularly for American authors, do not permit us to judge whether the influence of time is greater than that of country. Two outstanding exceptions to the death trend since Shelley, Emerson and Browning, were born on opposite sides of the ocean but within nine years of each other. But Arnold, also with a life preference, is two decades later than Emerson. Within the trend, on the other hand, are six of the Americans (counting Eliot) whose indices run surprisingly close together. Poe, often regarded as a melodramatic seer of blackness, shows 55 percent death words—but Whitman, Dickinson, Lanier, Eliot, and even Dickey are all within two points of this percentage.

Besides the total life and death percentages discussed so far, separate consideration of each of the eight words dealt with is desirable. For instance, the percentaged frequencies in each column of Table 1 can be rearranged in rank order according to their size, instead of the time order of the poets. Thus for *dying,* Thomas 11 percent and Eliot 8 percent would head the column, Dickinson, 7, would be third, and then would come Keats, Kipling, and Poe. The small end of the list would be constituted by Chaucer and Wyatt. A long-term though somewhat wavering drift is evident here—later poets on the whole run higher in this category—whether the cause be primarily linguistic or stylistic.

The abstract noun *life* is used by the poets in our list with the greatest over-all frequency of the eight words and also with the highest maximum frequency. Cowper, Goldsmith, and Burns form a cluster at the top of the rank order, joined only by Browning and Emerson among later poets. Obviously, a very high frequency of use of the noun *life* almost presupposes a majority of life words. Consequently a rather high frequency of the noun *life* by a poet who uses more death words marks an individual peculiarity. Thus both Tennyson (29) and Whitman (31) are fond of the word *life,* although their vocabularies are moderately on the death side as a whole. Contrarily, Shakespeare tends to avoid the word *life* in his sonnets, although his sonnet vocabulary is strongly life-weighted. The prophets and lovers of mortality who come at the end of the rank-order list with percentages for *life* below twenty are Thomas 4, Housman 12, Kipling 15, Yeats 15, and, nearly three centuries earlier, Donne 15, and Herrick 17. Donne is heavily death-biassed, but Herrick, like Shakespeare in his sonnets, is life-minded: they both prefer the verb *live* to the abstract noun.

At the top of our rank-order for *death* we find Thomas 40, then Milton 31, his single high; at the bottom Emerson 8, and Housman and Dickey, 10 each. Thomas of course is overwhelmingly death-oriented, but the other poets in this sub-list are surprising. Milton is on the life side in the total count; Emerson has the highest proportion of life words (71 percent) and Housman of death words (except for Thomas) among the poets. Emerson might seem almost pathologically afraid of reference to death, but Dickey shares his pattern of shunning one abstract noun but using the other relatively frequently. Housman, however interested in death, apparently dislikes abstract nouns. Instead of *death* he favors *dead* and *die,* being behind only Dickey and Thomas and with Yeats for *dead,* and over-all first for *die.*

It is the bulk of *Paradise Lost,* five times as long as *Paradise Regained,* which puts Milton near the top for the noun *death:* the frequency in *Paradise Lost* is thirty-four percent of the eight words in question. But the fact remains that Milton was interested to write the long poem of a lost Eden and lost immortality, even though Milton initiates the long stretch of almost solid life-preference. The poets who come next after Milton in liking the word *death* are Whitman, 29, who favors nouns as such, and Shelley and Swinburne, both 28, death-oriented and in this class surpassing even Donne. The poet whose ratio for both the nouns *life* and *death* together is highest is Burns, 62. He is abnormally low in adjectives and in participles and is below average in the verbs *live* and *die.* It is indeed a special lyrical genius that expresses itself so spiritedly with abstract nouns.

Alive and *dead* are incomplete counterparts, *living* and *dead* being opposites also. In any case, *alive* is not a specifically "poetic" word, or has not often been so considered. Burns and Keats never use it and no one uses it as often as *dead.* The poets who use the adjective *dead* most often are, in rank order, Dickey 33, Thomas 21, Yeats 20, Housman 20, Tennyson plays 19 (poems only 13); Donne's 16 is relatively high in this category. As Tennyson's plays mostly came late in his life, it is clear that all of these high-rankers wrote within the past century; Donne shows himself once more as a forerunner of the moderns. Heavy preoccupation with death in general seems to carry with it some tendency to the more frequent use of the stark and emotion-freighted adjective *dead.*

For *live* and *die* the tallies indicate what one might expect, that use and preference are complex for verb forms. The two verbs *live* and *die* are the next most frequent of our eight words after the abstract nouns, while occasional individual rejection of one or both of them is more extreme than for the nouns. For *live* high rankings are early, the highest rankings in lyrics, Herrick 35, the sonnets of Shakespeare 33 (but plays 18). The lyrical poems of Milton, incidentally, run up to 32 percent in this class, although the percentage for Milton as a whole is 19. Dryden and the eighteenth-century poets pretty consistently run medium, with a 16–18 percent of *live,* carrying over into Wordsworth 17, Coleridge 15 in poems but 22 in plays, Byron 15, and Arnold 17. With the full- and post-romantic swing to the death side, *live* goes down further, with two exceptions: Emerson 20 and Yeats 16. Emerson is generally biased toward life, but Yeats leans the opposite way. His idiosyncrasy is rather preference for verb over noun, reflected also by his *die* 24, *death* 14.

As regards the use of *die,* two influences seem to be at work which may reinforce or counteract one another. There is the tendency for *die* to go up in frequency when death words generically are favored. But there appear to be, also, poets who like the verb *die* as such, as compared with *death* or *dead,* and others who specifically dislike it. The trio Housman, Kipling, and Yeats show a strong preference for *die* over *death;* in Housman *die* is nearly four times more frequent (37 to 10), in Kipling more than double (33 to 14), in Yeats definitely in excess (24 to 14). Poe clusters with these three (21 percent *die* to 14 percent *death*). All these poets are strongly weighted toward death in general. There is, however, a trickle of poets, and some of them major poets, who favor death only mildly or even lean toward life but who are rather fond of the particular word *die.* Such are Chaucer, 22 percent *die* as against 18 percent *death,* but contrast only 13 percent *live* to 30 percent *life;* Herrick, 19:11; Pope, 21:13; Tennyson, 20:16. What else may tie these four together we do not venture to say. Emerson, too, though he is excessively partisan on the side of life, to some degree favors *die,* at any rate it is the death word he least avoids: *death* 8, *dead* 6, *die* 14, *dying* 1.

Finally, there are a few poets who are moderate in their over-all life–death attitude, such as Milton, Whitman, and Eliot, whose *die* frequencies are abnormally low: 9 percent for Milton, 5 for Whitman, 4 for Eliot. Here a common factor is discernible, though it has nothing to do with temperament; in fact, it is formal, even grammatical. These three poets operate unusually little with verbs and heavily with nouns, at any rate within our life–death sample. Compare *life* plus *death* against *live* plus *die:* Milton 58:28; Whitman 60:11; Eliot 56:10. In fact, Eliot's two verbs are surpassed in frequency by the sum of their derived participles, 10:13. Whitman's piling up of inventories may account for his excess of nouns. In Milton it is more likely his Latin models: in Virgil *vita* and *mors* make up 59 percent of his equivalent eight life and death word occurrences. Burns joins these three in his high proportion of nouns (62:27), as already remarked, but unlike them he shows an over-all heavy life bias.

Our two participles are relatively infrequent, and their separate tallies hardly suggest configurations of period or group as do the other six words, except as grammatical usage changed. There are some marked differences, but they seem individual. Thus Spenser and Wordsworth both run up to 11 percent for *living,* Milton to 8. In each case the frequency is high relative to the verb *live* and it does not extend to *dying-die.* These are probably personal idosyncrasies of these poets' diction. They contrast markedly, for instance, with Shakespeare's 3:18 for *living-live,* with the same inclination manifest in his 1:17 for *dying-die.* We have just mentioned Eliot's opposite tendency, his participles rivalling or exceeding his verbs. It is conceivable that Eliot marks the beginning of a turn in style. Thomas runs highest in the *dying* category with 11 percent, but of course he runs very high in all death words. It seems more likely that Eliot's staticism expresses a personal peculiarity. But whether the low degree of periodic consistency in the use of participles and the high degree of variability between individual poets are functions only of our special set of life and death words, or whether they extend to the grammatical form of English poetry generally, is something that remains to be tested.

Table 2 serves as a partial summary of the most pronounced personal bents, as well as period changes of taste and usage, in the choice between the several life and death words. The poets are again listed in chronological order, but their most positive preferences are made explicit without statistics by citing for each poet which word of our eight he used most often, then next most often, finally third most often.

Although one might analyze the data in other ways, to be genuinely useful more detailed analyses should be integrated with results derived from analogous compilations (and of course a more complete representation of poets would be desirable). No single study of this type can claim to be generally meaningful, but a series of interrelated investigations to establish something like a "semantic field," as we have suggested, would permit significant advances in our understanding of the processes of literary style.

TABLE 2

POET	WORD		
	Favored Most	Second Favored	Third Favored
Chaucer	life	die	death
Wyatt	life	death	live
Spenser	life	death	live + die
Shakespeare, sonnets	live	life	death
narratives	death	life	die
plays	death	life	live
Donne	death	die	dead
Herrick	live	die	life
Herbert	life	death	live + die
Milton	death	life	live
Dryden	life	death	live
Pope	life	die	live
Gray	die	life + death	
Collins	life	live + dead	
Goldsmith	life	die	death
Cowper	life	live	die
Burns	life	death	live
Wordsworth	life	live	death
Coleridge, poetry	life	death	live + die
plays	life	live	dead
Byron	life	death	live + die
Shelley	death	life	dead
Keats	death + life		die
Emerson	life	live	die
Poe	life	die	dead
Tennyson, poetry	life	die	dead
plays	life	dead	death
Browning	life	die	live
Whitman	life	death	dead
Arnold	life	live	death
Dickinson	life	death	die
Swinburne	death	life	dead
Lanier	life	death	dead
Housman	die	dead	life
Kipling	die	dead + life	
Yeats	die	dead	life
Eliot	life	death	dead
Thomas	death	dead	die
Dickey	dead	life	death

So we conclude by pleading for increased recognition of the utility of some humble, often disregarded tools of literary scholarship, concordances, word-indices, and the like. Properly used, these tools can encourage the development of new kinds of critical insights. Contrarily, without such tools even theoretical criticism is to a degree handicapped. The lack of concordances for most writers of prose fiction, for example, blocks off one pertinently related area of stylistic criticism. The kind of investigation we have illustrated suggests the possibility of establishing a sector of literary scholarship in which the systematic accumulation of research findings would be feasible and rewarding. This research appears especially valuable in forcing the scholar to test the limits of conventional periodization and genre definition. Most students of literature recognize these conventionalized definitions as not entirely satisfactory conveniences, which nevertheless, like all such conveniences, finally tend to control our thinking. The technique of stylistic analysis proposed here provides one means for evaluating, qualifying, and refining the received classifications of literary style.

JULIUS BUBOLZ FOUNDS AN INSURANCE COMPANY: A STUDY IN RURAL LEADERSHIP AND RESPONSIBILITY *

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On April 7, 1956, Julius Bubolz turned to his son and said, "Gordon, how is the business coming in from the new territory?"[1] Two days later at the age of 93 years and seven months the founder of the Home Mutual Insurance Company was dead.[2] Alert and active in the business to the very end, Julius Bubolz was born August 22, 1862, in Germany and at the age of seven emigrated to the United States, settling with his parents on a farm in Winnebago County. He attended public and parochial schools completing all the courses offered at that time. In fact, he took the eighth grade course twice as nothing was available beyond it. After clerking in a store for an uncle he worked briefly on the railroad before buying an 80-acre farm for $1,500 in 1882.[3]

This farm near Seymour, Wisconsin—a stake in a developing society—provided a basic orientation for Julius Bubolz as he began carving a livelihood out of the Wisconsin wilderness. Above all he developed a respect for the land. Neighbors sold their timber to lumber companies and thus stripped their land. Bubolz desperately needed the money to help pay the mortgage but he had a sense of ecology and conservation generally lacking in the late 19th century. Trees on hilly portions of the farm were never cut so they could protect the land from erosion. Flowers, animals, and birds only added to the enjoyment of a family walk through the woods. The farm eventually encompassed 242 acres.[4]

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* The author was given unrestricted permission to use the files and records of the Home Mutual Insurance Company. For the complete cooperation of the officers and staff, the author is also most appreciative.

[1] On August 24, 1965, all living children of Julius and Emelia Bubolz but two, together with two grandchildren, were brought together at the Home Mutual Insurance Company where they were interviewed in depth by Professor Walter Ebling, University of Wisconsin. The author is indebted to Dr. Ebling and the Bubolz family for this extended and perceptive interview which was recorded on tape. Ebling–Bubolz Tape; Gordon, p. 30.

[2] *Appleton Post–Crescent,* April 10, 1956.

[3] *Ibid.* Also, *Capital University Bulletin,* February, 1943, p. 3. Ebling–Bubolz Tape; Gordon, p. 3, Amelia, p. 4. Card from Esther, September 12, 1965, in Home Mutual Files.

[4] Half of the land was described as "level, well drained, and suited for intensive cultivation;" About one-third of the land was good cropland but had "quite a few problems that will require good conservation practice;" and the remainder was "not suited for cultivation, but . . . for grass or trees." Letter from Vernon G. Geiger, Outagamie County Soil Conservationist, April 4, 1967. Ebling–Bubolz Tape; Gordon, p. 30–31.

Save for the purchase of the farm in 1882, 1884 was the key year in providing the basic orientation for Julius Bubolz. Civic interest led him into a variety of public offices. His first official position was that of town clerk—a post he filled for 19 years. Careers of 27 years as justice of the peace and 28 years as school clerk also began in 1884. The next year he was appointed census enumerator for the Town of Cicero.[5] These positions developed the variety of his contacts and his experience in administration and public responsibility.

Bubolz was keenly aware of the importance of appearance. Only 21 and anxious to appear older, he grew a beard. He was enormously pleased that he was chosen town clerk in preference to a clean shaven man 10 years his senior. The beard accomplished its purpose. It helped him appear older when that was needed and 25 years later when he found it desirable to look younger, he shaved it off.[6]

Emelia Jeske became Mrs. Julius Bubolz one month after Julius was appointed town clerk. Emelia was distressed when he grew the beard and equally distressed when he shaved it off a quarter century later. She converted a Wisconsin homestead into a comfortable and happy home. A warm and vital person, Emelia's pleasant exterior concealed a remarkable capacity for hard work, managerial ability, drive, and determination. Fifteen children provided the extra hands so useful on a Wisconsin farm.[7]

Shortly after their marriage Emelia said, "There is no blessing on the community without a church, a place to worship our God." Julius solicited the support of 21 neighbors to found Emanuel Lutheran Church of Cicero. As the guiding force Julius was elected secretary of the congregation, a position he held for the next 61 years.[8] A firm faith in God was coupled with a deep and abiding faith in his fellow man. The church was, as many other pioneer projects, a community venture. The farmers in the Seymour–Cicero area built the roads and helped each other build barns and harvest crops as well as build the church. Cooperation was essential for progress—it was a way of life and it worked.

Faith, cooperation, and work might have sufficed in those pioneer days had it not been for the periodic windstorms that ripped their way through the area. Cooperation could rebuild a farmstead destroyed by fire but when their fields were devastated along with barns and homes these pioneers obviously needed more than storm cellars. Moreover, the pioneer community was a debtor community.

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[5] *Appleton Post Crescent*, April 10, 1956. *Capital University Bulletin*, p. 3. Card from Esther, September 12, 1965.

[6] Ebling–Bubolz Tape; Esther, Gertrude and Gordon, p. 5.

[7] *Ibid.;* Amelia, p. 27, Amelia, Esther and Gordon, pp. 35–36.

[8] *Ibid.;* Gordon, pp. 5–6. Also, *Capital University Bulletin*, p. 3.

Mortgages were not cancelled by a tornado and it was a very long year between harvests. In 1883 an August tornado destroyed Julius Bubolz' first crop when he had the grain cut and in shocks. The Cicero area survived another tornado in 1888.[9] News of the great cyclone that struck New Richmond, Wisconsin, on the evening of June 12, 1899, filled the Cicero residents with dread. 115 people were killed, 500 injured, 100 homes completely destroyed, and property damage was well above $750,000.[10] Julius Bubolz knew that something could be done to spread the risk. He didn't know just how, but he would find out.

The answer was found in mutual insurance but there were no mutual windstorm companies operating in this part of rural Wisconsin—only mutual fire insurance companies. Windstorm insurance was unheard of in the Cicero community and many farmers wondered whether such a company could operate successfully. Mutual insurance simply means that it is owned by the policyholders of the company. In this democratic arrangement the policyholders elect directors who, in turn, elect officers who manage the business, collect small sums as premiums, and pay the losses of policyholders who have agreed to mutual protection. Management includes setting up reserves for safe operation and then returning what is left over as dividends to the policyholders. The mutual handles insurance at cost, it is a cooperative project. Mutual insurance was not a new idea having been put into practice in London in 1696. Benjamin Franklin brought the idea to America and established the "Philadelphia Contributorship" in 1752. For the next century the idea grew slowly but by 1900 over 1,100 mutual companies had been formed. With such rapid growth many mistakes were made and poor management resulted in many failures. It was the task of Julius Bubolz to determine the principles for sound management to insure survival.[11]

Through reading, inquiry, and some experience Julius Bubolz was able to translate his thoughts into action. His stature as a church and civic leader stood him in good stead for here was one man in the Cicero community who could be trusted for honesty and judgment. Early in 1900 he invited a group of his neighbors

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[9] *50th Anniversary Bulletin,* p. 3. In 1883 Julius Bubolz almost lost his farm as a result of crop loss to wind. He was able to keep it only because he took a 12 per cent second mortgage with the farm as security. This experience left an indelible impression on his mind. Ebling–Bubolz Tape; Gordon, pp. 20–21.

[10] *The Milwaukee Journal,* June 13, 1899. The headline followed by decks of subheads read: "A TORNADO KILLS AND MAIMS HUNDREDS OF WISCONSIN PEOPLE: Hundreds of Dead, Dying and Injured; Tornado Strikes New Richmond and Fire Completes Work of Destruction; Men, Women and Children Crushed to Death by Flying Debris Without a Second's Warning."

[11] John Bainbridge, *Biography of an Idea; The Story of Mutual Fire and Casualty Insurance,* (New York, 1952), pp. 20–21, 28. Also, *Semi-Centennial History of the Northwestern Mutual Life Insurance Company of Milwaukee, Wisconsin, 1859–1908,* (Milwaukee, 1908), pp. 25–29.

to his home and explained his plan to them. Based on this interest others were canvassed during the next 60 days until 135 members comprised the original charter group. The plan of operation was simple. Each member had an equal voice in the management. Each promised to assume his share of the losses and expenses. These men took care of themselves by helping each other. After the fashion of the day, the original name was Farmers Home Mutual Hail, Tornado and Cyclone Insurance Company of Seymour, Wisconsin—since Seymour was the nearest town. The first policies were not the multi-claused documents of today but merely simple memoranda with most of the contract written between the lines. The company that was to be the Home Mutual Insurance Company was chartered March 1, 1900.[12]

Charles Ploeger, the largest dairy farmer in the county, was the first president and held that office until 1916.[13] The president, however, was little more than a figurehead whose sole responsibility was to preside over meetings. As stipulated in the by-laws the real power and responsibility resided in the secretary, Julius Bubolz, who

> "shall keep a record of proceedings of all meetings of the members and Board of Directors of the Company, preserve all Applications for Insurance, draw and countersign all orders on the Treasurer and prepare and keep all proper books for the business of the Company, under the supervision of the Board of Directors, and all Applications, Policy Registers and other Books, Contracts and other Instruments as are required to be kept at the home office and in his custody. He shall prepare and countersign all Policies of Insurance, Contracts of Agencies, answer all business communications of the Company, prepare and render a statement of the affairs of the Company for its annual meetings, and such other purposes as may be required by law, to collect all dues and premiums or advance assessments, pay all moneys belonging to the Company to its Treasurer and take his receipt therefore, and perform all other duties usually pertaining to the office of Secretary in similar corporations."[14]

However great his powers Secretary Bubolz did not have much to exercise them on. At the end of the first year the premium income was only $235.24.[15] Company growth was slow as it involved only one line of insurance and was initially sold only to farmers in the immediate area. By December 1902, assets came to only $316.92 with cash from premiums at $544.42 for a total of $861.34.[16]

Growth continued, however, because Bubolz' management was based on integrity rooted in his faith, his close knit family, and

[12] *50th Anniversary Bulletin*, p. 3. *Capital University Bulletin*, pp. 3, 15.
[13] Data in Home Mutual Files.
[14] Section 3, *By-Laws of the Farmers' Home Mutual Hail, Tornado and Cyclone Insurance Company of Seymour, Wisconsin*, March 1, 1900.
[15] *50th Anniversary Bulletin*, p. 13.
[16] *Fourth Annual Report*.

his interest in his fellowman. The company earned a reputation for fair and honest dealing, the proof of this being found in the settlement of losses. During 1902, seven farmers whose barns were damaged by cyclones in Outagamie and Shawano counties had settlements of from $2 to $69 for a total of $163. These losses and claims paid as stated in the report, were "scaled down and compromised."[17] Severe hailstorms in 1905 resulted in a small special assessment of $79 on policyholders.[18] But the frugal secretary found that the annual expense of $20 for examination of the company by the Insurance Commissioner would be waived if he brought the books to Madison. In the future he did just that.[19]

During 1906, 401 policies were written or renewed increasing the total to 1,800 covering $1,593,901 in risks.[20] Since there were only 13 losses the financial picture improved. By the close of 1914 the total number of policies in force had increased to 4,007. Risks had increased to $7,666,443 and assets of $6,251.93.[21] By the close of 1919 the policies numbered 6,398 with 147 "losses and claims paid and scaled down and compromised during the year."[22] After 20 years the company had paid out $42,192.88 in losses. Secretary Bubloz had run it with such frugality that since 1900 the company had never made a cyclone assessment and only three assessments because of hail. In this respect it had the best record of all mutual companies in Wisconsin and proudly boasted that it was "a company of the people, by the people, and for the people."[23] In an interview in 1943 Julius Bubolz candidly ascribed his success to a combination of morality and practicality when he said, "Aside from the ethics involved, it always pays more than it costs to be honest."[24]

If the integrity of Julius Bubolz provided the basis for public recognition and more business, it was the managerial and social skills of Emelia Bubolz that made much of this success possible. Emelia became the manager of the farm and together with the children virtually ran it so that Julius could devote more time to the growing business for he solicited applications, kept the records, and issued the policies. When this became too great a burden he

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[17] *Ibid.* In 1911 Julius Bubolz was elected Secretary–Treasurer. *50th Anniversary Bulletin,* p. 5.

[18] *Sixth Annual Report.* The discrepancy between the *Fourth Annual Report* rendered in December of 1902 and the *Sixth Annual Report* in 1905 was resolved in the period 1903 and 1904. Continuity was maintained from the *Sixth Annual Report* on.

[19] Julius Bubolz, "Address Commemorating the 40th Anniversary of This Company," MS in Home Mutual Files.

[20] *Seventh Annual Report.*

[21] *Fifteenth Annual Report.*

[22] *Twentieth Annual Report.*

[23] Julius Bubolz, "Address Commemorating the 40th Anniversary of This Company," MS in Home Mutual Files.

[24] *Capital University Bulletin,* p. 15. Also, *40 Years of Service, 1900–1940; Convention Program and Life Story of the Progressive 'Home Mutual',"* p. 6.

drafted the children into the enterprise. Esther later recalled how diligently she had to practice her penmanship so that she could write well enough to help write policies.[25] It wasn't until 1914 under pressure of increased sales and extraordinary losses that the secretary employed two office girls at $5.00 a week plus board. The two day annual meetings were gala events.[26] Although the formal meetings were held in the Seymour Hotel the directors ate and slept in the large Bubolz farm home for reasons of economy and because they enjoyed the gracious hospitality of the hostess. It might also have been because of the small director's fee for they received only $2.00 for attending a meeting plus train fare until 1924 when they were voted $3.00 per meeting.[27]

Economy was the watchword. For the first twenty years the company made no contribution toward the rent, fuel, or light in the Bubolz home. Then the directors allowed $50.00 a year until 1926 when it was raised to $100.00.[28] Such economies in operation saved the company enough money so that for the first 25 years the premium charges were only 25¢ per $100 for five years. When the State Insurance Department required larger reserves the company raised its rate to 30¢ per $100. However, this was not sufficient to take care of the large wind and hail losses of the late 20's and also build up a surplus so the rate was raised to 50¢ per $100 for five years in 1930. This rate was sufficient to meet all losses, build a substantial surplus and make the company the largest and strongest of its kind in Wisconsin. Through economy of operation and strength of purpose Julius Bubolz served the interests of his fellow farmers in Wisconsin.[29]

The decade of the 20's was the heyday of big business. In this period when men thought only in terms of profits and the key to success was the stock market, the virtues of cooperation that were part of the pioneer society and basic to mutual insurance came under heavy attack. Reports of the annual meetings cast light on this as Julius Bubolz and others briefed the agents on how to handle attacks on the company. A rumor was circulated that the company was in debt and ready to collapse. A careful review of the financial report provided adequate rebuttal.[30] Stock insurance companies disseminated the report that mutual insurance companies across the country were failing. Charts were presented to

[25] *50th Anniversary Bulletin,* p. 4. Ebling–Bubolz Tape; Esther, p. 8.

[26] *40 Years of Service,* p. 4.

[27] *Ibid. 50th Anniversary Bulletin,* p. 5. Ebling–Bubolz Tape; Esther and Amelia, pp. 36–37.

[28] *40 Years of Service,* p. 4.

[29] *Ibid.* Ebling–Bubolz Tape; Gordon, pp. 13–14.

[30] Julius Bubolz, "Secretary's Annual Message," *Thirtieth Anniversary Bulletin,* p. 17.

indicate that the rate of failure for stock and mutual companies was approximately the same.[31]

The primary criticism of mutual companies during the period was that of socialism as the stock companies wrapped themselves in the American flag and stood on a platform of capitalism. At the annual meeting which celebrated the 30th anniversary of Home Mutual, Henry Straight of Grand Rapids, Michigan, appealed to history to vindicate mutual insurance. He pointed out that Ben Franklin brought the mutual insurance concept to America and that Thomas Jefferson and John Marshall had stock in mutual companies—these the founding fathers. "Talk about socialism!" said Straight. "Why, if this is socialism let us have a little more of it."[32]

To have more of it was distinctly possible, Straight added. The mutual companies had a built-in advantage—they paid no dividends to stockholders. Their stockholders were the mutual policyholders. From 1919 to 1924, 19 stock companies paid $93,036,096 in dividends to their stockholders.[33] In mutual companies this would have gone to policyholders. All that was needed was a sound company, leadership, and able, hard working agents. By 1930 the company had developed a number of agents of this caliber. Anton Matheson of Manitowoc County, for example, wrote 400 policies in 1929 totalling $2.25 million.[34]

Nineteen thirty-one marked the end of an era for the company and opened new horizons. It shed the vestiges of its pioneer beginning when in 1931 it moved its headquarters from the Bubolz farm to modern offices in the Zuelke Building in Appleton.[35] Constantly increasing business and the desire to give all agents and assureds the most rapid service possible made this move imperative. A change of name was in keeping with the spirit of the time. "The Farmers' Home Mutual Hail, Tornado and Cyclone Insurance Company of Seymour, Wisconsin" had shortened its name in 1926 to "Home Mutual Hail–Tornado Insurance Company." In 1932 it was streamlined to its present form "Home Mutual Insurance Company." Perhaps the greatest tribute to the company's record of safety, service and low cost insurance protection occurred at this time when four smaller windstorm companies in Wisconsin after thorough investigation voted to join with Home Mutual rather than one of the 17 other Wisconsin mutual

[31] Henry Straight, "Comparative Strength of Mutual and Stock Insurance," *Thirtieth Anniversary Bulletin*, p. 28.
[32] *Ibid.*, p. 31.
[33] *Ibid.*
[34] *Ibid.*, p. 9.
[35] *The Story of Home Mutual*, 1933, p. 2.

windstorm companies.[36] The accent on change was also seen in personnel. Gordon Bubolz, son of the founder and a recent graduate of law school, became assistant secretary on September 10, 1926.[37] A new generation was now on the scene to cope with a new era of history which saw the U.S. plunged into depression and world war.

At the annual meeting celebrating the 30th anniversary, Julius Bubolz said, "This year the Home Mutual will be 30 years young. I say it will be 30 years young because I believe the company has not yet reached maturity, it has not reached the point where it will no longer progress. To the contrary, I believe the Home Mutual has reached a point where it has successfully gone through the most dangerous period of its life, which is the period of infancy. The Home Mutual has reached a point where it may anticipate a great era of expansion."[38]

He was absolutely correct. The assets in 1930 were $150,902 and in 1967, $9,334,778. The surplus in 1930 was $19,645 and in 1967, $1,884,346. At the end of three decades Home Mutual offered one insurance line (windstorm and hail coverage) in one state (Wisconsin). In 1967 it wrote nine lines of insurance and was licensed in 17 states.[39]

Extensive and intensive studies have been made of Carnegie, Rockefeller, and Morgan. There is no question but that they deserve such attention for they helped build urban, industrial America. In insurance we have the Bulkeley family, sole owners of AEtna Life Insurance Company which, at the end of its Centennial Year, 1953, had admitted assets of $2,370,717,579.[40] But these leaders of American industry and finance did not have a personal or direct effect on Cicero and Seymour in the period 1882–1930. Julius Bubolz did. As a leader in his community he played an important role in the development of rural Wisconsin. In recognizing the need for hail and windstorm insurance and acting to fill that need, he exercised responsibility of the highest order. His ambition was not wealth or fame but service to his fellow man. We have here a study in rural leadership and responsibility.

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[36] *Ibid.*, p. 8. The companies were the Wrightstown Morrison Mutual Cyclone Insurance Co. of Greenleaf, Wisconsin, the North Wisconsin Farmers Mutual Cyclone Insurance Company of Poskin, Wisconsin, the Buffalo County Mutual Storm and Cyclone Insurance Company and the Windstorm branch of the Price County Farmers' Fire Insurance Company. Also, *40 Years of Service*, p. 8.

[37] *50th Anniversary Bulletin*, p. 7. Also, *Who's Who in Insurance*, (New York), 1968, pp. 104–105. *Who's Who in the Midwest*, vol. 10, (Chicago, 1966), p. 143.

[38] *Thirtieth Anniversary Bulletin*, p. 16.

[39] Data supplied by Albin Bevers, Vice President, Home Mutual Insurance Company, April 23, 1968. The foundation was laid. The Home Mutual Group by 1968 was capable of handling a customer's complete financial plan—his fire and casualty insurance, life insurance and his investment program.

[40] Richard Hooker, *Aetna Life Insurance Company; Its First Hundred Years*, (Hartford, 1956), p. 224.

ANTI-GOLD RUSH PROPAGANDA IN THE WISCONSIN MINES

*Watson Parker**

Gold rushes are made, not born. They do not spring to life immediately upon the discovery of gold in far-off places, but arise, instead, from the publicity given to such discoveries by a variety of interested parties. Such propaganda, falling upon minds which are naturally receptive to it, or upon those ears made preternaturally attentive by unhappiness or misfortune, can have volcanic effects and move both men and mountains.

The rush to California received its most compelling impetus when, on December 5, 1848, President James K. Polk proclaimed that "the accounts of the abundance of gold in that territory are of such extraordinary character as would scarcely command belief were they not corroborated by the authentic reports of officers in the public service who have visited the mineral district."[1] Thus did Polk confirm the many rumors already widely prevalent concerning the riches of the land so recently ceded to the United States as a result of the War with Mexico.

The Wisconsin lead mining region, which lies mainly in southwestern Wisconsin, but includes parts of Illinois around Galena and the Iowa mines around Dubuque, was peculiarly susceptible to news of a new bonanza. The Walker Tariff of 1846 had permitted Spanish lead to enter the United States at ruinous prices, while the Wisconsin lead mines themselves, after nearly a generation of productivity, had begun to penetrate below the ground water level, and had become increasingly difficult and expensive to operate. A lead mining population already made restless by declining prices and increased costs of production was all too eager to seek its fortune in the new mines of the far west.

The interest which the Wisconsin miners and their neighbors took in California gold is perhaps best indicated by the large amount of information which the Wisconsin newspapers of the time found it advisable to print, quite evidently in response to a considerable demand for news of the developing gold fields. "It is

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[1] James D. Richardson, ed., *Messages and Papers of the Presidents* (Washington, 1900), IV, 636.

not our intention to foster anything like a mania with regard to the California Gold Mines," said the editor of the Galena *Gazette*, "but our readers have a right to know the current reports, and we have no desire to withhold them."[2] This equitable attitude was reflected in the widespread publicity given to the President's December 5 address, the frequent printing of advice on how to equip oneself for the trip to California, and on how to choose the best route by which to go there, and in a multiude of published letters from those who were on the way to, or who had at last reached, the mines of California. News of the rush was in demand, and few editors had sufficient fortitude to withhold it from their readers.

The editors of the mining region, however, were thoughtful and perspicacious men who realized that if favorable news and publicity could begin a gold rush, adverse propaganda could probably slow one down, and retain in the lead mines at least some of those sturdy citizens who might otherwise depart for California. These editors began their campaign subtly by putting forward general economic arguments against gold mining and inflation, by pointing out that all is not gold that glitters, and that happiness and comfort at home might in many cases be preferable to suffering and riches on the Pacific coast. As news came back from those rushers on the way to the mines the editors seem to have sought out tales of difficulties, sickness, and privation on the routes, by either sea or by land, that led to California. Disappointment in the mines, too, was a frequent topic, and reports of disillusioned miners were often prefaced by some sort of hortatory editorial "I told you so!" to make sure that the Wisconsin readers got the point. This is not to say, of course, that all the California news printed in the mining region papers was hostile to the gold rush; that was far from the case. Rather, the effort seems to have been to print all of the news, both good and bad, but to give undue prominence to the bad news, while publishing the good without comment. The editors apparently knew that they could not shut off the gold rush, but they seem to have hoped that they could slow it down.

The first point of attack against the rush lay in editorial statements about the undesirability of gold rushes in general. "The fatal dowry of gold which that new territory has brought to the Union is already producing its wonted effects. In the country itself all the usual occupations of industry—all the ordinary pursuits of life, are abandoned in the insane and insatiate thirst for treasure," cried the Galena *Gazette*.[3] "Is the discovery of the Gold mines of

[2] Galena *Weekly North-Western Gazette*, 27 December 1848.

[3] *Ibid.*, 17 January 1849.

California a blessing?" asked the Oshkosh *True Democrat.* "We say that it is not; we go farther, we think it is an injury. It is drawing men from producing to non-producing industry. There is already money enough in the country, and more is only injurious."[4] The burning question of slavery in the new territories was quickly raised by the Janesville *Gazette* which predicted that if the new lands should "resound, like Mr. Polk's plantation, with the crack of the overseer's lash and the groans of unrecompensed, hopeless Toil then far better for us and for all had they been left to the bear and the savage for ages to come."[5]

Individual miners, as well as the nation as a whole, cautioned the editors, would suffer from a gold rush. The mines would attract "the most degenerate class of foreigners in the territory," "the refuse population more than the good population" herded together with "no law, no government, no means of protecting life or property,"[6] a population composed of "desperate ruffians" among whom the honest miner might lose his life, if not his reputation. Indeed the Galena *Gazette* laid great stress upon this latter attribute, pointing out that "a man's character is worth considerably more than all the gold of California," and that conditions in the diggings might well "drive even a tolerably firm will and watchful conscience from the line of moral propriety."[7]

The editors also hoped that appeal to sentiment would deter the tender-hearted or weak-willed from attempting the trip to the mines. "What recompense would all the gold in the world be," queried the Lancaster *Herald,* "for the burial of one of your dear children . . . in the sands of the Great Desert?"[8] "Money can never make good the deep distress, suffering, and death which will ensue"[9] warned the Janesville paper. Poetry, a feature more popular in newspapers then than it is now, was used to discourage the gold seeker. A touching "Father's Advice to His Son, Leaving His Home for California," cautioned the prospective emigrant to make his peace with both his God and his family before departing for the mines:

> Then, if beneath the evening star,
> Beside the great Pacific's wave,
> Thou find'st an early tomb afar,
> His grace will there thy spirit save.

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[4] Oshkosh *True Democrat,* 23 February 1848.

[5] Janesville *Gazette,* 28 December 1848.

[6] Galena *Gazette,* 17 January 1849.

[7] *Ibid.,* 26 December 1848.

[8] Lancaster *Herald,* 24 February 1849.

[9] Janesville *Gazette,* 11 April 1850.

Or if upon thy safe return,
Thou find'st no more thy father here,
Pay one sad visit to his urn,
Drop on his dust one filial tear.[10]

More deliberate humor, generally in the form of parodies of California news, or instructions, was frequently employed in the attempt to make the prospective gold-rusher repent of his decision. A "Treatise on the Yellow Fever (Golden Fever)" written in imitation of the many columns of medical advice then common in the news pointed out that in the early stages of the gold mania "the disease might be easily counteracted by a small dose of common sense" but that in more advanced cases "a pill composed of five grains fear of Cholera, four grains of want of ready funds and two grains of reason will frequently produce a decided improvement." Inveterate cases, however, could be helped only by "an emollient embrocation of the comforts, ease and enjoyment of the patient at home . . . applied to his mind by his wife or some other female attendant."[11]

The editors soon concluded that appeals to morality, sentiment, or laughter would not long deter the westward rush of Wisconsin miners; they quickly turned to arguments addressed to the pocketbooks rather than the hearts of their readers. A Whig paper, for example, pointed out that President Polk's information about the new territory might well be highly suspect, for Polk, said the editor, "looks upon California as his bantling, and is extremely anxious to have it settled."[12] Stories of gold were claimed to be "exaggerated if not idle tales, calculated to draw the imaginative, the restless and improvident away from their regular employment."[13] Speculators who had California lands to sell were also blamed for much of the favorable propaganda, for "persons having lots in that region which at this time sell at the rate of $2,000 for one 36 by 160 ft, desire to see a rush for gold."[14] Even if there was gold in California, the editors agreed, a gold field some 150 miles long by 40 miles wide would not be quickly exhausted, and the gold rusher had no need to participate in any hasty or ill-considered emigration in order to get his share. The propaganda which had a generation earlier produced a rush to the Wisconsin mines was held up as an example of the disappointments which the rushers might expect in California. One editor reminisced that when the lead miners had come to Wisconsin "we found that it was indeed true that some had made from $100 to $200 per day . . .

[10] *Ibid.*, 26 April 1849.
[11] Lancaster *Herald*, 13 January 1849.
[12] Galena *Gazette*, 2 January 1849.
[13] Janesville *Gazette*, 28 December 1848.
[14] Mineral Point *Tribune*, 29 December 1848.

but . . . for every individual that had met with such good fortune there were nine hundred and ninety-nine who barely eked out a subsistence."[15]

News from emigrants on their way to the mines was also a common item in the papers of the lead region. One gold-seeker, writing from Chagres on the Isthmus, reported that "it rains in these latitudes ten months a year" and that even during the dry season the thunder and lightning were so terrific that they shook the ground and left the rattlesnakes and alligators glassy eyed.[16] During the *wet* season he implied things were a good deal worse. Cholera and smallpox were reported to be prevalent on the Isthmus, where they wrought havoc among the weary miners waiting interminable weeks to catch a northward ship to San Francisco. "Under these circumstances," said the Janesville *Gazette*, "nothing but infatuated recklessness is evinced in encountering such hazards, and the safe return of the adventurers is a thing more to be hoped than expected."[17]

The Overland Trail to California, in spite of its hardships, was both quick and cheap and thus attracted the greatest number of gold rushers and produced a correspondingly large number of letters-to-the-editor in the Wisconsin papers. One editor, summarizing reports from the various routes to the mines concluded that "Those who have taken the overland route generally advise their friends not to come that way, while others, taking the isthmus route, give the same advice. For the present we are inclined to consider the advice of each as good."[18]

Many a letter reiterated this editorial conclusion. One emigrant reported that St. Joseph, Missouri, the starting point of the Overland Trail, was "filled with gamblers, thieves, swearers, and others no better" and that "the most abandoned and iniquitous city in the world would turn away with disgust from the exhibitions of demoniac knavery and wickedness of St. Joseph."[19] Pressing westward into the desert, a correspondent reported that "not one man in a hundred at home can imagine so poor and awfully wretched a country as the valley of the Platte" and went on to assure his readers that even this wilderness was "very rich indeed compared with the remainder of the journey, from Fort Laramie to the base of the California mountains."[20]

The newspapers of the 1850's seem to have devoted an immense proportion of their space to advertisements for patent medicines and nostrums reputedly good for the ills of man or beast.

[15] *Ibid.*, 20 February 1849.
[16] Prairie du Chien *Patriot*, 14 March 1849.
[17] Janesville *Gazette*, 22 March 1849.
[18] Mineral Point *Tribune*, 1 March 1850.
[19] Janesville *Gazette*, 16 May 1850.
[20] Galena *Gazette*, 6 February 1850.

Possibly this lively interest in diseases and their cure may have led the editors to suppose that reports of the prevalence of sickness on the road to California might dissuade some of their readers from making the journey. The steamer *Mary,* for example, was reported to have begun a trip to Council Bluffs with four hundred Mormon emigrants aboard, only to bury fifty-eight of them along the way, victims of the dreaded cholera. Epidemics of both cholera and smallpox swept the entire nation, but the editors stressed that they seemed to strike with peculiar severity upon the plains where privation and exhaustion made the emigrants especially susceptible to their deadly ravages. "Not a day passes," said an early letter to the Galena *Gazette,* "that we do not meet with the graves of those who but a month since left home with buoyant hopes and light hearts."[21] Soon, however, the editors found it necessary to abandon this particular line of argument, for the cholera struck so vigorously in the lead mines that Galena in a single week lost one per cent of its entire population, and the citizens may well have begun to believe that even the plains might be healthier than Wisconsin.

Strangely enough the threat of Indian attack on the Overland Trail received very little mention. Only a few items on this subject made their way into the newspapers, and these, in the light of modern-day TV massacres, seem to have been minor and inconsequential scuffles. This lack of stories of Indian attacks, however, was compensated for by the striking and gruesome quality of the *one* story which did circulate widely—the tale of a "Horrible Revenge" which was visited upon the son of a Mr. Green, of Green's Woolen Factory at Fox River:

> It is reported while passing through a tribe of Indians, this young man, naturally full of mischief, killed a squaw. The tribe, having become well advised of the fact, hastened after the company and overtook them and demanded the murderer. At first the demand was resisted but after the Indians had informed them that they would destroy the company if their request was not granted, the youth was surrendered into their hands. They then stripped him and in the presence of his father and the whole company, skinned him from his head to his feet.[21]

The story, of course, appears to be apocryphal, for it is attached to a wide variety of western localities, and the name of the unfortunate victim is variously given as Green, Wasson, Picket, or Esterbrook. Nevertheless, as an invention designed to slow down migration to California it was certainly a triumph of editorial ingenuity. Even though it later had to be repudiated by the various papers which had published it, the tale has become firmly

[21] *Ibid.,*, 26 September 1849.
[22] Council Bluffs (Iowa) *Frontier Guardian,* 1 May 1850, exchanged from an earlier issue of the Galena *Jeffersonian.*

fixed in western folklore. To this day a "Rawhide" pageant is annually given by the townsfolk of Lusk, Wyoming. Each year they find it necessary to get a new man for the "lead."

A less painful problem, but one which was frequently mentioned, was the lack of good food, and the consequent indigestion to be encountered on the plains. One correspondent cautioned his hungry readers against eating too many prairie dogs, for this "causes considerable noise in the lower regions, about the time one wants to sleep, but cannot, for the barking of the dogs." He further pointed out that "as wild meat is of a running breed, and you of a tame one, you needn't be surprised to find yourself running the day after eating it."[23]

Such experiences on the Overland Trail taken all together caused many an emigrant to write back to his home-town paper that "nothing on earth would ever induce me to undertake the trip again," or "had I known, or could I have had the slightest conception of the discomfort of the route by land, I would certainly never have started. No one, not experienced, can form the slightest idea of the privation and suffering to which the traveller over these plains is subjected."[24]

Once in the mines, the emigrant was faced with a problem of making ends meet. Some correspondents said that "California and its gold mines are a perfect farce"[25] and that there was hardly any gold to be had. Others allowed that there was gold to be dug, with the most onerous labor, but that the cost of living, with flour $100 a barrel and other expenses in proportion, made it impossible to save enough to make the trip worth the effort. The thought of buying California whisky at $50 a gallon must have seriously discouraged a good many hard-drinking Cornishmen from ever leaving Wisconsin. The California rainy season, too, when no man could work at all, but living expenses went on just the same, was said to reduce the amount of gold a miner could lay by against his return to the states when he had seen the "bullefant." Even if a miner worked for others and got paid in gold for his labors, the chances were good that he might be given a spurious gold dust made of sulphuret of iron, for the Mineral Point *Tribune* mentioned that a New York manufacturer had "received an order for 700 lbs. of this worthless compound" for the San Francisco market.[26]

With such conditions reported in the mines, it is small wonder that many correspondents wrote, and editors happily printed, letter after letter urging the lead miners not to come to California. "Any

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[23] Galena *Gazette*, 17 January 1849.
[24] *Ibid.*, 26 September 1849.
[25] *Ibid.*, 24 October 1849.
[26] Mineral Point *Tribune*, 16 February 1849.

person doing a fair business had better remain at home,"[27] said one. "My advice is, to every one, to stay at home and be content with whatever lot may befall him there, rather than risk health and comfort,"[28] wrote another. "Tell all those who are in good circumstances at home not to come here, for they will surely repent it,"[29] said a third. It may have been good advice, but print it as they would, the editors of the lead region could not substantially diminish the rush of Wisconsin miners to the Pacific coast. By 1850 over two hundred men from Mineral Point alone, including 17 percent of the town's leading citizens, had left for the mines, and it was estimated that adjoining towns had been similarly depopulated. Even the newspapers appear to have suffered, for as a general thing 1850 shows a marked decline in both press and editorial work, indicating that some of the newspapermen, at least, may have departed for the California diggings.

The editors had done their best. Judicious selection of the news from California and diligent editorial comment upon it, alike had failed to stem the tide which flowed westward from the Wisconsin mines. Once started, the California rush had been too big for the editors to stop.

[27] Galena *Gazette,* 1 May 1850.
[28] *Ibid.,* 20 March 1850.
[29] *Ibid.,* 6 February 1850.

OSHKOSH GRADUATES VIEW PUBLIC SCHOOL TEACHING IN LETTERS TO RUFUS HALSEY FROM 1905 TO 1907

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To Rufus Halsey, president of the State Normal School at Oshkosh from 1899 to 1907, student welfare was a matter of primary concern. As a consequence, Halsey stressed close professional association with the student body. He fostered an informal sociability between faculty and pupils, and his administration witnessed a great increase over that of his predecessor in establishment of student academic and social organizations. Above all, Halsey believed there was no substitute for personal relationships on campus, and he considered a normal school whose enrollment exceeded five hundred students to be approaching a danger point at which such contact would be lost.

It was from the view of ensuring success in greater achievement of student welfare that Halsey stressed a program of pupil guidance which included counseling on the presidential level. Halsey not only wished the student on campus to have full benefit of presidential guidance, but also believed that if the institution were to serve the "highest interests of the state," its graduates should have the privilege of like counseling. Moreover, he thought it essential that the alumni have proper professional placement, especially those persons qualified for more responsible positions. If this objective were to be realized, there must be continuing study of the graduate's career, and according to Halsey personal contact was the best mechanism for so doing. He told fellow administrators during an all-normal school faculty institute held at Oshkosh in 1900, "You do not know with sufficient definiteness just what your graduates are doing,—how rapidly they have grown professionally . . . , unless by frequent correspondence or visits you come into close touch with their work."[1]

Halsey gave his ideas life by exacting a promise from graduates that they write him twice a year about their employment problems

[1] [Board of Regents of] Wisconsin Normal Schools, *Proceedings of an Institute of the Faculties of the Normal Schools, Held at Oshkosh, December 17–20, 1900* (Madison, 1901), pp. 305–306.

and professional objectives.[2] As a result, a body of letters unique in volume and scope among Oshkosh presidential files are present today in his papers. Extending from 1905 to 1907, the correspondence is mostly of Wisconsin origin, but whatever the source, it is a means for obtaining insights into teaching conditions in public schools at the beginning of the present century. It also reveals teacher attitudes toward those conditions.

Examination of the letters to Halsey discloses that adjustment to community patterns was a matter of first concern to the new teacher who often faced challenges to his or her capacity for adaptability. Carrie A. Parent wrote, "When I reached Racine, mud and rain welcomed me and immediately I found a dislike for the place." But a thoughtful superintendent had seen to it that three Oshkosh graduates be on hand to greet her at the train, and when each invited Carrie to dinner, things improved. Words could not express her delight when she saw the eager faces of her fellow alumni.[3] From Stiles, Eva Whipple confessed that there were several reasons for her not wishing to continue teaching at Oconto Falls. One was that en route to school she must walk over an immense hill and "Oconto Falls people never shovel snow in the winter."[4] From Theresa, Milton V. Jones informed Halsey that he had a busy classroom schedule, but no social life. "The people are pleasant," he stated, "but that is about as far as it goes. The saloon draws too much. With a population of about four hundred the town supports eight saloons and two breweries."[5] Ruby V. Fuller voiced a similar complaint at Elkhart Lake. Ruby remarked, "The town is entirely German and I can neither speak nor understand German. Besides this the place is so decidedly immoral that I do not care to stay. . . . They think of nothing but card-playing and beer drinking Sundays and every other day in the week. There is no English church. . . ."[6] Not everyone could report to Halsey as happily as did LaVergne Wood and John N. Stover. LaVergne taught in her home town of Brandon and consequently faced no arguments over which church she should attend and whether she should sing in the choir.[7] John taught at Cambridge where there were no saloons and the residents were "rich, retired farmers who on the whole believe[d] in good education, temperance, and churches."[8]

[2] State Historical Society of Wisconsin, Archives Division, Wisconsin State University, Oshkosh, President, Alumni Correspondence, Letters Received, series 90/1/1–1, Sara Bennett Jones to Halsey, September 11, 1905, mentions the requirement of writing twice a year. Hereinafter, all citations of letters to Halsey will be by date only.

[3] April 20, 1967. The letters cited in this article were written more than sixty years ago and hence have no bearing on present conditions in the communities mentioned.

[4] September 21, 1905.

[5] April 28, 1906.

[6] June 7, 1906.

[7] April 8, 1906.

[8] February 25, 1907.

Not all the teacher-graduates experienced difficulty in adjusting to community ways, even if they endured trying moments or were homesick for parents and friends or perhaps their *alma mater*. Resourceful individuals soon developed social outlets or became absorbed in their new surroundings. W. W. Werndlandt was admittedly "[un]acquainted with the rules of backwoods society" when he arrived at Elcho, but he came to know the tough lumberjacks and found the school board president courteous. And, although his pupils uttered threats against him and some residents showed "greed for the all-mighty dollar and . . . public recognition [sic]," Werndlandt thought Elcho a good place for "one interested in human nature in all its phases."[9] Moreover, teachers enjoyed occasional diversions from daily routine. At Embarrass, Louis U. St. Peter taught, it is true, in a building he described as "ramshackle," but he was intrigued by Indians who came from Keshena to pick cranberries in a marsh nearby and proceeded to stage a war dance after consuming intoxicants bought with their wages. Louis thought the dancing looked "very foolish," but even so he conceded it was "most amusing."[10]

A great tide of immigration was sweeping America at the turn of the century, and children of newcomers posed a worrisome problem for some Oshkosh alumni, mostly over lingering traits associated with cultural or social backgrounds. From Hilbert, Emily N. Cherosky outlined objections to the children's habit of using the German language at school. "I have told them they must not speak German within the school grounds. Am I right in doing so?" she queried.[11] From Sheboygan, Perly Thackray confided that her class were "all foreigners and [could not] speak a word of English, some . . . came from Russia only a few months ago. I haven't any American children. . . ." Moreover, Perly regarded her pupils as deficient in cleanliness and politeness. They did not know what to do with their hands.[12] Sophia Berge, who taught the first grade at Norway, Michigan, found herself in a quandary over a class entirely ignorant of English. "It is pretty hard to give these children regular first grade work," said Sophia.[13] Catharine E. Dolan wrote from Milwaukee that her pupils of foreign extraction were "not nearly as bright" as youngsters she had taught elsewhere.[14] And, Clara M. Calvert believed that if it were not for a strong principal in her school at Iron Mountain, Michigan, "extremely hard work" would result from disciplinary problems with immi-

[9] December 9, 1905.
[10] March 17, 1906.
[11] November 8, 1906.
[12] February 19, 1907.
[13] May 6, 1907.
[14] October 21, 1905.

grant pupils. To Clara, such children were "only about half civilized."[15]

But other Oshkosh graduates enjoyed the immigrant child. Ethel C. O'Leary wrote from Ironwood, Michigan, that although she had to "adapt" herself, she was "very proud of [her] fifty-two little Finns and Sweeds [sic]."[16] And, at Merrill, Wisconsin, Sara J. Morissey thought her forty-two children who represented "nearly every country in the Universe," were "all lovely." She wished that Miss Rose Swart, the Oshkosh normal school supervisor of student teaching, could visit her class. Sara said, "I know she would laugh. The children have such queer expressions, their vocabularies being so limited."[17] Josephine E. Gannon also enjoyed her immigrant pupils. "They seem like flowers in a bud," she remarked.[18]

Backward economic and social aspects of community life were another concern to the Oshkosh teacher-graduate. From Sheboygan, Ida C. Brown alleged that in a majority of homes in her school neighborhood, "every cent that can be spared from . . . getting the bare necessities of life is spent in the saloon. I have called at many . . . homes, and the standards of living in them, the conditions under which the children are being raised are appalling." Two years later, she stated, "In our ward we contend with the hardest of social conditions. Long before the pupils reach the fifth grade they are 'hard cases.' " Ida wished to instill ideals into her pupils each of whom she believed to possess good traits. But the goodness was often so deeply buried, months passed in uncovering it.[19] From the same city, Vesta Tibbits described poverty's effect upon school attendance. To assist with family income, many youngsters left school at the fifth grade, and classes dwindled accordingly. In 1904, there were [in her school?], fifty-six children in the fourth grade, twenty-six in the sixth, and only eight in the eighth.[20] Extra curricular activities also felt the impact of the working pupil. Oscar B. Thayer, teaching at Ashland, was unable to organize a football team because parents were poor and it was necessary for their sons to work after school to help earn the family livelihood.[21] And, from Mellen, Walter P. Hagman wrote that his pupils who were largely of foreign parentage would not stay in school as required by law. "Some children leave the very day they are fourteen," Hagman reported.[22]

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[15] March 9, 1906.
[16] November 5, 1905.
[17] March 6, 1906.
[18] March 9, 1907.
[19] October 8, 1905, and January 11, 1907.
[20] October 14, 1905.
[21] October 28, 1905.
[22] October 28, 1905.

Historically, pupil disciplinary problems have troubled teachers, and many of Halsey's correspondents discussed lack of discipline, especially on the part of their predecessors. Some brought him their cares in this area. From Mondovi, Clara E. Tompkins reported excellent results from administering corporal punishment to three recalcitrants,[23] and J. W. Riley was no less successful in punishing an unruly youth at Racine. Riley was forced to take stern measures, however, and said, "I got along all right with him until today, when I *had* to give him an *old timer*, a *gentle reminder*, a *pusher*, and a *persuader*. He is much taller than I . . . and tried to handle me, . . . he came out a bad second best."[24] But from Nekoosa, Mabel M. Hall told a different tale. Mabel had attempted to correct a naughty boy striking him "smartly across the shoulder . . ." with a pointer, but the lad dodged and the blow fell upon his head. Bleeding followed, and when a resultant investigation ended, Mabel was jobless.[25]

The Halsey materials also contain abundant indications of teacher unrest over low wages. Indeed, the average wage for female teachers in the county schools of Wisconsin for the school year 1906, was only $39.75 and that of males $62.34.[26] It was little wonder that Daisy M. Rich, who was teaching at Marshfield, thought wages "in most towns were not much more than enough to live on,"[27] and at Rhinelander, Clara Christensen commented, "salaries are so low, and living expenses so high, that one can hardly afford to stay. . . ."[28]

There were exceptions to the rule. W. A. Werndlandt enjoyed a monthly salary of $70 at Elcho; he remarked, however, "It is worth it to live . . . here."[29] Edwin S. Billings was fortunate in receiving a like sum at Footville in 1907, but the figure included pay for essential janitorial duties. Thus, if a janitor were hired from his income, Billings would suffer a wage reduction. Besides, he believed that if the work were to be done properly he must do it himself. "This is a serious objection to the position," Billings observed.[30]

If board and room were high-priced and interest on teachers' loans expensive, the financial aggravation was deeper. Catherine E. Dolan's school board at Mondovi not only held back a month's

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[23] October 30, 1905.
[24] January 23, 1906.
[25] December 11, 1905.
[26] *Thirteenth Biennial Report of the Department of Public Instruction of the State of Wisconsin July 1, 1906–June 30, 1908* (Madison, 1910), part II, p. 9, in volume II, State of Wisconsin, *Public Documents of the State of Wisconsin Being the Reports of the Various State Officers, Departments and Institutions, for the Fiscal Term Ending June 30, 1908.*
[27] January 27, 1907.
[28] April 22, 1907.
[29] October 21, 1906.
[30] April 23, 1907.

pay but also refused a contract until her second month of service. Meanwhile, Catharine could borrow money in order to live, but the interest she must pay was seven per cent.[31] J. J. Rettles, who taught at Westhope, North Dakota, earned fifty dollars a month, but his board cost twenty-five. The authorities paid Rettles by warrant, and if the treasury held sufficient funds, banks cashed the paper at full value. Otherwise, they discounted it at five per cent, thus reducing Rettle's salary through no fault of his own.[32]

There were those teachers who exerted pressure on the authorities for salary increments. After receiving half-hearted promises of an increase in pay, Idella D. Ray went so far as to warn her board that following Christmas she would not return to her post at Washburn. Idella's pluck resulted in a five-dollar-a-month increment which she thought was her due; nevertheless, she told Halsey that she felt guilty of misconduct.[33] It was a happy exception to most cases involving wages when George N. Murphy explained that he had unexpectedly received five dollars more per month than he had contracted for at Peshtigo—the board had decided to give him the same rate as that of his predecessor. "I felt greatly encouraged and have endeavored to give the people here full value for their money," he wrote.[34]

But for most teachers, finding a better paying position—perhaps in a big city—seemed the solution to inadequate income. This meant that to aid those seeking higher pay as well as individuals desiring professional advancement, Halsey became a one-man employment bureau answering dozens of calls. He helped more than one Oshkosh graduate to greater success, but he thought teachers should help maintain salary standards by not accepting too low wages.[35]

Compounding teacher unrest due to modest wages, were frustrations ranging through the course of professional life and experience. Jennie Goesling deplored lack of opportunity for self-improvement at Iron Mountain, Michigan,[36] and at Peshtigo, Wisconsin, principal Robert Wendt considered buildings so poor and crowded that good work was impossible. He decided to quit.[37] John M. Lorscheter, writing from Granton, told Halsey in an undated letter of January, 1907, that he was teaching fifteen classes a day and "The Board here has but little or no idea of what a teacher can and should do. They think all that is necessary is to

[31] July 17, 1905.
[32] December 26, 1905.
[33] December 22, 1905.
[34] May 23, 1907.
[35] Halsey to Agnes Haigh, August 8, 1908.
[36] February 26, 1906.
[37] February 27, 1906.

keep good order, while teaching should be . . . secondary. . . ." Lorscheter had reversed things, but had run into opposition in so doing. He would have written more, but he told Halsey "it only tires you to read our mournful tales." And E. M. Pauly, principal at Dunbar, was distressed over living conditions. "There is no possibility of getting any house to live in except such as is overrun with vermin," he stated. Pauly wished he were back at Oshkosh but nonetheless was attempting to inculcate his classes with the ideals of his *alma mater* whose wholesome influence came back to him "as sweetest remembrances and renewed inspiration."[38] From Bayfield, Sara Bennett Jones remarked that she almost hated the place because of parental interference with school work.[39] Nor was this all. At Footville, Edwin S. Billings thought it necessary to take residence in a hotel where gossips could not reach him so easily after a disturbance occurred over his re-grading the school.[40] And at Catawba, Bert Williams lost his position when the townspeople "voted to have all female teachers."[41]

But not all teaching situations were insurmountable. From Abbottsford, Henry E. Polley reported, "The only trouble of any consequence this year has been an attack by a village clergyman (Presbyterian). He is greatly alarmed about the idea of evolution that some h[igh] s[chool] pupils became interested in. He preached against a study of it in any way. . . . Yet we are not much alarmed for his influence in any matter is not very much."[42] And, although Markesan did not offer social diversions, Alta L. Pepper informed Halsey that her teaching assignment there was an improvement over her former post at the Northern Hospital [for the Insane]. Alta wrote, "there isn't the restraint and nervous strain experienced there."[43] From Mellen, Laura Walker wrote that she enjoyed her work, and liked the progressive spirit and invigorating climate of the North although "The thermometer registered fifty-two degrees below zero last week."[44] And if R. M. Radsch experienced difficulties in obtaining satisfactory pronunciation of English words from his German pupils at Oakwood, Wisconsin, he found the quiet life of the town delightful and "joy of joys, a fine compound microscope" with which he was attempting to duplicate biological work he had once accomplished on the fourth floor of the Oshkosh normal school building.[45]

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[38] April 13, 1907.
[39] February 17, 1906.
[40] November 17, 1906.
[41] July 3, 1907.
[42] January 19, 1907.
[43] March 17, 1906.
[44] February 10, 1907.
[45] November 5, 1905.

Finally, the teacher-graduate letters to Halsey reveal a pride in the Oshkosh training program and a determination to fulfill the mission of their *alma mater*. Not a few disclose the influence of Halsey whose personal and professional standards were firm and unimpeachable. Oshkosh graduates often submitted their teaching to self-appraisal, and if needed, determined to correct shortcomings. Sometimes they viewed the work of others with a critical eye. At Ashland, Emma L. Saxton did not consider her principal—a Milwaukee normal school alumnus—to be as thorough and progressive as an Oshkosh man would have been. "But I can forgive him," she wrote.[46] Emma J. Schulze, whose schedule at Whitehall included English composition, Literary Readings I, II, and III, plus Ancient and American history, civics, and all the music taught in her school, was grateful that "One of best things I acquired there [at the Oshkosh normal school] was a habit of systematic hard work." Moreover, Emma considered Oshkosh methods as "good as gold" when put to the practical test.[47] And, something of Halsey's image as an educator is discernible in a letter of Arthur Sperling who taught at Random Lake. Sperling wrote, "One finds that to conduct a school successfully, one has to gain the good will and fellowship of the students, not by favoritism, but by square, open dealing and careful judgment."[48] The same could be said of H. C. Leister who wrote from New London, "The world, as a whole, has no need for the pessimist and much less does the teaching profession need the pessimist. The teacher must be an optimist."[49]

Rufus Halsey died in July, 1907, as the result of a shooting accident.[50] With his passing, the students lost a sincere counselor and warm friend devoted to serving their best interests. Halsey's tenure as president of the Oshkosh Normal School was the shortest of its kind, but no other presidential file discloses a similar relationship existent between the alumni and the school head. To accomplish his purpose of assisting the graduates, Halsey needed to follow the students' careers and to acquaint himself with their problems and hopes. The students responded, and their letters, written in frankness, provide a documentary portrayal of the school and the teacher of two generations ago.

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[46] February 4, 1907.
[47] January 29, 1906.
[48] December 8, 1905.
[49] April 6, 1907.
[50] See *The Oshkosh Normal Advance*, Memorial Issue, September, 1907, for reviews of Halsey's work as an educator, and the *Oshkosh Daily Northwestern*, July 26, 1907, for details concerning his death.

GINSENG: A PIONEER RESOURCE

A. W. Schorger

Father Jartoux (1810), while in China, was ordered by the Emperor to prepare a map of Tartary. He was at a village in the latter country, when the natives brought him four ginseng plants which they had collected in the mountains. A letter from him, dated Peking, April 12, 1711, and published in Paris in 1713, described the plant and its medicinal properties. He thought that the plant would be found in other countries, particularly Canada. The Jesuit missionary Lafitau (1718), stationed at the mission of Sault St. Louis, chanced to read the letter and began, with the aid of the Indians, a search for the plant which resulted in its discovery near Montreal in 1716. Two years later he published a monograph on ginseng in Canada. The new edition of the book contains considerable information on the commercial history of ginseng in Canada.

The Chinese have long considered ginseng to be a sovereign remedy, and placed special emphasis on its virtue as an aphrodisiac. Kalm (1772), stated that the French used it for asthma, stomach disorders, and promoting fertility in women. Medical science has been unable to confirm any of the claimed physiological results.

The discovery of ginseng *(Panax quinquefolium)* in Canada was likened to that of gold in California and Australia. The root was very profitable to the small traders since a pound costing 2 francs in Quebec, sold as high as 25 francs in Canton. In one year there was sent to China ginseng valued at 500,000 francs. In 1751, owing to the great profit to be realized, the *Compagnie des Indies* monopolized the ginseng trade. The price paid in Canada ultimately rose to 80 francs (Garneau, 1882). This was a sufficient incentive to send everybody into the woods, and ginseng was collected out of season and regardless of age. In addition it was dried in ovens, further lowering the quality. The product was unacceptable to the Chinese, so that the Canadian trade decreased sharply by 1754, in which year the exports dropped to 33,000 francs.

Kalm (1772), was in Quebec in August, 1749. He states that at Quebec, in the summer of 1748, ginseng sold at six francs a pound, though the usual price was five francs. The demand for ginseng was so great that all the Indians near Montreal were searching for the root so that the farmers could not hire, as usual, a single Indian to assist in harvesting their crops.

The furcated root (Fig. 1) is in the greatest demand owing to the fancied resemblance to the thighs of a man. The value of the root, in the eyes of the Chinese, is enhanced by being rendered semitransparent by steaming, sometimes in the presence of sugar. The root should be five to seven years of age, and should not be dug until the latter part of August and preferably in September and October. Indiscriminate collecting has eradicated the plant from much of its range which is largely east of the Mississippi. Several states have passed protective laws. Wisconsin (1905) passed a law prohibiting the digging of wild ginseng between January 1 and August 1, or dealing in green ginseng between these

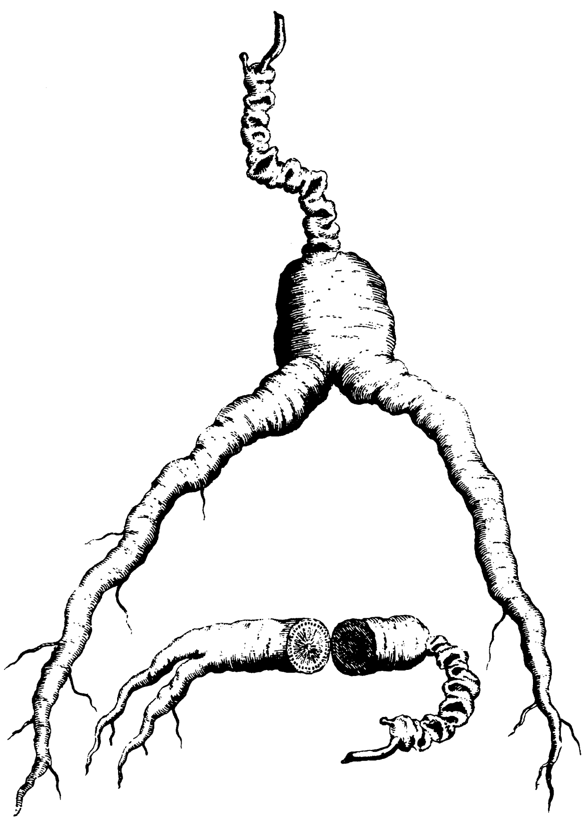

FIGURE 1. Root of ginseng (After Lafitau).

dates. In 1923 the owner of the land was excepted from the restrictions. The roots when dug should be washed thoroughly, and dried carefully at a moderate temperature to prevent molding. About two-thirds of the weight is lost in drying.

The fame of ginseng spread from Canada to New England, New York, and westward. The first settlers of Vermont found the plant in abundance. For a long time ginseng was purchased by most of the retail dealers in the state, the roots in the "crude state" bringing 34 cents a pound (Thompson, 1853). It was supposedly discovered in western New England in 1750 (Williams, 1809). Rev. Jonathan Edwards, in 1752, wrote to a friend in Scotland that ginseng had been discovered at Stockbridge, Massachusetts, the year previous (Speer, 1870). The Albany traders were eager buyers of the article for export to England. The discovery had a demoralizing effect on the Indians. Young and old ranged far and wide to collect it. This kept them from public worship, and when in Albany to sell the product, they were subjected to various vices. In 1773, the *Hingham,* sailed from Boston to China with 55 tons of ginseng (Williams, 1957).

The trade in ginseng, colloquially called "sang," from the beginning was largely in the hands of the fur traders. The American Fur Company handled the root. Astor is reputed to have made, in 1782, the first shipment of ginseng to China following the revolution.* Astor (1910), in 1815, wrote to Ramsay Crooks that the ginseng should reach New York by the first of May. Even today most of the wild ginseng is purchased by fur buyers.

One of the early dealers in ginseng in New York was Sir William Johnson (1721–65). His papers contain numerous references to the trade. On November 29, 1750, he delivered 41 pounds of ginseng. A letter of September 12, 1751, to Samuel and William Baker, London, inquired for the price of ginseng to be expected in England. He had most of the members of the Five Nations gathering ginseng, and, owing to its scarcity he had obtained only four hogsheads over a period of three months. If ginseng sold under 12s. a pound he would be a loser. In 1752 he heard of ginseng selling from 32s. to 40s. a pound. The plant could not have been scarce for in 1766 the chief of the Tuscaroras asked for a trader as it was plentiful in their country. A shipment of ginseng which Johnson sent to London in 1759 was valued at £ 144.4.7. Ginseng was highly profitable to the buyers in 1752, but the following year they were nearly ruined. The Indians in Broome County, who had

* L. T. Williams, l.c. p. 344. The date at least is incorrect since Astor did not arrive in America until 1783 and did not engage in the fur trade until the following year.

collected it in large quantities, however, benefitted considerably (Hawley, 1850).

The Moravian missionaries (Beauchamp, 1916) among the New York Indians in 1752, depended heavily on the ginseng which they dug to furnish their necessities, such as blankets and shoes. When they arrived at some of the Indian villages, they were nearly depopulated as the inhabitants were away gathering ginseng. The demand for ginseng seems to have been low in 1755 for the missionaries received for their roots only a traveler's kettle from a reluctant trader.

The noble, Daniel de Joncaire, Sieur de Chabert et de Clausonne, was sent to the Bastile in Paris in 1761 to await trial for undoubtful corruption in handling supplies for Fort Niagara. He used ginseng in his defense: "I enjoyed a prosperity acquired by the most legitimate means. . . . This is the chief source of my fortune. The craze for ginseng spread from Europe to Canada. My connection with the Indians made it possible for me to profit by this. They gathered this plant as much as I wished, at 15 livres the pound; it sold at Montreal for 24 livres. If this trade had lasted a longer time, I could have made great loans to the State and the King" (Severance, 1917).

Attempts were made frequently to propagate ginseng in Europe though the seed will not germinate or the root grow if allowed to dry. Barbé-Marbois (1929) was in the Oneida Reservation in September, 1784, where he had engaged an Indian to collect five or six barrels of ginseng to be shipped to France for transplanting. His statement that, prior to the discovery of ginseng in America, the supply from Tartary was so limited that in China it was worth its weight in gold, shows the incentive.

The early settlers of New York also collected ginseng. The inhabitants of the town of Kirkland, Oneida County, were greatly in need of food in 1789 on account of a crop failure the previous year. A local merchant accepted ginseng in payment for supplies in place of gold and silver (Durant, 1878). It is surprising that the plant persisted in quantity for so long a period. Dwight (1822) wrote in September, 1799, that the Brothertown and Oneida Indians, near Clinton, New York, at that season, collect annually a thousand bushels of ginseng for which they receive two dollars a bushel. Most of it was sent to Philadelphia, thence to China.

Philadelphia remained for many years the principal port for export. In 1752 it was hoped by the merchants of this city that a market for ginseng could be created in England. This hope did not materialize and by 1772 ginseng was no longer exported to England (Jansen, 1963). While Schoepf (1911) was at Laurel Hill, Pennsylvania, he met a man with two horses carrying 500 pounds of ginseng bound for Philadelphia. Much was brought to Fort Pitt. An energetic man could collect 60 pounds in a day. The price paid was about a shilling sterling per pound. In going over the Alleghany Mountains in September, 1794, Washington (Fitzpatrick, 1925) met "numbers of persons and Pack horses going in with Ginseng."

The members of the Moravian Mission (New Salem) on the Huron River, northern Ohio, relied largely on ginseng for support. Zeisberger (1885) recorded on August 29, 1787, that nearly all the brethren were gathering ginseng. There was a great demand for it, while skins were worthless. The price was $3.00 a bushel. The plant was abundant in some places and scarce in others. Where plentiful a man could collect a full half-bushel in a day. There was a big demand for ginseng in Ohio in the period 1798–1808 (Hildreth, 1852).

Large amounts of ginseng were purchased by Daniel Boone in Kentucky (Bakeless, 1939). Owing to the absence of an Indian population, the collection of the roots must have been made largely by the white settlers. He personally collected some ginseng. The winter of 1787–88, he started up the Ohio in a boat containing nearly 15 tons of ginseng. The boat overturned, and before the cargo could be salvaged and transported to Philadelphia the price had declined. Undismayed he had on hand 15 "caggs" of ginseng in the fall of 1788.

According to the botanist Michaux (1805), ginseng in 1802 was the only product from Kentucky that would bear the cost of transportation overland to Philadelphia. It was collected by people having some leisure, and by hunters who carried a digging tool in addition to a rifle. A collector seldom dug more than 8 or 9 pounds of the roots in a day. These roots were less than an inch in diameter even after an age of fifteen years. He received a shilling for the dry roots which brought twice that amount in Philadelphia. The process whereby the Chinese rendered the roots transparent, i.e. by steaming, was considered a secret, although knowledge of it was long known, and worth 400 piasters (dollars). Some of the Philadelphia merchants paid six or seven piasters per pound for the beneficiated roots.

Large quantities of ginseng were being sent to China from Wisconsin and Minnesota in the 1860's (Speer, 1870). About 1845, Green County, Wisconsin, was known as the "sang" country. The supply was soon exhausted as men, women, and children devoted their leisure time to collecting the roots. A. Ludlow of Monroe purchased all that was available for shipment to New York. A boy in 1846 within three months, collected 500 pounds for which he received $0.22 a pound (Bingham, 1877). Much was collected in the Bark River woods, Jefferson County, where it was abundant (Warner, 1930). As late as 1900 ginseng could still be found in the county in considerable amount. John Hooper obtained about 5000 plants annually during the three years 1904–1906, by personal collection and purchase of a small number (Moore, 1940). There does not appear to have been any early interest in the plant in Dane County. In 1893, it was said of ginseng in the vicinity of Madison: "Occasional in rich woods. Becoming rather rare" (Cheney, 1893).

The collection of ginseng received much attention in Sauk County. Charles Hirschinger, when ten years of age came with his family to a farm near Baraboo in 1847. As an aid to the family, he dug ginseng for which he received a few cents a pound (Cole, 1918). Mrs. L. H. Palmer, a widow, with the aid of her children collected and sold at a dollar a pound, sufficient ginseng to pay the mortgage on her place. Thousands of pounds were dug in the town of Ironton. Though initially bringing a dollar a pound, the price fell to fifty cents; nevertheless, ginseng brought comfort to many families. This was particularly true about 1859, when times were difficult (Western Hist. Co., 1880). During June of this year the merchants at Tomah were doing a thriving business in ginseng which was to be found in quantity to the southward (Tomah, 1859). However, a New York firm, Schiffelin Brothers and Company, contributed a letter stating that ginseng was not in the best of condition until fall, and should not be collected before that time (Ripon, 1859).

Within a few weeks, in the spring of 1859, over $1200 had been paid for ginseng collected in the valley of the Baraboo River. The price of 12½ cents probably represented that of the green root (Baraboo, 1859). At this time the number of diggers of ginseng in the Trimbelle woods, Pierce County, was estimated at 300. One load of about 1200 pounds was noticed. The price of the green root was 9 to 10 cents a pound. Fraudulent practices consisted in soaking the roots in water and inserting sand into the large ones (Prescott, 1859).

Men and boys about 1860 were occupied in digging ginseng in Dunn County. Haugen (1927) relates that in the summer of 1861 he went with a party to Maple Springs, town of Eau Galle, and spent a month digging the roots. The men received six cents a pound, and individuals sometimes dug as high as thirty pounds a day. The boys received six dollars a month and board. In the spring of 1864 speculators were paying fifteen cents a pound for the green root at Menomonie. Ginseng to the amount of $8,000 had been purchased (Menomonie, 1864). At the same time ginseng was in great demand at Mauston (Mauston, 1864). The occupation of George W. Shaffer, of Downsville, was farming and digging ginseng (Forrester, 1891–92).

Ginseng was plentiful in 1866 in the town of Rock Elm, Pierce County, and was worth ten cents a pound in the green state. The ginseng trade revived at Ellsworth in the fall of 1875, and twenty cents a pound was paid for it (Ellsworth, 1875). This price prevailed in 1878 (Ellsworth, 1878). Trade was active in 1879. E. L. Davis advertised for 100,000 pounds of ginseng. Sanderson and Campbell were shipping several hundred pounds weekly. The initial price of thirty cents a pound soon fell to twenty cents (Ellsworth, 1879). E. R. Condit of the village of Rock Elm, in the fall of 1880, had on hand two tons of ginseng which he had purchased. It was "the only legal tender in exchange for goods at our store, bringing 15 cents a pound" (Weld, 1906). J. P. Fetherspil came to the town of Springfield in 1896, and acquired a wide reputation as a collector and grower of ginseng (Easton, 1909).

Ginseng was a boon to the settlers of Vernon County in the years 1854–1856 (Rogers, 1907), as in the dry condition it brought from $0.50 to $1.00 a pound (Union Publ. Co., 1884). Owing to the scarcity of money, ginseng circulated as currency. In the town of Liberty, a young couple about to be married, brought with them an artistically arranged basket of ginseng with which to pay the minister (Stout, 1899).

Most of the ginseng marketed in the northern counties was collected by the Indians. In the 1870's, Fred E. Bailey had a trading post at Rice Lake, Barron County. He hired Indians to dig ginseng and trap furbearers (Gordon, 1922). Indians, in the 1880's and 1890's, came to Perkinstown, Taylor County, to collect ginseng, which was also purchased from them in the town of Hammel (Latton, 1947). John Brinkman, in Wood County, began trading with the Indians about 1880. One season he bought nearly $3000 worth of ginseng, paying $2.00 a pound for it (Jones, 1923). Only a few years prior to 1922, Indians came to Antigo, Langlade County, to sell ginseng and other products which they had gathered in the woods (Dessureau, 1922). In Lincoln County the Indians obtained from $2.00 to $5.00 a pound (Drew, 1898).

The most extensive recorded experience in collecting ginseng is that of Jabez Brown (1855) in Sauk County. His first entry is for September, 1855. On the 25th of this month he dug a bucketful. On July 16, 1858 he dug 15 pounds of green roots. He and his father on September 10 dug about 20 pounds each, and each made about $1.50. His entry for September 18 reads in part: "I hunted sang all day but got but about half a bushel. I came home late very tired. It is curious to see what excitement the Sang business has got up in this country. All classes of men are digging. Some make as high as three dollars per day. I have dug from ten to about twenty pounds per day of green roots. In the extreme money pressure it is all the article that will fetch cash or goods. Some individuals have dug hundreds of lbs. and in Bad Ax, Sauk and Richland Cos. thousands and thousands of lbs. have been dug. Men go out with wagons and teams and provisions and bedding and camp in the woods to dig Gin Sang."

The fall of 1858 Brown began buying ginseng to take to market at Richland Center where he arranged with a merchant to deliver from two to four hundred pounds at 37½ cents per pound. The ginseng was purchased in small lots for which he paid from 30 to 32 cents a pound. On October 11, he and an associate sold 382½ pounds in Richland Center at 38 cents a pound. Within a few years the price increased greatly. In July, 1870, a merchant at Richland Center paid $3.00 per pound for the dry product, and the following year $3.75 (Pease, 1870).

Statistics on the early trade in ginseng in Wisconsin are almost entirely wanting; however, the state is reported to have shipped ginseng to the value of $40,000 in 1858 and $80,000 in 1859 (Nash, 1895). As soon as the wild plant became scarce, attempts were made to cultivate it. In 1877 it was stated that all attempts to grow it in Wisconsin ended in failure. One man after spending several hundred dollars was unsuccessful in growing it from seed (Ann. Rept. 1877). Eventually the difficulties were overcome so that most of the ginseng exported today is from cultivation. It is one of the wild plants which does not conform readily to man's ministrations. The tribulations of the Fromm Brothers in growing it in Marathon County have been well described (Pinkerton, 1953).

References

Ann. Rept. Com. Agr. for 1877. p. 545.

ASTOR, J. J. 1910. Letter, N. Y., Feb. 14, 1815. Wis. Hist. Colls. 19:369.

BAKELESS, JOHN. 1939. Daniel Boone. New York. p. 331.

Baraboo Republic, June 30, 1859.

BARBÉ-MARBOIS, F. 1929. Letters . . . 1779–1785. New York. p. 204.

BEAUCHAMP, W. M. 1916. Moravian journals relating to central New York. Syracuse. p. 113, 120, 122, 124–27, 132, 134, 138, 153–54, 203, 243.

BINGHAM, H. M. 1877. History of Green County, Wisconsin. Milwaukee. p. 118, 119.

BROWN, JABEZ. 1855. Diary. Wis. Hist. Soc. Library.

CHANEY, L. S. and R. H. TRUE. 1893. On the flora of Madison and vicinity. Trans. Wis. Acad. Sci. 9:72.

COLE, H. E. 1918. A standard history of Sauk County, Wisconsin. Chicago. I:69, 84.

DESSUREAU, R. M. 1922. History of Langlade County, Wisconsin. Antigo. p. 2.

DREW, LOLA E. [1898?] History of the Indians [of Lincoln County]. MS. Wis. Hist. Soc.

DURANT, S. W. 1878. History of Oneida County. New York. p. 457.

DWIGHT, T. 1822. Travels: in New England and New York. New Haven. 3:182.

EASTON, A. B. 1909. History of the St. Croix Valley. Chicago. p. 920.

Ellsworth Herald, Aug. 4, 1875.

———. June 19, 1878.

———. June 11, 18, 25; July 2, 9, 1879.

FITZPATRICK, J. C. 1925. The diaries of George Washington. Boston. II:289.

FORRESTER, G. 1891–92. Historical and biographical album of the Chippewa Valley, Wisconsin. Chicago. p. 600.

GARNEAU, F. X. 1882. Histoire du Canada. Montreal. II:154.

GORDON, S. and F. CURTISS-WEDGE. 1922. History of Barron County, Wisconsin. Minneapolis. p. 198.

HAUGEN, NILS. 1927. Pioneer and political reminiscences. Wis. Mag. Hist. 11: 139.

HAWLEY, J. 1850. Journey to Onohoghgwage in 1753. Doc. Hist. N.Y. 2:1035.

HILDRETH, S. P. 1852. Biographical and historical memoirs . . . settlers of Ohio. Cincinnati. p. 308.

JANSEN, A. L. 1963. The maritime commerce of colonial Philadelphia. Madison. p. 93.

JARTOUX, PÉRE. 1810. Lettre. Lettres édifantes et curieuses. Toulouse. 18:97–110; 1714. The description of a Tartarian plant called gin-seng. Phil. Trans. Roy. Soc. London. 28:237–247.

JOHNSON, SIR WILLIAM. 1921–1965. Papers. Albany. I:311, 346, 373; 12:168; 13:126.

JONES, GEORGE O. 1923. History of Wood County, Wisconsin. Minneapolis. p. 11.

KALM, P. 1772. Travels in North America. London. II:272–273.

LAFITAU, JOSEPH FRANCOIS. 1718. Concernant la précieuse plante du gin seng la Tartarie decouverte en Canada. Paris. 88 pp.; 1858. New ed. Montreal. 46 pp.

LATTON, A. T. [1947]. Reminiscences and anecdotes of early Taylor County. n.p. p. 33, 43.

Mauston Star. June 8, 1864.

Menomonie Lumberman. June 18, 1864.

MICHAUX, F. A. 1805. Travels to the westward of the Allegany Mountains. London. p. 158, 207–212.

MOORE, E. B. and R. SANFORD. 1940. Spring flora on Farmer's Island, Lake Mills, Wisconsin. Trans. Wis. Acad. Sci. 32:71–74.

NASH, G. V. 1895. American ginseng: its commercial history, protection, and cultivation. U.S.D.A., Div. of Botany, Bull. 16:22 pp.

PEASE, D. E. 1870. Account book. Wis. Hist. Soc. Library.

PINKERTON, KATHRENE. 1953. Bright with silver. New York. 364 pp.

Prescott Democrat. June 28, 1859.

Ripon Times. July 15, 1859.

ROGERS, E. M. 1907. Memoirs of Vernon County. Madison. p. 52.

SCHOEPF, J. D. 1911. Travels in the Confederation (1783–1784). Philadelphia. p. 236.

SEVERANCE, F. H. 1917. An old frontier of France. New York. II:405.

SPEER, W. 1870. The oldest and newest empire. Cincinnati. p. 61.
STOUT, STANLEY. 1899. History of the town of Liberty, Vernon County, Wis. MS. Wis. Hist. Soc.
THOMPSON, Z. 1853. History of Vermont. Burlington. I:221.
Tomah Chief. June 25, 1859.
Union Publ. Co. 1884. History of Vernon County, Wisconsin. Springfield. p. 664.
WARNER, MRS. AMBROSE. 1930. Recollections of farm life. Wis. Mag. Hist. 14:196.
WELD, A. P. The story of Pierce County. *Spring Valley Sun*, Feb. 22, 1906.
Western Hist. Co. 1880. The history of Sauk County, Wisconsin. Chicago. p. 626.
WILLIAMS, L. O. 1957. Ginseng. Economic Botany 11:344.
WILLIAMS, S. 1809. The natural and civil history of Vermont. Burlington. I:85–86.
Wisconsin. Chapter 194, Laws of 1905, Secs. 1481 a–e.
ZEISBERGER, D. 1885. Diary. Cincinnati. I:366, 369; II:48, 54.

LAKE SIZE AND TYPE ASSOCIATED WITH RESORT LOCATIONS AND DENSITY IN NORTHEASTERN WISCONSIN: I. ONEIDA–VILAS AREA

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SYNOPSIS

Of the 2,450 lakes in the Oneida–Vilas region of Northeastern Wisconsin, 951 are named lakes and 301 of these were used by resort establishments in 1964. They contained 1,206 resorts, or slightly over 25% of the State's total. In general, about three-fourths of the resorts were situated on drainage-type lakes over 100 acres in size with a medium to high fertility rating. However, over 10% were on lakes of 100 acres or less, and over 20% were on lakes classed as low or very low in biological productivity. Further, about one-fourth of all resorts had less than 40 acres of available water surface (per resort), and one-fifth had a shoreline factor of less than 0.5 mile. Almost 4% of the resorts were on 21 shallow lakes which were subject to periodic winterkill. Dwelling density on the resort lakes averaged 6 buildings per mile of shore, with a range of 0 to 20 dwellings per mile. The larger resorts in this region were, with few exceptions, on the larger drainage-type lakes with medium to high productivity ratings. Certain guidelines for selecting or evaluating resort sites are included in this report, which was presented at the 98th Annual Meeting of the Wisconsin Academy of Sciences, Arts, and Letters at Eau Claire, Wisconsin, in April 1968.

Many tourist-lodging businesses in Northern Wisconsin, and particularly the so-called "resorts", are situated on lakeshore lands. This site provides atmosphere, esthetic qualities, and convenient access to water-based recreation—swimming, boating, angling, water skiing, nature study, and so on.†

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† Water-oriented activities, which dominate the recreation picture in Northeastern Wisconsin, have great appeal to a majority of our vacationing tourists. A survey of prospective vacationers in 1964, conducted by the Department of Resource Development and directed by Prof. I. V. Fine, showed that 52% of the people who were interviewed had indicated water activities as their *main* pursuit while on their most recent long recreation trip. Sightseeing and "touring" were close behind—and probably related to water as well. A study of tourist-accommodations people in 1962, also by Fine, indicated that 76.8% of the operators in Northeastern Wisconsin considered *fishing* as their main attraction with *boating* and *swimming* (also water-based) a fairly close second at 59.7%. Only 10 percent of these operators said they had no recreational waters on or adjacent to their premises.

In a 1959 study of tourist preferences. Fine found that the following activities (and facilities) were rated "good to excellent" by high percentages of the vacationers surveyed:

fishing—46.3%	boating—88.1
swimming—75.4	sightseeing—92.3

The last-mentioned study also revealed that 62.9% of all recreational travelers who vacation in Wisconsin during the mid-summer period (July and August) visited the Northeast region.

The quality of recreation provided, as well as the probable success of a resort enterprise, is closely related to the quality of the lake being utilized. Lakes vary greatly with respect to size, type, fertility, depth, water clarity, shoreline, etc. Many lakes are too small, too shallow, too infertile—or otherwise inadequate—to provide good recreation, a quality environment, or high scenic values. As this study shows, some of our resort establishments are located on these low-quality lakes.

Wisconsin has over 8,700 lakes, of which nearly 60% (or 5,100) are named. Only 13% of the total, or 1,134 lakes, are over 100 acres in size. At least 90% of our 4,500 resort enterprises are associated with this relatively small group of lakes—which range in size from 100 acres upward to 137,700 acres (Lake Winnebago).

What lake characteristics and factors can be identified most closely with resort locations and distribution? The purpose of this report it to provide some general answers to this question.

A resort is defined as a visitor-housing business with accommodations for at least two families (six people or more) in a scenic recreational environment.

This study included *all* of the resorts and resort lakes in Oneida and Vilas counties in 1964. This area has over 25% of the state's totals for both resorts and lakes. The figures showed 1,206 resorts on 301 lakes. Basic data on the lakes studied were obtained from recent county inventories of surface water resources, as published by the Wisconsin Department of Natural Resources. Data on resort numbers were obtained from the State Board of Health and by field surveys.

The 301 resort lakes comprised 12.3% of all lakes (2,450 total) in the Oneida–Vilas area, and 31.7% of all the *named* lakes. This area has a total of 951 named lakes, mostly over 10 acres in size, including all of the larger ones. In addition there are 1,499 unnamed lakes, all under 100 acres and 92% under 10 acres in size. Less than ten of these were used by resort establishments. Generally speaking, the 2,150 lakes not being used are probably too small, too infertile, too marshy, or otherwise not suitable for resort development.

With respect to over-all quality, and especially biological productivity, lakes are somewhat comparable to soils and soil fertility. They vary greatly, just like farms or farm fields. There is fully as much variation in productivity between landlocked lakes rated as "very poor" and drainage lakes rated as "excellent" as there is between a sandy, abandoned farm in northern Wisconsin and a fertile, prairie-soil farm in southern Wisconsin.

What are the main factors involved in lake quality? From the standpoint of resort utilization, or human recreation, the following lake characteristics assume major importance:

1. *TYPE*—drainage, landlocked, spring, bog, etc.
2. *SIZE*—area, shape, configuration.
3. *FERTILITY*—water acidity, hardness, nutrient content.
4. *DEPTH*—maximum depth, area under 5′ depth, area over 10′ depth.
5. *CLARITY*—water color, turbidity, algae, etc.
6. *SHORELINE*—type, length, soils, vegetation.

There are other lake characteristics, of course, but the primary lake-quality factors of (1) size, (2) depth, and (3) productivity (fertility) would rate a high priority in the evaluation of any lake for recreational purposes. The matter of *lake type,* or classification, would also deserve careful consideration along with these basic factors in the appraisal of a given lake for its potential or optimum usage. Such things as water quality, lakeshore types, and shoreline developments might be considered in addition.

This paper is concerned chiefly with the type of lakes used, the size of lakes used, fertility ratings, and certain water-space factors related to resort density. The resort counts and lake-inventory data were compiled in 1964 and 1965. Subsequent studies will relate resort distribution to other lake-quality factors, including depth, water clarity, shoreline characteristics, and present usage of the lakes concerned.

Classifying Resort Lakes

A lake is defined as an inland body of standing water, with meandered shoreline, that is navigable at least 9 out of 10 years. Some authorities say that a lake must have at least 10 acres of surface water and that anything less than 10 acres is a "pond." However, our official inventory of surface waters in Wisconsin includes named and unnamed lakes down to 1.0 acre (even smaller) in total area. And, our studies of resort locations reveal that a number of these establishments are presently located on lakes under 10.0 acres in size!

As to classification of lakes by type, the following *lake types* are recognized and have been identified in some or all of the Wisconsin county inventories:

1. *Drainage* lakes—natural lakes and impoundments having both inlets and outlets (affluent and effluent streams).

2. *Landlocked* lakes—lakes that are fed by seepage water; no inlets and no outlets (water level is dependent on groundwater table).
3. *Drained* lakes—very similar to landlocked lakes; no inlet, but have very small or intermittent outlets.
4. *Spring* lakes—somewhat similar to landlocked lake; seldom have inlets, but have outlets of substantial flow.
5. *Bog* lakes—small, kettle-hole lakes with encroaching bog vegetation, usually brown-colored water. (Normally acid if landlocked, but may be alkaline if connected with a stream.)
6. *Impoundments*—lakes with over 50% of the depth attributable to a manmade structure.

The two major categories, drainage lakes and landlocked lakes, are often further divided into two subclasses: acid and alkaline. For example, *acid* drainage lakes and *alkaline* drainage lakes are differentiated in some of the Wisconsin county inventories.

In this study of resort lakes in Oneida and Vilas counties, all named lakes were included under three categories: (1) *Drainage* lakes; (2) *Landlocked* lakes; (3) *Spring* lakes. All "drained" lakes are classed as landlocked lakes, as are the bog lakes that have no inlet or outlet. (All impoundments are included with the drainage lakes.)

Each of these lake types has significant natural properties and limnological characteristics peculiar to it, based on the general chemical and physical properties. Production of plant and animal life, for example, varies considerably with the type of lake.

In general, drainage lakes and spring lakes have the highest fertility levels. Water sources for these two types have higher mineral contents, because of their greater exposure to the soil and subsoil minerals. The groundwater of spring lakes, as a general rule, will have a greater mineral concentration than that of drainage lakes. This fact is especially evident in the small spring lakes with limited watersheds. Landlocked lakes generally have the lowest fertility levels, although some exceptions do occur. Within the landlocked category, drained lakes are slightly more fertile than the average (for seepage lakes), while bog lakes are almost always acid and relatively infertile.

Lake size is an important consideration. The smaller lakes often have inadequate or limited space (water surface) for many activities and, generally, are more readily injured by heavy pressures and overuse. Some limnologists feel quite strongly that no motors of any kind should be permitted on lakes under 50 acres in size. There is considerable justification for this belief, although we feel that a 40-acre minimum might be more appropriate. Large lakes can sometimes be a problem too, because of large waves during high winds, the increased difficulty in locating fishing grounds, or the improved prospects for getting lost.

In this study of resort lakes, nine size categories were used initially, but these are reduced to only four in this report. They are as follows:

Lake Size Class	*Area of Surface Water*
Class I —large	1001 Acres and up
Class II —medium large	501 to 1000 Acres
Class III—medium	101 to 500 Acres
Class IV—small	1 to 100 Acres

Threinen and others suggest three (3) lake-size categories as follows: Small (under 100 A.); Medium (101 to 1000 A.); Large (more than 1000 A.). However, in considering resort distribution and lake usage in the Oneida–Vilas area, it seemed appropriate to separate the medium-sized lakes of 101 to 500 acres from those of 501 to 1000 acres. Thus, the accompanying tables include these two classes of medium-sized lakes. From the standpoint of resort distribution, density and lake utilization, important differences were found between them.

Resorts and Lake Type

Table 1 shows the distribution of resort establishments by type and size of lake used. These data include all resorts identified by the Board of Health in 1964 and all resort lakes in the Oneida–Vilas region.

This area has a total of 951 named lakes and approximately one-third of these, or 301 named lakes, contained all of the 1,206 resorts. Thus, over two-thirds (68.3%) of the named lakes had no resorts on them. Many of the lakes in the latter group were sizeable, good-quality ones, and this suggests a potential for future resort development. The average size of the 301 lakes used by resorts was 390.6 acres, and the over-all density was 4.0 establishments per resort lake.

A large majority of the resorts (915) were located on drainage lakes, although only 28 percent of the 951 named lakes were of this type. Of the 267 drainage-type lakes, 60.7% or 162 had resorts on them. The average lake size for this group was 482 acres, and the average resort density was 5.6 resorts per lake.

Landlocked (or seepage-type) lakes were predominant among the named lakes, comprising 62.0% of the total. However, only 101 of these 590 lakes (or 17.1%) had resorts, with a total of 189

TABLE 1. RESORT DISTRIBUTION BY TYPE AND SIZE OF LAKE IN THE ONEIDA–VILAS AREA OF WISCONSIN

TYPE AND SIZE CLASS OF LAKES	TOTAL NO. OF *Named* LAKES (BY LAKE CLASS)	NO. OF *Named* LAKES WITH RESORTS	% OF *Named* LAKES WITH RESORTS	TOTAL NO. OF RESORTS (BY LAKE CLASS)	% OF ALL RESORTS	AVERAGE NO. RESORTS PER LAKE WITH RESORTS
DRAINAGE LAKES			%		%	
I. Large—over 1000A.	33	22	66.7	276	22.89	12.5
II. Med. Large—501–1000A.	36	33	91.7	258	21.39	7.8
III. Medium— 101–500A.	127	87	68.5	341	28.27	3.9
IV. Small—under 100A.	81	20	24.7	40	3.32	2.0
Subtotals.	267	162	60.7%	915	75.87%	5.6
LANDLOCKED LAKES			%		%	
I. Large—over 1000A.	3	3	100.0	5	0.41	1.7
II. Med. Large—501–1000A.	8	5	62.5	18	1.49	3.6
III. Medium— 101–500A.	74	38	51.3	98	8.13	2.6
IV. Small—under 100A.	505	55	10.9	68	5.64	1.2
Subtotals.	590	101	17.1%	189	15.67%	1.9
SPRING LAKES			%		%	
I. Large—over 1000A.	0	0	0.0	0	0.0	0.0
II. Med. Large—501–1000A.	5	5	100.0	21	1.74	4.2
III. Medium— 101–500A.	34	24	70.6	64	5.31	2.7
IV. Small—under 100A.	55	9	16.4	17	1.41	1.9
Subtotals.	94	38	40.4%	102	8.46%	2.7
Totals.	951*	301	—	1,206	100.0%	4.0 (Ave.)

*In addition, the Oneida–Vilas area has 1,499 unnamed lakes under 100A each.

establishments. The average size of the landlocked resort lakes was 170 acres, and the average density was 1.9 resorts per lake used.

The remaining 94 named lakes—9.9% of the grand total—were spring-type lakes. Two-fifths of these lakes (40.4%) had resorts. The average size of spring lake used by resorts was 260 acres, and the average resort density was 2.7 resorts per lake.

All in all, we find that slightly over three-fourths of all resort enterprises in the region were located on drainage-type lakes, 15.7% were on landlocked lakes, and only 8.4% were on spring-type lakes. In fact, 72.5% of the 1,206 resorts were on 142 drainage lakes of medium-to-large size (over 100 acres), and the resort density on these lakes was 6.2 resorts per lake. It is noteworthy that these 142 lakes comprise only one-seventh (14.9%) of the total named lakes in the area, and only one-seventeenth (5.8%) of the 2,450 lakes found in the two counties.

Resorts and Lake Size

There are 36 Class I lakes (over 1,000 acres each) in the Oneida–Vilas area, of which 33 are drainage lakes and 3 are landlocked lakes. Over two-thirds of them—25 lakes—were used by resorts. These lakes, which averaged 1,504 acres each, had a total of 281 resorts—or 23.3% of the 1,206 establishments. There was an average density of 11.2 resorts per lake used.

Class II lakes (501 to 1,000 acres) in the Oneida–Vilas area total 49, and 43 of them or 87.8% were used by resorts. Most of these (33) were drainage-type lakes, with the remainder divided equally between the other two types (5 landlocked and 5 spring lakes). The number of resorts on them was 297 or 24.6% of all resorts in the 2-county area. Resort density was 6.9 per lake used.

There are 235 named Class III lakes (101 to 500 acres), of which 149 or 63.4% had resorts. This group of lakes (about 71% drainage-type) had a total of 503 resorts, or 41.7% of the grand total, and a density of 3.4 resorts per lake.

Finally, there were 641 named Class IV lakes (100 acres or less) in this area, of which 84 or about 13.0% were used by resorts. Of the 84 total, 55 were landlocked lakes, 20 were drainage-type, and 9 were spring type. These lakes contained 125 resorts, which is 10.4% of the total establishments in the area, and the density was 1.5 resorts per lake used.

It is interesting to note that almost 5% of all resorts in the region were on 46 lakes under 50 acres in size, and 31 of these lakes were either low or *very low* in fertility! As suggested previously, practically all of the unnamed lakes were too small, too shallow, too marshy or too unproductive to be of interest to resort operators. Oneida County has a total of 726 unnamed lakes (all under 100 acres) of which 673 have less than 10 acres of water surface. In Vilas County there are 773 such lakes, of which 710 are under 10 acres in size.

Water Area Per Resort

One index for measuring the resort density (or crowding) on a given lake is the acreage of "available" surface water per resort—or WA/R ratio. This factor is obtained by dividing the total acreage of the lake by the number of resorts thereon. Thus, a lake of 1,000 acres with 10 average resorts* on its shoreline would have a WA/R value of 100. This is slightly higher than the average figure for resort lakes of the Oneida–Vilas area. The average values for our 12 categories of lakes used by the 1,206 resorts in the region are shown in Table 2.

We note that 25.1% (303) of the 1,206 resorts were on lakes with a WA/R ratio less than 40. These 303 resorts are on 78 lakes, of which 53 are Class IV lakes (under 100 A), 23 are Class III lakes (101 to 500 acres), and 2 are Class II lakes. The distribution of these 303 resorts is as follows:

	Number of Resorts	Number of Lakes
Drainage Lakes:		
Class II	52	2
Class III	122	17
Class IV	33	13
Subtotals	207	32
Landlocked Lakes:		
Class II	0	0
Class III	24	5
Class IV	47	34
Subtotals	71	39
Spring Lakes:		
Class II	0	0
Class III	11	1
Class IV	14	6
Subtotals	25	7
Over-all Totals	303	78

* The average cottage resort in northern Wisconsin has seven (7) cabins or cottages, eight (8) boats and motors, and a capacity for about thirty (30) guests when filled.

TABLE 2. SURFACE WATER ACREAGE PER RESORT (WA/R RATIO) IN THE ONEIDA–VILAS LAKE REGION OF WISCONSIN

Type and Size Class of Resort Lakes	No. of Resort Lakes	No. of Resorts	Water Acreage Per Resort (WA/R Ratio)				% Resorts Each Class with 40 A. or Less
			Under 40 A.	41–80 A.	81–200 A.	201 A.+	
			No. Resorts	No. Resorts	No. Resorts	No. Resorts	
DRAINAGE LAKES:							
I. Large	22	276	0	74	133	69	0.00%
II. Medium Large	33	258	52	112	82	12	20.16
III. Medium	87	341	122	161	50	8	35.78
IV. Small	20	40	33	5	2	0	82.50
Subtotals	162	915	207	352	267	89	22.62
LANDLOCKED LAKES:							
I. Large	3	5	0	0	0	5	0.00
II. Medium Large	5	18	0	0	15	3	0.00
III. Medium	38	98	24	49	18	7	24.49
IV. Small	55	68	47	17	4	0	69.12
Subtotals	101	189	71	66	37	15	37.57
SPRING LAKES:							
I. Large	0	0	0	0	0	0	0.00
II. Medium Large	5	21	0	10	4	7	0.00
III. Medium	24	64	11	18	31	4	17.19
IV. Small	9	17	14	1	2	0	82.35
Subtotals	38	102	25	29	37	11	24.51
Totals	301	1,206	303	447	341	115	25.12%
% of All Resorts	—	100.0	25.1	37.1	28.3	9.5	—

Thus, we see that 207 of these 303 resorts (which have WA/R values under 40) are on 32 drainage-type lakes, of which 30 are either small or medium in size. Another 71 resorts are located on 39 landlocked lakes, and 34 of these lakes are under 100 acres in size. The remaining 25 resorts are on 7 spring-type lakes, of which 6 are less than 100 acres. It would appear that those resorts with limited water surface are predominately on lakes under 500 acres in size, with almost one-third of them on 53 lakes of less than 100 acres each.

About three-eighths (37.6%) of the 189 resorts located on landlocked lakes had a WA/R value of 40 or less; whereas only 22.6% of the 915 resorts on drainage-type lakes were in this category. For spring-type lakes, the 40-or-under group included 24.5% of the 102 resorts located on them.

Well over half (62.2%) of the 1,206 resorts had a WA/R value of 80 or less. Of these 750 resorts—each with 80 acres or less water surface—74 were on Class I lakes, 174 on Class II lakes, 385 on Class III lakes, and 117 on Class IV (small) lakes.

The WA/R factor varied from about 5.0 acres (Dog Lake and Minnow Lake) to well over 1,400 acres (Ike Walton Lake) in Vilas County. These were the extremes, and the values for lakes in Oneida County fell within this range. No attempt was made to separate lakes with high concentrations of private dwellings from those with relatively low concentrations, but the dwelling density (cottage and home numbers) per mile of shoreline was calculated for 135 of the 301 resort lakes. (See Table 5 for summary.) It is noteworthy that some of the lakes with the lowest WA/R values also had rather high concentrations of private dwellings and cottages on their shores. This denotes a crowded condition which could very well have deleterious effects. This may result in rapid deterioration and a shorter life for the lakes concerned.

On a particular lake, the surface water acreage per resort (WA/R value) is becoming more important each year, especially with the rapid increase in private dwellings on the preferred lakes. A WA/R value of 40 is considered minimal for a good-quality lake with a low dwelling density (less than 10 cottages per mile of shoreline). The average for all 301 resort lakes was 97.5 A.

The spatial requirements of certain aqua sports—notably speedboating and water skiing—are rather great. These sports are pursued not only by resort guests, but also by residents and transient visitors on most larger resort lakes. One lake authority has stated that about 20 acres of water surface are needed for one powerboat and skier making a complete (360°) turn! Thus, a lake with 80 acres of surface area may serve very well for one cottage resort (averaging seven rental cottages and 30 guests), but it might be somewhat too small for two such establishments when both are operating at or near capacity. If this same 80-acre lake had three or four resorts on it, as some already have, along with 10 or 12 dwellings per mile of shore, the utilization conflicts on a hot July day can be visualized quite readily. On most resort lakes, the surface-water area must be shared with residents, cottage owners, area fishermen, transient boaters, and other non-resort people.

Three small lakes in Vilas county had less than 10 acres of water surface per resort (WA/R values of 5, 6, 9), and all three had private cottages as well, with an average density of 9 dwellings per lake! In the Oneida–Vilas area, there were 87 resorts on 29 lakes which had WA/R values under 21 acres. Over half, 50 resorts, were on Class IV lakes (under 100 acres); the remainder of 37 were on Class III lakes. Landlocked lakes predominated in this group; there were 17 of them with a total of 25 resorts, and all were Class IV lakes. There were nine (9) drainage-type lakes with 47 resorts, and three (3) spring-type lakes with 15 resorts. The lakes in this group had an average of 8.38 private dwellings on their shores, or about 6 per mile of shoreline. This figure approximates the average dwelling density for all resort lakes in this region.

SL/R Ratio Studied

Another index of resort distribution on a given lake is the amount of "available" shoreline per resort, or the SL/R ratio. Since it is another measure of resort density, or crowding, it further highlights the spatial requirements in resort-lake usage. This value is obtained by dividing the total miles of shoreline on a given lake by the total number of resorts thereon. The SL/R values obtained reflect the average length of shoreline per resort on specific lakes, disregarding the amount of lakeshore actually owned by the resorts or other landowners on those lakes. The average values (and resort distribution) for our 12 categories of resort lakes are shown in Table 3.

For example, a lake with 12.0 miles of shoreline and 12 resorts thereon would have an SL/R value of 1.00—or somewhat less than the average figures for the 2-county area. (Oneida county is 1.36, while Vilas lakes have an average value of 1.11 miles per resort.)

It is true that those lakes having large numbers of resort establishments are also attractive to second-home owners, and thus they often have above-average concentrations of homes and cottages. This tends to complicate the interpretation of SL/R values. How-

TABLE 3. SHORELINE PER RESORT (SL/R RATIO) IN THE ONEIDA–VILAS AREA OF WISCONSIN

TYPE AND SIZE CLASS OF RESORT LAKES	NO. OF RESORT LAKES	NO. OF RESORTS	SHORELINE PER RESORT (SL/R RATIO)				% OF RESORTS EACH CLASS WITH .5 MI. OR LESS
			Under 0.5 mi.	.51–1.0 mi.	1.01–2.0 mi.	2.01 mi.+	
			No. Resorts	No. Resorts	No. Resorts	No. Resorts	
DRAINAGE LAKES:							
I. Large—1001A+	22	276	38	102	103	33	13.77%
II. Med. Large—501–1000A	33	258	60	115	68	15	23.26
III. Medium—101–500A	87	341	90	133	89	33	26.39
IV. Small—100A	20	40	10	10	14	2	25.00
Subtotals	162	915	198	360	274	83	21.64
LANDLOCKED LAKES:							
I. Large—1001A+	3	5	0	0	0	5	0.00
II. Med. Large—501–1000A	5	18	0	11	0	7	0.00
III. Medium—101–500A	38	98	8	34	38	18	8.16
IV. Small—100A	55	68	9	33	23	3	13.24
Subtotals	101	189	17	78	61	33	9.00
SPRING LAKES:							
I. Large—1001A+	0	0	0	0	0	0	0.00
II. Med. Large—501–1000A	5	21	0	10	0	11	0.00
III. Medium—101–500A	24	64	11	14	28	11	17.19
IV. Small—100A	9	17	4	9	4	0	23.53
Subtotals	38	102	15	33	32	22	14.71
Totals	301	1,206	230	471	367	138	19.07
% of All Resorts	—	100%	19.07	39.06	30.43	11.44	—

ever, dwelling density is evaluated in a subsequent section of this paper, and it can be related quite easily to the resort distribution on each lake.

The SL/R value, in our opinion, should be at least 0.5 mile per resort under average circumstances—especially on landlocked lakes where there is no easy access or channels to other waters—and particularly where the dwelling density exceeds 10 units per mile of shore.

Why is "available" shoreline important? First, much of the recreational activity on most lakes takes place within ¼ mile of the shore. The central area of a large lake—particularly one without islands—is used very little. Secondly, certain major activities such as fishing and canoeing are high users of shoreline, and the "acres per boat" or "people per acre" figures are less significant. Thirdly, lakes vary greatly in shore length per 100 acres of surface. For example, Dollar Lake and Watersmeet Lake in Vilas County are about 100 acres each. Dollar (nearly round) has 1.4 miles of shore, whereas Watersmeet (spider shaped) has 10.5 miles. Dollar (3 resorts) has an SL/R value of 0.47 miles; Watersmeet (8 resorts) has 1.3 miles. These are extremes, of course, but they illustrate the point.

Of the 1,206 resorts in the Oneida–Vilas region, about 19.0% (230 resorts) had SL/R values of less than 0.5 mile. Of this group, 38 were on Class I lakes; 60 on Class II lakes, 109 on Class III lakes, and 23 on Class IV (under 100 acres). The big majority of them (86.1%) were on drainage-type lakes. The remainder was almost evenly divided (7.4% and 6.5%) between landlocked lakes and spring lakes, respectively.

Resorts and Lake Fertility

A reasonably reliable index of lake quality, or biological productivity, is the fertility rating or total alkalinity of the water in a given lake. This is a key factor in the quality of resort lakes, since it is not only associated with fishery yield and composition but also the prevalence or abundance of algae, aquatic plants, plankton, etc.

Generally speaking, soft-water (acid) lakes are relatively infertile. Most landlocked lakes are of this type. On the other hand, most hard-water lakes show a medium or high fertility rating. This index, expressed as total alkalinity in Wisconsin lake inventories and determined by chemical tests, is a measure of the dissolved solids (carbonates, bicarbonates, hydroxides, etc.) in a sample of water. It is commonly reported as parts per million of calcium carbonate (ppm $CaCO_3$) and is an indicator of lake productivity. The following classification is used to indicate fertility ratings of the 301 resort lakes in this study:

Productivity	Total Alkalinity	Water Hardness	Fertility Rating
VL = Very low	1– 4 p.p.m.	Ultra soft	Very infertile
L = Low	5–2C p.p.m.	Very soft	Infertile
M = Medium	21–40 p.p.m.	Soft	Fairly fertile
H = Medium high &	41–90 p.p.m.	Med. hard	Fertile
High	91+ p.p.m.	Hard	Very fertile

In this report the last two categories are combined into one, i.e., "high" fertility. Lakes in this class are generally the most productive and support a large population of fast-growing fish, other organisms, and aquatic plants. Conversely, lakes rated as "very low" or "low" are relatively unproductive—like a poor soil—with a limited population of slow-growing fish and relatively clear, weed-free water. Fish are sometimes stunted, especially if predators and large fish are inadequate to control the population.

Table 4 shows the distribution of our 1,206 resorts by lake fertility, type and size class. Four levels of fertility, or productivity, are indicated for each of the 12 lake type-and-size categories. The table reports both the number of resorts and the number of resort lakes under each fertility class. It is noteworthy that 78.8% of all resorts were on lakes of medium or high fertility; further that 825 (86.8%) of these 950 resorts were on drainage-type lakes. Thus, it appears that the great majority of resort establishments have selected, wisely or by chance, resort lakes of good or above-average productivity.

However, there were 256 resorts on 115 lakes of low or very low fertility. They comprised over one-fifth (21.2%) of all resorts in the region. Almost two-thirds of these resorts (161 establishments) were on infertile landlocked lakes; 90 were on drainage-type lakes; only 5 were on spring lakes.

At the "very low" level of water fertility—or productivity—there were 54 resorts on 42 lakes. Thirty of these lakes were small, 100 acres or less, and only two were over 500 acres in size. All 42 were landlocked lakes, and most of them were questionable or undesirable sites for resorts, because of their small size and limited fishery.

TABLE 4. RESORT DISTRIBUTION BY LAKE TYPE AND LAKE FERTILITY IN THE ONEIDA–VILAS AREA

TYPE AND SIZE CLASS OF RESORT LAKES	NO. OF RESORT LAKES	NO. OF RESORTS	RESORT DISTRIBUTION BY LAKE FERTILITY CLASS*								% OF ALL RESORTS ON LOW-FERTILITY LAKES
			Very Low		Low		Medium		High		
			No. of Lakes	No. of Resorts	No. of Lakes	No. of Resorts	No. of Lakes	No. of Resorts	No. of Lakes	No. of Resorts	
DRAINAGE LAKES:											
I. Large	22	276		0		0	(15)	199	(7)	77	0
II. Medium Large	33	258		0	(4)	36	(23)	169	(6)	53	3.00
III. Medium	87	341		0	(16)	50	(55)	227	(16)	64	4.17
IV. Small	20	40		0	(3)	4	(13)	29	(4)	7	0.33
Subtotals	162	915		0	(23)	90	(106)	624	(33)	201	7.50
LANDLOCKED LAKES:											
I. Large	3	5	(1)	1	(1)	1	(1)	3		0	0.17
II. Medium Large	5	18	(1)	6	(3)	11	(1)	1		0	1.41
III. Medium	38	98	(10)	14	(23)	65	(5)	19		0	6.58
IV. Small	55	68	(30)	33	(20)	30	(4)	4	(1)	1	5.25
Subtotals	101	189	(42)	54	(47)	107	(11)	27	(1)	1	13.41
SPRING LAKES:											
I. Large	0	0		0		0		0		0	0
II. Medium Large	5	21		0		0	(5)	21		0	0
III. Medium	24	64		0		0	(14)	36	(10)	28	0
IV. Small	9	17		0	(3)	5	(6)	12		0	0.41
Subtotals	38	102		0	(3)	5	(25)	69	(10)	28	0.41
Grand Totals	301	1,206	(42)	54	(73)	202	(142)	720	(44)	230	21.22%

*NOTE—The figures in parentheses indicate number of lakes in each category.

DWELLING DENSITY ON RESORT LAKES

As mentioned previously, non-resort shoreline developments, including cottages, seasonal homes, year-round residences, camps and marinas, affect lake usage by and water availability for resort enterprises. Heavy usage by resorts plus a high concentration of private dwellings can mean an overcrowded condition on the lake concerned. However, both factors can be measured and evaluated, separately and together, to determine the pressure on a given lake in quantitative terms.

Table 5 indicates the cottage-dwelling density on 135 resort lakes in Vilas County, where dwelling counts were taken. The average number was 26.4 dwellings per lake, and the average density was just under 6 dwellings per mile. This rates as a "moderately-low" concentration when measured by the following scale:

Dwellings per Mile of Shoreline	*Concentration or Density Rating*
1 to 4	Low
5 to 10	Moderately Low
11 to 20	Medium
21 to 30	Moderately High
31 to 50	High
51 and Over	Very High

On a given lake, the total number of dwellings (seasonal and year around) is divided by the total miles of shoreline to determine the dwelling density. On the resort lakes studied, this factor varied from 0 to over 20/mile. For the 12 type-size categories of resort lakes, the average dwelling density ranged from 1.18/mile to 9.55/mile, with the greatest variation among landlocked and spring-type lakes. However, this value averaged approximately 6.0 per mile for each of the three major lake types, with spring lakes (6.53) being slightly higher than the two other categories.

Class II landlocked lakes had the greatest dwelling density, 9.55 per mile. Class III spring lakes (with 8.14) and Class IV drainage lakes (with 7.75) had the next highest densities in terms of dwellings per mile of shoreline.

As would be expected, the larger lakes have more dwellings *per lake*, but somewhat fewer per mile of shoreline. However, the differences in dwelling density were rather small, as the following data indicate:

Size Group	No. of Resort Lakes	Dwellings Per Lake	Dwellings Per Mile
I. 1000 Acres +	13	66.2	5.86
II. 501–1000 Acres	23	45.7	5.97
III. 101–500 Acres	58	23.2	5.95
IV. 100 Acres or Less	41	7.5	6.37

In general, lakes of the Oneida–Vilas region are relatively uncrowded in terms of dwelling density, especially when compared to the majority of lakes in southern Wisconsin. Densities of 20 or more dwellings per mile of lakeshore were evident in only a few cases, mostly on smaller lakes. However, when a 100-acre lake has a medium concentration of 11 or more cottages per mile of shore, plus two or more cottage resorts of average size, we are beginning to approach conditions that could easily lead to overcrowding in a few years.

This study of dwelling density involved 3,564 private cottages and homes on 135 resort lakes. This is almost one-third of all such dwellings, which numbered approximately 12,000 in this two-county area in 1964.

Lakes With Large Resorts

There were 25 resort establishments in the Oneida–Vilas area which had 30 bedroom units or more. These enterprises were located on 22 resort lakes, which range in size from 110 acres (smallest) to 3,870 acres. The lake type, size, and general characteristics of these 22 lakes are reported in Table 6.

In general, the larger resorts were located on the larger, better-quality lakes. Although eight of the 22 lakes used were Class III lakes (101 to 500 acres), almost two-thirds of them were Class I or Class II lakes, and the average size of all 22 was over 1,000 acres. All but one of these lakes were of the drainage type, and all but three were medium to high in fertility rating.

These lakes were also popular with cottagers and owners of private dwellings. Only one of the 22 lakes had no dwellings other than resorts, and the other 21 averaged slightly over 7.0 dwellings per mile of shoreline—or about 20% higher than the average dwelling density for all resort lakes. However, this density was more than doubled on four of the 22 resort lakes; these were located fairly close to a major city or village, which may account for the higher densities of 14.5 to 17.4 per mile.

TABLE 5. COTTAGE AND HOME CONCENTRATIONS ON RESORT LAKES (VILAS COUNTY ONLY)

TYPE AND SIZE CLASS OF RESORT LAKES	NO. RESORT LAKES W/COTTAGES AND HOMES	TOTAL NO. COTTAGES AND HOMES	DWELLINGS PER RESORT LAKE (AVE. NO.)	DWELLINGS PER MILE OF SHORELINE (AVE. NO.)
A. DRAINAGE LAKES:				
I. Large	12	849	70.8	6.25
II. Medium Large	18	892	49.5	5.67
III. Medium	36	834	23.2	5.47
IV. Small	15	152	10.1	7.75
Subtotals	81	2,727	33.7 (Ave.)	5.86 (Ave.)
B. LANDLOCKED LAKES:				
I. Large	1	11	11.0	1.18
II. Medium Large	3	127	42.3	9.55
III. Medium	13	239	18.4	5.77
IV. Small	22	136	6.2	6.01
Subtotals	39	513	13.2 (Ave.)	5.92 (Ave.)
C. SPRING LAKES:				
I. Large	0	0	0	0
II. Medium Large	2	33	16.5	3.30
III. Medium	9	271	30.1	8.14
IV. Small	4	20	5.0	3.17
Subtotals	15	324	21.6 (Ave.)	6.53 (Ave.)
Grand Totals	135	3,564	26.4 (Ave.)	5.92 (Ave.)

Five of these 22 lakes appeared to be somewhat "crowded" already—three of them almost certainly because of high dwelling densities. (This will be verified by a field survey and study.) On these five, the WA/R factor was less than 40 acres; and the SL/R factor ranged from 0.25 to 0.59 mile. These figures indicate a limited water area and a rather low shoreline factor per resort, even with a low dwelling density. But three of the five lakes are well above average in this respect, having densities of 7.98, 11.13, and 14.52 per mile. These three lakes are definitely not the most crowded lakes in the Oneida–Vilas area, but their example is noteworthy since each of them contains one of the area's larger resorts on its shores. Another lake in this group of five had two large resorts, but its dwelling density was only 3.48 per mile. Even so, one of the two resorts was being subdivided into lakeshore lots, which may be an indication of its operational problems and the low fertility of the lake. It is believed, however, that problems of this nature which result from over-use of lake resources can be foreseen or better identified by using the space and shoreline factors previously described, along with published information on lake type, depth, fertility, etc.

Lake Depth Important Too

We have said very little about water depth, an important factor in lake quality, because shallow lakes (under 10 feet of depth) are often small and have been largely ignored by resort developers and second-home builders. Such lakes have esthetic and wildlife values, but are often limited as to fishery and boating or swimming opportunities. Many of these shallow lakes, especially the landlocked variety, have a regular or periodic winterkill of fish; thus they are often referred to as "winterkill lakes." Wisconsin has more than one thousand of this type.

Depth is usually a major factor in winterkill, since these lakes generally have a maximum depth under 10 feet and are likely to have a high percentage of their surface area under five feet deep. However, shallow lakes of the drainage or spring type are frequently not subject to winterkill, whereas certain other lakes up to 20 feet in maximum depth may have die-offs regularly.

Threinen's reports indicate that there are approximately 546 lakes with a maximum depth of nine (9) feet or less in this two-county area. The majority of these are small and unnamed, but at least 16 of them are resort lakes. In fact, almost one-third of the 301 resort lakes have a maximum depth under 20 feet.

There are at least 118 known winterkill lakes in Vilas County (with an average maximum depth of 6.1 feet), and probably as

TABLE 6. LAKE CHARACTERISTICS ASSOCIATED WITH THE 25 LARGEST RESORT ESTABLISHMENTS IN THE ONEIDA–VILAS AREA OF WISCONSIN

Name and Type of Lake		No. of Resorts on Lake	Resort Lake Characteristics				
Name	Type		Size (In Acres)	Fertility Rating	WA/R (Acres)	SL/R (Miles)	Dwellings per Mile
Trout	D-I	12	3,870.0	M	322.5	1.58	3.26
Tomahawk	D-I	14	3,626.6	H	259.0	2.05	5.26
Lac Vieux Desert	D-I	14	2,853.0	M	203.8	1.18	4.18
Squirrel	D-I	13	1,352.0	H	104.0	0.88	7.28
Minocqua	D-I	15	1,285.0	H	85.7	1.23	14.65
White Sand	D-I	9	1,195.0	M	132.8	0.61	15.45
Star	D-I	3	1,150.0	M	383.3	3.93	1.61
Little St. Germain	D-II	38	956.0	M	25.2	0.34	7.98
Plum	D-II	15	938.0	H	62.5	0.92	4.42
Long	D-II	7	872.0	M	124.6	1.13	7.97
Eagle	D-II	4	591.0	M	147.7	1.15	9.57
Lost	D-II	14	541.0	L	38.6	0.33	3.48
Boulder	D-II	6	525.0	H	87.5	1.07	2.19
Big Manitowish	D-II	12	506.0	M	42.2	0.65	6.92
Moen	D-III	8	460.0	L	57.5	0.49	17.44
George	D-III	15	434.5	M	29.0	0.41	14.52
Thompson	D-III	9	382.4	M	42.5	0.87	9.74
Spirit	D-III	4	342.4	M	85.6	1.00	4.00
Spider	D-III	9	256.0	M	28.4	0.59	11.13
Deer	D-III	3	174.7	L	58.2	1.34	6.50
Garth	L-III	1	114.1	M	114.1	1.80	3.33
Brandy	D-III	8	110.0	M	13.8	0.25	0
Averages		10.6	1,024.3	M+	111.3	1.08	7.31

many more in Oneida County. A number of resort lakes are in this group. This study revealed 46 resorts on 21 winterkill lakes, 30 in Oneida County and 16 in Vilas County (almost 4% of all resorts). All in all, there were 27 resorts on 16 lakes with a maximum depth of nine feet or less, and a total of 333 resorts on lakes that were under 20 feet in depth. Most of these shallow resort lakes, however, were not subject to severe winterkill.

There are also some resort locations in this region that experience a periodic "summerkill" of fish, particularly in algae-laden bays of fertile lakes. Both winterkill and summerkill conditions tend to reduce recreational opportunities or esthetic values for resort guests, and lakes subject to them cannot be considered as good sites for resort operation or development.

Summary and Discussion

There are 951 named lakes in the Oneida-Vilas area of Northeastern Wisconsin, of which 301 were used by resorts in 1964. Of the 301 resort lakes, 162 were drainage type, 101 were landlocked, and 38 were spring-type lakes. The distribution of resort enterprises was 915 on "D" lakes, 189 on "L" type, and 102 on "S" lakes. Almost three-fourths of all establishments were on "D" lakes over 100 acres in size. About one-fourth of the resorts were on Class I lakes (over 1,000 acres). Another fourth were on Class II lakes (501 to 1,000 acres), and about two-fifths were on Class III lakes (101 to 500 acres). The remainder (10.37%) were on Class IV lakes (100 acres or less).

Well over half of all resorts (62.2%) had a WA/R ratio (water acreage per resort) of 80 acres or less. One-fourth of them had under 40 acres of water. About one-fifth had a SL/R factor of 0.5 mile or less, under ½ mile of shoreline per resort. Over one-fifth of all resorts were on 115 lakes of low or very low fertility; 78.7% were on 186 lakes of medium or high fertility. Almost 5% of the resorts were on 42 landlocked lakes of very low fertility, and well over 3% were on winterkill lakes.

On these resort lakes, dwelling densities averaged almost six buildings per mile of shore. Over 75% of all resorts and almost 75% of all dwellings were on drainage-type lakes.

A study of the lake characteristics associated with the 25 largest resort establishments in the region was included. This group of 22 resort lakes averaged 1,024 acres each, and all but one were drainage-type lakes. Only three of these lakes had a low fertility rating, 14 were medium and 5 were highly fertile. Five of these lakes showed signs of being overdeveloped, with low WA/R and

SL/R values coupled with above-average concentrations of dwellings. Dwelling densities for these lakes averaged slightly over seven buildings per mile, with a range of 1.61 to 17.44 per mile, compared to an average of 5.92 for all resort lakes. In general, the larger resorts, all of which had 30 bedroom units or more, were associated with the larger, more fertile, and better-quality lakes.

As a result of this study and related field observations, the following comments and suggestions are offered:

1. Resorts should not be located on any lake under 50 acres in size. In fact, it is felt that no motors or powerboats should be operated on these small bodies of water, particularly landlocked lakes. Yet 4.6% of all resorts in the Oneida–Vilas area were situated on lakes in this group.
2. It is questionable whether any resorts should be situated on *landlocked* lakes smaller than 100 acres, as they are usually infertile and easily damaged. Motors rated over 10 h.p. should not be used on them. This region had a total of 68 resorts on such lakes.
3. A minimum of 40 acres of surface water per resort is recommended on lakes where dwelling densities are low or moderately low (10 or fewer dwellings per mile). With medium dwelling densities (11 to 20 per mile), the WA/R factor should be at least 50 acres. When the density is greater, 21 or more dwellings per mile, this "space" value could be 60 or higher. One-fourth of all lakes in the Oneida–Vilas area had WA/R values under 40, and 87 resorts on 29 lakes showed WA/R values of 20 or less.
4. The SL/R factor, miles of shoreline per resort, ought to be 0.50 or more, since most of the water-based recreation is related to the use of shoreline. Yet 19% of all resorts in this area had SL/R values of 0.50 or less, and 33 resorts on five lakes had SL/R values under 0.25 mile.
5. Resort lakes should preferably have a fertility rating of "medium" or higher. Those with a low—and especially a very low—fertility rating just cannot withstand the present day fishing pressures and produce game fish of satisfactory quantity or quality. Yet, 54 resorts (4.5% of all resorts in this region) were located on lakes of very-low fertility.
6. The dwelling density on a given lake should be under 20 per mile, if that lake is to provide the kind of seclusion and recreational opportunity that most resort guests are seeking when they come to Northern Wisconsin. Only a few resort lakes in the Oneida–Vilas area are now approaching this figure. However, with the rapid increase in "second homes" and private

lake cottages, many lakes will probably become rather heavily developed and thus lose their northwoods atmosphere, even with land-use zoning and other building regulations.

7. Certain kinds of lakes should probably be avoided, by new resort enterprises at least, aside from the basic size, type, and fertility characteristics they possess. These lakes might include:

    a. Very shallow lakes where the maximum depth is under 10 feet, regardless of lake type.
    b. Winterkill lakes with a known history of regular or periodic fish die-offs during winter months because of oxygen deficiencies.
    c. Summerkill lakes with low-oxygen areas at certain periods in the summer season.
    d. Highly-acid, bog-type lakes with brownish water and low fertility. Such lakes usually have a high percentage of soft, marshy shoreline—and thus may never be crowded—but their fishery is usually too limited and the water color and quality is not desirable for recreationists.
    e. High-algae lakes that produce greenish or brownish "blooms" and scum quite regularly each summer. Such lakes are usually highly fertile, and hence may be good for fishing, but the odors and esthetic characteristics are objectionable to swimmers, boaters and vacationers in general.
    f. Lakes seriously affected by pollutants of any type.

8. It is urged that a comprehensive lake use and conservation plan be prepared as soon as practicable for each and every inland lake of 500 acres or more in Wisconsin. Ultimately, perhaps by 1975, a detailed plan could be developed for each of our 1,200 lakes and flowages that are over 100 acres in size. These inventory studies, which include the findings and recommendations of qualified lake specialists, would provide the following information:

    1. Geographic description
    2. Physical features (of lake and basin)
    3. Water quality and chemical data
    4. Aquatic resources
    5. Shoreline and related resources
    6. Present land use and development
    7. Current and future problems
    8. Protection measures needed
    9. Lake use possibilities and future development

This report, which involved over 25% of Wisconsin's resorts and inland lakes, suggests that we need to take a more careful look at our lake resources and how they are used. These resources are more valuable with each passing year, but they also are quite vulnerable to misuse and are highly perishable. In some cases, it appears that lakes too small, too infertile, and too shallow are being used. A few of the better lakes seem to be overcrowded already, and water pollution is in evidence. Perhaps the time has arrived for a re-evaluation and careful study of resort patterns and the resort lakes being used or developed. Such an effort would help to insure the protection of these most valuable resources and will benefit Wisconsin's recreation industry as well.

REFERENCES

ANDREWS, L. M. and C. W. THREINEN. (1966) *Surface Water Resources of Oneida County.* Conservation Division, Wis. Dept. Natural Resources, Madison. 284 pp.

BIRGE, E. A. and CHAUNCEY JUDAY. (1914) *The Inland Lakes of Wisconsin.* Bulletin No. 27, Series 9, Wis. Geol. and Nat. History Survey, Madison. 137 pp.

BLACK, J. J., L. M. ANDREWS, and C. W. THREINEN. (1963) *Surface Water Resources of Vilas County.* Conservation Division, Wis. Dept. Natural Resources, Madison. 318 pp.

FINE, I. V. (1966) *Wisconsin and The Vacationer.* Wisconsin Department Resource Development, Madison, 25 pp.

FINE, I. V. and R. E. TUTTLE. (1962) *Wisconsin Vacation-Recreation Papers,* Vol. II, No. 3. University of Wisconsin, Madison, 24 pp.

FINE, I. V. and E. E. WERNER. (1960) The Wisconsin Vacationer, *Wisconsin Vacation-Recreation Papers,* Vol. I, No. 11. University of Wisconsin, Madison, 15 pp.

HUMPHRYS, C. R. and J. O. VEATCH. *Classifications for Michigan's Inland Lakes.* Water Bulletin No. 8, Dept. Resource Development, Michigan State University, East Lansing. 18 pp.

MONTHEY, L. G. (1963) *Classification and Inventory of Tourist-Lodging Businesses in Wisconsin.* Recreation & Touristry Notes RT-01, University of Wisconsin. 10 pp.

MONTHEY, L. G. (1964) *The Resort Industry of Wisconsin.* Wis. Academy Science, Arts & Letters Transactions, Vol. 53—Part A, pp. 79–94.

THREINEN, C. W. (1962) *Some Spatial Aspects of Aquatic Recreation.* Fish Management Misc. Report No. 6, Conservation Division, Wis. Dept. Natural Resources, Madison, 11 pp.

Wisconsin Lakes. (1968) WCD Publication 218–68, Conservation Division, Wis. Dept. Natural Resources, Madison. 36 pp.

WCD Lake Use Report No. FX-31. *Booth Lake, Walworth County, Wisconsin.* (1968) Conservation Division, Wis. Dept. Natural Resources, Madison. 16 pp.

GLACIAL GEOLOGY OF NORTHERN KETTLE MORAINE STATE FOREST, WISCONSIN

Robert F. Black

Abstract

More than a century ago typical stagnant-ice features were recognized and correctly interpreted in the world-famous Kettle Interlobate Moraine in eastern Wisconsin. The common border of the Green Bay and Lake Michigan lobes of late-Woodfordian age. (Cary) is a drainageway established on and partly let down from the surface junction of the two lobes. In the Northern Kettle Moraine State Forest that drainageway, now 0.5 to 3.0 miles wide, is a marked depression that is floored largely with stratified clastics. Rising abruptly from the center of the depression are numerous striking moulin kames and from the flanks numerous crevasse fills, eskers, kames, and other stagnant-ice features that constitute "end" moraines of the two lobes. The "end" moraines are 0.5 to 3.0 miles wide and merge abruptly up ice into ground moraine with drumlins and scattered stagnant-ice features. Abrupt bends in the interlobate moraine seem related to bedrock topography and local direction of ice movement of the opposing lobes.

Many representative stagnant-ice features are preserved in the Northern Kettle Moraine State Forest, but most of the moulin kames are outside it. These kames are the best examples to be found for hundreds of miles around and are among the best to be found in the world. However, they are being destroyed rapidly because of the demand for construction aggregates.

Introduction

Since its inception in 1937, the Northern Kettle Moraine State Forest and environs has been one of the more popular public recreational areas in Wisconsin. The center of the Forest is only 45 miles north of Milwaukee (Fig. 1) and serves especially the heavily populated area from Chicago north to Green Bay. The Forest contains many excellently developed and representative glacial features which are internationally famous, but others even more important or striking lie just outside it. The kettles—depres-

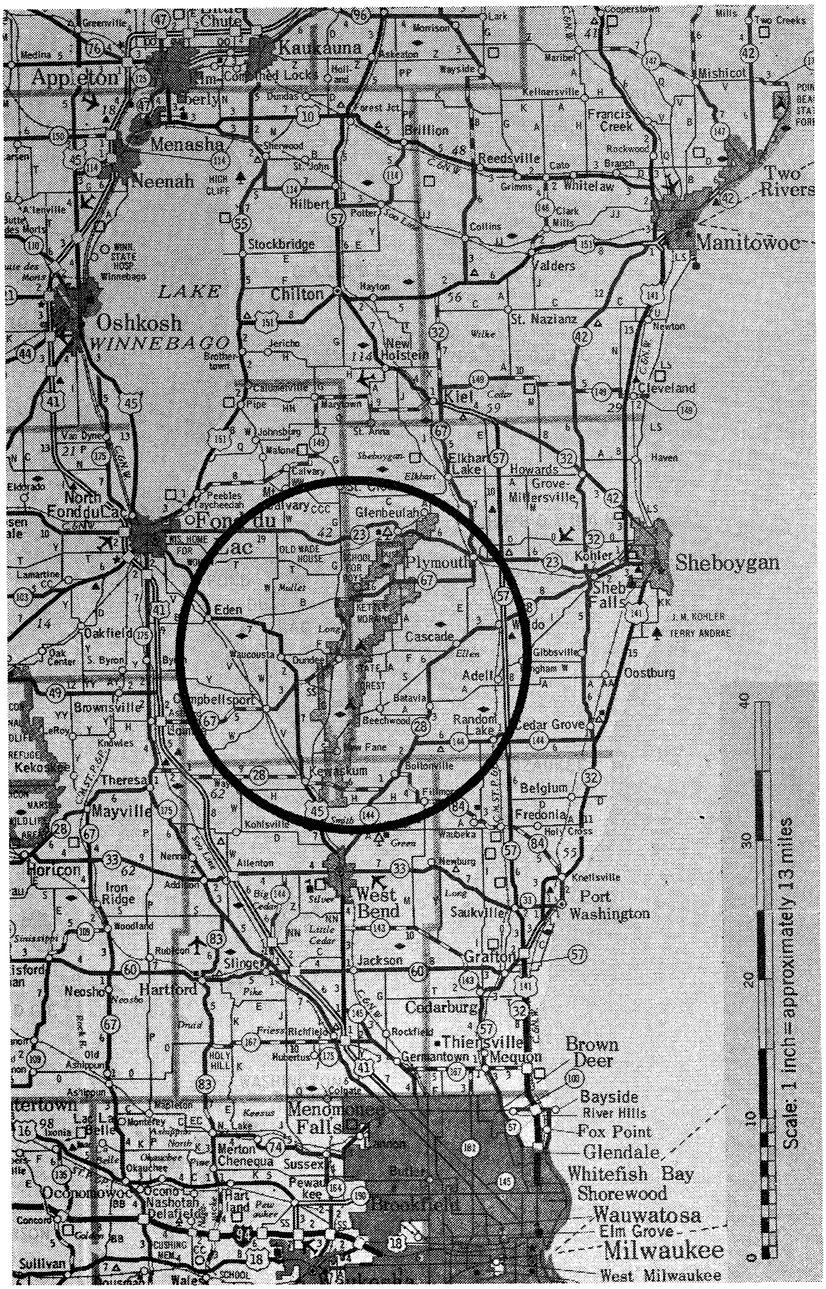

FIGURE 1. Portion of the official Wisconsin State Highway Map, centering on the Northern Kettle Moraine State Forest.

sions from the melting out of buried ice blocks—are the first in the world to have been described adequately and interpreted correctly (Whittlesey, 1860 and 1866; Chamberlin, 1877 and 1878; White, 1964). Alden (1918, p. 308) cited the area east and northeast of Kewaskum (Fig. 2) as ". . . one of the finest examples of terminal-moraine topography in the United States." Many thousands of tourists and students each year who visit the Forest do so in part because of their interest in the various glacial features, of which many may be seen along the Kettle Moraine Drive (Fig. 2). It seems timely to outline for them the glacial history of the area as we now know it, because the earlier literature is largely out of print and not focused specifically on the Forest area.

The Northern Kettle Moraine State Forest includes some 24,000 acres in a very irregular area about 22 miles long and 1 to 4 miles wide (Fig. 1). It extends from the vicinity of Glenbeulah in Sheboygan County southwesterly and then southerly to the vicinity of County Highway H, about three miles southeast of Kewaskum, in Washington County. The Forest encompasses much of the area along the common boundary between Fond du Lac and Sheboygan Counties. In and adjacent to the Forest a variety of topographic features rise abruptly some tens of feet to 200 or 300 ft. above prominent lowlands. The precipitous wooded slopes interspersed between typical well-kept Wisconsin farmlands (Fig. 3) and abundant lakes (Fig. 4) makes the area especially photogenic. The numerous lakes and the wooded hills and trails make for an ideal vacation land close to major centers of population.

The Northern Kettle Moraine State Forest lies athwart the internationally famous Kettle Interlobate Moraine. The moraine, as the name implies, was built between two ice lobes—the Green Bay lobe on the west and the Lake Michigan lobe on the east (Alden, 1918, p. 308–309)—during Woodfordian time, between 13,000 and 22,000 radiocarbon years ago (Black and Rubin, 1967–68). This is the ". . . master topographic feature of the whole series of glacial deposits in eastern Wisconsin" (Alden, 1918, p. 235) which first attracted the attention of early explorers. The moraine consists of silt and sand and coarse, angular to well-rounded rock fragments of the local light grey Niagaran dolomite particularly, but also of rocks from northern Wisconsin, Upper Michigan, and Canada. The composition and texture of the drift comprising the moraine varies markedly from place to place within the area. The drift was dumped between the two lobes of ice as they butted against each other and was also deposited under and on top of the dirty ice along that junction during the final stagnation and destruction of the ice. Hence, some debris was deposited directly from the ice,

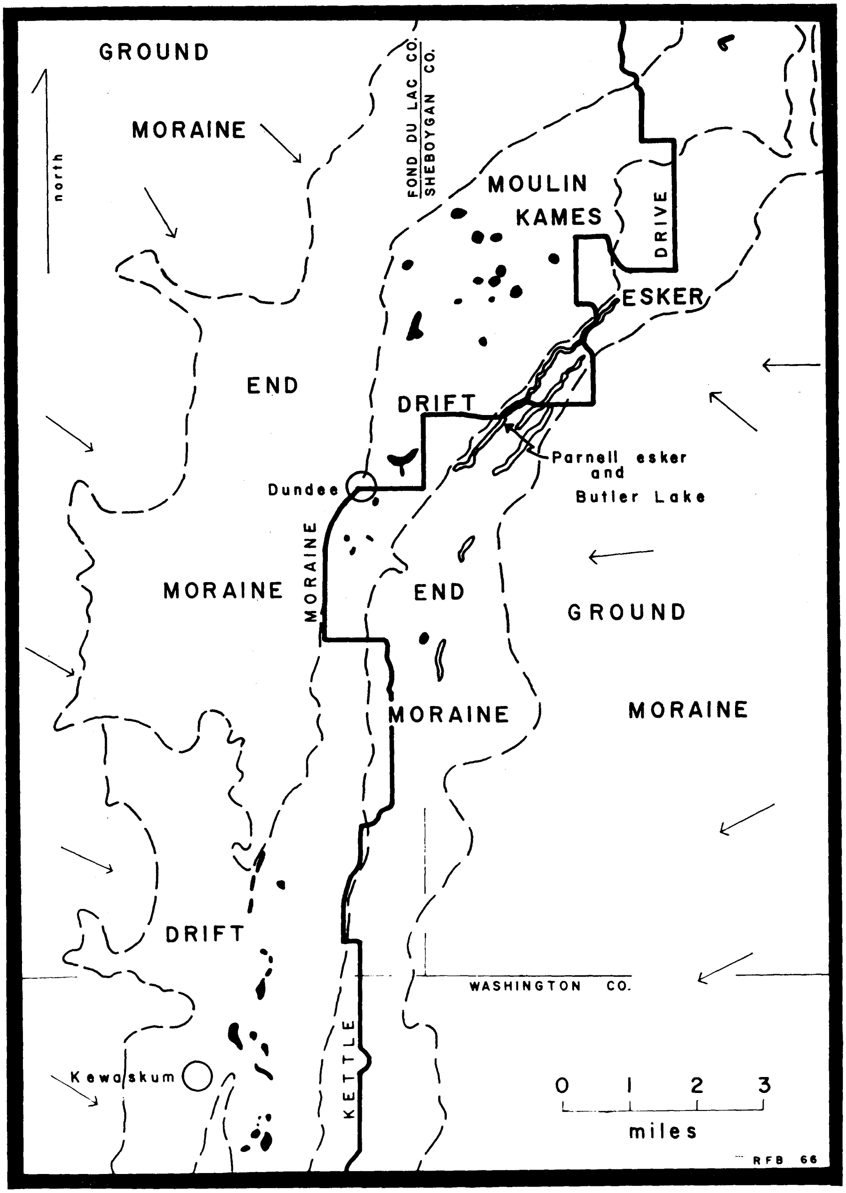

FIGURE 2. Part of the Northern Kettle Moraine State Forest and environs showing the Kettle Moraine Drive and its relation to the major glacial features. Local direction of ice movement is shown by arrows. Base from portions of Campbellsport and Kewaskum topographic quadrangles of the U. S. Geological Survey. Mapping was done largely from air photos, with local field checks.

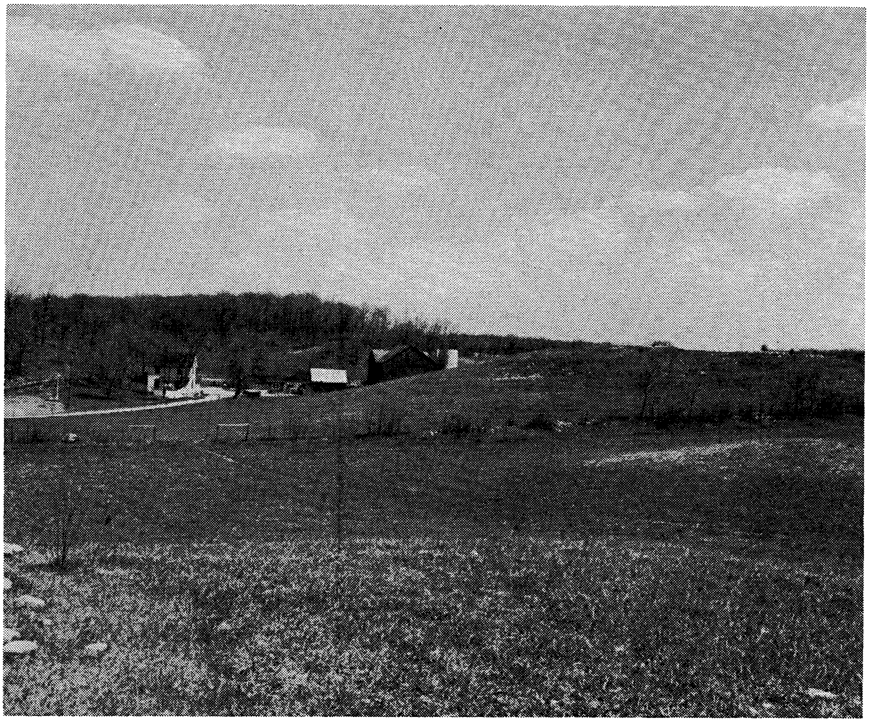

FIGURE 3. Typical farm and wooded hills in the Kettle Interlobate Moraine, 1.5 miles south of Glenbeulah. Note light-colored, rounded cobbles of Niagaran dolomite.

but other material was displaced and reworked by gravity movements and running water. Glacial-fluvial and glacial-lacustrine deposits are especially common. The buried blocks of glacial ice subsequently melted out, pitting the surface with thousands of irregular kettles from a few feet (Fig. 5) to several miles in extent.

A privately owned area within the northcentral part of the Forest, northeast of Dundee (Fig. 2), contains one of the most striking groups of moulin kames (conical hills of drift deposited under the ice) to be found anywhere in the world (Figs. 6 and 7). [Moulin (moo′lăn′) Fr., is defined by Webster's dictionary as "A nearly vertical shaft in a glacier into which a stream of water pours." The debris carried in by the water is piled up at the base of the moulin, building the moulin kame.] The kames should be protected immediately from further exploitation as they are the best examples to be found for hundreds of miles around. Several

FIGURE 4. Butler Lake, a kettle lake, as seen from the top of the Parnell esker, 2.5 miles northeast of Dundee.

less well developed or less "showy" moulin kames in another group east and north of Kewaskum have already been destroyed.

Relatively few studies have been made of the glacial phenomena in the Kettle Interlobate Moraine or of their detailed history. Much of what we know was learned 50 to more than 100 years ago when Wisconsin's outstanding glacial geologists of that heyday were active in their reconnaissance studies of the State. Far more information yet awaits discovery through detailed systematic investigations than we have learned in our various rapid reconnaissance observations. This means that even the interested layman may unearth critical discoveries which can perhaps provide important clues to the geologic history of the area. The serious student will use the following U. S. Geological Survey topographic maps in his

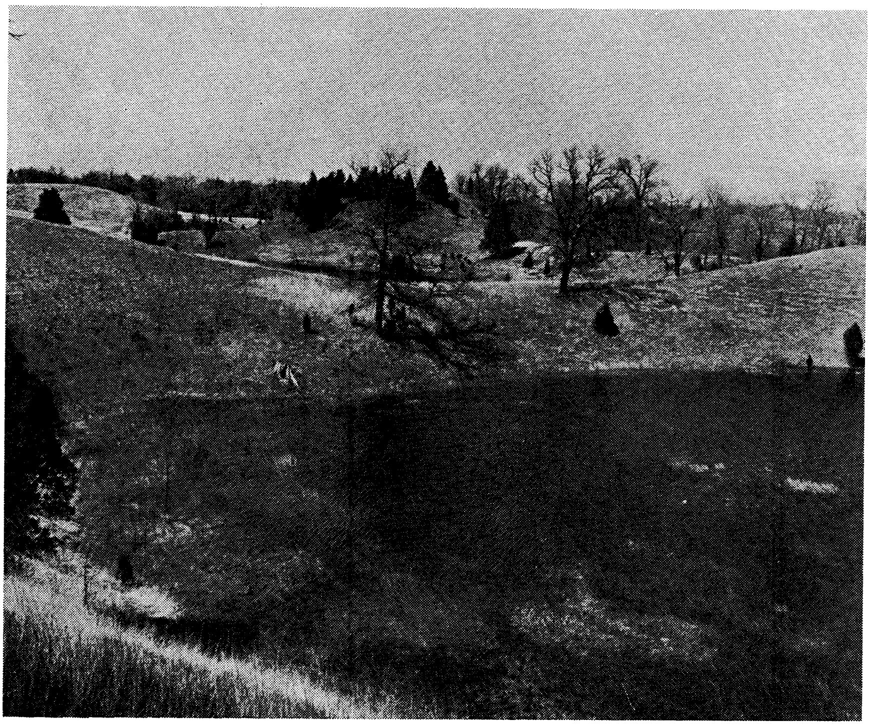

FIGURE 5. Knob and swale topography, 1.5 miles southwest of Dundee. Some rounded knobs are kames and others are till. The elongate ridges are crevasse fills; the ponds occupy kettles.

visit to the area: Kiel, Kewaskum, West Bend, Campbellsport, and Sheboygan Falls. The place names used herein refer to those maps, but they cannot be reproduced here.

The Kettle Interlobate Moraine was last mapped by Alden (1918) as part of a reconnaissance in southeastern Wisconsin and has hardly been touched since. Much study is needed to modify his findings significantly or to understand fully the history of individual forms or even of many large units. Different interpretations are possible within the framework of existing data. However, it seems clear that several local fluctuations of the two lobes were involved during Woodfordian time. The junction thus is a zone of partial mixing or interstratifying of material from each lobe. Outwash gravel and other glacial deposits were reworked and redeposited, commonly on pre-existing ice, as the junction shifted back and forth.

The area is so large and diverse that it is not feasible nor necessary for purposes of this report to describe each feature. Rather,

FIGURE 6. Moulin kames from left to right—McMullen Hill, Conner Hill, and Johnson Hill—northeast of Dundee.

part of the area is subdivided largely by air photo interpretation into mappable units or groups of similar geomorphic features (Fig. 2). These are not pure units because of the almost infinite detail available within any relatively small segment. Nonetheless, they serve to emphasize such features as end moraines and stagnate-ice or "dead-ice" moraine with knob and swale topography (Fig. 5), moulin kames (Figs. 6–8), outwash, eskers (Figs. 9 and 10), crevasse fills (Fig. 5), kettles (Figs. 4 and 5), and the like. These and other features are described more fully later.

Because of its variety and superb development of "text-book" features, its proximity to centers of population and heavy recreational use, and its historical importance in the development of concepts in glacial geology, this area is one of the most important in

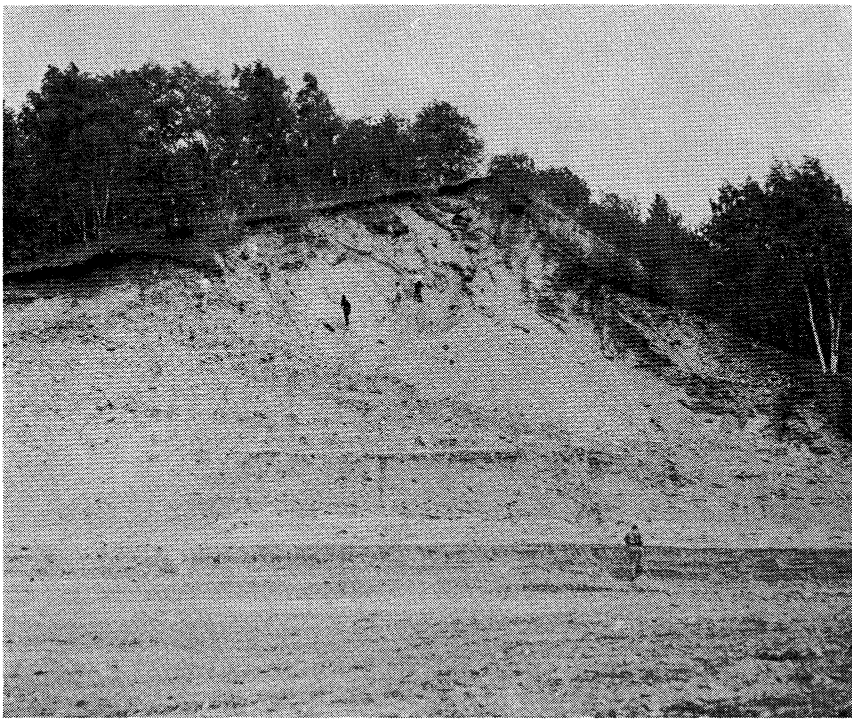

FIGURE 7. Cut in Garriety Hill, a moulin kame northeast of Dundee.

the State. Further expansion of the Forest, in spite of high land values, is exceedingly desirable and cannot wait long before many features will be irrevocably lost.

GENERAL DESCRIPTION OF THE MORAINE

In 1876 T. C. Chamberlin orally presented a paper to the Wisconsin Academy of Sciences, Arts, and Letters on the extent and significance of the Wisconsin Kettle Moraine (Chamberlin, 1878). In those days when great geologists were formulating principles of the concepts of glacial geology, Chamberlin was a true giant among them (Fenton and Fenton, 1952). Although today some of his words and phrases are no longer popular and editors would cut and prune his remarks in order to save space, Chamberlin's description of the moraine bears the test of time so well that this writer feels compelled to quote him directly. In describing the surface form of the moraine he wrote: "The superficial aspect of the formation is that of an irregular, intricate series of drift ridges and hills of rapidly, but often very gracefully, undulating contour,

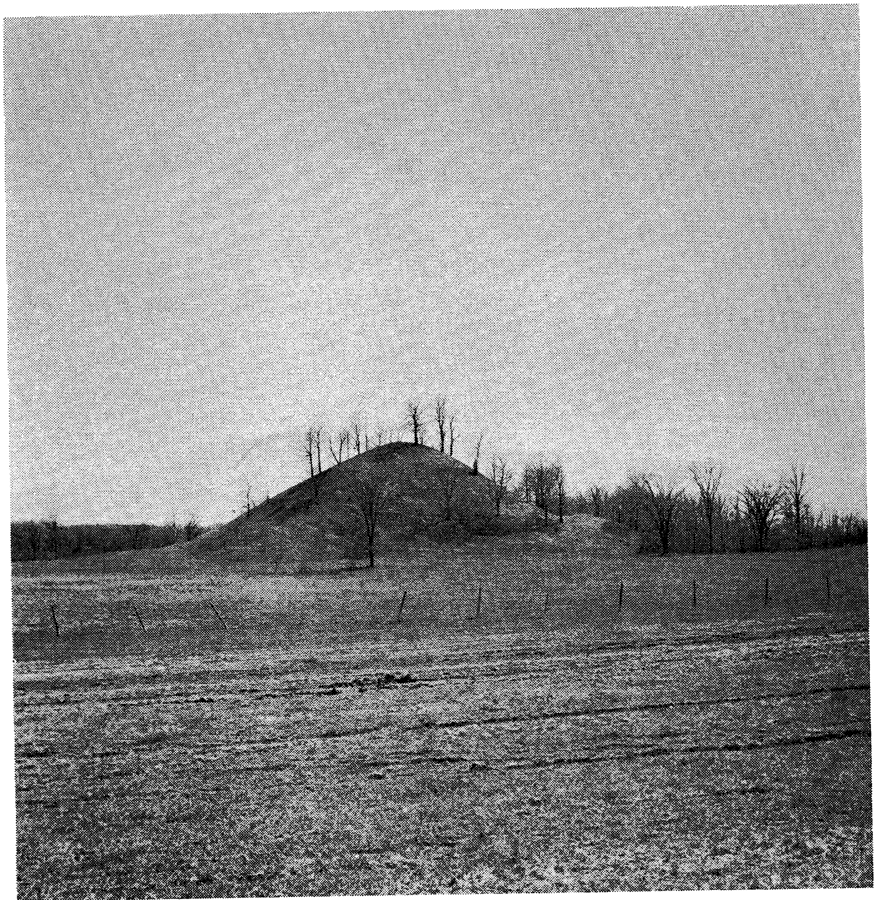

FIGURE 8. A small moulin kame, 0.3 miles southeast of Dundee.

consisting of rounded domes, conical peaks, winding and, occasionally, geniculated ridges, short, sharp spurs, mounds, knolls and hummocks, promiscuously arranged, accompanied by corresponding depressions, that are even more striking in character. These depressions, which, to casual observation, constitute the most peculiar and obtrusive feature of the range, and give rise to its descriptive name in Wisconsin, are variously known as 'Potash kettles,' 'Pot holes,' 'Pots and kettles,' 'Sinks,' etc. Those that have most arrested popular attention are circular in outline and symmetrical in form, not unlike the homely utensils that have given them names. But it is important to observe that the most of these depressions are not so symmetrical as to merit the application of these terms. Occasionally, they approach the form of a funnel, or

FIGURE 9. Part of the Parnell esker and Butler Lake, as seen from the air, at a geologic marker.

of an inverted bell, while the shallow ones are mere saucer-like hollows, and others are rudely oval, oblong, elliptical, or are extended into trough-like, or even winding hollows, while irregular departures from all these forms are most common. In depth, these cavities vary from the merest indentation of the surface to bowls sixty feet or more deep, while in the irregular forms the descent is not unfrequently one hundred feet or more. The slope of the sides varies greatly, but in the deeper ones it very often reaches an angle of 30° or 35° with the horizon, or, in other words, is about as steep as the material will lie. In horizontal dimensions, those that are popularly recognized as 'kettles' seldom exceed 500 feet in diameter, but, structurally considered, they cannot be limited to this dimension, and it may be difficult to assign definite lim-

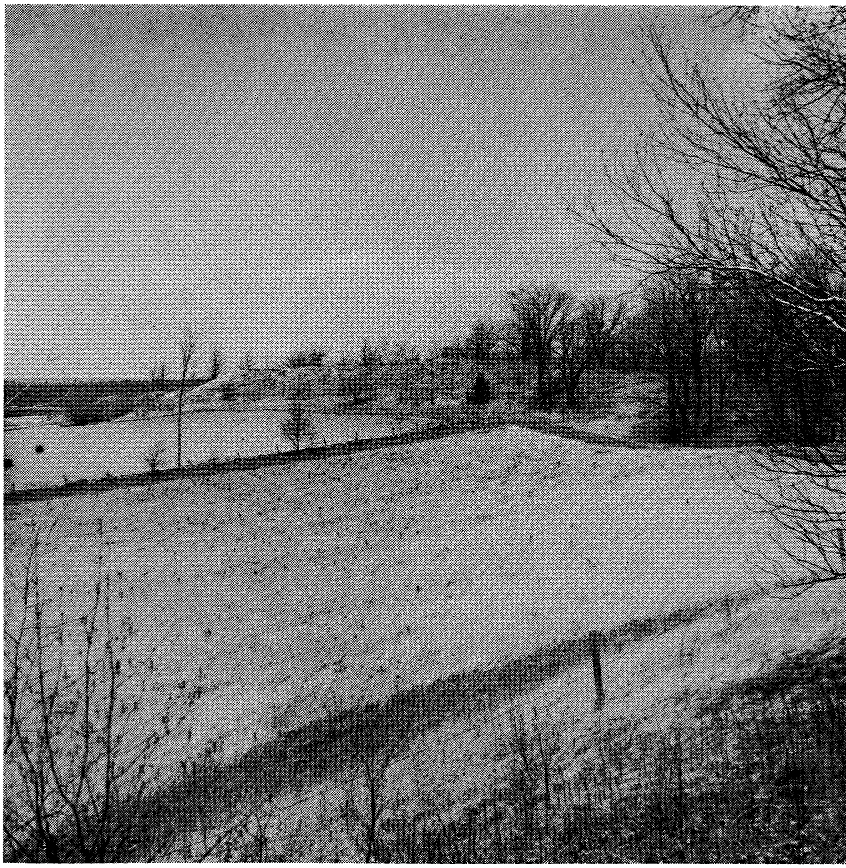

FIGURE 10. Part of the Parnell esker, near Butler Lake, as seen on the ground.

its to them. One of the pecularities of the range is the large number of small lakes, without inlet or outlet, that dot its course. Some of these are mere ponds of water at the bottom of typical kettles, and from this, they graduate by imperceptible degrees into lakes of two or three miles in diameter. These are simply kettles on a large scale.

"Next to the depressions themselves, the most striking feature of this singular formation is their counterpart in the form of rounded hills and hillocks, that may, not inaptly, be styled inverted kettles. These give to the surface an irregularity sometimes fittingly designated 'knobby drift.' The trough-like, winding hollows have their correlatives in sharp serpentine ridges. The combined effect of these elevations and depressions is to give to the surface an entirely distinctive character.

"These features may be regarded, however, as subordinate elements of the main range, since these hillocks and hollows are variously distributed over its surface. They are usually most abundant upon the more abrupt face of the range, but occur, in greater or less degree, on all sides of it, and in various situations. Not unfrequently, they occur distributed over comparatively level areas, adjacent to the range. Sometimes the kettles prevail in the valleys, the adjacent ridges being free from them; and, again, the reverse is the case, or they are promiscuously distributed over both. These facts are important in considering the question of their origin.

"The range itself is of composite character, being made up of a series of rudely parallel ridges, that unite, interlock, separate, appear and disappear in an eccentric and intricate manner. Several of these subordinate ridges are often clearly discernible. It is usually between the component ridges, and occupying depressions, evidently caused by their divergence, that most of the larger lakes associated with the range are found. Ridges, running across the trend of the range, as well as traverse spurs extending out from it, are not uncommon features. The component ridges are themselves exceedingly irregular in height and breadth, being often much broken and interrupted. The united effect of all the foregoing features is to give to the formation a strikingly irregular and complicated aspect." (Chamberlin, 1878, p. 202–204).

Chamberlin in actuality was referring to the surficial features of the end moraine of what is now called the late Woodfordian or Cary ice as it was deployed through the entire State of Wisconsin and not just the interlobate moraine in what is now the Northern Kettle Moraine State Forest. Nonetheless, his description can scarcely be improved upon for the area.

In speaking of the nature of the material, Chamberlin (1878, p. 205) emphasized that ". . . *all* the four forms of material common to drift, vis.: clay, sand, gravel, and boulders, enter largely into the constitution of the Kettle range, in its typical development. Of these, gravel is the most conspicuous element, *exposed to observation.*" Chamberlin (1878, p. 210) further recognized that most bedrock units in Wisconsin and Upper Michigan were represented in any one section of the drift, including native copper from Keweenaw Peninsula, but that the bulk of the drift was derived locally. Thus, most gravel is composed of the local white to very light gray Niagara dolomite, well rounded by water work. However, we now know that more than one local advance of ice was involved and that reworking of outwash gravel by later advances was commonplace. Hence, some constructional forms contain nonstratified gravel instead of till. Deposition of the reworked gravel directly from ice without water working took place.

Other details of the moraine in Wisconsin were presented early, and it was compared with its counterpart in other states (Chamberlin, 1877 and 1883). In the latter paper, the term "interlobate moraine" was first introduced (Chamberlin, 1883, p. 276) and properly diagnosed as to origin in contrast to normal medial moraines. A reconstruction of the ice flow directions (Fig. 11) demonstrates conclusively the lobate character of the ice and the opposing movements of the junction of the two lobes. This gross story has changed little in the intervening 90 plus years.

Chamberlin's important role in the development of the concepts of glacial geology would not have been possible were it not for the clear observations and lucid writings of his predecessors. In connection with the Kettle Interlobate Moraine, Charles Whittlesey is singled out. It was he (White, 1964) who in the mid-1800's first recognized the "kettle moraine" and correctly interpreted the origin of the kettle holes to buried glacial ice rather than to drifting icebergs as was in vogue at the time. This was truly astonishing insight, and is but one of the major accomplishments of that amazing man.

The Greenbush Kettle, two miles south of Greenbush on the Kettle Moraine Drive, has been favored with a geological marker sign for years. It is one of the most symmetrical deep circular depressions visible from the road. Many others are more irregular (Figs. 4 and 5) but just as typical whether with or without water in them.

In brief, the Northern Kettle Interlobate Moraine is conspicuous because of its more abrupt irregularity and sharpness of feature compared with the undulating ground moraine with smoothly contoured drumlins and till-covered bedrock rises on both sides. The light grey gravel of the Interlobate Moraine also contrasts markedly with the reddish brown and light yellowish brown sandy till of the ground moraine. Neither its maximum elevation (1,311 feet at Parnell tower, 5.8 miles northeast of Dundee) nor its general relief of 100 to 200 feet are significantly different from the till plains and drumlins adjoining. However, it is characterized by major lowlands at 950 to 1,000 feet, such as that occupied by Long Lake and the East Branch of the Milwaukee River. The flatness of such lowlands and the abrupt rise of drift deposits flanking them also emphasize the glacial features. Farming of the lowlands contrasts with the wooded drift hills to spice the view.

DRAINAGE

The Kettle Interlobate Moraine lacks an integrated drainage network. Many closed depressions drain through the coarse gravel below and do not need surface streams. Others intersect the ground water table and have perennial ponds or lakes. Elkhart Lake, a large kettle north of the Forest, with high land around it, drains westward to Sheboygan Marsh and the Sheboygan River. Crystal Lake, next south of Elkhart Lake, has no outlet. However, Mullet River (see U. S. Geol. Survey topographic map—Kiel) flows by only ¼ mile to the southwest in its arc around the north end of the Kettle Moraine Forest. It continues southeasterly and eastward in a tortuous route to join the Sheboygan River at Sheboygan Falls. Interestingly, those two rivers have adjoining headwaters, and their uppermost courses are parallel yet flowing in opposite directions about one mile apart northwest of Long Lake. Both rivers have very intricate courses to Lake Michigan, probably in part controlled by fracture patterns in the stagnating ice which permitted the supraglacial streams to superpose themselves on the underlying drift and bedrock.

The East Branch of the Milwaukee River, flowing southward into the Milwaukee River southeast of Kewaskum, drains most of the Northern Kettle Moraine Forest proper. Its course follows the trend of the moraine and generally lies almost precisely on the reconstructed boundary between the two lobes of ice. (This is somewhat west of the boundary indicated by Alden, 1918, pl. 3). Probably its origin dates back to the initial abutment of the ice of the two lobes where it developed in the axial depression along that junction. It has remained apparently in that position since.

In the wastage of the Lake Michigan lobe, however, additional channels were formed on the stagnating ice. Mink Creek lies in a channel that starts about two miles northeast of Parnell and flows generally southerly past Beechwood in a course with abrupt right-angle bends. These seem also to reflect the fracture pattern of the ice as the initial stream was let down on the surface below. Many other examples exist in the area, but no detailed three-dimensional field study of any of them has been attempted. They need to be integrated into the history of the Moraine.

ORIGIN OF THE GLACIAL FEATURES

Figure 2 shows the distribution of some glacial features that characterize certain parts of the area. For convenience in the classification, each unit is named for the most abundant or striking feature or features it contains. These units are: Ground moraine (and drumlins), drift, end moraine (or stagnate-ice or dead-ice moraine), and special features such as moulin kames and eskers. Ground moraine with drumlins and till-covered bedrock rises comprises most of the area up ice from the front of both lobes. Small stagnate-ice features in that unit are common. The orientation of drumlins, fluted forms, and striae recorded by earlier workers and summarized by Alden (1918, pl. 4) show clearly the regional movements of the ice of both lobes. Arrows on Figure 2 show local trends of the ice recorded by drumlinoid or fluted forms. Even though the general deployment of ice shown in Figure 11 and by Alden (1918, pl. 4) is not expected to be changed in gross form, detailed field work is needed to show ice movement in relation to individual segments of the moraine. Bedrock striae formed in early advances during Woodfordian time are not everywhere parallel with the alignment of molded forms—the last to be produced.

In the area of Figure 2, stratified drift, including outwash, glacial-lacustrine deposits and other water-formed features, are almost as prevalent as end moraine or stagnate-ice or dead-ice moraine formed more directly by the ice. The washed surfaces and deposits reflect in part the cleaner ice of the two lobes juxtaposed and in part the concentration of runoff along the junction of the two lobes. The normal surface gradient up ice in each lobe would have led water to the junction of the lobes, from which its escape could only have been to the south along that junction. Such water-worked stratified drift varies in size from the coarse, bouldery material of glacial streams to the sand, silt, and clay in ponded water. Drift obviously has formed in places on buried ice blocks to leave pitted outwash; elsewhere it seems that entire portions of stream beds or lake sediments have been dropped down as continuous ice below melted out. Most parts of the well-washed drift, however, were formed adjacent to ice, but not on it. Original stratification is preserved.

Even during deglaciation the widening and northward migrating gap between the two lobes effectively concentrated glacial-fluvial activity between the lobes. Thus, it was the locus for many striking forms. Eskers (Figs. 9 and 10) and moulin kames (Figs. 6 to 8) formed under the stagnate ice by subglacial streams fed through moulins or openings through the ice sheet. Their subglacial waters also flowed toward that same gap. Crevasse fills (Fig. 5), topographically commonly like short eskers, were formed in crevasses open to the sky in part by supraglacial streams and in part by mass movement of surface debris into the crevasses.

Small moulin kames are scattered throughout much of the area, but none is better developed or displayed than those in the group

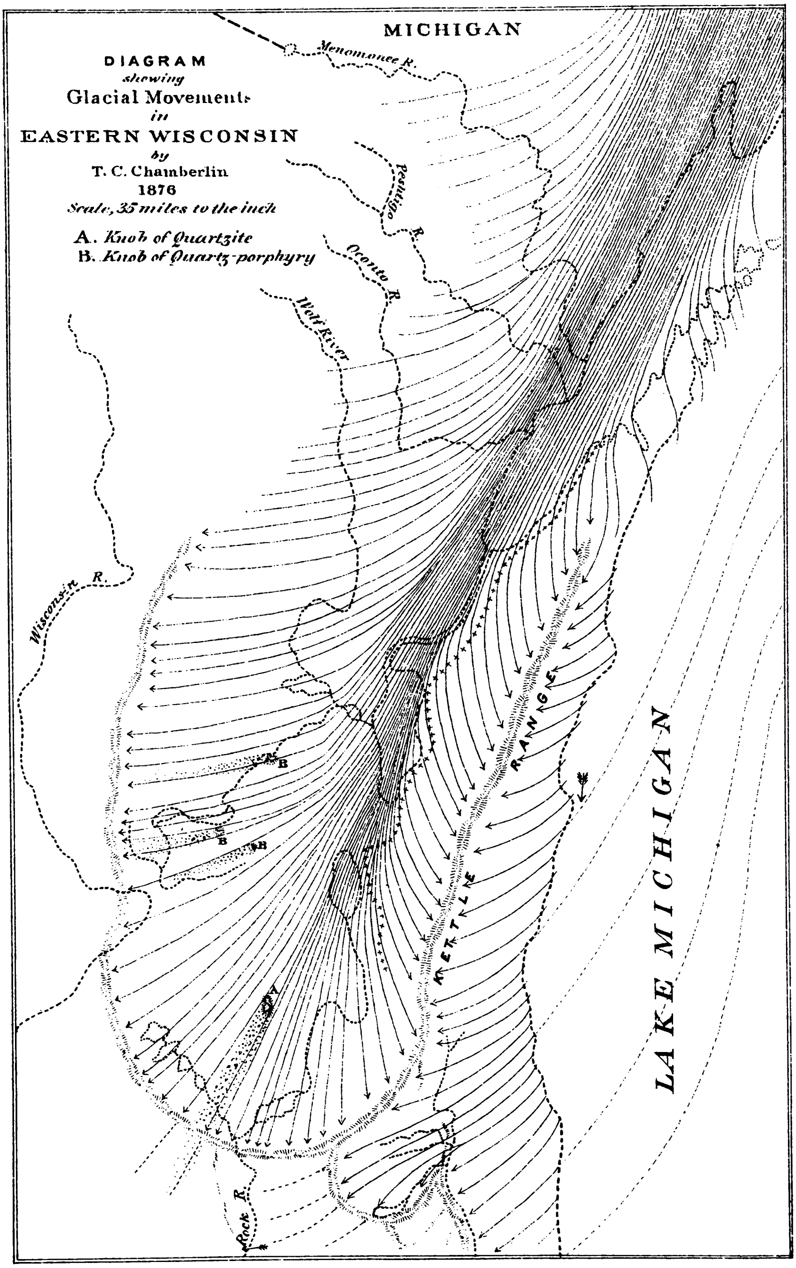

FIGURE 11. Diagram showing glacial movements in eastern Wisconsin by T. C. Chamberlin, 1876.

northeast of Dundee (Fig. 2). There, in the widest part of the washed drift area, are some of the best moulin kames to be found anywhere in the world. Beautifully conical hills, such as McMullen (Fig. 6), Garriety (Fig. 7), Conner, and Johnson, rise at the angle of repose of the material more than 100 feet above the flat, washed, drift plain surrounding them. Numerous smaller kames, only a few tens of feet high, are commonly less conspicuous among the drift ridges and are too small to show on Figure 2. Many are just as symmetrical as the larger ones in the lowlands. Other more irregular moulin kames, such as Dundee Mountain (which has a geologic marker), are also present and grade into crevasse fills or into ice-walled lake deposits (openings so enlarged that lakes formed within the glacial ice walls). Such forms originated where melt waters on the ice dropped through moulins or crevasses, dumping their detritus at the base. Openings ranged from nearly vertical, circular pipes (moulins) to very elongate fractures and rounded to irregular large openings; commonly, water and debris were fed into the fractures at more than one place along the sides and ends of crevasses, building irregular forms below the ice. Many large fractures were fed not just with running water, but also with mud flows, debris slides, and the like. Ponded water in some also trapped deltas and lacustrine sediments. Thus, the material in such features as moulin kames and crevasse fills ranges from normal till, through the available sizes of water-transported material, to ponded sediments. The cross section of Garriety Hill is typical (Fig. 7). It shows rounded to angular gravel, sand, silt and clay deposited as unsorted till in irregular masses, and as sorted sediment in alluvial flows, pond sediments, and the like. Water that formed the northern group of moulin kames drained westward under the ice to join the drainageway through Long Lake Valley. Their channels are readily discernible on aerial photographs.

End moraine and stagnate-ice or dead-ice moraine are not differentiated on Figure 2 because of their general similarity of origin. The terms are used loosely here for lack of detailed understanding of their genesis. They might have been subdivided for descriptive purposes into those areas characterized by elongate ridges and valleys and those with circular knobs and swales. In the interlobate area all are believed to result from ice stagnation and the melting out of blocks of ice of the appropriate geometry to fit the surface depressions. Such geometry is predicated on the movement of the ice at the time the ice and debris were mixed, on its fractures, or on the manner of burial by overriding ice, outwash, debris slides, etc.

The detailed deployment of the moraines in the Northern Kettle Interlobate Moraine is of considerable interest in the reconstruction of events as related to the flow of ice. From the vicinity of Kewaskum north to Dundee and to Long Lake, the trend of the Interlobate Moraine is almost north. From Long Lake the Interlobate Moraine turns fairly abruptly to the northeast to Elkhart Lake where it again swings to the north. At least part of the explanation of the bends may lie in the topography of the bedrock which unquestionably has exercised some control on the deployment of the ice. The deep pre-glacial valley at Sheboygan Marsh and Elkhart Lake must have provided relatively easy access for the ice of the Green Bay Lobe, leading it more rapidly and farther to the southeast than was possible over the bedrock hills south of that Marsh. The hills restrained the ice of the Green Bay Lobe, allowing the ice of the Lake Michigan lobe to push farther westward. Such kinks and bends in the terminal area are commonplace along the entire late Woodfordian front in Wisconsin. They are of considerable importance in understanding the development of such features as are found in the Northern Kettle Interlobate Moraine, but space does not permit their reconstruction here. Much fieldwork is called for to unravel the details of their history.

Small moulin kames in the stagnate-ice moraines are probably contemporaneous with the related features, immediately preceding kettle formation. However, the precise timing of the formation of the main group of moulin kames versus the main moraines to west and east is conjectural.

The writer hypothesizes that shortly after the two lobes butted together, the thickness of ice gradually increased from 100 to 300 feet at the start to a thickness perhaps of several thousand feet when the ice extended southward into the center of Illinois. Ablation (loss of ice) particularly by melting aided by a surface stream at the junction of the two lobes would be countered by ice movement from the base of the ice sheet diagonally upward to that junction at the surface. Upward flow at the terminal zones of glaciers is commonly at angles of 10 to 45 degrees, bringing debris from the base toward the surface to replace ice lost in the ablation zone and to maintain the surface profile of the glacier. When ice was at its maximum thickness at the junction, the basal debris may not have reached the surface. As the ice thinned during the waning of the late Woodfordian glaciation, it would intersect the surface. As thinning continued to perhaps 200 or 300 feet of ice, fractures penetrated in favorable places, aided by meltwaters, to the bottom of the glacier. In them the moulin kames, eskers, and crevasse fills began to grow. However, at that time the thicker ice away from the junction was continuing to move forward even though the terminal zone was stagnate. The shear planes and flow layers that brought debris up from the base presumably angled obliquely downward and away from the actual surface junction of the two lobes to the general location of the main moraines on both sides of the drift area. At the locus of the moraines, basal ice and debris were interstratified by flow of ice while the basal ice closer to the junction was stagnated and remained relatively free of debris. Thus, the two main moraines, one for each lobe, are in a sense end moraines even though they do not mark the terminal position of the ice nor were they deposited at the outer edge of the ice. They represent the outer edge of the *active* ice for each lobe and were separated by a zone of *stagnate* ice shaped like a very broad, low wedge with its apex upward, at least during the waning of the glaciation. It seems relatively clear that stagnation took place over much of the area because so many small ice-contact, washed-drift features are superposed on all other forms.

CONCLUSIONS

Many details of the reconstruction of the events that led to the surface features in the Northern Kettle Interlobate Moraine are imperfectly known. New topographic maps and aerial photographs unavailable to Alden (1918) and earlier workers now permit an analysis of surface forms to be made in far more detail than was possible for him in his reconnaissance study. Surface analysis, however, is only part of the story. Serious mistakes have been made in the past in the interpretation of glacial forms by morphology alone. Sub-surface exploration must be carried on concurrently before a firm foundation can be laid that would permit us to change significantly the gross picture of the Kettle Interlobate Moraine as commonly accepted. Such detailed study has had little economic incentive, but should be undertaken before gravel pit operations remove or modify evidence that might be the key to part of the story. A beautiful story can be constructed on evidence available, but an even larger part of the story is still unsupported in fact. The prospects in future study are especially intriguing.

Thus, in brief, the heavy use of the area for recreation and consequent loss of land for cottages and commercial development require our immediate action to preserve many glacial forms, like kames, eskers, and stagnate-ice features. Demands for gravel are increasing and many glacial forms are being removed *en toto*. We must protect not only the many striking forms but also the "normal" forms now before they are exploited. Many shown in the mapped area of Figure 2 are outside of the Forest proper. It is hoped that some of the better ones ultimately will find their place in the public trust. If not, the gravelly deposits will disappear as have some moulin kames and crevasse fills immediately east of Kewaskum, on the north side of Highway 28.

References Cited

ALDEN, WILLIAM C., 1918, The Quaternary geology of southeastern Wisconsin: U. S. Geol. Survey Prof. Paper 105, 356 p.

BLACK, ROBERT F., and RUBIN, MEYER, 1967–68, Radiocarbon dates of Wisconsin: Wis. Acad. Sci., Arts, and Letters, v. 56, p. 99–115.

CHAMBERLIN, T. C., 1877, Quaternary Formations—the drift: Chap. V, p. 199–246, in Geology of Wisconsin, v. 2, 768 p. Commissioners of Public Printing.

CHAMBERLIN, T. C., 1878, On the extent and significance of the Wisconsin kettle moraine: Wis. Acad. Sci., Arts, and Letters, Trans., v. 4, p. 201–234.

CHAMBERLIN, T. C., 1883, Terminal moraine of the second glacial epoch: U. S. Geol. Survey Third Annual Report, p. 291–402.

FENTON, CARROLL LANE and FENTON, MILDRED ADAMS, 1952, Giants of geology: Doubleday and Co., 333 p.

WHITE, GEORGE W., 1964, Early description and explanation of kettle holes: Jour. Glac., v. 5, p. 119–122.

WHITTLESEY, CHARLES, 1860, On the drift cavities, or "potash kettles" of Wisconsin: Amer. Assoc. Advancement Sci., Proc., 13th meeting, 1859, p. 297–301.

WHITTLESEY, CHARLES, 1866, On the fresh-water glacial drift of the northwestern states: Smithsonian Contr. Knowledge, No. 197, 32 p.

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AGE AND GROWTH OF THE WALLEYE IN LAKE WINNEBAGO

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Introduction

The walleye, *Stizostedion vitreum vitreum* (Mitchill), is an abundant sport fish in Lake Winnebago and connecting waters and it attracts more fishermen to the Lake Winnebago area than any other sport fish. This report describes the age and growth of this species in Lake Winnebago and is part of a study on the life history of the walleye.

Maintenance stocking of walleyes is not practiced in the study area and accordingly this paper refers exclusively to a natural population.

Materials and Methods

The 1,237 walleyes used in this study consisted of 1,017 yearling or older fish collected during October and November, 1960 and 220 young-of-the-year walleyes collected from June—October, 1961. All young-of-the-year fish were taken with 12-foot otter trawls while Lake Erie type trap nets, 12-foot otter trawls and an A.C. shocker unit were used to collect the older fish.

The length measurements of adult walleyes were made on fresh specimens. The total lengths were measured to the nearest tenth of an inch on a standard measuring board. The length measurements of young-of-the-year walleyes were made on preserved specimens (10 percent formalin). The weight of each fish was determined to the nearest hundredth of a pound; no young-of-the-year fishes were weighed. All fish, for which length and weight were recorded (1,017 fish), were used in the study of the length-weight relation.

Key scales from 1,237 fish were taken from above the lateral line on the left side and came from the intersection of the third row above the lateral line and the first scale row before the first dorsal spine. The scales were impressed on cellulose acetate slides, 0.03 inch thick, by a roller press similar to that described by Smith (1954). Butler and Smith (1953) demonstrated that this method of preparation does not affect the measurements of scales. The examination and measurements of scales were made by means of a micro-projector at the magnification 44X. The length of each scale and the distances from the focus to each annulus were measured along the anterior radius most nearly collinear with the focus as described by Hile (1954) and recorded to the nearest tenth of an inch.

Ages were determined by counting the annuli and are given in terms of completed years of life. They are expressed by Roman numerals corresponding to the number of annuli so that fish in the second year of life belong to age-group I (Hile, 1948).

Sex and state of maturity were determined for all fish except the 220 young-of-the-year fish collected in 1961. Determination of sex in adult walleyes is easy as the testes have a whitish-gray appearance, and the ovaries are yellowish with readily visible eggs. Size and shape of gonads, blood vessels on gonads, and color of gonads were used to sex immature fish (Eschmeyer, 1950). In fish of comparable size, the gonads are distinctly the wider in the female. The testis tapers towards the apical and over a considerable portion of its total length, while the region of tapering is much shorter in the ovary. Ordinarily, at least one of the ovaries tends to be translucent. The dorsal blood vessel of the testis lies in a groove; that of the ovary is on the surface. Veins are usually visible passing across the ovary, while this cross-venation is not found on the testis.

The fecundity of 130 walleyes over a size range of 16.6–25.2 inches in total length and a range of 1.39–6.00 pounds was determined. The ovaries from these walleyes were preserved in 10 percent formalin. The weight of each ovary was determined just prior to sampling and a transverse section was made through an ovary. The section was weighed, and the number of eggs within was determined by actual count. The section represented 1.2 to 7.4 percent of the entire ovary. The total number of eggs per fish was estimated on a proportional basis.

Results and Discussion

1. Age and Growth

The precise time of annulus formation of Lake Winnebago walleyes was not established. Annulus formation probably occurs in May or early June. Carlander (1945) reports that walleyes form an annulus in late May or early June in Lake of the Woods, Minnesota and Cleary (1949) reported the same for Clear Lake, Iowa.

Use of the scale method to determine the age of the Lake Winnebago walleyes is justified by the following observations:

1. Fish known to be young-of-the-year had no annuli on the scales.
2. The number of annuli increased with the size of the fish.

The body-scale relationship was determined from the measurement of 1,237 walleyes which were grouped into half-inch groups from 1.0 to 24.5 inches. The mean body length for each group was plotted against the corresponding mean lengths of the anterior scale radii and the relationship may be expressed as:

$$L = 1.443 + 3.171 \ (R)$$

where L = total length in inches
and R = anterior scale radius $\times$ 44

The body-scale relationship was linear.

The calculations of length at each annuli were made from measurements of the anterior radius applied in the formula:

$$L_1 = C + \frac{S_1}{S} (L - C)$$

where L_1 is the length of the fish at the time of each annulus formation, C is the length of the fish at the time of scale formation, S_1 is the length of the anterior radius of the scale at each annulus, S is the length of the anterior radius at capture and L is the total length of the fish at time of capture. The length of the fish at the time of scale formation is 40 millimeters (1.6 inch) as determined from close examination of 220 specimens (Priegel, 1964). The regression line of the body-scale relationship intercepts the abscissa at 1.443 which is slightly less than the value determined for body length at time of scale formation.

The average calculated lengths of males and females in different age groups of walleyes gave evidence of sex differences in growth rate so the data for males and females were kept separate (Tables 1 and 2.)

Two estimates of general growth are given in the bottom section of Tables 1 and 2. One is based on the grand average calculated total lengths and the second on the summation of the grand average annual increments of length. The present discussion is based on the sums of increments, since this curve should represent the average growth that walleyes might have if the population was not subjected to selective destruction of individuals with the more rapid growth. (Figure 1.)

TABLE 1. CALCULATED TOTAL LENGTH AT END OF EACH YEAR OF LIFE OF EACH AGE GROUP OF LAKE WINNEBAGO MALE WALLEYES AND AVERAGE GROWTH FOR THE COMBINED AGE GROUPS

Age Group	Number of Fish	Length (Inches) at End of Year							
		1	2	3	4	5	6	7	8
I	58	7.1							
II	27	5.8	11.7						
III	62	5.2	10.2	13.6					
IV	60	5.4	9.9	12.7	14.8				
V	89	5.6	9.9	12.2	13.7	15.2			
VI	80	5.4	10.1	12.5	13.7	14.7	16.0		
VII	38	5.6	10.2	12.6	13.7	14.6	15.4	16.4	
VIII	11	5.6	10.2	12.6	13.9	14.8	15.4	16.0	16.8
Grand average calculated length		5.6	10.2	12.7	14.2	15.1	15.6	16.2	16.8
Mean annual increment		5.6	4.6	2.5	1.4	1.0	0.7	0.6	0.7
Growth based on summation of increment		5.6	10.2	12.7	14.1	15.1	15.8	16.4	17.1

TABLE 2. CALCULATED TOTAL LENGTH AT END OF EACH YEAR OF LIFE OF EACH AGE GROUP OF LAKE WINNEBAGO FEMALE WALLEYES AND AVERAGE GROWTH FOR THE COMBINED AGE GROUPS

Age Group	Number of Fish	Length (Inches) at End of Year							
		1	2	3	4	5	6	7	8
I	111	7.6							
II	84	6.2	12.1						
III	79	5.3	10.2	14.6					
IV	90	5.4	9.6	13.4	16.8				
V	109	5.7	9.6	12.8	15.2	17.7			
VI	77	5.6	9.8	12.8	14.8	16.5	18.9		
VII	36	5.8	9.7	13.5	14.6	15.9	17.3	19.3	
VIII	6	5.4	9.7	13.3	15.3	17.0	18.4	20.4	21.0
Grand average calculated length		6.0	10.1	13.4	15.6	17.3	18.6	19.5	20.5
Mean annual increment		6.0	4.1	3.2	2.2	1.8	1.6	1.2	1.0
Growth based on summation of increment		6.0	10.1	13.3	15.5	17.3	18.9	20.1	21.1

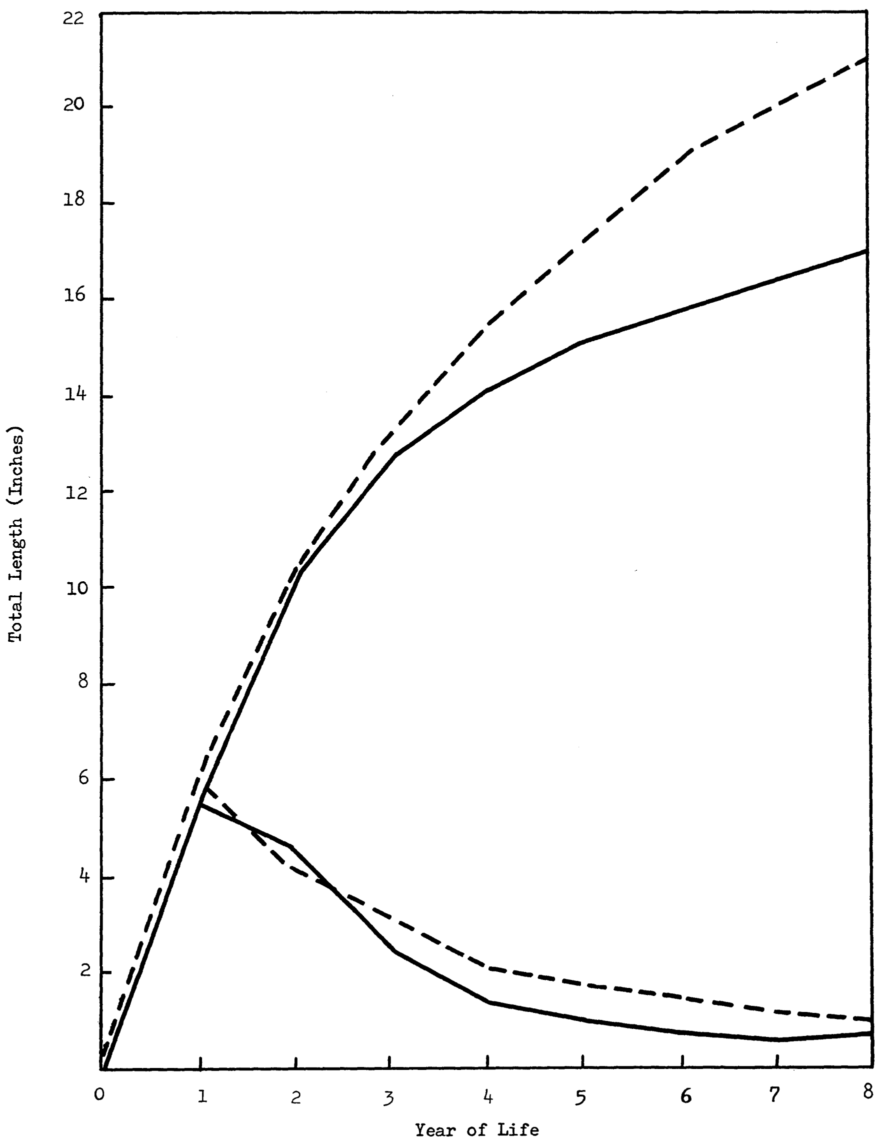

FIGURE 1. General growth in length and annual increment in length of Lake Winnebago walleyes. Males, solid line; females, broken line.

Comments on general growth and a comparison of the growth of the sexes are best made from Table 3 which was prepared from data of Tables 1 and 2.

The total lengths of the sexes in the first year of life showed a 0.4 inch advantage for the females but a 0.1 inch advantage for the males at the end of the second year of life. The advantage of the females increased from 0.6 inches at the end of the third year to 4.0 inches at the end of the eighth year. If the 13-inch size limit was still in effect, this difference in growth rate between male and female fish would have affected the age at which the legal size was reached. The male walleye took 4 years to reach legal size and the female 3 years.

The greatest increase in length for both sexes took place during the first year of life (6.0 inches for the females and 5.6 inches for the males). The amount of growth dropped during the second year, and the decrease continued for the females through the eighth year; but, the males made nearly the same amount of growth each year after the fifth year (0.6 inches to 0.7 inches).

Many authors have reported on the growth rates of walleyes in various bodies of water (Table 4). The walleye population in each individual body of water differs in growth rate from other bodies of water. The greatest growth occurred in southern reservoirs, Norris Reservoir and Clayton Lake.

The Lake Winnebago walleye is one of the slowest growing fish when compared to the walleye populations mentioned in Table 4. Only the growth rate of the walleye in Lake Gogebic, Michigan, is similar to the Lake Winnebago walleye. Lack of forage fishes and competition from other fish species (burbot, sauger and yellow

TABLE 3. CALCULATED TOTAL LENGTHS (INCHES) AND LENGTH INCREMENTS OF MALE AND FEMALE WALLEYES OF LAKE WINNEBAGO IN DIFFERENT YEARS OF LIFE

Year of Life	Males		Females		Size Advantage of Females
	Calculated Length	Increment	Calculated Length	Increment	
I	5.6	5.6	6.0	6.0	+0.4
II	10.2	4.6	10.1	4.1	−0.1
III	12.7	2.5	13.3	3.2	+0.6
IV	14.1	1.4	15.5	2.2	+1.4
V	15.1	1.0	17.3	1.8	+2.2
VI	15.8	0.7	18.9	1.6	+3.1
VII	16.4	0.6	20.1	1.2	+3.7
VIII	17.1	0.7	21.1	1.0	+4.0

TABLE 4. CALCULATED GROWTH OF WALLEYES REPORTED FROM VARIOUS WATERS

Locality	Number of Fish	Average Calculated Total Length (Inches) Reported from Various Waters										
		1	2	3	4	5	6	7	8	9	10	11
Present study	411 (males)	5.6	10.2	12.7	14.1	15.1	15.8	16.4	17.1	—	—	—
	585 (females)	6.0	10.1	13.3	15.5	17.3	18.9	20.1	21.1	—	—	—
Des Moines River, Iowa (Schmulbach, 1959)	112	8.4	11.5	14.4	16.6	18.7	20.3	21.7	22.5	22.6	—	—
Clear Lake, Iowa (Cleary, 1949)	319	5.9	10.9	14.5	17.2	19.3	21.4	23.6	26.3	27.0	27.7	28.1
Trout Lake, Wisconsin (Schloemer & Lorch, 1942)	429	5.3	9.7	13.7	16.6	19.0	20.7	21.7	22.3	23.1	23.3	—
Norris Reservoir, Tennessee (Stroud, 1949)	2,898	10.3	16.4	18.7	19.9	20.8	21.0	22.1	24.9	—	—	—
Minnesota Lakes (Eddy & Carlander, 1929)	6,599	4.9	9.1	12.7	15.8	19.1	21.6	24.2	26.6	28.2	—	—
Lake Gogebic, Michigan (Eschmeyer, 1950)	252 (males)	4.4	9.3	11.8	13.9	15.2	16.3	16.9	17.3	17.7	18.0	—
	267 (females)	4.9	9.4	12.4	14.5	16.3	17.9	18.9	19.8	20.4	21.0	—
Spirit Lake, Iowa (Rose, 1951)	321	7.2	11.1	14.4	17.5	19.9	22.2	23.7	24.9	26.0	27.8	—
Clayton Lake, Virginia (Roseberry, 1950)	254	9.9	15.2	19.8	23.2	26.1	27.6	29.9	32.2	—	—	—
Northern Green Way, Wisconsin (Balch, 1951)	390 (males)	6.6	10.0	12.8	15.1	17.2	18.6	19.7	24.8	25.8	26.8	—
	442 (females)	6.7	10.2	12.9	15.7	18.1	19.8	21.1	26.8	27.9	—	—

perch) in Lake Winnebago are probably the limiting factors for the slow growth rate in the walleye. The long spawning migration (90 miles maximum) may also be a factor related to slow growth since these migrations must result in great energy loss.

2. Age At Maturity

Only those females showing eggs forming in the ovary were considered mature, and the males were considered mature if the testis showed the characteristic whitish-gray color. Since all fish were collected during the late fall, no difficulties were encountered between distinguishing immature and mature fish.

The information on the age and degree of maturity of the walleye included in this sample is presented in Table 5. The average age of maturity was considered as that age at which 50 percent of the fish reach maturity. (Table 5). The male walleye would generally be considered as mature at the end of the third year of life. At the end of the sixth year of life, all males were mature. The female walleye would be considered as mature at the end of the sixth year of life. Only at the end of the eighth year of life were all females mature. The males show a definite tendency to mature earlier in life.

The average total length at which more than 50 percent of the males are mature is 12.7 inches. The average total length at which more than 50 percent of the females are mature is 18.9 inches. Hile (1954) reported that 50 percent of the Saginaw Bay walleyes had reached sexual maturity at 15.5 inches for the male and 17.0 inches for the females. Eschmeyer (1950) for Gogebic Lake, Michigan, showed that males mature at 12.2 inches in total length and females at 15.4 inches. In Red Lake, Minnesota, males mature at age group

TABLE 5. SEX COMPOSITION OF AGE GROUPS OF LAKE WINNEBAGO WALLEYES AND (IN PARENTHESES) PERCENTAGE MATURE

Age Group	Number of Males	Number of Females
I	58	111
II	27 (37)	84
III	62 (73)	79
IV	60 (93)	90 (8)
V	89 (96)	109 (32)
VI	80 (100)	77 (67)
VII	38 (100)	36 (81)
VIII	11 (100)	6 (100)
Total	425 (77)	592 (22)

5 and females at age group 6 (Smith, Krefting, and Butler 1952). Balch (1951) reported that about one-half of the male walleyes are mature by the time they reach 15.5 inches and that one-half of the females in the 17-inch group were mature in Northern Green Bay waters of Lake Michigan.

3. Length-Weight Relation

Length-weight relation was calculated from fish grouped by half inch total length intervals from 7.0 to 24.5 inches. There was no significant difference between sexes so all fish were combined. Length-weight relation of Lake Winnebago walleyes is expressed by the regression:

$$\text{Log } W = -5.3596 + 3.2162 \text{ Log } L$$

where W = weight in pounds
and L = total length in inches

In the graphical representation of the length-weight relation (Figure 2) the smooth curve represents the calculated weights, and the dots the empirical ones. The agreement of the calculated and empirical weights was satisfactory. The discrepancies were more pronounced among the larger fish; but, on the whole, distribution of the disagreements had no particular trend. Discrepancies among the larger fish resulted from the smaller number of fish and actual weights were great enough to make relatively modest disagreements seem larger.

Calculated growth in weight (Table 6) was determined by applying calculated lengths (sum of the average increments of length) of Tables 7 and 8 to the length-weight relation. The annual increments of weight for the males increased irregularly, while the annual increments of weights for the females showed a gradual increase during the first six years. Increments in individual years of life for the females were 0.05 pounds in the first year of life to a maximum of 0.56 pounds in the sixth year of life. It took the males five years to reach 1 pound and the females slightly under 4 years to obtain 1 pound.

4. Fecundity

A few estimates have been published on the egg production of the walleye, but most of these estimates have been made on a small number of fish and the size range has been limited. Vessel and Eddy (1941) who had the largest sample (62 fish) from Cut-Foot Sioux Lake, Minnesota, estimated the egg production of walleyes from 1.5 to 5.0 pounds at 39,000–128,000 eggs. Eschmeyer (1950) estimated egg production from Lake Gogebic, Michigan, walleyes

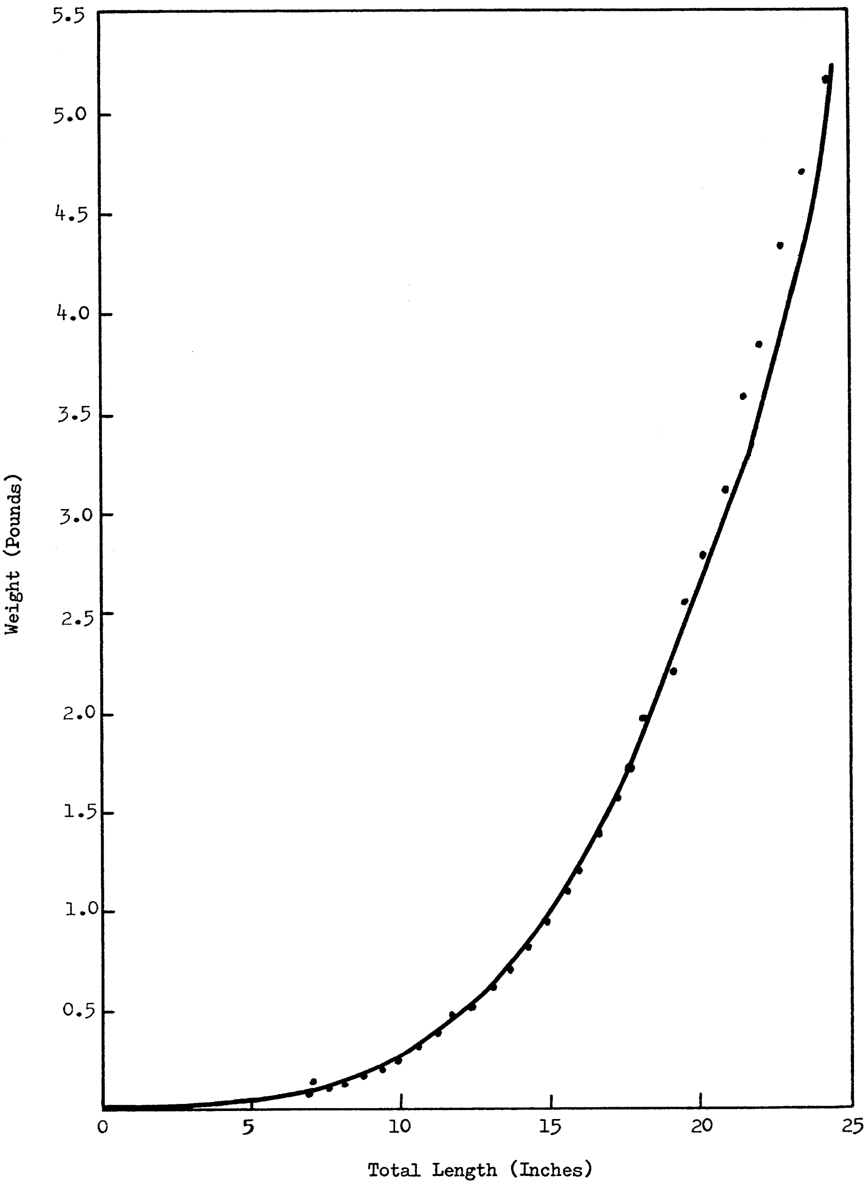

FIGURE 2. Length-weight relation of the Lake Winnebago walleyes. Dots represent the empirical data and the smooth curve is the calculated data.

TABLE 6. CALCULATED WEIGHTS IN POUNDS AT THE END OF EACH YEAR OF LIFE OF LAKE WINNEBAGO WALLEYES

Year of Life	Male		Female	
	Calculated Weight	Increment	Calculated Weight	Increment
I	0.04	0.04	0.05	0.05
II	0.28	0.24	0.27	0.22
III	0.60	0.32	0.68	0.41
IV	0.84	0.24	1.11	0.43
V	1.05	0.21	1.63	0.52
VI	1.20	0.15	2.19	0.56
VII	1.37	0.17	2.68	0.49
VIII	1.59	0.22	3.08	0.40

Weights are from the general length–weight relation and correspond to lengths at the end of year of life on the general growth curve for scales taken above the lateral line.

TABLE 7. ESTIMATED EGG PRODUCTION OF LAKE WINNEBAGO WALLEYES

Length Groups in Inches (T. L.)	Number Sampled	Average Weight of Fish	Average Weight of Ovaries (grams)	Average Sample Weight of Ovaries (grams)	Average Percentage of Ovaries Counted	Average Calculated Number of Eggs
16.5–16.9	1	1.39	38.1	2.0	5.2	62,617
17.0–17.4	1	1.50	24.4	1.8	7.4	43,255
17.5–17.9	6	1.95	64.5	1.9	3.2	65,616
18.0–18.4	6	2.12	57.8	1.9	3.3	77,832
18.5–18.9	11	2.34	74.2	2.3	3.3	93,532
19.0–19.4	15	2.61	89.3	2.3	2.7	98,904
19.5–19.9	24	2.73	94.7	2.5	2.8	105,417
20.0–20.4	21	2.89	104.4	2.7	2.6	108,052
20.5–20.9	12	3.18	117.2	3.5	3.1	114,738
21.0–21.4	13	3.60	141.1	3.3	2.4	138,414
21.5–21.9	7	3.94	159.9	3.2	2.0	148,913
22.0–22.4	6	4.04	158.9	3.2	2.1	143,794
22.5–22.9	2	4.67	243.7	4.0	1.6	89,377
23.0–23.4	3	4.63	189.0	3.1	1.7	169,250
24.0–24.4	1	5.20	291.9	3.5	1.2	227,181
25.0–25.4	1	6.00	155.1	3.6	2.3	127,569

(34 fish) at 36,871–154,906 eggs for fish from 16.0–22.9 inches in total length. Smith (1941) calculated that three Norris Reservoir walleyes of 25.0–26.5 inches in total length produced from 77,500–87,400 eggs.

The estimates of the egg production for walleyes by half-inch size groups are given in Table 7. The egg production ranged from 43,255 eggs for a 17.4 inch, 1.50 pound walleye to 227,181 eggs for a 24.2 inch, 5.20 pound walleye. The heaviest walleye (6.00 pounds and 25.2 inches) had a count of 127,569 eggs.

SUMMARY

1. Age determinations and growth histories were calculated by the scale method from a sample of 1,237 walleyes.

2. Body-scale relation is expressed by the formula:

$$L = 1.443 + 3.171\ R$$

where L = total length in inches
and R = anterior scale radius $\times$ 44

3. Difference in growth rate for the sexes was noted. The advantage of the females increased from 0.6 inches at the end of the third year to 4.0 inches at the end of the eight year. If the 13-inch size limit was still in effect, it would take the male walleye four years to reach legal size and the female three years.

4. The annual increments of weight for the males increased irregularly while the annual increments of weight for the females showed a gradual increase during the first six years. It took the males five years to reach one pound and the females slightly under four years to obtain one pound.

5. The average age of maturity was considered as that age at which 50 percent of the fish reach maturity. The male walleyes would be considered as mature at the end of the third year of life. At the end of the sixth year of life, all males were mature. The female walleyes were considered as mature at the end of the sixth year of life. Only female fish at the end of the eighth year of life were all mature.

6. The Lake Winnebago walleye is one of the slowest growing walleye when compared to the walleye populations of other waters.

7. The egg production of the Lake Winnebago walleye ranged from 43,255 eggs for a 17.4-inch, 1.50-pound walleye to 227,181 eggs for a 24.2-inch, 5.20-pound walleye.

8. Length-weight relation is expressed by the formula:

$$\text{Log } W = -5.3596 + 3.2162 \text{ Log } L$$

where W = weight in pounds
and L = total length in inches

Literature Cited

Balch, Robert. 1951. The age and growth of the yellow pike-perch, *Stizostedion v. vitreum* (Mitchill) in the Green Bay waters of Lake Michigan. Invest. Rpt. No. 652, Fish Mgt. Div., Wis. Cons. Dept., mimeo.

Butler, Robert L. and Lloyd L. Smith, Jr. 1953. A method for cellulose acetate impressions of fish scales, with a measurement of its reliability. Prog. Fish. Cult., 15:175–178.

Carlander, Kenneth D. 1945. Age, growth, sexual maturity, and population fluctuations of the yellow pike-perch, *Stizostedion vitreum vitreum* (Mitchill) with reference to the commercial fisheries, Lake of the Woods, Minnesota. Trans. Amer. Fish. Soc., 73:90–103.

Cleary, Robert E. 1949. Life history and management of the yellow pikeperch, *Stizostedion vitreum vitreum* (Mitchill) of Clear Lake, Iowa. Iowa St. Univ. J. Sci., 23(2):195–208.

Eddy, Samuel and Kenneth D. Carlander. 1939. Growth of Minnesota fishes. Minn. Conservationist 69:8–10.

Eschmeyer, Paul H. 1950. The life history of the walleye, *Stizostedion vitreum vitreum* (Mitchill) in Michigan. Bull. Inst. Fish. Res. (Mich.) 3:1–99.

Hile, Ralph. 1948. Standardization of methods of expressing lengths and weights of fish. Trans. Amer. Fish. Soc. 75:157–164.

———. 1954. Fluctuations in growth and year-class strength of the walleye in Saginaw Bay. U.S. Fish and Wildlife Service, Fish. Bull. 56:7–59.

Priegel, Gordon R. 1964. Early scale development in the walleye. Trans. Amer. Fish. Soc. 93(2):199–200.

Rose, Earl T. 1951. Notes on the age and growth of Spirit Lake Yellow pikeperch (*Stizostedion* v. vitreum). Proc. Iowa Acad. Sci. 58:517–526.

Roseberry, Dean A. 1951. Fishery management of Claytor Lake, an impoundment on the New River of Virginia. Trans. Amer. Fish. Soc. 80:194–209.

Schloemer, Clarence L. and Ralph Lorch. 1942. The rate of growth of the walleye pike, *Stizostedion vitreum vitreum* (Mitchill) in Wisconsin's inland waters, with special reference to the growth characteristics of the Trout Lake population. Copeia. No. 4, pp. 201–211.

Schmulbach, James C. 1959. Growth of the walleye in the Des Moines River, Boone County, Iowa. Proc. Iowa Acad. Sci., 66:523–533.

Smith, Charles O. 1941. Egg production of walleyed pike and sauger. Norris Reservoir fish differ from some species in other localities. Prog. Fish Cult. 54:32–34.

Smith, Lloyd L., Jr., Laurits W. Krefting and Robert L. Butler. 1952. Movements of marked walleyes, *Stizostedion vitreum vitreum* (Mitchill) in the fishery of the Red Lakes, Minnesota. Trans. Amer. Fish Soc. 81:179–196.

Smith, Stanford H. 1954. A method of producing plastic impressions of fish scales without the use of heat. Prog. Fish Cult. 16:75–78.

Strong, Richard H. 1949. Growth of Norris Reservoir walleye during the first twelve years of impoundment. Journ. Wildl. Mgt. 13(2):157–177.

Vessel, Matt F., and Samuel Eddy. 1941. A preliminary study of the egg production of certain Minnesota fishes. Minn. Bur. Fish Res. Invest. Rept. 26:26 pp.

REGULARLY OCCURRING FLUCTUATIONS IN YEAR-CLASS STRENGTH OF TWO BROOK TROUT POPULATIONS

*Ray J. White and Robert L. Hunt**

During a 12-year period (1953–64) year class strength of wild brook trout *(Salvelinus fontinalis)* fluctuated rhythmically in two central Wisconsin streams, Lawrence Creek (Adams and Marquette Counties) and Big Roche-a-Cri Creek (Adams and Waushara Counties). In this paper we discuss the nature of these rhythmic year class fluctuations and examine some possible reasons for their regularity.

Population dynamics of trout have been studied since 1953 in Lawrence Creek primarily to test angling regulations (emphasis switched to trout habitat management in 1964), and since 1957 in the Roche-a-Cri to assess effects of trout habitat management. Normal statewide angling regulations for trout applied to the Roche-a-Cri: season from early or mid-May until September 7, a minimum legal size limit of 6 inches and a bag limit of 10 trout per day. Angling pressure was greatest during seasons when trout were most abundant. At Lawrence Creek, length of the fishing season was the same, but 6 combinations of experimental restrictions on size, bag and gear were tested in various parts of the stream during 1955–64. Changes in angling regulations caused angler exploitation of the trout population to vary greatly (Hunt, Brynildson and McFadden, 1962; Hunt and Brynildson, 1964; Hunt, 1964).

DESCRIPTION OF THE STREAMS

Although the streams lie only 18 miles apart, their physical, hydrological and vegetational characteristics differ. Lawrence Creek usually has somewhat better living conditions for brook trout. The stream arises in a terminal moraine and flows eastward through a rolling landscape of glacial drift. Our study area, extending from the headwaters to an artificially impounded lake, comprises 3.4 stream miles. The Roche-a-Cri, directly north of Lawrence Creek, flows westward from the same moraine across a

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glacial outwash plain. The study area covered in this paper includes the upper 6.1 miles of trout water. Each stream passes through patches of forest, marshy meadows and thickets of brush. Many distinct springs feed Lawrence Creek. Its discharge at the downstream end of the study area is about 25 cfs during periods of baseflow. The streambed falls an average of 11.5 feet per mile. In contrast, the Roche-a-Cri receives less ground water seepage and flows through flatter terrain (its gradient = ca. 7 ft./mile). At a point 4 miles below the stream's source, baseflows vary from 5 to 9 or more cfs depending on recent precipitation. Figure 1 contrasts the relatively stable discharge of Lawrence Creek with the greatly fluctuating streamflow of the Roche-a-Cri. Figure 2 shows monthly low-flows for the Roche-a-Cri. These low-flow data give some indication of varying limitations on space available to brook trout in that stream.

With its greater discharge and steeper gradient Lawrence Creek has larger areas of gravel streambed relatively free of sand and silt. In summer and fall an abundance of watercress *(Nasturtium officinale)* and veronica *(Veronica connata)* offer hiding cover for trout and support a rich trout food supply. In the Roche-a-Cri,

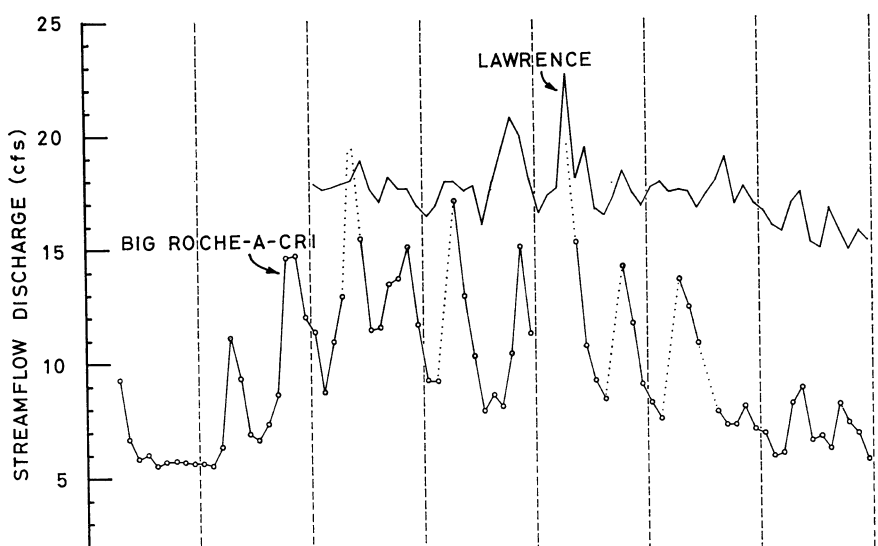

FIGURE 1. Monthly mean streamflow discharges at gaging stations on Lawrence Creek (2.5 miles below its source) and on Big Roche-a-Cri Creek (3.9 miles below source).

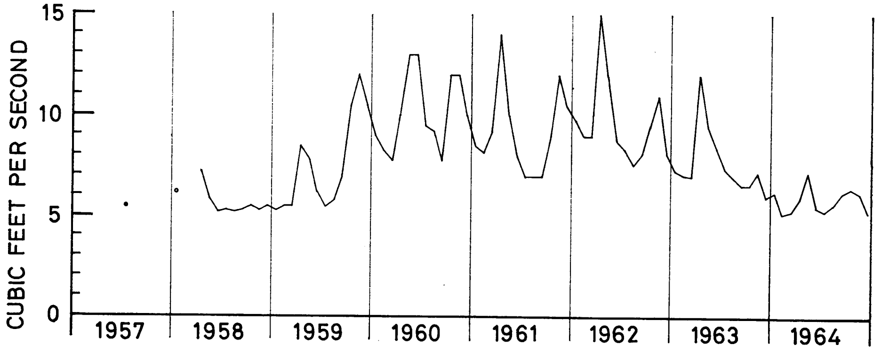

FIGURE 2. Lowest streamflow discharge recorded each month at the Big Roche-a-Cri Creek gage.

sand covers most of the bottom. Here, perhaps owing to the greater variability of streamflow, watercress beds often do not develop until autumn. Only in years of ample rainfall or during a general trend of streamflow increase, for instance in 1959–60 (Figures 1 and 4), does the Roche-a-Cri's cress flourish in springtime or early summer.

Three miles of the Roche-a-Cri that flowed through grazed land were fenced during 1956–58 to keep cattle away from the stream. Fencing allowed streambank vegetation to thrive and provide trout with hiding places among twigs and leaves that dangled into the water. From 1958 through 1962 current-deflectors and overhanging bank covers were constructed along 4 miles of stream in the study area. These devices added more cover for trout and concentrated the current to clean sand off streambed gravel.

THE TROUT POPULATIONS

Wild brook trout are the predominant fish in both streams. During our investigations, trout population densities ranged from less than 20 pounds per acre in some sections of both streams in poor years to nearly 250 pounds per acre in upstream sections of both streams during favorable years. But on the average, Lawrence Creek maintained larger populations. The Roche-a-Cri's main concentration of brook trout occupies a section of stream approximately equal to Lawrence Creek in length, but this section has only half the surface area of Lawrence Creek.

Few wild brown trout *(Salmo trutta)* or rainbow trout *(S. gairdneri)* occur in the Roche-a-Cri, though at times during several decades prior to the study these species were heavily stocked in the study area as well as in the 20 or more miles of water tolerable to trout (but lacking spawning grounds) below the study area. Even within the study area where brook trout reproduce well, brown and rainbow trout spawn with poor success. At various times during the study small numbers of hatchery-reared brown and rainbow trout moved into the lower portion of the study area from stocking sites several miles downstream. During 1953–60 about 1,200 age-0 and age-1 hatchery-reared brook trout were also stocked annually in the study area as part of the routine fishery management program. However, in view of the usual high mortality of stocked trout during the first few weeks after release, this stocking was probably a minor supplement to the total springtime population of trout in the study area. Hatchery brook trout are not included in the data to be discussed since the 1% to 3% of such stocked trout that survived to maturity did not contribute significantly to total spawning. Other fishes common in the Roche-a-Cri are: mottled sculpin *(Cottus bairdi)*, pearl dace *(Margariscus margarita)*, creek chub *(Semotilas atromaculatus)*, brook stickleback *(Eucalia inconstans)* and white sucker *(Catostomus commersoni)*.

Lawrence Creek is free of brown trout and has only a sparse population of wild rainbow trout. The stream has not been stocked with hatchery trout since 1948. Other than trout, Lawrence Creek contains mottled sculpin, white sucker, creek chub, brook stickleback and blacknose dace *(Rhinichthys atratulus)*.

Methods

Trout populations were estimated by mark-and-recapture electrofishing in April, prior to the angling season, and in September soon after angling ceased.

In this paper September estimates of age group 0 are used as initial measures of year class strength. Since age-0 trout are too small in April to be efficiently captured by our electrofishing gear, they could not enter into estimates at that time.

During electrofishings in September, 60% to 80% of the age-0 trout were marked by removing fins in combinations denoting year class, i.e., the year of birth. Population estimate procedures, precision of the estimates ($\pm$ 2 to 6% for age group 0; $\pm$ 1 to 8% for age group I, but generally around $\pm$ 2 to 4% for both groups) and methods of calculating egg production annually are discussed by McFadden (1961), Hunt et al. (1962) and Hunt (1966).

Results and Discussion

In both streams year-to-year fluctuations in abundance of age-0 brook trout followed a rhythm of alternating upward and downward turns, that is, one having 2 years between peaks (Figure 3; Table 1). Among the combined 20 data-years for the 2 streams, encompassing 18 between-year changes in population level, the pattern was interrupted only once: the 1956–57 interval at Lawrence Creek.

In Lawrence Creek numbers of age-0 brook trout present in September varied from 4,166 in 1958 to 22,646 in 1959. The mean number present during 12 successive Septembers was 10,712. The strongest year class was 5.4 times larger than the weakest year class and 2.1 times larger than the average numerical strength. In the Roche-a-Cri over an 8-year period, the number of age-0 brook trout present in September ranged from 2,012 in 1957 to 9,915 in 1960. Mean strength of the 8 year classes was 5,396. The strongest year class was 4.9 times as numerous as the weakest year class and 1.8 times larger than the mean abundance (Table 1).

Keith (1962) suggests that most biologists would favor the definition of "population cycle" as defined by Davis (1957):

> "In ecological usage the term 'cycle' refers to a phenomenon that occurs at intervals. These intervals are variable in length, but it is implied that their variability is less than one would expect by chance and that reasonably accurate predictions can be made."

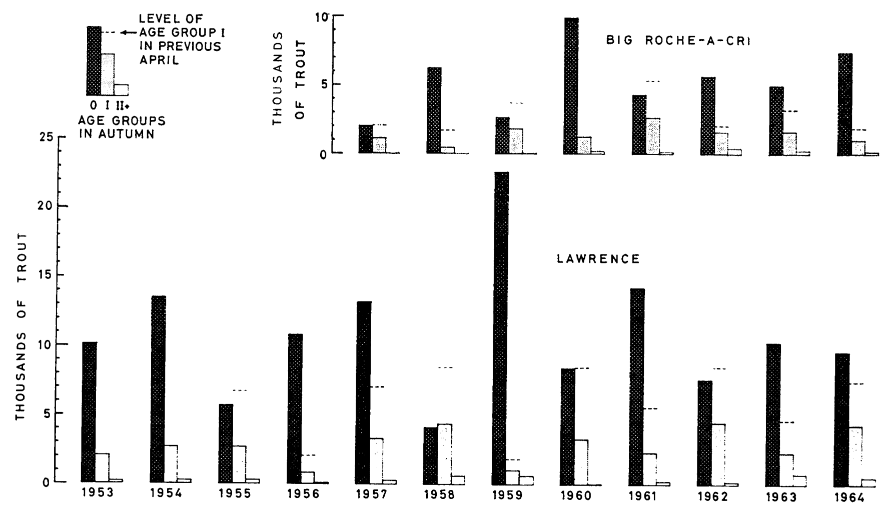

FIGURE 3. Numbers of brook trout in the study areas of Lawrence and Big Roche-a-Cri Creeks. (Although no inventory of the Roche-a-Cri population was made in spring, 1960, the number of age group I trout was probably low since the 1959 year class was a weak one.)

TABLE 1. AGE STRUCTURE OF APRIL AND SEPTEMBER POPULATIONS OF WILD BROOK TROUT IN LAWRENCE AND BIG ROCHE-A-CRI CREEKS

YEAR	Lawrence Creek				
	April		September		
	Age I	Age II+	Age 0	Age I	Age II+
1953	—	—	10,113	2,040	277
1954	—	—	13,523	2,749	296
1955	7,782	1,647	5,720	2,754	324
1956	2,012	1,207	10,853	816	133
1957	7,029	483	13,258	3,370	251
1958	8,485	2,069	4,166	4,393	635
1959	1,815	2,707	22,646	1,044	654
1960	8,510	409	8,507	3,324	51
1961	3,602	842	14,313	2,360	246
1962	8,567	1,221	7,611	4,523	225
1963	4,644	2,540	10,367	2,388	792
1964	7,489	1,669	9,680	4,382	569
Average 1955–64	5,993	1,479	10,712	2,935	388

YEAR	Big Roche-a-Cri Creek				
	April		September		
	Age I	Age II+	Age 0	Age I	Age II+
1953	—	—	—	—	—
1954	—	—	—	—	—
1955	—	—	—	—	—
1956	—	—	—	—	—
1957	2,034	333	2,012	1,135	15
1958	1,743	634	6,229	474	24
1959	3,749	152	2,637	1,817	58
1960	—	—	9,915	1,257	220
1961	5,038	*	4,361	2,630	156
1962	2,030	*	5,632	1,609	422
1963	3,262	*	4,964	1,623	256
1964	1,925	*	7,420	1,072	218
1957–64	2,826	—	5,396	1,452	171

*Not yet calculated.

According to this definition the fluctuations we observed constitute cycles of offspring abundance. Both cycles followed 2-year intervals, the shortest possible interval for an animal that reproduces once annually. Although the frequency of fluctuation was regular, levels of abundance did not always swing above and below a long-term mean value, as would be necessary to meet the strict mathematical definition of a cycle. Our contention is, however, that there did seem to be a recurring ecological phenomenon worthy of critical examination.

The rhythmic fluctuations in the 2 streams, while of equal frequency, were out of phase. In the years when Lawrence Creek contained large numbers of age-0 trout, the Roche-a-Cri had low numbers. This phase difference persisted all 8 years of simultaneous study.

The cycles persisted in both streams despite somewhat different environmental characteristics and different general levels of trout populations and they persisted despite large changes in density of total stocks and in age composition of those stocks in each stream (Table 1). Great variation in percentage of brook trout stocks removed from Lawrence Creek by anglers also failed to upset the cycle. Under liberal angling regulations—toward the beginning of the study—anglers took 32% to 65% of preseason populations and as much as 129% by weight. Under very restrictive size and bag limits, angler exploitation fell to 1% by number and 7% by weight (Hunt et al., 1962). These relatively low angler harvests resulted in higher populations of older trout and egg production became less dependent upon age-I trout as more adults survived the fishing season to spawn a second or third time. These changes in survival rates and structure of the spawning stocks may have contributed to the lower amplitude of fluctuations in age group 0 populations in Lawrence Creek during the later years of our study. In the Roche-a-Cri, the cyclic fluctuations also diminished in amplitude toward the end of the study as populations of age-II and older trout increased (Table 1). Progress in the management of trout habitat may have induced these changes, but despite these trends of improvement in the trout habitat and the trout population, the cycle persisted.

It is especially interesting that the cycles were out of phase in the 2 streams. Consequently it is unlikely that a climatological factor was governing the cycles. If that component of the climate, whatever it may be, which is most influential on trout would have had an alternate-year fluctuation during the period of study, it should have affected both trout populations similarly.

This is not to say that climatological changes failed to affect the trout populations, and in particular age group 0. The highest age-0 population in the Roche-a-Cri, that of 1960, coincided with sharp increases in precipitation (Figure 4) and in streamflow (Figure 2) during autumn 1959 through summer 1960. Not only was volume of the Roche-a-Cri greater than usual in the spring and summer of 1960, but in-stream vegetation, particularly watercress, was comparatively lush during May, much earlier than in most years. Space and concealment for young trout was undoubtedly greater than normal—and, judging by Tarzwell's (1937) findings on the food-harboring capacities of underwater vegetation, the trout food supply was probably better too. Such rather sudden environmental improvements, coinciding with whatever factors cause the "even-year" (1958, 1960, 1962, etc.) peaking on the Roche-a-

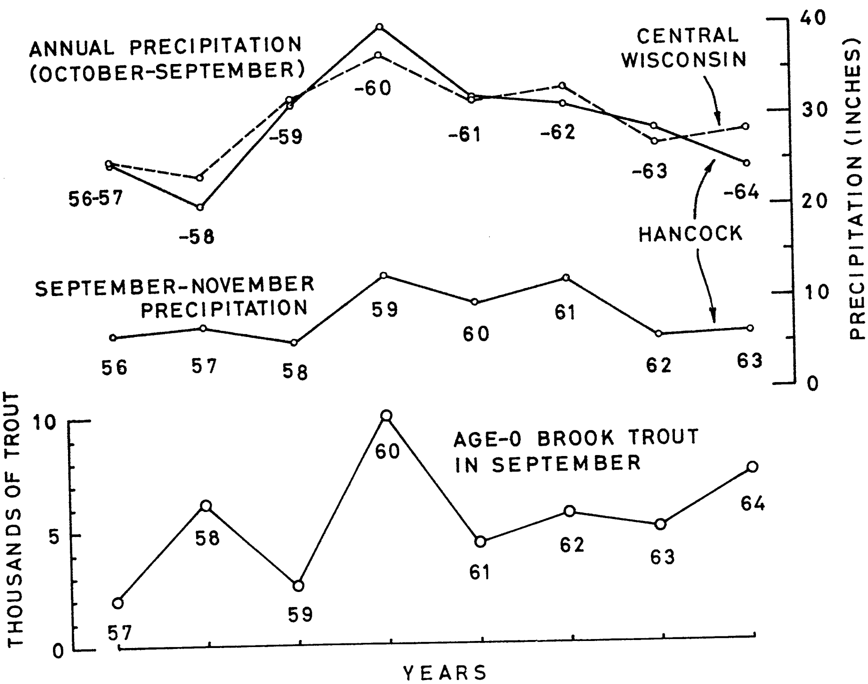

FIGURE 4. Numbers of age-0 brook trout in September in Big Roche-a-Cri Creek and records of precipitation from its vicinity. Plotted above each trout level are precipitation for September through November of the *preceding* year and precipitation during the 12 months (October–September) prior to trout inventory, i.e. the approximate period covered by development of age group 0. Precipitation data are from the Hancock Experimental Farm, 5 miles south of the stream and from the U. S. Weather Bureau compilation for central Wisconsin stations.

Cri, probably reinforced the upward amplitude for one year of the cycle. Lawrence Creek, with a more stable hydrological regime, appeared to have no unusual streamflow during 1960 (Figure 1). Similarly but conversely, an environmental event in Lawrence Creek could have accounted for the upset of the cycle in that stream during 1957. According to qualitative observations by one of the authors (White), watercress was unusually abundant in Lawrence Creek that year. While regional rainfall was low in 1956–57 (Figure 4) and it is unlikely that local variation was great enough to have stimulated aquatic vegetation through increased streamflow; nevertheless, throughout most of the study area the stream was walled with cress on each side to an extent not noted since. Perhaps at no other time during our study did age-0 brook trout in Lawrence Creek have such good hiding cover. Thus, there is some reason to suspect that a low phase of the population cycle was counteracted by an environmental change especially favorable to survival of young trout during 1957. In any event, the cycle was interrupted that year and thrown into a new phase, one having highs in odd numbered years. Environmental crises, on the other hand, might be expected to exaggerate cyclic lows and cancel highs, but no phenomenon of this sort was evident.

Despite the unlikelihood that climate maintained the cycles, monthly and seasonal streamflow data for the Roche-a-Cri (Figures 1 and 2), were examined to see if there were any patterns of fluctuation that coincided with the fluctuations of year class strength in that stream. No similarities were found. However, since our streamflow records did not cover the first year of the study and were not complete with respect to high flows, a search was made through precipitation data from a weather station near the Roche-a-Cri. (There is none near Lawrence Creek). One set of these data, precipitation during September through November, showed a pattern of year-to-year fluctuations resembling that of the trout cycle (Figure 4). While rainfall might be interpreted as having influenced streamflow at spawning time (October into early December) and hence as having affected success of natural reproduction, there is nothing in the streamflow data to support this contention. Neither is September–November precipitation significantly correlated with the following-year abundance of age group 0. Consequently, some mechanism intrinsic to both brook trout populations and acting after the egg stage seems a more likely regulator of the cycles.

If, as is the case in these two populations, age group I comprises the great majority of the "mature" (age I and older) trout, then such 2-year cycles could, given an initial disparity between any two consecutive year classes, be simply and directly maintained through the following processes: (1) domination of egg production by age group I which results in alternate-year variation similar to that of "even-year" and "odd-year" pink salmon *(Onchyrhynchis gorbuschka)* populations (Neave, 1952 and 1953), (2) a suppressive effect (predation and/or competition) of age group I on simultaneously occurring age-0 populations. Such suppression would be strong and weak in alternate years. Should both processes occur within the same population, they would complement each other, that is, act in synchrony. High egg production would push age group 0 upward one year and strong suppression by numerous age I trout from the same year class would push age group 0 downward the next year (Figure 5).

For these two brook trout populations, however, the first process seems unlikely. Even though most of the egg production in most years is attributable to age group I (Table 2), numbers of age 0 trout in September are not correlated with the numbers of eggs from which they originated (Figure 6). Since mortality at the egg and sac-fry stage is known to be less than 10% (McFadden, 1961) and since June inventories (Hunt, 1966) show that age-0 mortality progresses at a rather slow rate after the 4th or 5th free-swimming month, most age 0 mortality—and, in fact, the greater share of total mortality in the life of a year class—takes place during the first few months following emergence of fry into the stream.

The second regulatory mechanism, the suppression process, seems more plausible. Age-I trout could be preying on age-0 trout or could be limiting in some way the accessibility of a rather fixed environmental resource. Indeed, numbers of age-0 trout in Lawrence Creek are inversely and significantly correlated with numbers of simultaneously occurring age groups I (Figure 7 and Table 3). If age-I trout were determining the level of age-0 abundance, the time of this effect would most logically be during

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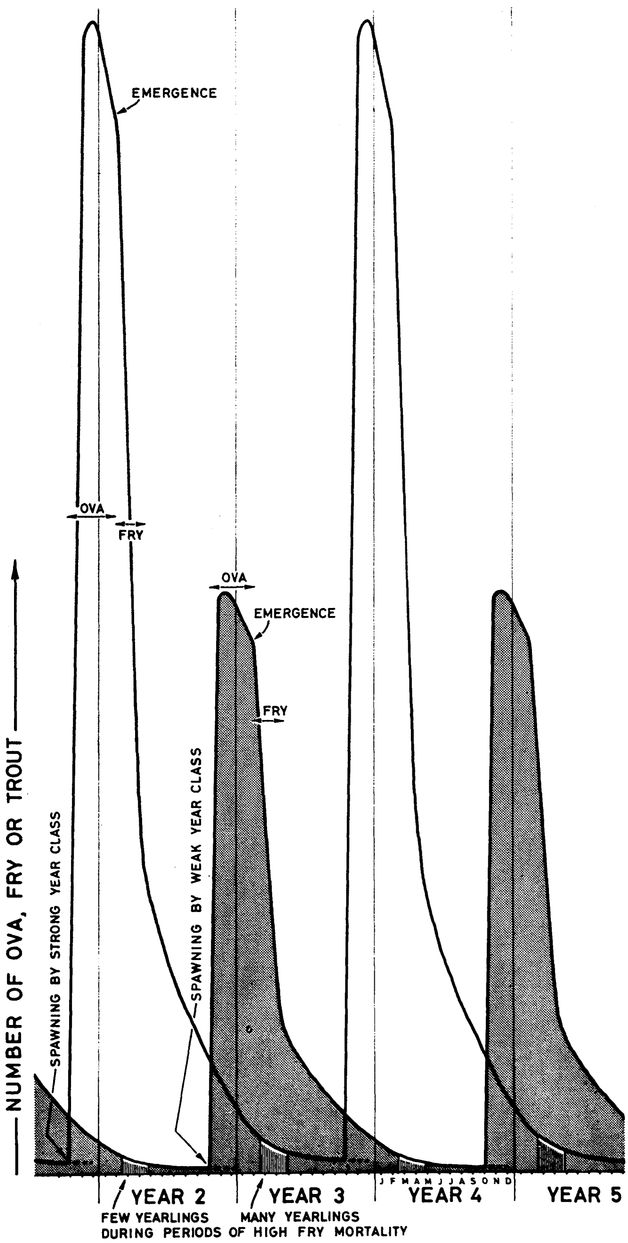
FIGURE 5. Curves of numerical trends within year classes of a hypothetical brook trout population in which: (1) reproduction is entirely by age group I, (2) strong year classes, producing high numbers of eggs, spawn strong year classes, (3) weak year classes spawn weak ones, (4) many age-I trout are present during the fry stages of weak year classes and (5) few age-I trout exist during the fry stages of strong year classes. Survivorship after completion of spawning is approximated from Lawrence Creek data (Hunt, 1966, Appendix Table 22; and McFadden, 1961) and is kept uniform for all year classes, thus eliminating compensatory complications. Were age group I suppressing age-O abundance, survivorship curves of weak year classes should be considered steeper than shown here.



EMERGENCE
OVA
FRY
OVA
EMERGENCE
FRY
NUMBER OF OVA, FRY OR TROUT
SPAWNING BY STRONG YEAR CLASS
SPAWNING BY WEAK YEAR CLASS
YEAR 2
YEAR 3
J F M A M J J A S O N D
YEAR 4
YEAR 5
FEW YEARLINGS
MANY YEARLINGS
DURING PERIODS OF HIGH FRY MORTALITY

TABLE 2. ESTIMATED NUMBER OF EGGS PRODUCED BY BROOK TROUT OF VARIOUS AGE GROUPS IN LAWRENCE CREEK DURING AN ELEVEN YEAR PERIOD. PERCENTAGE OF TOTAL ANNUAL EGG PRODUCTION IN PARENTHESES

YEAR	AGE GROUP					TOTAL
	I	II	III	IV	V and VI	
1953	439,531 (74)	142,905 (24)	8,837 (1.5)	—	—	591,273
1954	612,168 (79)	150,762 (19)	10,438 (1.3)	2,318 (0.4)	—	775,686
1955	458,081 (77)	125,846 (21)	11,246 (1.9)	—	1,218 (0.2)	596,391
1956	196,905 (74)	66,243 (25)	1,493 (0.6)	—	1,337 (0.5)	265,978
1957	739,295 (84)	75,024 (8)	68,683 (7.8)	—	—	883,002
1958	756,462 (74)	243,424 (24)	27,116 (2.6)	2,200 (0.2)	—	1,029,202
1959	191,745 (41)	261,323 (55)	18,821 (4.0)	—	—	471,889
1960	660,980 (96)	18,980 (3)	6,820 (0.9)	—	—	686,780
1961	489,092 (79)	126,251 (21)	2,096 (0.3)	—	—	617,439
1962	852,705 (89)	93,754 (10)	14,813 (1.5)	—	—	961,272
1963	513,519 (63)	283,144 (35)	16,250 (2.0)	1,724 (0.2)	—	814,637
Average	537,322 (76.8)	144,334 (20.6)	16,965 (2.4)	567 (0.08)	232 (0.03)	699,420

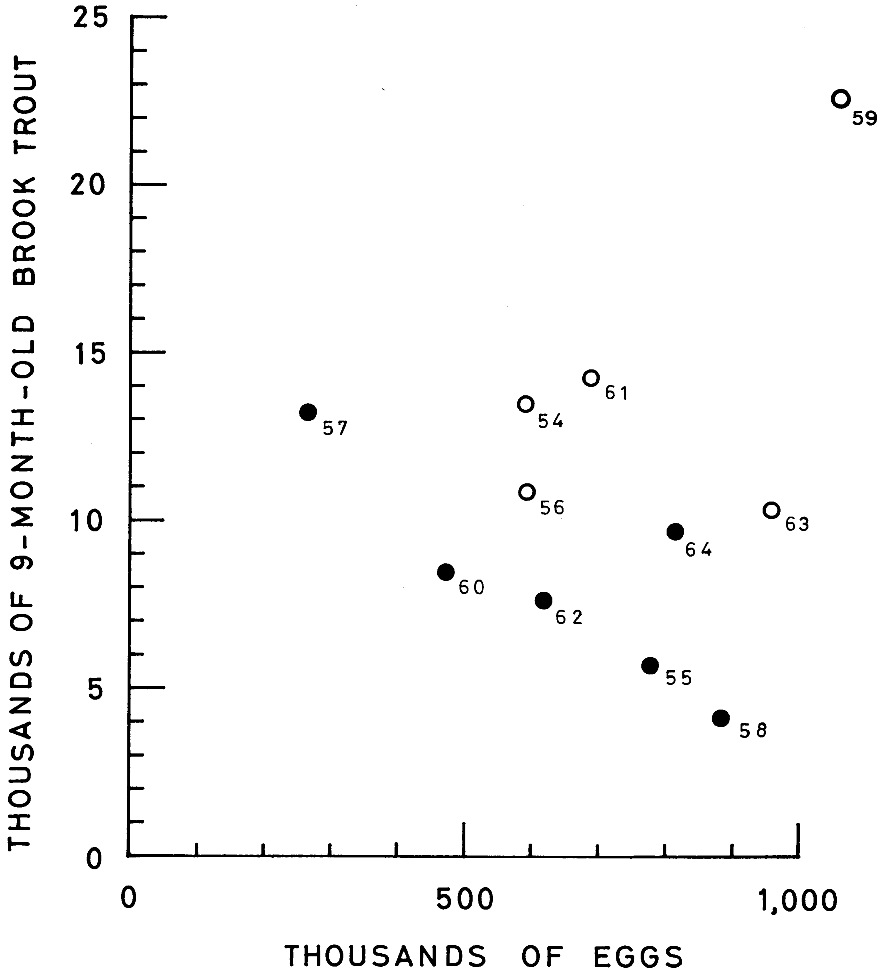


FIGURE 6. Numbers of age-0 brook trout in Lawrence Creek in September plotted against numbers of eggs from which they developed. Numbers by the points denote year classes. Solid points are those for year classes coinciding with lower-than-average April abundances of age group I.

spring when fry mortality is greatest. Hence, age-0 levels would be more closely correlated with springtime rather than autumn levels of age group I. The coefficient of correlation for age groups 0 against April age-I populations is higher than the correlation for age groups 0 against September age-I populations (Table 3), but with the low number of observations involved, the difference between the 2 coefficients is not statistically significant.

TABLE 3. COEFFICIENTS OF CORRELATION AND VALUES OF STUDENT'S *t* FOR REGRESSIONS OF NUMBERS OF AGE-0 BROOK TROUT IN SEPTEMBER ON NUMBERS OF OLDER TROUT IN LAWRENCE CREEK DURING 1953–64

REGRESSION OF NUMBER OF AGE 0 IN SEPTEMBER ON:	NUMBER OF YEARS OF OBSERVATIONS (n)	COEFFICIENT OF CORRELATION (r)	t-VALUE ($df=n-2$)
April Populations			
Number of age I	10	−.753	−3.218*
Number of age I plus older trout	10	−.732	−2.977*
Number of age II plus older trout	10	.205	0.592 n.s.
Total weight of all trout	9	−.174	−0.055 n.s.
September Populations			
Number of age I	12	−.608	−2.421*
Number of age I plus older trout	12	−.564	−2.161 n.s.
April and September Populations Averaged			
Number of age I	10	−.729	−3.017*
Number of age I plus older trout	10	−.702	−2.781*

*Significant at the 0.05 confidence level.
n.s. = not significant at the 0.05 level.

Numbers of age-0 trout are not correlated with numbers of trout older than age-I. Perhaps body size or behavior of these older trout reduce interactions with post-emergent young.

Cannibalism or competition for space and/or food are the sorts of processes that would tend to cause an inverse correlation such as that in Figure 7.[1] Cannibalism has been cited in other studies as a factor accounting for changes in abundance of young fish, but conclusive evidence of cannibalism in our streams is lacking.[2] For

[1] A disease-crowding process would seem a further but less likely possible mechanism behind the observed relationship. All we know of disease in these streams is that almost every brook trout carries gill copepods *(Salmincola edwardsii)*, that emaciation of smaller trout due to this burden appears worse than that of larger trout, and that during times of high trout population density the number of copepods on each trout's gills appears greater than during population lows. It is thought that the passing on of relatively high infestations of copepods by the higher populations of age-I trout to fry would be too erratic to account for the inverse relationship of age-0 and age-I densities (Figure 8).

[2] Cannibalism was postulated as the governor of a possible 4-year cycle among brown trout in 2 New Zealand streams (Burnett, 1959—another out-of-phase cycle!). Survival of stocked fingerling brook trout increased when older brook trout were removed from a lake (Smith, 1956). When the number of larger trout in a small lake increased, survival of stocked fingerling rainbow trout decreased (Miller and Thomas, 1957). There are logical yet indirect indications that predation on sockeye fry *(Onchyrhynchus nerka)* by smolts and residual non-migrants of preceding strong year classes may cause the 4-year cycle of that salmon in the Fraser River (Ricker, 1950). In a mixed population of warm water fishes in an Illinois lake, 4- or 5-year cycles of abundance were attributed to predation by dominant broods of crappies (*Pomoxis* sp.) but no data on predation were furnished (Thompson, 1941).

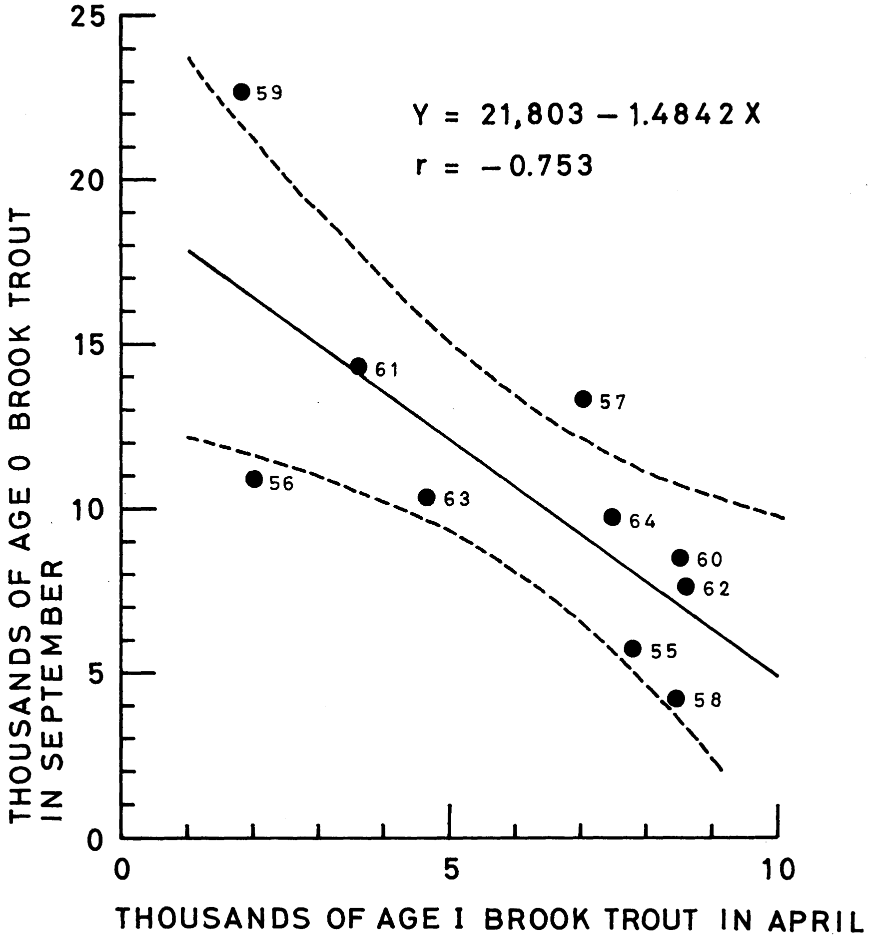


FIGURE 7. Numbers of age-0 brook trout in September plotted against age-I abundance during April of the same year in Lawrence Creek. Numbers by the points denote the year classes of age groups 0. Correlation is significant at the 0.05 confidence level (Table 2).

example, during 1960–66, we examined 1,400 stomachs of age-I-and-II brook trout collected in all seasons by daytime electrofishing and angling. Not a single case of cannibalism was found (unpubl. data of R. L. Hunt and D. A. White). To account for even 10% of the average mortality of age group 0 between emergence and mid-June, each fish in the average population of older trout during that time would have to consume approximately 15 fry per day. However, no fry were found in 160 stomachs collected from adult trout during such a 5-month period. Although cannibalism among brook trout has been demonstrated elsewhere,[3] there are no indication that it takes place on a scale sufficient to account for the hundreds of thousands of fry that perish in Lawrence Creek and Roche-a-Cri each spring.

Competition rather than predation seems a more likely relationship between age-0 and age-I brook trout, especially in view of the investigations of LeCren (1965) who varied the numerical density of brown trout fry in small experimental waterways and found their survival and growth to be inversely density-dependent. This result was apparently due to territorial behavior. Fry not able to secure a territory drifted downstream and died by starvation usually between 20 and 40 days before feeding began. Density-dependent "disappearance" of age-0 trout from Lawrence Creek is indicated in analyses of September age-0 levels as a function of egg production plus age-I abundance (McFadden, in press). A rough representation of such an analysis can be seen in the negative slope of the solid black points in Figure 6. Greater dispersal of young from main nursery areas in years of higher age-0 density (Hunt, 1965) implies that the apparent compensatory mortality in Lawrence Creek prior to September may be partially attributable to movement downstream out of the study area. If space competition from age-I trout is similarly affecting fry or fingerlings, this could account for the observed numerical relationships between the 2 age groups, and for the 2-year cycle of yearclass abundance.

Although the number of age-0 trout that disappear is not correlated with the number of contemporary age I trout (Figure 8), age

[3] Following release of several thousand brook trout fry into a small Ontario stream, collection of 16 age-I-and-II brook trout mainly by means of a flashlight and handnet at night revealed 4 stomachs containing fry, the greatest number in any one stomach being 8 (H. C. White, 1924). After stocking fry in a Prince Edward Island stream, 319 "adult and yearling" brook trout were captured, "those whose stomachs were distended" (number not reported) were examined, and only one fry was found (H. C. White, 1927). In sections of the same stream, screened to permit only certain types of predators to operate on fry stocks of known size, comparison of mortality rates led to the conclusion that "competition and cannibalism" by larger trout were greater menaces to fry than were predation by birds or sticklebacks *(Eucalia inconstans),* but no proof of cannibalism was put forth (H. C. White, 1927 and 1930).

group I may act as a "level-setter" of year class strength. The "rather fixed environmental resource", be it space, food or whatever, could determine a general numerical density (carrying capacity) to which age group 0 must diminish each year regardless of the number of age-I trout. With this carrying capacity at a level of (for instance) 40,000 to 80,000 fry, the greatest share of post-emergence mortality has occurred by the time this level is attained. The amount of additional fry mortality that might be dependent upon the density of age I trout would be a relatively small component of total fry mortality but an important component in the ultimate determination of year class strength. While such a mechanism may bring cannibalism back into the realm of possi-

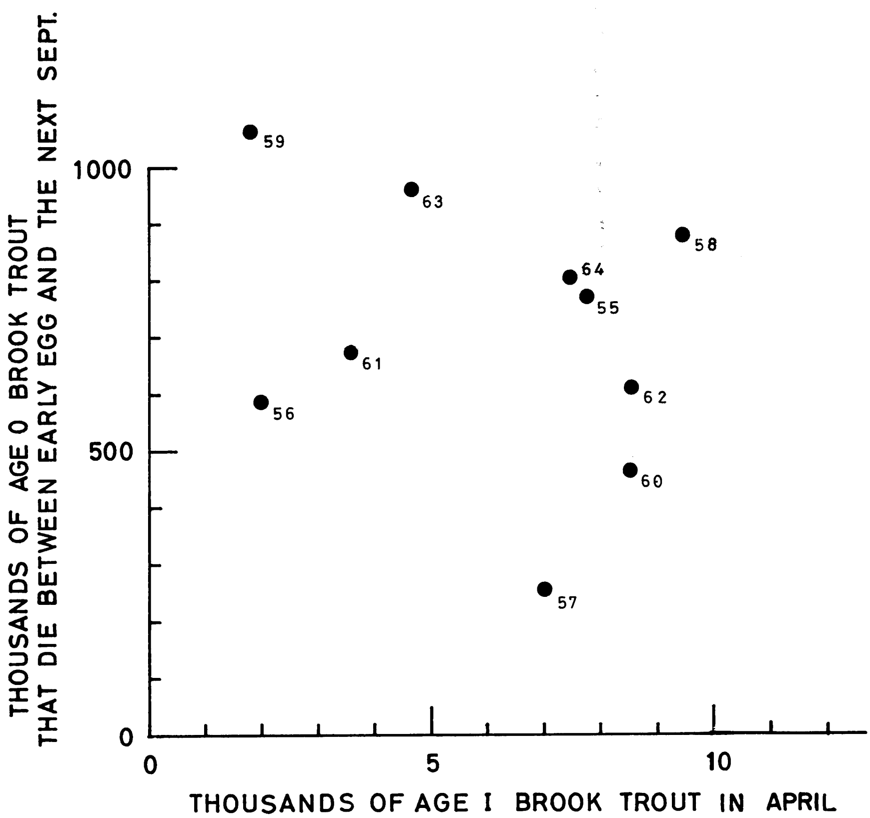


FIGURE 8. Absolute mortality of brook trout in Lawrence Creek during the 10 to 11 months from the egg stage to the next September plotted against number of age-I trout present during April of this period. Numbers by the points denote the year classes of age groups 0.

bility, the negative evidence regarding such predation in Lawrence Creek makes competition seem the more likely process needing further investigation.

To investigate more closely relationships between stocks of age-I and age-0 trout, experiments similar to those of LeCren (1965) should be conducted utilizing various sizes and densities of age-I trout introduced as factors modifying existing fry-space relationships. Suppression of age-0 brook trout by older brook trout could also be tested under the more natural conditions in our streams by measuring survival of trout fry at selected high and low springtime densities of older trout. Low densities of older trout could be achieved by electrofishing to remove them in winter after the spawning season. High densities could be attained by stocking wild brook trout from other nearby streams.

Our study points up the need for identifying the causes of mortality among wild trout fry and for direct observation of behavioral relationships between age groups and size groups of brook trout under wild conditions.

Acknowledgements

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References Cited

BURNET, A. M. R. 1959. Some observations on natural fluctuations of trout population numbers. N. Z. J. Sci. 2:410–421.

DAVIS, D. E. 1957. The existence of cycles. Ecology 38(1):163–164.

HUNT, R. L. 1964. Evaluation of fly-fishing-only at Lawrence Creek (a three-year progress report). Misc. Res. Rept. No. 10 (Fisheries). Wis. Conserv. Dept., Madison, Wis. (mimeo).

————. 1965. Dispersal of wild brook trout during their first summer of life. Trans. Am. Fish. Soc. 94(2):186–188.

————. 1966. Production and angler harvest of wild brook trout in Lawrence Creek, Wisconsin. Tech. Bull. No. 35. Wis. Conserv. Dept., Madison, Wis.

————, and O. M. BRYNILDSON. 1964. A five-year study of a headwaters trout refuge. Trans. Am. Fish. Soc. 93(2):194–197.

————, O. M. BRYNILDSON and J. T. MCFADDEN. 1962. Effects of angling regulations on a wild brook trout fishery. Tech. Bull. No. 26. Wis. Conserv. Dept., Madison, Wis.

KEITH, L. 1962. Wildlife's ten-year cycle. University of Wisconsin Press.

LECREN, E. D. 1965. Some factors regulating the size of populations of freshwater fish. Mitt. Internat. Verein. Limnol. 13:88–105.

McFADDEN, J. T. 1961. A population study of the brook trout, *Salvelinus fontinalis*. Wildl. Monog. No. 7.

————. (In press.) Dynamics and regulation of salmonid populations in streams. A symposium, "Salmon and Trout in Streams", sponsored by the H. R. MacMillan Lectures in Fisheries at the University of British Columbia, February 22–24, 1968.

MILLER, R. B., and R. C. THOMAS. 1957. Alberta's "pothole" trout fisheries. Trans. Am. Fish. Soc. 86:216–218.

NEAVE, F. 1952. "Even-year" and "odd-year" pink salmon populations. Trans. Roy. Soc. Canada XLVL:55–70.

————. 1953. Principles affecting the size of pink and chum salmon populations in British Columbia. J. Fish. Res. Bd. Can. 9(9):450–491.

RICKER, W. E. 1950. Cycle dominance among the Fraser sockeye. Ecology 31: 6–26.

SMITH, M. W. 1956. Further improvement of trout angling at Crecy Lake, New Brunswick, with predator control extended to large trout. Can. Fish Culturist 19:13–16.

TARZWELL, C. M. 1937. Experimental evidence on the value of trout stream improvement in Michigan. Trans. Am. Fish. Soc. 66:177–187.

THOMPSON, D. F. 1941. The fish production of inland streams and lakes. *In* A symposium on hydrobiology. Univ. of Wis. Press: 206–217.

WHITE, H. C. 1924. A quantitative determination of the number of survivors from planting 5,000 trout fry in each of two streams. Contr. Can. Biol. Fish. n. s. 2(9):137–139.

————. 1927. A preliminary report on trout investigation in Forbes Brook P. E. I. in 1925 and 1926. Contr. Can. Biol. Fish. n. s. 3(15):365–376.

————. 1930. Trout fry planting experiments in Forbes Brook P. E. I. in 1928. Contr. Can. Biol. Fish. n. s. 5(8):203–212.

DISTRIBUTION, STANDING CROPS, AND DRIFT OF BENTHIC INVERTEBRATES IN A SMALL WISCONSIN STREAM[1]

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Abstract

Bottom samples showed genera of *Tricorythodes, Stenonema, Cheumatopsyche* and *Chimarra* occurred more frequently at downstream than upstream stations, while *Neophylax* occurred only near the main spring. Principal organisms found in the stream drift were *Gammarus pseudolimneaus* Bousfield and *Baetis vagans* McDunnough. Both had higher drift rates at night than during the day. Total stream drift of *Gammarus* caught upstream apparently did not affect the drift caught 152 m downstream.

Introduction

The many small spring-fed streams in southwestern Wisconsin appear to be excellent for studies of the ecology of an entire stream and its watershed. They are short (some less than 800 m) and narrow (some 0.3 m wide); they receive a constant supply of spring water; and they appear productive in benthic invertebrates. The purpose of this study, undertaken in one such stream, was (1) to determine the standing crops of its principal organisms and (2) to measure the kinds and quantities of organisms (drift) carried by the stream current.

Stream drift, an important source of food to fishes, has been reported by Needham (1938), Dendy (1944), Waters (1962 a), Miller (1963), and others. Waters (1962 b) used drift rates and standing crop measurements to determine the production of invertebrates appearing in the drift. The feasibility of using his method in this stream was examined.

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[1] A grant from the Research Board of the State Universities of Wisconsin supported the research.

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Description of the Stream

Samples were taken from Bear Branch (local name), a small stream in Grant County, Wis. (T3N, R2W, Sec. 32). The stream flows south and receives a constant supply of water from a spring located 1,675 m from the mouth at the Little Platte river. Stream widths range from .6 to 2.5 m. Average depths in riffle areas are 7 to 10 cm. Following rainstorms, water levels had extreme fluctuations. A normal discharge rate, during October 1965, was 0.21 m^3/sec. Above the spring, the stream is often dry and no samples were taken there.

The temperature of the spring water is fairly constant throughout the year, ranging from 9.0 to 9.5°C in 1965. During the summer, water temperatures increased rapidly downstream from the spring. For example, on 1 August 1965, temperatures were 14.0, 16.5, 19.0, 23.0, 24.0 and 28.0°C at the respective distances below the spring of 180, 240, 300, 485, 850 m and at the mouth. In the winter, relatively warm spring water resulted in higher temperatures near the spring than downstream. On 24 January 1965, the temperature dropped from 9.0°C at the spring to 7.0 and 4.0°C at 240 and 850 m, respectively, below the spring.

Because the stream is shallow, water temperatures fluctuate during the day. At 240 m below the spring, they were 13 to 15°C October 16, 8 to 10°C October 23, and 8 to 9°C November 19, 1965.

Total alkalinity of the stream water during July 1966 ranged from 303 to 308 ppm, as determined by titration with .02N H_2SO_4, and methyl orange as an indicator.

The upper 300 m of the stream is relatively straight, with pools, riffles and a growth of watercress, *Nasturtium officinale.* Below this, the stream meanders and widens. No trees or shrubs overhang it, and its banks are well-cropped by cattle.

Materials and Methods

Bottom samples were collected in riffle areas of the stream with a sampler (Waters and Knapp, 1961), which encompassed 0.1 m^2 of bottom; the mesh size of its net was 256 μ. Three stations were sampled. Stations 1 and 4, located 60 and 240 m, respectively, below the spring, will be referred to collectively as upstream areas; station 15, 910 m below the spring, as the downstream area.

Organisms found in the drift were captured with stationary nets (Waters, 1962 a,b). Each was made of 256 μ mesh Nytex[3] nylon netting, and fitted to a 0.3 × 0.2 m frame made of brass welding

[3] Trademark of Tobler, Ernst and Traber, Inc., New York.

rod. The nets were held in place by iron rods driven into the stream bed.

To establish the total daily drift passing from riffle areas, the stream was completely blocked by drift nets at the downstream end of the station 4 riffle for 24-hr periods on 7 June, 31 August–1 September and 22–23 October 1966, and at the downstream end of a riffle at station 2 (91 m below the spring) on 7 June. The nets were lifted, emptied and replaced in intervals usually ranging from 1 to 3 hrs.

Wet weights were determined by centrifuging the organisms in wire-mesh cones to remove surface moisture, and then weighing them to the nearest 0.0001 g on an optical analytic balance. Samples were preserved in 5% formalin and no corrections were made for weight loss caused by preservation.

Results

Qualitative Analysis of Bottom Samples

Invertebrates found in bottom samples from one station were sometimes scarce or absent at others. Nymphs of mayflies belonging to the genera *Tricorythodes* and *Stenonema* were common at station 15, infrequent at station 1 and absent at station 4 (Table 1). Those found at station 1 were probably carried from above the spring, where cursory inspection indicated their presence. The species *Baetis vagans* McDonnough, dominant mayfly nymph of the upstream stations, was less frequent and abundant downstream.

TABLE 1. PERCENT FREQUENCY OCCURRENCE OF INVERTEBRATES FOUND IN 0.1 M^2 BOTTOM SAMPLES TAKEN FROM SEPTEMBER 1965 THROUGH APRIL 1966

Organism	Percent Frequency Occurrence		
	Upstream Stations		Downstream Station
	Station 1	Station 4	Station 15
Gammarus	100	100	50
Baetis	82	100	75
Tricorythodes	9	0	50
Stenonema	18	0	100
Hydropsyche	90	90	100
Cheumatopsyche	0	64	75
Chimarra	0	9	100
Neophylax	36	0	0
Number of bottom samples	11	22	4

Of the Trichoptera larvae, the genera *Cheumatopsyche* and *Chimarra* were found more frequently downstream than upstream. *Hydropsyche* occurred with about equal frequency in both areas. *Neophylax* was restricted to station 1. *Gammarus pseudolimnaeus* Bousfield was always present in upstream areas, but less frequent downstream.

There was no detectable difference among stations in the frequency occurrence of the other major groups of organisms in the bottom samples: Turbellaria *(Dugesia)*; Annelida (Enchytraeidae); Decapoda *(Orconectes)*; Hydracarina; Hemiptera; Megaloptera *(Sialis)*; Coleoptra (Elmidae, Dytiscidae); Diptera *(Chrysops, Tipula, Antocha, Limnophora, Atherix)*; Simuliidae; Tendipedidae; Gastropoda *(Physa, Limnaea, Ferissia)*; and Pelecypoda *(Sphaerium)*.

Quantitative Analysis of Bottom Samples

At station 1, *Gammarus* comprised 51% of the total weight of 11 combined samples, trichopteran larvae, 38%, *Baetis*, 2%. The remaining 9% was mostly chironomid larvae.

At station 4, *Gammarus* comprised 22% and trichopteran larvae 63% of the combined weight of 21 samples. *Baetis* comprised 2%; the remaining 13% was largely chironomid larvae.

At station 15, *Gammarus* comprised only 6%, trichopteran larvae 62%, mayfly nymphs 1% of the combined weight of 4 samples. The remaining 31% was mostly dipteran larvae of which chironomid larvae contributed a little more than half.

In the upstream areas, the maximum standing crop for any one sample collected from 11 September 1965 to 4 April 1966 was 0.36 g/0.1 m^2 at station 4 for *Baetis* nymphs on 2 April 1966. Two major emergences of *Baetis* were directly observed: one from late October through November and another from early April to early May. The maximum standing crop for trichopteran larvae, mostly *Hydropsyche*, was 7.4 g/0.1 m^2 at station 4 on 15 January 1966. For *Gammarus*, the maximum standing crop was 2.5 g/0.1 m^2 at station 4 on 14 November 1965 and 6 February 1966.

Measurement of Drift

Gammarus and *Baetis* nymphs were the major components of the drift. Other organisms included chironomid larvae and adults and occasionally other dipteran larvae. Fig. 1 shows the hourly drift rates of *Gammarus* and *Baetis* on 7 June 1966, indicating greater total drift at night for both species. Drift rates of *Gammarus* were nearly identical at stations 2 and 4 (Fig. 1, Table 2),

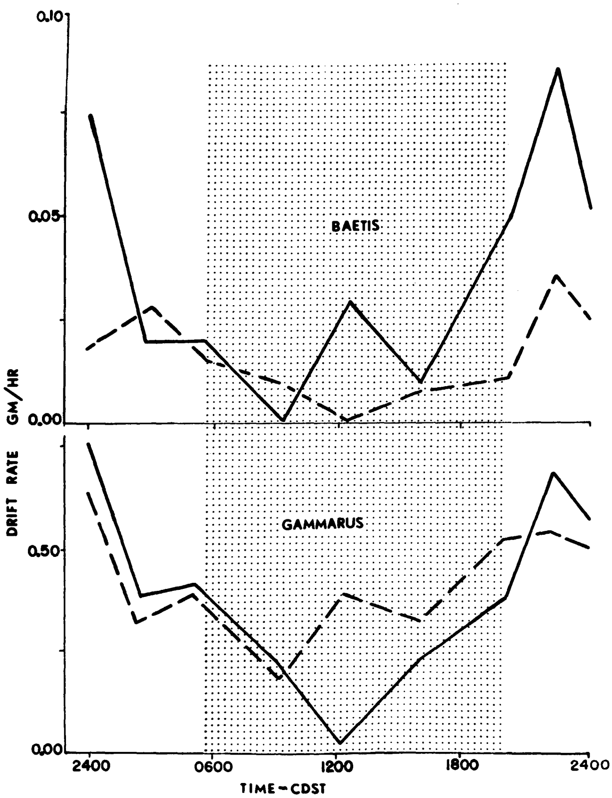

FIGURE 1. Drift rates of *Gammarus* and *Baetis* in g/hr at station 2 (solid line) and station 4 (broken line) on 7 June 1966. Stippled area indicates time of daylight.

whereas the hourly drift rates of *Baetis* were generally larger at station 2 than at 4.

The average standing crops, determined from two bottom samples taken at each station on 8 June 1966 were 0.10 (range 0.067 to 0.126 g) and 0.03 (range 0.040 to 0.019) g/0.1 m^2 for *Baetis* at stations 2 and 4, respectively; and 1.48 (range 0.12 to 2.85) and 1.21 (range 0.658 to 1.754) g/0.1 m^2 for *Gammarus* at stations 2 and 4, respectively. The higher drift rates of *Baetis* at station 2 may be the result of higher standing crop at that station, while the nearly uniform drift rates of *Gammarus* correspond to nearly identical standing crops at both stations.

The total stream drift of *Gammarus* is less variable than that of *Baetis* (Table 2), ranging from 2.7 to 13.3 g per day, a factor

TABLE 2. TOTAL STREAM DRIFT (G/DAY) OF *Gammarus* AND *Baetis*, FOR THREE 24-HR PERIODS, 1966

DATE, 1966	TOTAL STREAM DRIFT IN G/DAY			
	Station 2		Station 4	
	Gammarus	*Baetis*	*Gammarus*	*Baetis*
June 7	8.3	0.72	9.4	0.34
Aug. 31–Sept. 1	—*	—*	13.3	5.00
Oct. 22–23	—*	—*	12.8	1.30

*No samples taken.

of approximately 5; whereas the total stream drift of *Baetis* ranged from 0.34 to 5.00 g per day, a factor of approximately 15.

DISCUSSION

Tricorythodes, Stenonema, Cheumatopsyche, and *Chimarra* were more frequent at downstream than at upstream stations, while *Neophylax* occurred only near the spring. The principal organisms found in the stream drift were *Gammarus* and *Baetis*. While *Gammarus* is abundant in the drift during most of the year, *Baetis* occurs in significant quantities only during late winter—early spring and late summer—early fall, periods just preceding major emergences. The maximum standing crop of *Baetis* of 3.6 g/m^2 reported in this study is low when compared with the maximum standing crop of 10.0 g/m^2 reported in Valley Creek, Minn. (Waters, 1962 b). These low standing crops may limit the use of the drift method (Waters, 1962 b) for estimating production rates in Bear Branch.

A diurnal periodicity of drift rates for both *Gammarus* and *Baetis* agrees with results reported by several workers and reviewed by Waters (1965). A clearer picture of the diurnal periodicity might have resulted in this study if shorter sampling intervals had been used and if possible disturbances by cattle in the stream had been eliminated.

The complete blockage of the stream with drift nets at station 2 on 7 June 1966 did not influence the drift of *Gammarus* entering the nets which also completely blocked the stream at station 4. This suggests the drift is not accumulative from upstream to downstream areas for distances of at least 152 m.

ACKNOWLEDGEMENTS

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LITERATURE CITED

DENDY, J. S. 1944. The fate of animals in stream drift when carried into lakes. Ecol. Monogr. 14:333–357.

MÜLLER, KARL. 1963. Diurnal rhythm in "organic drift" of *Gammarus pulex*. Nature. 198:806–807.

NEEDHAM, P. R. 1938. Trout streams. Comstock Pub. Co., Ithaca, New York. 233 pp.

WATERS, T. F. 1961. Standing crop and drift of stream bottom organisms. Ecology. 42:532–537.

———. 1962 a. Diurnal periodicity in the drift of stream invertebrates. Ecology. 43:316–320.

———. 1962 b. A method to estimate the production rate of a stream bottom invertebrate. Trans. Am. Fish. Soc. 91(3):243–250.

———. 1965. Interpretation of invertebrate drift in streams. Ecology. 46(3): 327–334.

———., and R. J. KNAPP. 1961. An improved stream bottom fauna sampler. Trans. Am. Fish. Soc. 90(2):225–226.

BIOLOGY OF THE COREIDAE IN WISCONSIN

T. R. Yonke[1] *and J. T. Medler*[2]

From July 1, 1962, through June 15, 1967, numerous observations and collections were made of various members of the order Hemiptera. Special interest centered around species in the alydid-coreid-rhopalid complex. Much of the literature in these groups has been of a taxonomic nature with relatively little or no work reported on the biologies and field histories of the respective species. To fill this void in the knowledge of the Coreoidea a study was initiated on the biologies and field histories of members of the Alydidae, Rhopalidae and Coreidae that are found in Wisconsin.

Previously information was reported on the biologies of 4 species of Alydidae in Wisconsin, including *Megalotomus quinquespinous* (Say) (Yonke and Medler, 1965); *Alydus conspersus* Montandon, *A. eurinus* (Say) and *A. pilosulus* Herrich-Schaeffer (Yonke and Medler, 1968). Limited observations have been conducted on 2 Rhopalidae, *Corizus crassicornis* (Linnaeus) and *Harmostes reflexulus* (Say) (Yonke and Medler, 1967).

This is a report on the study of the Coreidae in Wisconsin. Ten species have been recorded for the state. Three species were extremely rare—*Anasa armigera* (Say), *Chariesterus antennator* (Fabricius), and *Leptoglossus oppositus* (Say). *Coriomeris humilis* Uhler and *Merocoris distinctus* Dallas were uncommon. Five species frequently encountered were *Acanthocephala terminalis* (Dallas), *Anasa tristis* (DeGeer), *Archimerus alternatus* (Say), *Catorhintha mendica* Stål, and *Euthochtha galeator* (Fabricius). The first 4 species mentioned were not collected by the authors, but were represented in the Department of Entomology Museum, University of Wisconsin.

Of the latter 5 species the squash bug, *A. tristis,* has been thoroughly studied. The squash bug is of economic importance on the cucurbits. The most comprehensive work to date was that of Beard (1940). Also, the biology of *C. mendica* has been adequately determined (Balduf, 1942, 1957). For the other 3 species, however,

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there is no published information on the biologies except for Blatchley (1926) who presented only a few brief notes. The principal part of this text reports studies conducted on *A. terminalis*, *A. alternatus*, and *E. galeator*.

Methods and Materials

Collection trips were made throughout southern Wisconsin from April until December in order to obtain field information. The principal collection sites were at Gibraltar Rock, Columbia County; Devils Lake State Park, Ferry Bluff and Parfreys Glen in Sauk County; and Wyalusing State Park, Grant County.

Surveys were made by net-sweeping of prairie, woodland, and disturbed "weedy" habitats to determine if the bugs were present. If encountered, a more intensive search of the area was made to determine the host plants and make observations.

The term, host plant, is used here to denote the actual feeding of the bug on a particular plant in the field. A "collection record" signifies only that the specimen was collected from a particular plant which may or may not have been a host plant and for which no feeding was observed.

A special attempt was made to collect parasitized specimens and rear out the adult parasites. All adults and nymphs observed in the field with Dipterous eggs on them were brought back to the laboratory, and the specimens placed in rearing cartons where they were held until the parasites emerged. Field collected eggs were also placed in laboratory rearing cartons in an attempt to obtain Hymenopterous parasites. All stages of coreids found in the field were brought alive to the laboratory in Madison and placed in 1 pint rearing containers. This technique was developed by Scheel, Beck, and Medler (1956). The substitute food used in the laboratory cartons consisted of fresh green beans (Fig. 1). The food was changed 2 or 3 times a week or as needed. Nymphs and adults of *E. galeator* and later instar nymphs and adults of *A. alternatus* and *A. terminalis* fed well on this diet.

Rearings in the laboratory were used to complement field information and to some degree determine the biology of these bugs. The term "laboratory biology" is employed to designate that the bugs were reared under laboratory conditions and on a substitute non-natural food. The cultures were maintained at room temperature ($25 \pm 4°C$), and approximately normal daylight.

Daily records were kept on preoviposition period, the number of eggs produced, incubation period, oviposition period, time spent in each instar, copulation frequency and duration, and adult longevity. Notes were made on any peculiar or interesting habits exhibited

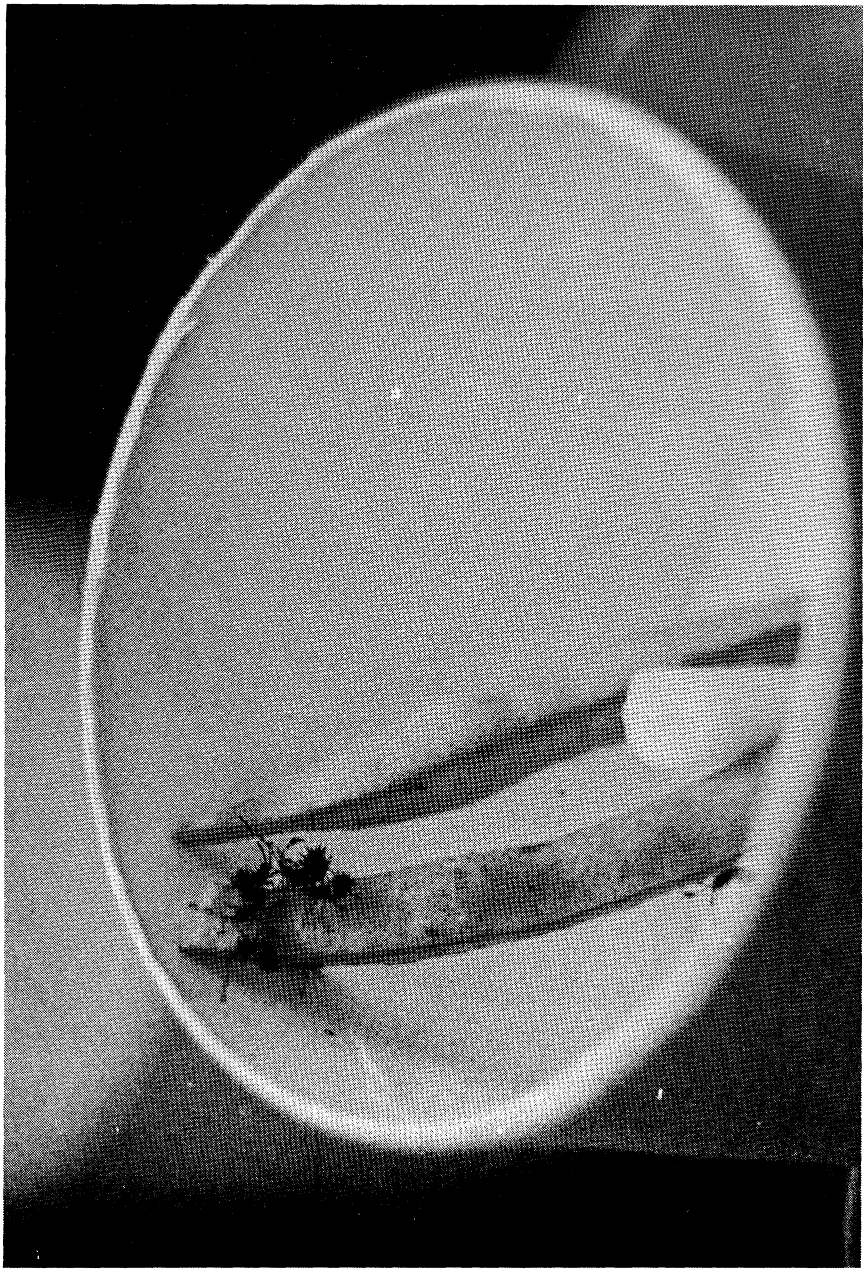

FIGURE 1. Feeding aggregation of 7 second-instar nymphs of *Euthochtha galeator* on the laboratory diet of fresh green bean.

by these insects. The old cartons and cotton rolls were replaced with fresh ones approximately every 3 weeks or as needed to reduce contamination.

RESULTS AND DISCUSSION

Acanthocephala terminalis (Dallas)

The main field study area for this species was at Ferry Bluff (Sauk County) where it was collected from June through September. Additional observations and collections were made at Wyalusing State Park, Devils Lake State Park, and Parfreys Glen.

Figure 2 shows the seasonal occurrence of *A. terminalis* in southern Wisconsin during 1962–1967. There was 1 generation per year. Adults appeared June 13 and were found throughout the summer until September 24. Members of the overwintered generation were collected and brought to the laboratory where gravid females oviposited bright whitish eggs. No eggs or first-instar nymphs could be found in the field; therefore, the data for these stages were obtained from eggs laid by females while transporting them to, or in, the laboratory. No eggs were oviposited by females collected from the field after July 15. Of 47 eggs obtained in this manner all but 2 hatched in from 7–14 days (x = 9.68). Data presented for Instar 1 were determined by recording the dates of eclosion. Second-instar nymphs were collected in the field from June 30–August 11; third-instar nymphs from June 30–August 11; fourth-instar nymphs from July 8–August 11; and fifth-instar

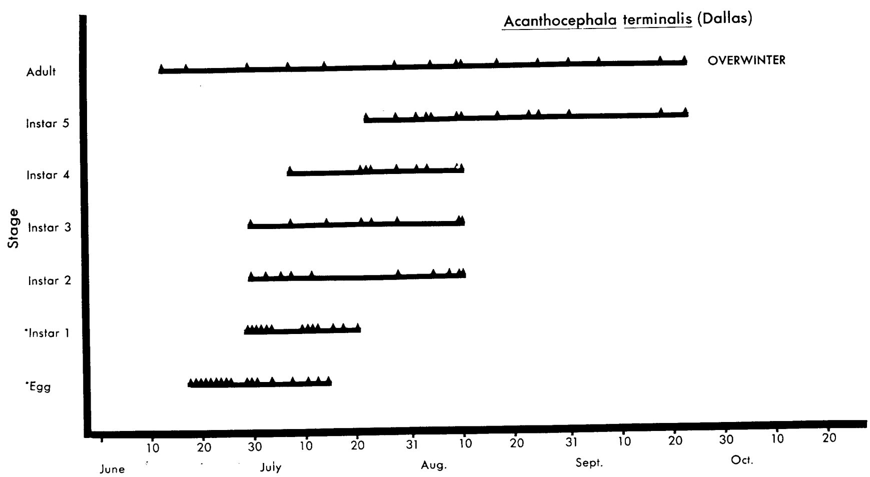

FIGURE 2. Seasonal occurrence of *Acanthocephala terminalis* in Wisconsin, 1962–1967, showing inclusive dates and actual collection records (peaks).

nymphs from July 23–September 24. Eggs and first- and second-instar nymphs would have to occur in the field earlier, and third- and fourth-instar nymphs later than figure 2 shows. Also, it was expected that there was an overlap in late July and August of the occurrence of the overwintered adults and the new summer generation adults. Fifth-instar nymphs collected from the field and brought into the laboratory began molting into the adult stage as early as July 27. On August 10, 1966, 1 second-, 3 third-, 4 fourth-, and 4 fifth-instar nymphs were collected on *Vitis riparia* Michx. at Ferry Bluff.

Three host plants were established for the nymphs and adults of *A. terminalis* (Table 1). Four females were found at Wyalusing State Park feeding on the tender shoots of staghorn sumac, *Rhus typhina* L., on June 18, 1964; as was a second-instar nymph on July 12, 1965. Second- through fifth-instar nymphs and adults were collected over the entire season at Ferry Bluff from both *V. riparia,* river grape, and *Physocarpus opulifolius* (L.) Maxim., nine-bark. Fifth- instar nymphs and adults were also collected from *V. riparia* at Parfreys Glen on August 18, 1966. Both nymphs and adults were observed feeding on the succulent stems and petioles of these plants. One fourth-instar nymph was found feeding on the upper surface of a leaf of *V. riparia.*

Adults were easily disturbed and were very rapid fliers. Immatures were occasionally found resting on the upper surfaces of leaves but more frequently they were hidden under leaves or along the main stems of the plants. This secretive habit along with their dark color made them somewhat difficult to find. At no time were they in great abundance.

Immatures and adults were also collected from *Fraxinus* sp. (ash), *Rubus (Eubatus)* sp. (blackberry), *Tilia americana* L. (basswood), *Desmodium acuminatum* (Muhl.) Wood (tick tree-foil), *Ulmus rubra* Muhl. (slippery or red elm) (Table 1). No feeding was observed in any of these instances so that no definite host plant association could be made; however, it was possible that any or all were fed on and could have served as hosts.

No parasites were obtained from either nymphs or adults, and no parasite eggs were found on any of the bugs.

Field collected specimens were brought to the laboratory and placed on green beans in the cartons. Although individuals from the first-instar nymph to the adult stage fed on this diet they did not do well. Nymphal mortality was very high from the second-instar through the fifth. Only 2 individuals went through their entire development from egg to adult on beans. One female spent 3, 9, 6, 8, and 17 days in each of the 5 respective stadia for a total of 43 days; the other, a male, spent 4, 9, 7, 13, and 28 days in the

TABLE 1. HOST PLANT RECORDS OF *Acanthocephala terminalis, Archimerus alternatus,* and *Euthochtha galeator*

STAGE [1]	*Acanthocephala terminalis*			*Archimerus alternatus*			*Euthochtha galeator*		
	Egg	Nymph	Adult	Egg	Nymph	Adult	Egg	Nymph	Adult
Host Plants									
Achillea millefolium	—	—	—	—	—	—	—	—	X*
Agrimonia gryposepala	—	—	—	—	—	—	—	5	X*
Ambrosia artemisiifolia	—	—	—	—	5*	—	—	—	—
A. trifida	—	—	—	—	5*	X	—	—	—
Amphicarpa bracteata	—	—	—	—	2–5*	X*	—	3	—
Aster ericoides	—	—	—	—	—	—	X	1	—
A. pilosus	—	—	—	—	—	—	—	5*	—
A. sagittifolius	—	—	—	—	—	X*	—	—	—
Aster spp.	—	—	—	—	—	X	—	5	—
Aureolaria grandiflora var. *pulchra*	—	—	—	—	—	—	—	3–4	—
Carya spp.	—	—	—	—	—	—	—	—	X
Cryptotaenia canadensis	—	—	—	—	5*	—	—	—	—
Desmodium acuminatum	—	5	—	X	1–5*	X*	—	2*	—
D. canadense	—	—	—	—	5*	—	—	—	—
D. dellenii	—	—	—	—	4–5*	—	—	—	—
Erigeron annuus	—	—	—	—	5*	X*	—	—	—
Eupatorium rugosum	—	—	—	—	5*	—	—	—	—
Fraxinus spp.	—	—	X	—	—	—	—	—	—
Galium concinnum	—	—	—	—	—	X*	—	—	—
Graminae spp.	—	—	—	—	—	—	X	—	—
Helianthus decapetalus	—	—	—	—	—	X*	—	—	—
Monarda fistulosa	—	—	—	—	—	X*	—	—	X*

TABLE 1 *(Continued)*

STAGE[1]	*Acanthocephala terminalis*			*Archimerus alternatus*			*Euthochtha galeator*		
	Egg	Nymph	Adult	Egg	Nymph	Adult	Egg	Nymph	Adult
Host Plants									
Physocarpus opulifolius	—	2–5*	X	—	—	—	—	—	—
Podophyllum peltatum	—	—	—	X	—	—	—	—	—
Prunus americana	—	—	—	—	—	—	X	—	—
Quercus ellipsoidalis	—	—	—	—	—	—	—	2*	X*
Rhus glabra	—	—	—	—	—	—	X	—	—
R. typhina	—	2	X*	—	—	—	—	—	—
Robinia pseudoacacia	—	—	—	—	—	X	—	—	—
Rubus (*Eubatus*) spp.	—	4–5	—	—	—	—	—	—	—
Solidago altissima	—	—	—	—	—	X*	—	—	X
S. gigantea	—	—	—	—	—	X	—	—	—
Solidago spp.	—	—	—	—	—	X	—	—	—
Symplocarpus foetidus	—	—	—	—	—	X*	—	—	—
Tilia americana	—	3–4	—	—	—	—	—	—	—
Ulmus rubra	—	5	X	—	—	—	—	3,5	—
Urtica dioica	—	—	—	—	—	—	X	—	—
Vitis riparia	—	2–5*	X*	—	—	—	—	—	—

[1]1–5 = nymphal instars. *Definitely associated host plant (feeding observed in the field).

5 stages for a total of 61 days. Out of 66 adults, both field collected and laboratory reared, 34 were males and 32 were females. The time spent in nymphal development was 58.2 days (Table 2) based on accumulated mean values. Values for Table 2 were compiled primarily from data on second- through fifth-instar nymphs collected from the field and brought to the laboratory.

Growth ratios were fairly consistent (Yonke and Medler, In Press, a). The closeness of fit for the values indicated a uniform growth rate, and therefore tended to substantiate the data presented in Table 2 on the time required for nymphal development. However in comparing laboratory data from Table 2 with field occurrence records in Figure 2, the time required for nymphal development would appear to be longer in the laboratory than in the field.

Anasa tristis (DeGeer)

The following observations in Wisconsin were consistent with the biology of this species as determined by Beard (1940) in Connecticut. The squash bug was not especially abundant in the state. On July 23, 1963, 7 eggs were collected from the upper surface of a leaf of a squash plant. Four hatched on July 27, and 1 on July 28. They molted to the second instar on July 30, but then died. Two fifth-instar nymphs collected from squash plants on September 17, 1963, molted to the adult on September 29.

Four adults were also collected and placed on green bean in the laboratory. They were observed copulating frequently, but no eggs were laid. They lived for 42, 183, and 190 days, respectively. Eleven fourth- and fifth-instar nymphs and 4 adults were collected from squash on September 21, 1963. A Dipterous larva emerged from an adult squash bug and pupated on October 8. After 76 days an adult *T. pennipes* emerged. Another *T. pennipes* was

TABLE 2. DURATION OF NYMPHAL STADIA OF *Acanthocephala terminalis* IN THE LABORATORY

INSTAR	1	2	3	4	5
NUMBER OF OBSERVATIONS	67	42	14	7	8
Range (days)	3–7	7–18	6–18	8–13	14–28
Mean ± standard deviation	3.6±0.81	12.9±3.13	12.8±3.74	9.9±2.27	19.0±5.37
Accumulated mean days		16.5	29.3	39.2	58.2

placed in the carton and the 2 were observed copulating twice; however, no eggs were deposited on the coreids.

Archimerus alternatus (Say)

The main study areas for this species were at Parfreys Glen, Wyalusing State Park, Ferry Bluff, Gibraltar Rock in Columbia County, and Devils Lake State Park. This was the most abundant species of the Coreidae found in Wisconsin.

Figure 3 shows the seasonal life history of *A. alternatus* in Wisconsin during 1962–1967. There was 1 generation per year with overwintering in the adult stage. Adults were found continuously from June 2–October 8. This species was well represented in the museum collection of the Department of Entomology, University of Wisconsin. These records showed its occurrence from May 12–October 9. An overlap of overwintered adults and those of the new summer generation probably occurred in late July and August. Eggs were found in the field on June 13, 15, 29, and July 1 and 13.

First-instar nymphs were collected in the field from June 28–July 13; second-instar nymphs from June 18–August 11; third-instar nymphs from June 29–August 27; fourth-instar nymphs from July 8–September 1; and fifth-instar nymphs from July 15–September 26. Eggs and first-instar nymphs would have to occur in the field earlier and first-and fourth--instar nymphs later than is shown in Figure 3.

Table 1 lists the plants on which eggs, nymphs, and adults of *A. alternatus* were collected in Wisconsin from 1964–1967. Adults

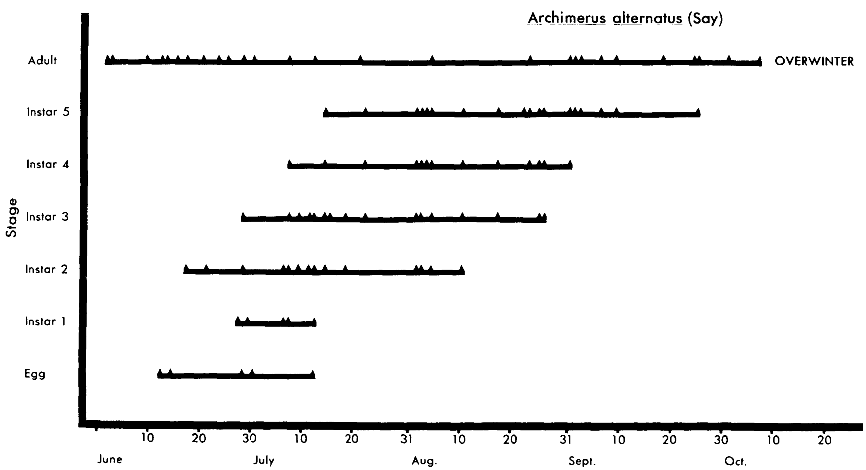

FIGURE 3. Seasonal occurrence of *Archimerus alternatus* in Wisconsin, 1962–1967, showing inclusive dates and actual collection records (peaks).

of this species tended to aggregate on certain species of plants in June. On June 13, numerous adults were found copulating on ragweed, *Ambrosia trifida* L., and goldenrod, both *Solidago gigantea* Ait. and *S. altissima*. Adults were found feeding in the apical region of the stem of *S. altissima*. These plants grew in open fields or near the edges of woods. On June 14, 1966, in a stand of oak with a maple-basswood understory located 5 miles south of Platteville in Grant County, 4 pair of adults were found feeding on *Aster sagittifolius* Willd. (Figure 4) and 1 male on bedstraw, *Galium concinnum* T. & G. However, no eggs were found on any of the plants in the area. In an open area at Parfreys Glen on July 15, more than 40 adults were found on a group of *Desmodium acuminatum* (Muhl.) Wood plants. From 2 to 7 adults were found feeding a few inches below the apex of each of the developing stems. Their feeding caused wilting and death of the stem. Many pairs of adults were copulating and 7 individually laid eggs were found, of which 2 were on the upper surface and 5 on the under surface of leaves of *D. acuminatum*. They were collected and brought to the laboratory where they hatched—2 on July 28 and 30, and July 1, and 1 on July 2. Adults continued to be found predominantly on *D. acuminatum* throughout the entire season. This same group of plants was examined on July 16, 1966, and over 30 adults, but no eggs, were found. An abundance of adults were also found on them on June 24 of that year. These observations would indicate that *A. alternatus* migrated to *D. acuminatum* in June. Oviposition occurred primarily on these plants, but eggs could also be found scattered over plants growing nearby. One egg was found on the stem of *Agrimonia gryposepala Wallr.* growing right next to the clump of *D. acuminatum*. Females also frequently oviposited on the dorsal surfaces of the head, thorax or wings of other females or males in the vicinity. The eggs would be carried on these adults until they hatched. This would undoubtedly aid in dispersal of the insect.

Adults were also found feeding on horse-mint, *Monarda fistulosa* L., and the sunflower, *Helianthus decapetalus* L., in June. In addition adults were collected from, but not observed feeding on, *Aster* sp. and *Robinia pseudoacacia* L. in June. One egg was found on the underside of a leaf of may apple, *Podophyllum peltatum* L.

Nymphs were predominant in the months of July and August. That the second through fifth nymphal stages were especially abundant on *D. acuminatum* (Table 1) was indicated by the respective numbers present: July 7, 1965, 13 second- and 1 third-instar nymphs; July 8, 1964, 6 second-, 29 third- and 9 fourth-instar nymphs; July 8, 1966, 44 second- and 3 third-instar nymphs; July 22, 1966, 17 second-, 21 third-, and 1 fourth-instar nymphs;

FIGURE 4. *Archimerus alternatus* adults feeding on *Aster sagittifolius* on June 13, 1966, Grant County, Wisconsin.

August 3, 1965, 1 second-, 10 third-, and 16 fourth-instar nymphs; and on August 24, 1966, 8 fourth- and 58 fifth-instar nymphs. Two other legumes also served as host for second- through fifth-instar nymphs. They were readily found on hog-peanut, *Amphicarpa bracteata,* (L.) Fern. and fourth- and fifth-instar nymphs less frequently on *D. dellenii* Darl. On August 18, 1966, 5 fourth- and fifth-instar nymphs were found feeding on the latter species in the apical portion of the stem and on leaf petioles. Nymphs in all stages were generally found in a resting position, inclined anterior to posterior at about a 30° angle, whenever they were not feeding.

First- through fourth-instar nymphs appeared to be obligophagous. In contrast, fifth-instar nymphs exhibited an interesting feeding habit in that the number of host plant species that they fed on increased, therefore, being similar to the polyphagous habits of the adult stage.

It was not until the fifth-instar that nymphs appeared to move about much over the vegetation. No early-instar nymphs were found on any plants except the host plants as previously noted. However, fifth-instar nymphs were found resting and feeding on ragweed, both *A. artemisiifolia* L. and *A. trifida;* on honewort, *Cryptotaenia canadensis* (L.) D. C.; and on *D. canadense* (L.) D. C. On September 1, 1966, they were observed feeding on white snakeroot, *Eupatorium rugosum* Houtt. Also, many fifth-instar nymphs continued to feed on *D. acuminatum* even after seeds were produced (Fig. 5).

The distribution of *A. alternatus* may eventually be shown to coincide with the distribution of *D. acuminatum.* This would be over the entire eastern United States and include the southern two-thirds of Wisconsin (Fassett, 1939).

Adults collected in September were found feeding on the daisy, *E. annus* and on skunk cabbage, *Symplocarpus foetidus* (L.) Nutt. Adults were also found on *Aster* sp., *A. trifida,* and *Solidago* spp.

The reactions of all of the plants were similar where feeding pressure was great, that is, where 2 or more bugs fed for a prolonged period. Adults feeding in June (Figure 4) and second-through fifth-instar nymphs were all found to produce the same effect. The terminal portion of from 2 to 6 inches above the feeding loci gradually turned black and died. Where feeding pressure was severe early enough in the season no flower or seed production occurred.

Adults exhibited a death feign whenever they were disturbed. They would drop from the plants and remain motionless in the litter for as long as 5 minutes.

Two new parasite records were obtained from eggs of *A. alternatus.* Two eggs of this species were collected at Wyalusing State

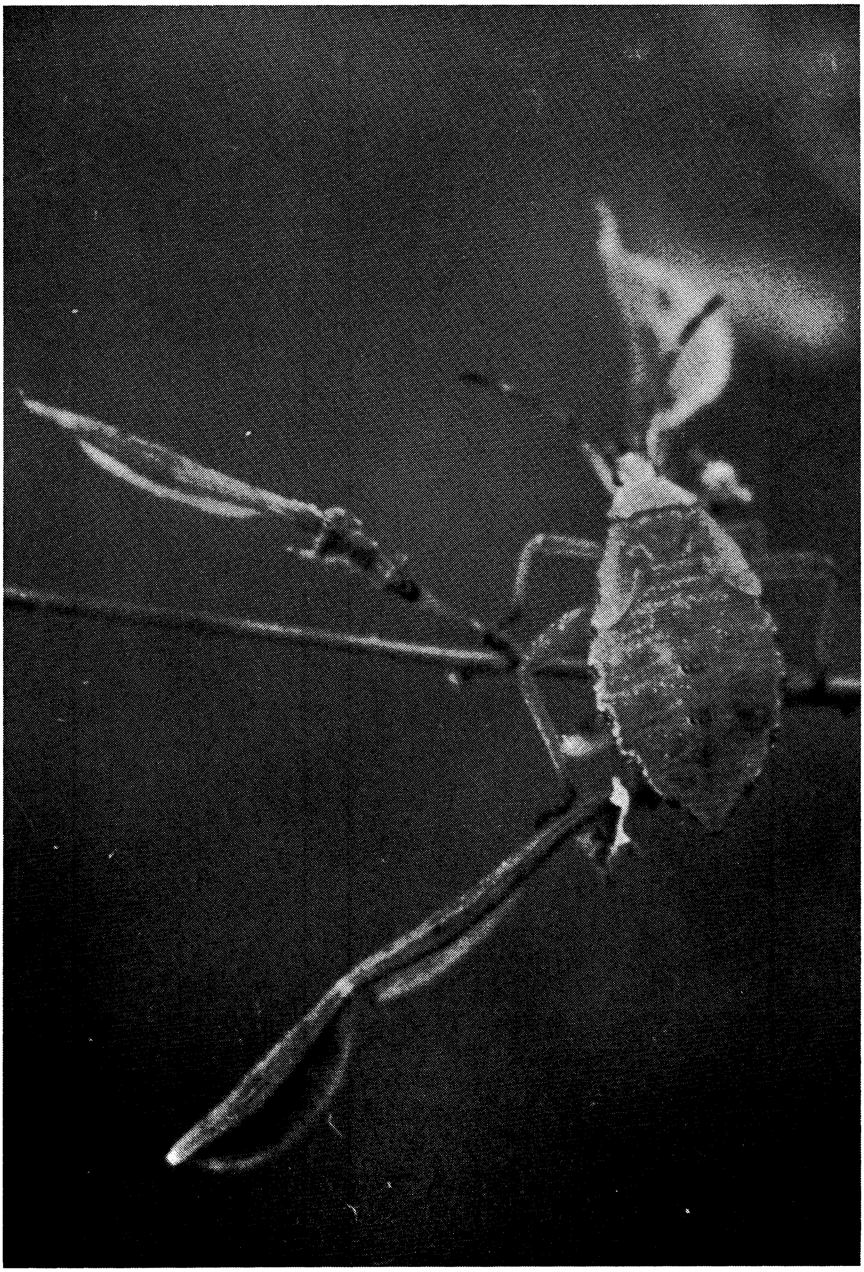

FIGURE 5. Fifth-instar nymph of *Archimerus alternatus* feeding on the seed petiole of host, *Desmodium acuminatum.*

Park on June 29, 1964. One was from the underside of a leaf of may apple. From it 7 Hymenopterous parasites, both males and females, of *Ooencyrtus clisiocampae* (Ashm.) (Encyrtidae), emerged on July 12. These adults were placed in a rearing carton with 5 eggs of *A. alternatus* oviposited in the laboratory and another generation of parasites was obtained from these eggs. Egg parasitism will be discussed in greater detail under *Euthochtha galeator.*

Another Hymenopterous parasite, a female *Anastatus pearsalli* Ashm., emerged from the other field collected egg of *A. alternatus.* The date of emergence was not known. On July 13, 1965, while collecting along a roadside 3 miles west of Sauk City 1 egg of *A. alternatus* was found on a blade of grass. It was brought to the laboratory and on September 8, 1965, a female *A. pearsalli* emerged.

Six adult *T. pennipes* were reared from *A. alternatus* in Wisconsin. The only previous report of this parasite-host relationship was given by Patton (1958) who listed it from Florida.

The following specimens were all obtained at Wyalusing State Park. One female collected on June 14, 1963, produced a Dipterous larva on June 22. It spent 11 days in the pupal stage and emerged into an adult on July 3. A male collected on June 18, 1964, produced a larva on June 22, which spent 12 days in pupation before it emerged an adult. Another male collected August 5, 1964, produced a larva on August 11. It spent 14 days in pupation. In addition 3 *T. pennipes* adults were obtained from field collected fourth- or fifth-instar nymphs that were reared to the adult stage in the laboratory. The parasites emerged on August 17 and 24, and September 9, and spent 13, 12, and 16 days, respectively, in pupation. Upon examination of the exuviae of these bugs no parasite eggs were found, indicating that they had been parasitized in the field at least 1 instar prior to when they were collected. They then molted and carried the larva with them until they emerged an adult. The presence of the parasite, therefore, does not necessarily result in the death of the nymph. This is consistent with the observations of Beard (1940) on the behavior of the larva in nymphs of the squash bugs.

Out of 27 second- and third-instar nymphs collected on June 29, 1964, at Wyalusing State Park, 2 second-instar nymphs were each found to have 1 Dipterous parasite egg on the dorsal surface of the abdomen. One molted to the third instar on July 1, and the other on July 2, leaving the parasite eggs on their cast skins. Examination under the microscope showed that 1 was in the process of cutting its way out of the egg and the other was still intact within the egg. These eggs fit the description of Worthley (1924) for *T. pennipes* and were probably of that species.

Trichopoda pennipes adults mated in the rearing cartons and 1 female deposited 15 eggs on an adult female of *A. alternatus*. A Dipterous larva emerged after 15 days, pupated, and spent 15 days in the pupal stage before molting into an adult.

Desmodium acuminatum plants were collected from the field on July 16, 1965, placed in pots, and brought into the laboratory to facilitate observation of the behavior of the first 3 instars of *A. alternatus*.

Groups of 5 bugs which hatched on the same day and were all of the same instar were placed on each set of plants. A set consisted of 3 to 5 stems per pot. Three groups of 5 first-instar nymphs each were placed on the upper surfaces of the leaves of 3 sets of plants. All 15 bugs remained for 3 or 4 days on the leaves where they were placed. Three of the 15 were observed with their stylets inserted through the leaf surface, and most nymphs showed a distended abdomen indicating that they fed in the first instar. Shortly after molting, the second-instar nymphs began to migrate over the plants. Eight were feeding on the petioles of the flowers or seeds within 1 day after molting. The other 7 nymphs escaped from the plants.

Second- and third-instar nymphs after being removed from the rearing cartons and placed on the leaves immediately began moving over the plants, but again they were always found feeding on the stem or petioles within 2 days after release.

On July 2, 1966, plants of *D. acuminatum* were collected from the field, potted, and brought into the laboratory. They were placed in 1 of 2 rearing cages. Again nymphs were observed. Five first-instar nymphs from the laboratory cartons and 2 second-instar nymphs collected the same day from the field were released on the bottom of the cage. The first instars remained there for 2 days and then moved onto the plants and took the "resting position" on the undersides of leaves. However, within 10 minutes 1 of the second-instar nymphs had moved onto the plant and began feeding on the main stem about 4 inches down from the tip of the 18-inch long stem. Two days later the other second-instar nymph assumed a position immediately next to the first. The 2 bugs remained together for 3 more days before moving. Behavior of the third-instar nymphs was similar to that of the second.

Nymphs and adults would gather together and feed at about the same position on the stem even though other stems in the same set of plants were free of any bugs. This aggregation behavior was found in the field. It was also found in the laboratory on *D. acuminatum* in the rearing cages, and on green bean in the rearing cartons (Figure 6). The bugs produced the same feeding stress on the plants grown in the laboratory as was found in the field, causing the apical portions of the stems to die above the feeding loci.

Some observations were conducted on these bugs in the rearing cartons in the laboratory. Third- through fifth-instar nymphs and adults fed well on green beans; however, the development of the second-instar nymphs on this diet was impaired.

Cultures were established each year from eggs obtained from females or nymphs collected in the field in June. Adults were observed copulating frequently in the rearing cartons. Eggs of this species were oviposited singly as were those of *A. terminalis*. Heidemann (1911) reported that the eggs of *Archimerus calcarator* (Fabricius) were laid in a row, but not joined. Although occasionally *A. alternatus* would lay a few eggs in an irregular row there was no definite oviposition pattern. He also reported 14 "chorial processes" for the egg. The number of micropylar processes found for *A. alternatus* were considerably greater, as noted under the description of the egg of this species (Yonke and Medler, In press b). A mean of 2.1 eggs per day (n = 17, range = 1.0–4.5) were oviposited by females in the laboratory, with a mean value of 57 eggs (n = 17, range = 10–128) for the total number of eggs oviposited per female. The maximum number of eggs laid in any 1 day by a single female was 15. The mean oviposition period was 37.2 days (n = 17, range = 5–120). Although it may not be applicable to a univoltine species overwintering in the adult stage, a mean preoviposition period of 33.5 days (n = 17, range = 22–58) was observed in the laboratory.

The mean incubation period of 67 eggs was 13.4 days with a range of from 10–20 days. Out of 258 eggs oviposited in the laboratory 85.3% hatched.

Eclosion took place by means of a pseudopercular cap. The bug forced it open by means of a series of pulsating movements. The cap split first at its most ventral point and then proceeded posteriodorsally. This took only a few minutes.

Nymphal development took 48.6 days (Table 3) based on an accumulation of the means. The values, except for those of Instar 2, employed in construction of Table 3 were obtained from observations on nymphs feeding on green beans in the rearing cartons. Since this species did not develop from egg through to adult on beans the values for Instar 2 were obtained from observations of second-instar nymphs that developed on *D. acuminatum* in the laboratory rearing cages. The time spent in nymphal development agreed favorably with the data presented on seasonal history in Figure 3.

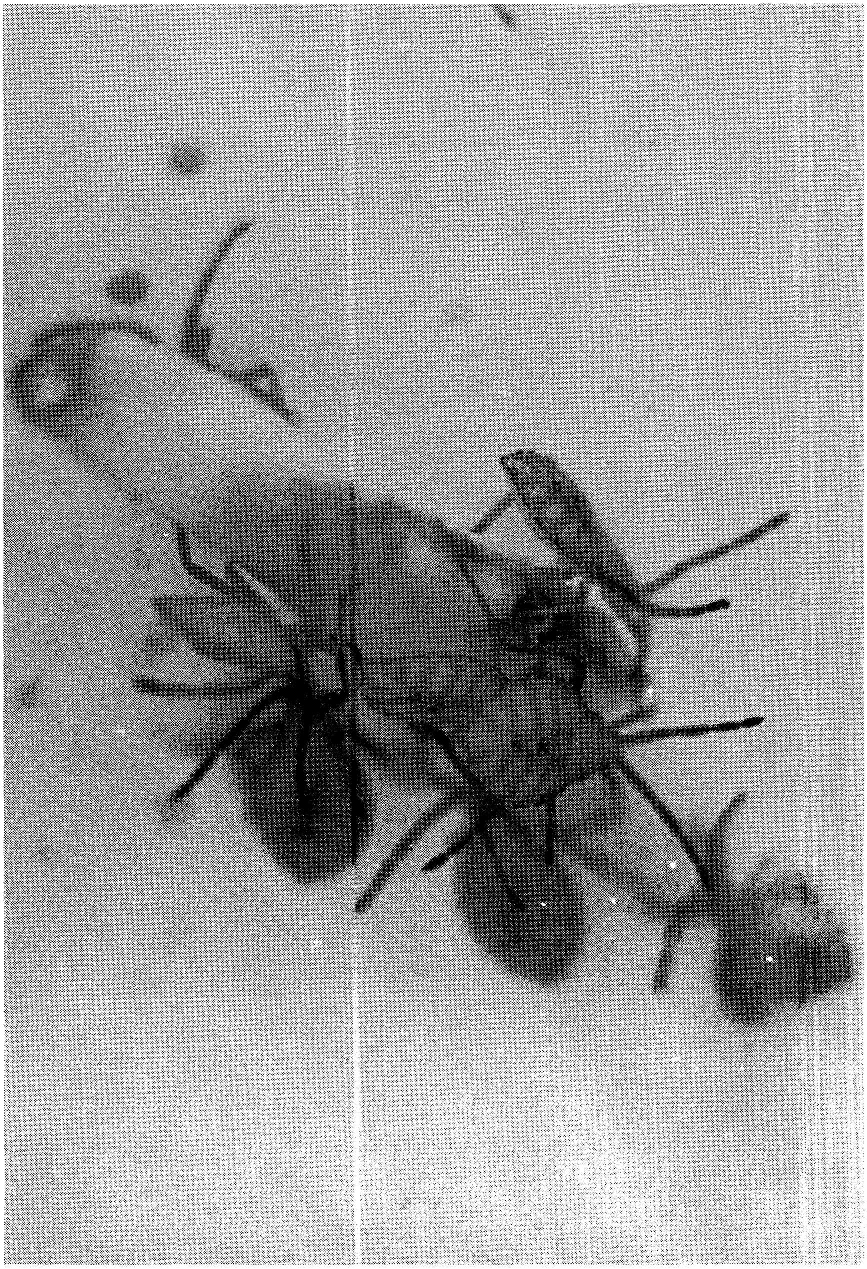

FIGURE 6. Feeding aggregation of 8 second-instar nymphs of *Archimerus alternatus* on the laboratory diet of fresh green beans.

TABLE 3. DURATION OF NYMPHAL STADIA OF *Archimerus alternatus* IN THE LABORATORY

INSTAR	1	2[1]	3	4	5
NUMBER OF OBSERVATIONS	54	7	26	54	54
Range (days)	3–7	5–10	4–16	7–17	10–30
Mean ± standard deviation	4.6±0.92	7.6±1.89	8.3±2.72	11.2±1.86	16.9±5.11
Accumulated mean days		12.2	20.5	31.7	48.6

[1]Values presented for Instar 2 were taken from observations of the bugs on *Desmodium acuminatum* in rearing cages.

The growth ratios were very constant for this species. (Yonke and Medler, In press b). The closeness of fit for the values indicated a uniform growth rate and, therefore, tended to substantiate the data presented in Table 3.

Out of 484 adults either collected in the field or reared in the laboratory 231 were males and 253 were females.

Deformed antennae in the form of a reduction in the size and number of segments were observed on some bugs reared in the laboratory. It was thought that this might have been due to the non-host diet. However, examination of field collected adults also produced specimens with similar abnormalities.

Catorhintha mendica Stål

Adults, eggs, and nymphs were collected from *Mirabilis nyctaginea* growing on railroad embankments in Dane, Jefferson, Rock, and Sauk counties. They were not found on any other plant. Early-instar nymphs were collected from under the involucral bracts which enclosed the flowers and seeds, and later-instar nymphs fed on the petioles. Additional observations of this bug and its host were made at Kankakee, Illinois. On September 3, 1966, many adults and 151 nymphs were collected of which there were—1 first-, 8 second-, 56 third-, 78 fourth-, and 9 fifth-instar nymphs. Adults and nymphs were collected from the field and brought alive to the laboratory where they were placed on green beans. Adults fed readily and lived from 3–85 days, but the nymphs did not survive. Females laid from 2–7 eggs per batch ($n = 20$, $x = 3.5$). They hatched in from 5–8 days ($n = 28$, $x = 6.4$). These data are in agreement with the data presented by Balduf (1942) for this species.

Euthochtha galeator (Fabricius)

The main field study area for this species was at Parfrey's Glen. Additional observations and collections were made at Wyalusing State Park, as well as a few other locations.

Figure 7 shows the seasonal occurrence of *E. galeator* in Wisconsin during 1962–1967. There was 1 generation a year with overwintering in the adult stage. Adults were found from May 25–October 8. No adults were found between July 6 and August 11 indicating that the overwintered adults died off at about that time. This species was well represented in the museum collection of the Department of Entomology, University of Wisconsin. These records showed its occurrence from May 5–October 27. There were no records between July 13 and August 6. Field collected nymphs brought back to and reared in the laboratory began molting into the adult stage on July 25.

Eggs were found in the field from June 13–July 20. First-instar nymphs were collected in the field from June 13–July 13; second-instar nymphs from June 13–August 3; third-instar nymphs from July 13–August 10; fourth-instar nymphs from July 18–August 10; and fifth-instar nymphs from July 24–September 19. Eggs and first-instar nymphs would have to occur in the field earlier, and third- and fourth-instar nymphs later than Figure 7 shows.

On June 13, 1963, while collecting at Wyalusing State Park, 13 eggs and first-instar nymphs of *E. galeator* were found on the upper surface of a leaf of *Aster ericoides* L. growing in an open field. The bright red nymphs were still aggregated about the eggs

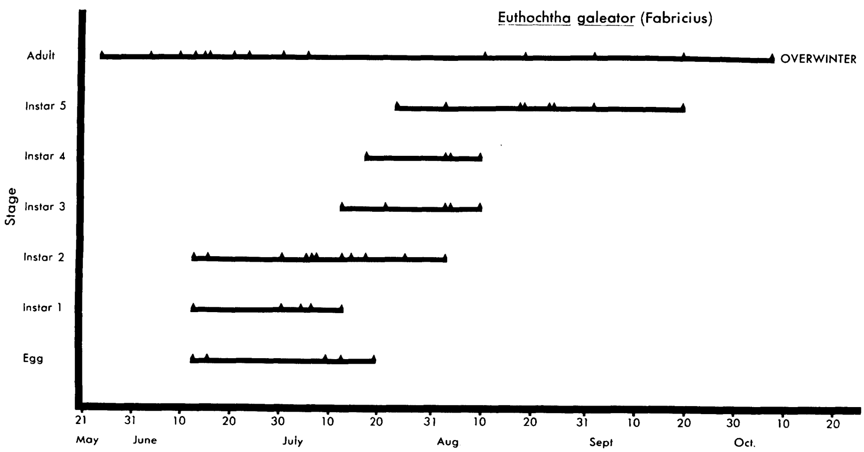

FIGURE 7. Seasonal occurrence of *Euthochtha galeator* in Wisconsin from 1962–1967 (peaks).

when they were collected. On the same date a cluster of 13 more eggs were found on *Urtica dioica* L., nettle. They were brought back to the laboratory and placed in a rearing carton. Eight first-instar nymphs hatched on June 29 and 1 on June 30. Also on June 28, 12 encyrtid parasites, *O. anasae* (Ashm.), emerged from 4 of these eggs. This constituted a new host record for *O. anasae,* there being no previous published association of this parasite and host. These adults were placed in a carton with eggs of *E. galeator* obtained from females in the laboratory. The adult parasites died by July 20, and were removed from the carton. On July 30, the eggs were examined under the microscope and found to have many small oval masses about the inner surfaces of the chorions. They also were dark in color, in contrast to the reddish or gold color of the normal eggs. More than 70 adult parasites emerged from the eggs on August 1; 17 more parasites on August 2; 4 on August 4; and 1 on August 5. Some parasites escaped from the carton so an exact count could not be made. Both males and females of *O. anasae* were obtained. An unsuccessful attempt was made to obtain another laboratory generation of parasites.

Six eggs of *E. galeator* were found on June 16, 1964, on a blade of grass growing on the sandy bank along the Wisconsin river at the Mazomanie Wildlife Refuge, Dane County. They were positioned in a line, end to end. Five hatched on June 22 and 1 on June 23.

On July 10, 1965, 6 eggs were found oviposited on the upper surface of a leaf of wild plum, *Prunus americana* Marsh. Closer observations revealed slightly raised brown spots on the leaf where 7 more eggs had been laid but were no longer attached. One adult Hymenopterous parasite, *Anastatus pearsalli,* emerged from 1 egg of *E. galeator* on August 11, and 5 more emerged, each from a single egg, on August 12. *Anastatus pearsalli* failed to parasitize laboratory reared eggs and they died by August 14.

Two additional batches of eggs were found. In 1 there were 11 eggs that had already hatched, and in the other there were 14 eggs. Ten eggs of the latter batch hatched in the laboratory on July 16, and 4 hatched on July 17. All 3 batches of eggs were found in a disturbed weedy habitat at Parfrey's Glen. In the same area on July 13, 1965, 8 first-instar nymphs were observed in aggregation resting on the upper surface of a leaf of *Rhus glabra* L. and 9 eggs that had hatched were found on the underside of the leaf.

On July 12, 1964, 7 encyrtid parasites, *O. clisiocampae,* obtained from an egg of *A. alternatus* collected in the field on June 29, 1964, were placed in a rearing carton with 20 laboratory eggs of *E. galeator*. The parasites were observed on the eggs and on July 27, numerous parasites emerged from all 20 *E. galeator* eggs. A total of 124 parasites were obtained from these and 5 additional laboratory eggs of *A. alternatus* which were also present in the carton.

Six host plants were found for nymphs and adults of *E. galeator* (Table 1). They were determined by observations of the bug feeding on the respective plants in the field. The host plants were *Agrimonia gryposepala* Wallr. or roots fibrous, *Achillea millefolium* L., *Aster pilosus* Willd., *M. fistulosa* or horsemint, *D. acuminatum,* and *Quercus ellipsoidalis* E. J. Hill. Of these plants, adults were found feeding and copulating most frequently on *A. gryposepala.* Since adults had been found frequently at Parfrey's Glen on *A. gryposepala* in June of 1966, special trips were made in June of 1967 to see if the bugs could be located on these plants again. On June 4, 4 pairs of bugs were found on 4 separate clones of *A. gryposepala,* 5 were feeding and 2 pair were copulating. On June 15 another pair was found copulating on this plant.

While a male *E. galeator* was being observed feeding on a petiole of *A. millefolium,* a female flew to the plant and approached the male, but flew away when disturbed. Adults were often found in June resting on the leaves of composites. Both males and females were swept with a net from *Solidago altissima* Mill. on June 13, 1966, at the Mt. Hope Conservation Area in Grant County.

Second-instar nymphs were found feeding on *Q. ellipsoidalis* and *D. acuminatum* and fifth-instar nymphs on *A. pilosus* and *A. gryposepala.*

Nymphs and adults were collected also from *A. bracteata, Aureolaria grandiflora* var *pulchra* (Benth.) Pennell, *Carya* sp., and *Ulmus rubra* Muhl. Therefore, it would appear that *E. galeator* is not monophagous, but rather can and does utilize a number of host plants representing different families.

Adults exhibited a death feign. Whenever disturbed they would either drop from the plant and remain motionless, or fly away quickly.

Nine adult Dipterous parasites, *T. pennipes,* were reared in the laboratory from 4 male and 5 female field collected adults. There were no previous published records of *T. pennipes* from *E. galeator.* Four parasites were obtained from adults collected at Parfreys Glen on June 24, 1966. Larvae emerged from the bugs and pupated on June 27, July 2, 10, and 20, 1966; and spent 18, 15, 14, and 20 days respectively, in their pupal stages. Adult parasites did not live longer than 7 days and although they were observed copulating they did not oviposite on the bugs in the rearing cartons. One female *E. galeator* that was parasitized laid 3 batches of 19, 10, and 12 viable eggs. A female and a male collected on July 1, 1966, each produced a parasite on July 6 and 12, respectively.

The 1 obtained from the female emerged an adult on July 26, but that from the male died in the pupal stage.

On August 4, 1964, a fifth-instar nymph of *E. galeator* was collected at Parfreys Glen and brought to the laboratory where it molted into an adult male on August 25. On September 3, a Dipterous larva, *T. pennipes,* emerged from it and pupated. No parasite egg was found on the exuvium of the fifth instar indicating that it had been parasitized in an earlier instar and had successfully molted with the larva inside. A female was collected from Mazomanie Wildlife Refuge on August 23, 1963. A larvae emerged from it and pupated on August 24 and emerged to an adult on September 9.

One male *E. galeator* was collected from Kankakee, Illinois, on August 6, 1965, brought back alive to Madison, and placed in a rearing carton. On August 9, a parasite emerged, pupated, and on August 27 emerged as an adult.

From 1 to 5 parasite eggs were found randomly oviposited over the bodies of the bugs.

Some observations were conducted on the bugs in the rearing cartons to gain information on their biology. Both nymphs and adults fed readily on the laboratory diet of fresh green beans.

Cultures were established each year from eggs obtained from females, eggs, or nymphs collected from the field in June. This species oviposited its eggs in batches similar to those of *A. armigera* and *A. tristis,* with a mean number of 16.0 eggs per batch (number of batches = 62, range = 2–32). In 22 observations individual females oviposited from 3–19 batches of eggs with a mean of 8.2 batches per female. The greatest number of eggs oviposited by a single female in the laboratory was 259.

A mean time of 6.0 days (n = 60, range = 1–24) elapsed between oviposition of individual batches of eggs. Generally when only 1 or a few days passed between oviposition fewer eggs were oviposited per batch. In 14 observations a mean time of 40.7 days were spent in the oviposition period, with a range of from 11–89 days.

A delayed preoviposition period ranging from 26–143 days (n = 5, x = 95.6) was observed for females reared in the laboratory from the nymphal stage. These females would have normally overwintered and not copulated or oviposited until the following spring. This delayed preoviposition time was a reflection of that behavior. In fact, a preoviposition period, if defined as the time elapsing between the molting of the insect to the adult stage until first oviposition, would not be a pertinent part of the biology of a univoltine species that overwinters as an adult.

The period of incubation for 566 eggs oviposited in the laboratory ranged from 7–17 days with a mean time of 12.9 days. Out of a total of 720 eggs obtained in the rearing cartons 636 hatched, or 88.3%.

Eclosion took place by means of the pseudopercular cap. The bug forced it open by means of a series of pulsating movements. The cap split first at its most ventral point and then proceeded posterio-dorsally. This took only a few minutes.

First-instar nymphs were observed in the rearing cartons with their stylets inserted in green beans. It was assumed that they were feeding; however, they would successfully develop in the absence of any food during that stadium as long as moisture through the wick was available. In fact these nymphs were lethargic and frequently aggregated on or near the eggs until they molted into the second instar. Second- through fifth-instar nymphs spent much of the time feeding.

Nymphal development took 54 days, with the second, third, and fourth stadia being about equal (Table 4). This was based on an accumulation of the means. These laboratory data agreed fairly well with the field occurrence records given in Figure 7.

The growth ratios were fairly consistent (Yonke and Medler, In press c). The closeness of fit for the values indicated a uniform growth rate, and therefore tended to substantiate the data presented in Table 4.

Frequently nymphs aggregated while feeding. Figure 1 shows an aggregation pattern of 7 second-instar nymphs feeding in a relatively small area on 1 of the 2 green beans present in the rearing carton. One additional bug was present in the carton.

Out of 206 adults either collected in the field or reared in the laboratory 102 were males and 104 were females. Adults generally

TABLE 4. DURATION OF NYMPHAL STADIA OF *Euthochtha galeator* IN THE LABORATORY

INSTAR	1	2	3	4	5
NUMBER OF OBSERVATIONS	136	80	51	54	42
Range (days)	2–5	6–18	6–18	5–18	8–28
Mean ± standard deviation	3.4 ± 0.83	11.1 ± 3.13	10.2 ± 3.12	12.2 ± 3.43	17.1 ± 5.49
Accumulated mean days		14.5	24.7	36.9	54.0

survived for a long time. Two adults collected from the field in June lived 204 and 212 days under laboratory conditions.

Merocoris distinctus Dallas

This species occurs in Wisconsin, although nowhere common. Adults occurred from June 9–October 26. Also, 1 adult was recorded for "April."

One adult was collected while sweeping Midway Prairie, La Crosse County, on June 15, 1967. Another adult was observed on June 17, 1967, at Crex Meadows, Burnett County, associated with a carrion spot on the pavement of a road. One fifth-instar nymph was collected September 1, 1964, while sweeping a disturbed weedy area at Parfreys Glen; however, continued sweeping and investigation of individual plants did not produce more. It was held on green bean in the laboratory, molted into an adult on October 5, and died on October 17. There is apparently 1 generation per year in Wisconsin with overwintering in the adult stage. One adult each was collected on September 30, 1963, and October 2, 1965, on goldenrod, from Curtis Prairie, University of Wisconsin, Arboretum, Madison.

SUMMARY

From July 1, 1962, through June 15, 1967, numerous observations and collections were made of coreid species found in Wisconsin. Ten species were recorded. *Anasa armigera* (Say), *Chariesterus antennator* (Fabricius), and *Leptoglossus oppositus* (Say) were extremely rare. *Coriomeris humilis* Uhler and *Merocoris distinctus* Dallas were uncommon. Five species frequently encountered were *Acanthocephala terminalis* (Dallas), *Anasa tristis* (DeGeer), *Archimerus alternatus* (Say), *Catorhintha mendica* Stal, and *Euthochtha galeator* (Fabricius).

The field histories and laboratory biologies were determined for *Acanthocephala terminalis, Archimerus alternatus* and *Euthochtha galeator*. All 3 species went through 1 generation a year in Wisconsin and overwintered in the adult stage.

Adults of *Acanthocephala terminalis* were collected in the field from June 13 to September 4. No parasites were found for this species. Three host plants determined for nymphs and adult were *Physocarpus opulifolia* (L.) Maxim., *Rhus typhina* L., and *Vitis riparia* Michx. Eggs had an incubation time of 7 to 14 days (mean = 9.7). The mean time spent in nymphal development was 58.1 days.

Adults of *Archimerus alternatus* were collected in the field from June 2 to October 8. They were found feeding on *Solidago altis-*

sima Mitt., *Aster sagittifolius* Willd., and *Galium concinnum* T. & G. in early June. They moved from these plants to *Desmodium aciminatuo* (Muhl.) Wood, tick trefoil, on which oviposition generally occurred. First-through fourth-instar nymphs were restricted to *D. acuminatum,* D. *dilienii* Darl., and *Amphicarpa bracteata* (L.) Fern., hog peanut. Fifth-instar nymphs fed on these 3 plants and also fed on a number of other plants, including *Ambrosia artemisiifolia* L., *Ambrosia trifida* L., *Cryptotaenia canadensis* (L.) D.C., *Desmodium canadense* (L.) D.C., and *Eupatorium rugosum* Houtt. Host plants of the summer generation adults included those recorded for the immatures, and in addition *Erigeron annus* (L.) Pers., dairy; and *Symplocarpus foetidus* (L.) Nutt., skunk cabbage. Feeding on all plants occurred on the stems and petioles, causing the terminals above to wilt.

Two hymenopterous parasites were obtained from field-collected eggs of *A. alternatus.* They were *Ocencrytus clisiocampae* (Ashm.) (Encyrtidae) and *Anastatus pearsalli* Ashm. (Eupelmidae). These were new records. Adults of the dipterous parasite, *Trichopoda pennipes* Fabricius (Tachinidae), were reared from field-collected adults.

Feeding aggregations of *Archimerus alternatus* were observed both in the field and in the laboratory for nymphs and adults. A mean number of 2.1 eggs per day was oviposited by females in the laboratory. Incubation took 13.4 days. The mean time spent in nymphal development was 48.4 days.

Euthochtha galeator adults were collected in the field from May 25 to October 8. The 6 host plants found for nymphs and adults were *Agrimonia gryposepala* Wallr., *Achillea millefolium* L., *Aster pilosus* Willd., *Monarda fistulosa* L., *D. acuminatum* (Muhl.) Wood, and *Quercus ellipsoidalis* Hill.

Three parasite species were obtained from field-collected eggs and adults of *E. galeator.* They included 2 Hymenoptera, *A. pearsalli* Ashm. and *Ooencyrtus anasae* (Ashm)., and 1 Diptera, *T. pennipes* Fabricius. These were new records. In addition, *C. clisiocampae* parasitized *E. galeator* eggs in the laboratory.

A feeding aggregation was also observed for nymphs of *E. galeator.* This species oviposited its eggs in batches (mean = 16.0 eggs per batch). A mean time of 6.0 days elapsed between oviposition of individual batches of eggs. Incubation of eggs took 7 to 18 days (mean = 12.9). The mean time spent in nymphal development was 54 days.

References Cited

Balduf, W. V. 1942. Bionomics of *Catorhintha mendica* Stål. (Coreidae, Hemiptera). Bull. Brooklyn Entomol. Soc. 37:158–166.

———. 1957. The spread of *Catorhintha mendica* Stål. (Coreidae, Hemiptera). Proc. Entomol. Soc. Wash. 59:176–185.

BEARD, R. L. 1940. The biology of *Anasa tristis,* DeGeer with particular reference to the tachinid parasite, *Trichopoda pennipes* Fabr. Conn (New Haven) Agr. Exp. Sta. Bull. 440:594–679.

BLATCHLEY, W. S. 1926. Heteroptera or true bugs of Eastern North America. The Nature Publishing Co., Indianapolis. 1116 p.

FASSETT, N. C. 1939. The leguminous plants of Wisconsin. Univ. Wis. Press, Madison. 157 p.

HEIDEMANN, O. 1911. Some remarks on the eggs of North American species of Hemiptera–Heteroptera. Proc. Entomol. Soc. Wash. 13:128–140.

PATTON, C. N. 1958. A catalogue of the larvaevoridae of Florida. Fla. Entomol. 41:29–39, 77–89.

SCHEEL, C. A., S. D. BECK, AND J. T. MEDLER. 1956. Feeding and nutrition of certain Hemiptera. Proc. Tenth Int. Congr. Entomol. 1956: 303–308.

WORTHLEY, H. N. 1924. The biology of *Trichopoda pennipes* Fab. (Diptera, Tachinidae), a parasite of the common squash bug. Psyche 31:7–16, 57–77.

YONKE, T. R., AND J. T. MEDLER. 1965. Biology of *Megalotomus quinquespinosus* (Say). Ann. Entomol. Soc. Amer. 58:222–224.

———. 1967. Observations on some Rhopalidae (Hemiptera). Proc. N. Central States Branch Entomol. Soc. Amer. 22:74–75.

———. 1968. The biologies of 3 species of *Alydus* in Wisconsin (Hemiptera: Alydidae). Ann. Entomol. Soc. Amer. 61:526–531.

———. In Press a. Description of the immature stages of Coreidae: 1. *Euthochtha galeator.* Ann. Entomol. Soc. Amer

———. In Press b. Description of the immature stages of Coreidae: 2. *Acanthocephala terminalis.* Ann. Entomol. Soc. Amer

———. In Press c. Description of the immature stages of Coreidae: 3. *Archimerus alternatus.* Ann. Entomol. Soc. Amer.

HOST RECORDS AND PHENOLOGY OF LOUSE-FLIES ON WISCONSIN BIRDS

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INTRODUCTION

Louse-flies (Diptera: Hippoboscidae) are ectoparasites which feed on the blood of birds and mammals. Most species infest birds and are agile, elusive creatures that spend most of their lives well hidden and protected by the feathers of their hosts. Reproduction depends on at least one mating and involves the production of one young at a time. Embryonic and larval development of the off-spring occurs within the body of the female fly. Shortly before pupation the larva is dropped from the fly and falls from the bird to the ground. Some species overwinter as pupae, while others emerge in one to several months. Each new adult must find a suitable host within a few days after emergence, and mating depends on the presence of both sexes on the same host. These interesting flies are relatively rare in collections because few entomologists have access to large numbers of living, wild birds and most ornithologists who handle wild birds have neither the time nor the interest to devote to the ectoparasites.

A list of records of louse-flies for Wisconsin and surrounding states as well as some information about the habits of the flies is found in MacArthur (1948). Bequaert's (1952–1956) monograph on the Hippoboscidae of North America provides an exhaustive compilation and analysis of all aspects of the life histories, distribution and taxonomy of Hippoboscidae in North America. Our present knowledge of the life history, distribution and host relations of the louse-flies which live on passerine birds has benefited from the recent increase in the use of mist-nets and Helgoland traps for capturing wild birds. Bennett (1961) collected louse-flies from passerine hosts in Algonquin Park, Ontario, between mid-May and mid-September in 1957–1960 and kept some of the flies on captive birds to study their longevity and host preferences. Workers in Britain (Corbet, 1956b, 1961; Hill, 1962, 1963) and in Scandinavia (Hill *et al.,* 1964) studied the distribution, life histories and host preferences of three species of *Ornithomyia* during the summer, when these louse-flies are most abundant. Much less is known about the louse-fly infestation of migrating and wintering birds or about the louse-flies of raptorial birds at all seasons of the year.

In the present study we have analyzed records of louse-flies collected in Wisconsin from a wide variety of raptorial and passerine birds. Most of the specimens were taken during spring and autumn migration, but we also collected flies on hawks and owls in winter. This report is based on data from a total of 1,281 individuals of eight species of Hippoboscidae taken on 695 individuals of 60 species of birds.

TECHNIQUES

Raptorial and passerine birds have been trapped regularly during spring and autumn migration at the Cedar Grove Ornithological Station, located on the western shore of Lake Michigan about 64 km north of Milwaukee, Wisconsin. A description of the station area is found in Mueller and Berger (1966). Birds were checked for Hippoboscidae during a total of 11 autumns and 6 spring seasons, beginning in 1955; during this period 4,393 raptorial birds and 53,979 passerine birds and woodpeckers were handled.

A concerted effort was made to check each captured raptorial bird for the presence of Hippoboscidae. Hawks were trapped individually in nets and usually removed from the netting immediately after capture. The usual method of checking for louse-flies on hawks and owls was to blow on the feathers or to spread them by hand. The disturbed flies darted among or on the feathers, seeking shelter in another region, or flew to the person handling the bird or, less frequently, to a window of the banding laboratory. A few flies were certainly overlooked or otherwise escaped capture. The flies were captured manually and immediately doused with alcohol or water to immobilize them momentarily until they could be secured in small vials.

Passerines and a few smaller raptorial birds, such as the Sharp-shinned Hawk and small owls, were taken in mist-nets set in dense brush. The mist-nets were checked at approximately 40 minute intervals, and the birds removed from the netting as quickly as possible. Passerine birds were transported to the laboratory in opaque containers, and then segregated according to species in sorting cages made of wire screen of 0.2 mm mesh. Some transfer of flies from one bird to another may have occurred as the birds were being transported to the laboratory; however, we believe that the darkness in the containers drastically reduced the activity of the birds and probably also the movements of the flies. Most flies that remained on their hosts until they reached the laboratory became a part of our collection. Undoubtedly more flies would have been collected from passerine hosts if the birds had been checked for ectoparasites immediately on capture and prior to their removal from the nets, but the time and facilities available did not permit a more thorough collection of flies from passerine birds.

Hawks and owls were also obtained from the State Experimental and Game Farm at Poynette, Wisconsin, during the period of autumn through early spring in the years of 1958 through 1963 and on several occasions in the autumns of 1956 and 1964. A total of 475 hawks and 137 owls was handled. These birds had been taken in steel traps set on poles, and they were held for one to several days in aviaries before examination, with separate enclosures for owls and hawks. Most of the birds were Great Horned Owls (135) and Red-tailed Hawks (316), although 7 other raptorial species were represented. The birds were transported in individual burlap bags to Madison, Wisconsin, where they were checked for ectoparasites, measured, banded and released.

In addition, hawks and owls were captured with the Bal-chatri trap (Berger and Mueller, 1959) in the central and southern part of Wisconsin, principally during the spring migrations. Species from which louse-flies were collected were the Red-tailed Hawk, Broad-winged Hawk, Sparrow Hawk, Great Horned Owl, Barred Owl and Long-eared Owl. They were either checked immediately for flies, banded, etc., or they were first transported to a suitable banding laboratory. A number of persons contributed flies taken from birds caught in a number of localities, and we have no accurate record of the number of hawks and owls handled.

Louse-flies which were collected prior to 1958 were pinned and dried. Since dried debris and badly shrunken abdomens made sexing difficult, subsequent collections were preserved in 70 per cent ethanol, with each vial containing all flies taken from a single host. Except for the few individuals which had been mutilated at the time of capture, those louse-flies preserved in alcohol remained in excellent condition for determination of species, sex, and occurrence of phoresy and mites. MacArthur's (1948) key to the Hippoboscidae of the Eastern United States was used for preliminary identification of the flies. The more exhaustive key of Bequaert (1954, 1955, 1956) was used to reexamine all individuals which appeared in any way unusual. Specimens of *Ornithomyia* were checked against the key of Hill *et al.* (1964). Woodman's (1954) key was used for the identification of Mallophaga.

Host Records

Eight species of Hippoboscidae were collected, but only three of these were at all common: *Lynchia americana* (896 specimens), *Ornithomyia fringillina* (267), *Ornithoica vicina* (102), *Ornithoctona erythrocephala* (7), *Lynchia nigra* (5), *Lynchia angustifrons* (1), *Lynchia albipennis* (1), and *Microlynchia pusilla* (1). *M. pusilla* is a new record for Wisconsin and neighboring states (cf. MacArthur, 1948). Louse-flies were found on 11 species of Falconiformes, 6 species of Strigiformes, 2 species of Piciformes and 41 species of Passeriformes. Many of these are new host records for Wisconsin and neighboring states (cf. MacArthur, 1948), indicated by a superscript "a" in Table 1. Host records new to North America (cf. Bequaert, 1956; Bennett, 1961) are indicated by superscript "b".

The number of birds of each species on which flies were found and the total number of birds handled provide a crude minimum estimate of infestation (Table 1). These data are incomplete for the following reasons: (1). A plus (+) mark notation in the "No. Handled" column of Table 1 indicates that additional members of this species were trapped by the Bal-chatri and the exact number is not known. (2). Passerine birds were not examined as thoroughly as were raptorial birds. (3). No data are presented for species of birds from which no louse-flies were taken. A complete list of the passerine birds taken in autumn at Cedar Grove can be found in Mueller and Berger (1968).

The sex could be determined for 1,107 of the 1,281 specimens; the condition of the rest of the specimens, most of which were collected prior to 1958, precluded determination of sex. Taking the sample as a whole, 88 per cent of the flies were females. This unbalanced ratio in our sample is undoubtedly a result of our collecting in late summer and autumn; since females live longer than males, they dominate samples taken after the period of emergence of the adults (cf. Bennett, 1961; Hill, 1963).

Ornithoica vicina is an extremely small louse-fly that is easily overlooked. We first observed this species in August 1959 in the ears of a Great Horned Owl. A total of 120 Great Horned Owls has subsequently been checked for the presence of louse-flies, and 23 individuals yielded a total of 71 female and 2 male *O. vicina*, all from the ears. Seven specimens of this fly were found in the ears of a Barred Owl, and one specimen each was found in the ear of a Screech Owl and a Saw-whet Owl. A variety of other raptorial birds and passerines harbored this fly on the body plumage, but not in the ears (Table 1). We found no other species of louse-fly in the ears of any bird. Although *O. vicina* was reluctant to move from the ear of an owl, this fly was observed to escape from passerines caught in mist-nets, alighting momentarily on the person handling the bird before flying away. Because of their small size, these flies were harder to find on body plumage than in the ears. Despite this

TABLE 1. HOST RECORDS FOR HIPPOBOSCIDAE COLLECTED IN WISCONSIN, 1955–65

HOST[o]	NO. HANDLED	NO. INFESTED	SEXES/FLIES ♀♀	SEXES/FLIES ♂♂	TOTAL NO. FLIES*
A. *Ornithoica vicina*					
Red-tailed Hawk	940†	1	1	0	1
Sparrow Hawk[a]	170†	1	1	0	1
Screech Owl[a, b]	10	2	2	0	2
Great Horned Owl[a]	138†	26	71	2	74
Barred Owl[a]	10†	1	5	2	7
Long-eared Owl[a]	17†	1	1	0	1
Saw-whet Owl[a]	234	2	1	1	2
Eastern Kingbird[a, b]	19	1	1	0	1
Catbird[a]	2,650	1	1	0	1
Veery[a]	835	1	1	0	1
Swainson's Thrush[a]	9,845	1	0	1	1
Ruby-crowned Kinglet[a]	1,721	1	1	0	1
Rusty Blackbird[a, b]	2	1	1	0	1
Song Sparrow[a]	723	1	1	0	1
Unknown Host		4	7	0	7
TOTALS—*Ornithoica vicina*		45	95	6	102
B. *Ornithomyia fringillina*					
Sharp-shinned Hawk[a]	1,860	10	8	0	12
Red-tailed Hawk[a, b]	940†	2	2	0	2
Marsh Hawk[a]	308	1	1	0	1
Pigeon Hawk	241	1	1	0	1
Great Horned Owl[a]	138†	1	1	0	1
Saw-whet Owl[a]	234	2	1	0	2
Yellow-shafted Flicker[a]	197	5	5	0	5
Yellow-bellied Sapsucker[a]	268	1	1	0	1
Traill's Flycatcher[a]	1,363	1	1	0	1
Blue Jay[a]	91	1	0	1	1
Black-capped Chickadee[a]	953	3	3	0	3
Red-breasted Nuthatch[a, b]	83	1	1	0	1
Catbird[a]	2,650	15	10	2	15
Brown Thrasher[a]	206	5	5	0	6
Robin	400	3	2	0	3
Wood Thrush[a]	103	1	1	0	1
Hermit Thrush	2,475	24	24	0	25
Swainson's Thrush[a]	9,845	52	43	4	55
Gray-Cheeked Thrush[a]	2,109	9	9	0	9
Ruby-crowned Kinglet[a]	1,721	1	1	0	1
Cedar Waxwing[a]	613	3	2	0	3
Solitary Vireo[a]	140	1	1	0	1
Red-eyed Vireo[a]	2,600	5	5	0	5
Philadelphia Vireo[a]	624	2	0	1	2
Myrtle Warbler[a]	1,015	1	1	0	1
Bay-breasted Warbler[a]	77	1	1	0	1
Blackpoll Warbler[a]	399	1	1	0	1
Ovenbird[a]	1,069	3	3	0	3
Northern Waterthrush[a]	1,111	3	2	0	3
Mourning Warbler[a]	203	2	2	0	2
Redstart[a]	1,930	3	3	0	3
Scarlet Tanager[a]	87	2	1	1	2
Cardinal	121	1	1	0	1
Rose-breasted Grosbeak[a]	505	2	2	0	2

TABLE 1. HOST RECORDS FOR HIPPOBOSCIDAE COLLECTED IN WISCONSIN, 1955–65—(Continued)

HOST°	NO. HANDLED	NO. INFESTED	SEXES/FLIES ♀♀	SEXES/FLIES ♂♂	TOTAL NO. FLIES*
Evening Grosbeak[a]	320	1	1	0	1
Purple Finch[a]	422	1	1	0	1
Pine Siskin[a,b]	143	1	1	0	1
Rufous-sided Towhee[a]	125	1	1	0	1
Slate-colored Junco	1,940	3	3	0	3
Tree Sparrow[a]	693	1	1	0	1
White-crowned Sparrow[a]	152	1	0	0	1
White-throated Sparrow	3,615	20	19	1	22
Fox Sparrow[a]	1,068	2	2	0	2
Lincoln's Sparrow	233	1	1	0	1
Swamp Sparrow	889	2	2	0	2
Song Sparrow	723	8	7	0	8
Unknown Passerine		47	38	3	47
TOTALS—*Ornithomyia fringillina*		258	222	13	267
C. *Ornithoctona erythrocephala*					
Sharp-shinned Hawk[a]	1,860	1	1	0	1
Broad-winged Hawk	14†	4	1	3	4
Pigeon Hawk[a]	241	1	0	0	1
Unknown Hawk		1	1	0	1
TOTALS—*Ornithoctona erythrocephala*		7	3	3	7
D. *Lynchia americana*					
Goshawk[a,b]	136	17	26	4	35
Sharp-shinned Hawk[a]	1,860	28	20	6	32
Cooper's Hawk	229†	9	6	2	10
Red-tailed Hawk	940†	159	216	56	355
Red-shouldered Hawk[a]	40†	4	2	3	5
Broad-winged Hawk[a]	14†	14	16	0	22
Swainson's Hawk[a,b]	3	1	0	0	1
Golden Eagle[a]	2	1	1	0	1
Marsh Hawk[a]	308	2	1	0	2
Sparrow Hawk[a,b]	170†	1	0	0	1
Barn Owl[a]	1	1	1	0	1
Screech Owl[a]	10	1	1	0	1
Great Horned Owl	138†	99	315	25	361
Barred Owl	10†	6	4	1	6
Long-eared Owl	17†	1	0	0	1
Evening Grosbeak[a,b]	320	1	0	1	1
Unknown Hawk		47	45	7	61
TOTALS—*Lynchia americana*		392	654	105	896
E. *Lynchia angustifrons*					
Broad-winged Hawk	28†	1	0	1	1

TABLE 1. HOST RECORDS FOR HIPPOBOSCIDAE COLLECTED IN WISCONSIN, 1955–65—(Continued)

Host°	No. Handled	No. Infested	Sexes/Flies ♀♀	♂♂	Total No. Flies*
F. *Lynchia nigra*					
Sharp-shinned Hawk	1,860	2	1	1	2
Broad-winged Hawk [a, b]	14†	1	0	0	1
Sparrow Hawk [a]	170†	1	0	1	1
Unknown Hawk		1	0	1	1
TOTALS—*Lynchia nigra*		5	1	3	5
G. *Lynchia albipennis*					
Unknown Hawk		1	0	1	1
H. *Microlynchia pusilla* [a]					
Catbird [a, b]	2,650	1	0	1	1
TOTALS—60 species		695 [x]	975	134	1,281

[a]New record for Wisconsin and neighboring states (cf. MacArthur, 1948).
[b]New record for North America (cf. Bequaert, 1952-56; Bennett, 1961).
*Total includes flies not sexed because the specimen was mutilated or dessicated.
†Represents a minimum number of birds of this species handled; we have no record of the number of birds trapped by the Bal-chatri.
[x]Sixteen birds harbored more than one species of fly.
°Scientific names of birds are given in the appendix.

bias in collection probabilities, we feel strongly that owls are important hosts for this species. This was suggested, but with reservations, by Bequaert (1953).

O. vicina is apparently not very selective as to host; it is quite adaptable to life on a number of species, both passerine and raptorial. On the Great Horned Owl and the Barred Owl infestations may be heavy, and the same bird is likely to harbor *Lynchia americana* on the body plumage. We found 14 cases of Great Horned Owls infested with both species of fly, and one individual caught at Wild Rose, Wisconsin, in August carried 14 *O. vicina* in the ears and 7 *L. americana* on other parts of the body. We collected no more than one individual *O. vicina* from any passerine bird, and Bennett (1961) found that *O. vicina* was much less common on passerine birds in Algonquin Park than *Ornithomyia fringillina.*

Ornithomyia fringillina is resident on a variety of birds; it prefers passerines, but shows little host specificity (cf. Bequaert, 1954). We have records from 6 species of raptorial birds, 2 woodpeckers, and 38 species of passerine birds (Table 1). This louse-fly is not common on raptorial birds, even on those such as the Sharp-shinned Hawk which feed principally on passerines; only 10 of 1,860 Sharp-shinned Hawks caught at Cedar Grove were infested with this species. Our collection indicates no pronounced preferences among passerine hosts, and infestations of all species were light (cf. Table 1). Our data from passerine birds are in no way comparable with those of Bennett (1961) for Algonquin Park. The relative infrequency of even the most common louse-flies on passerine birds at Cedar Grove (Table 1) can be attributed both to the collecting techniques and to the fact that we handled birds after the peak of infestation (cf. Bequaert, 1954: 137–138; Bennett, 1961).

Bennett (1961) felt that certain passerines were favored over others, particularly those Fringillidae, blackbirds, and thrushes that inhabit the environment near the ground. In Britain and Scandinavia, where there are three species of *Ornithomyia,* there may be stronger host-preferences than those of *O. fringillina* in the New World (cf. Hill, 1962b). According to Hill (1962b) and Hill *et al.* (1964) the "important hosts" for *O. fringillina* in the Old World are *exclusively* small passerines, mostly hedgerow species; on larger passerines and on raptorial birds *O. fringillina* appears to have been supplanted by the larger fly, *O. avicularia,* whereas *O. chloropus* prefers birds which frequent moorlands.

We found *Ornithoctona erythrocephala* only on hawks. This very large louse-fly was found on the Sharp-shinned Hawk, the Broad-winged Hawk, and the Sparrow Hawk (Table 1). One Sharp-shinned Hawk had both *O. erythrocephala* (1 individual) and *L. americana* (2 individuals), and a Broad-winged Hawk had one *O. erythrocephala* and one *L. americana.* These are our only records of infestation of an individual host by more than one species of fly, excepting those Great Horned Owls that carried *O. vicina* and *L. americana.*

Lynchia americana was found on 15 species of raptorial birds (Table 1). The only specimen from a passerine was on an Evening Grosbeak on 10 November 1963, and this individual (a male) could have been a stray which took up temporary residence on the grosbeak. These flies were generally reluctant to vacate their raptorial hosts even when the bird's feathers were disturbed; most specimens were collected as they darted among the feathers, although some flew to the person handling the bird. Infestations were often heavy, e.g. 17 Great Horned Owls, 8 Red-tailed Hawks and 3 Goshawks had more than 6 *L. americana:* the greatest individual infestation was 23 *L. americana* on a Great Horned Owl.

L. americana prefers large raptorial birds with large-feathered, loose plumage which provides both a good hiding place and an environment which does not deter movement of flies as does a densely feathered, compact plumage. Only one *L. americana* was found on a falcon, on a Sparrow Hawk on 7 September 1956; none were found on 241 Pigeon Hawks and 81 Peregrine Falcons, both of which have relatively compact plumage. The Great Horned Owl is clearly favored; nearly 60 per cent of the Great Horned Owls captured at Poynette and Cedar Grove carried on the average four of these flies. Other species on which this fly is common are the Red-tailed Hawk and the Goshawk and probably the Swainson's Hawk and the Barred Owl. Small hawks and owls are much less likely to harbor *L. americana:* for example, only 1.5 per cent of 1,860 Sharp-shinned Hawks and one of 234 Saw-whet Owls were infested.

Until recently *Lynchia fusca* (Macquart 1845) was considered a distinct species; MacArthur (1948) called it "The Owl Fly" (also cf. Bequaert, 1953:264). However, after reexamination of the specimens, Bequaert (1955) was convinced that *L. fusca* is conspecific with *L. americana,* and Maa (1963:35) supports this synonomy. Using MacArthur's (1948) key we found that these *Lynchia* were in fact difficult to distinguish and that the one host on which louse-flies consistently showed the characters of *L. fusca* was not an owl but the Broad-winged Hawk (specimens of *"L. fusca"* were found on 9 of the 12 Broad-winged Hawks from which *L. americana* were taken in the spring). Other flies with characters of *"fusca"* were on a Sharp-shinned Hawk (in April), a Red-tailed Hawk (in August) and three Great Horned Owls (September, November and December). MacArthur (1948) reported no *"L. fusca"* from Wisconsin and only one record for a neighboring state (on a squirrel in Michigan!). We see no reason why *L. fusca* should not be considered conspecific with *L. americana.*

We have collected 5 *Lynchia nigra* in Wisconsin; two from Sharp-shinned Hawks (1 May and 9 May 1964), one from an unknown hawk on 29 April 1965, one from a Broad-winged Hawk on 4 May 1958 and one from a Sparrow Hawk on 4 April 1958. We also found a *L. nigra* on a Sparrow Hawk in Zapta County, Texas, on 7 January 1956. According to Maa (1963:115) this species is essentially Neotropical; the Wisconsin specimens were most likely transported some distance on their hosts during spring migration. Two other species of *Lynchia* were taken from hawks in Wisconsin: a male of *L. albipennis* on a hawk on 12 May 1965 and a male of *L. angustifrons* on a Broad-winged Hawk on 5 May 1961. Since *L. albipennis* apparently prefers Ciconiiformes (cf. MacArthur, 1948; Maa, 1963), it is unusual to find one on a hawk. Spring and summer records of *L. angustifrons* from the United States and southern Ontario are probably strays (cf. Maa, 1963).

A male *Microlynchia pusilla* was found on a Catbird at Cedar Grove on 4 May 1965. This is the only record of *M. pusilla* from Wisconsin (cf. MacArthur, 1948) and the northernmost record for North America (cf. Bequaert, 1955; Maa, 1963). Also present in our collection is an individual of this species from a Harris Hawk *(Parabuteo unicinctus)* in Kennedy County, Texas, on 22 January 1956. This species is fairly common in southwestern United States (Bequaert, 1955), but its presence on a hawk is unusual (cf. Bequaert, 1955; Maa, 1963).

PHENOLOGY

We found only one species of louse-fly, *Lynchia americana,* to be present in the adult stage all year round in Wisconsin. One species, *Ornithoica vicina,* was found in every season except spring; *Ornithomyia fringillina* was present only in late spring, summer and fall. Four species *(Ornithoctona erythrocephala, Lynchia albipennis, Lynchia angustifrons,* and *Lynchia nigra)* were found only in spring and presumably were carried into Wisconsin on migratory hosts that winter in southern areas. The occurrence of *Microlynchia pusilla* can be considered accidental. A detailed account of the seasonal occurrence of the eight species of louse-flies follows, based on our collections and supplmented with information from Bequaert (1952–1956) and Bennett (1961).

Ornithoica vicina was absent from birds trapped in Wisconsin during late winter and spring; our earliest record was from an Eastern Kingbird on 14 June 1958, six weeks earlier than Bennett (1961) found it in Algonquin Park. This species was present, but not common, on passerine birds during fall migration. The only heavily infested individuals were owls in August and throughout fall and early winter. The latest date on which a male was taken was 23 October, but females were taken as late as 24 January in the ears of Great Horned Owls. Since these flies were not found in late winter and throughout the spring, our data cannot support Bequaert's (1953:265) hypothesis that owls represent a temporary reservoir of overwintering flies that are held in reserve to infect passerine migrants in the spring.

In Algonquin Park, Bennett (1961) reported the peak of abundance in late August and none later than early October. Bennett (1961:401) found that at a constant temperature of 75° F the time required for metamorphosis in *O. vicina* varied considerably around a mean of 78 days and that developmental time at 75° was prolonged by interspersing an extended period of chilling at

45° F. Apparently females of this species live for at least 4 months, but males may not live longer than one month (Bennett, 1961:396).

Our data and those of Bennett (1961) suggest that the population of *O. vicina* gradually builds up during the summer by the emergence and reproduction of flies that overwinter as pupae, not by overwintering adults or by the introduction of any significant number of flies from the south on spring migrants. The persistence of adults into late January argues for the emergence of flies during the fall, presumably from pupae deposited during the summer. The last males die in late fall and no females survive beyond mid-winter. It is possible that there is an alternation of diapause and non-diapause generations in northern North America such that adults emerging from diapause pupae during June and July give rise to a non-diapause generation that emerges in August or September and reproduces until December or January, giving rise to a second generation that overwinters in a pupal diapause. Alternatively, the overwintering pupae may not have a true diapause, which requires chilling, but they may simply remain dormant through the cold season and resume development with the return of warm weather.

Ornithomyia fringillina is rare in Wisconsin in spring; from nearly 9,500 passerine birds trapped between 1 April and 10 June we collected only three specimens of this fly, two in late May and one in early June. These are more than a month earlier than previous records for northern North America (cf. Bequaert, 1954; Bennett, 1961). We caught more passerine birds during September than during any other month, and it is not surprising that most of our collections of *O. fringillina* are also from September. We found no males after late September and no females after early November. In Algonquin Park, Bennett (1961) collected no *O. fringillina* until mid-July; he reported the peak of abundance in the two-week period around August 1. Assuming an early August peak for *O. fringillina* in Wisconsin, then the decline in infestation of passerines was already well underway when we began netting birds in late August at Cedar Grove.

The absence of this species in late fall and through the winter and its extreme rarity in spring and early summer argues against the overwintering of adults, even on migrant hosts in their winter home, and against the introduction of any significant number of adults on spring migrants. According to Bequaert (1954) *O. fringillina* is confined to cool temperate areas, occurring in northeastern United States from 3 July to 6 November. Bennett (1961) and Hill (1963) present evidence that this species has an obligatory diapause with a period of chilling necessary for development to resume. We suspect that as metamorphosis occurs through June and July the numbers gradually build up until mid-August and then slowly decline as adult mortality proceeds without further emergence of adults in fall. In this way the emergence of flies appears to coincide with the reproduction of the hosts (cf. Hill, 1963). In Algonquin Park, Bennett (1961) found *O. fringillina* on 10 per cent of adult passerine birds and 17.5 per cent of immatures; he presents experimental evidence that these flies, when confined with birds in small cages, select immature birds over adults, and he suggests that adults may be more efficient at catching and eating the flies. In nature these flies may not actively select immature birds, but they may be more frequently found on immature birds because these hosts are both more accessible and more abundant than adults at the time the flies emerge.

Ornithoctona erythrocephala was occasionally found on hawks in spring. Bequaert (1954) considers this genus essentially tropical with little evidence that the adults or pupae can withstand cool temperate winters in North America. He suggests (p. 200) "that it is introduced there afresh every spring on some migratory breeding host".

The incidence of infestation of raptorial birds by *Lynchia americana* shows a peak during the fall, with fairly large numbers of females and a few males present through the winter and spring, particularly on the Red-tailed Hawk and the Great Horned Owl (Table 2). Although we have very few summer records because of very little trapping, males appear to be as common as females in late July and during the first half of August, with an increasing preponderance of females in the fall and winter. The persistence of both sexes suggests that breeding may occur year-round, but with the number of adults gradually decreasing during the winter. Some adults are undoubtedly brought up from the southern states on migrant hosts in spring, but the population is not substantially augmented until eclosion of new adults in summer.

Bennett (1961:396) found that adult females of *L. americana* survived in captivity for 4–5 months, whereas most males lived only 15–20 days. The length of the pupal stage is temperature dependent and interrupted without ill effect by prolonged chilling at 45° F (p. 401). If reproduction does occur in Wisconsin in winter, it would seem that the pupae must be resistant to temperatures far below 45°, even below freezing, for prolonged periods. It would seem that development of this species does not depend on a period of chilling but that cool temperatures are not deleterious to development.

TABLE 2. INCIDENCE OF *Lynchia americana* ON HAWKS AND OWLS TAKEN AT CEDAR GROVE AND POYNETTE

Host Species	Fall			Winter			Spring–Summer		
	August–November			December–February			March–July		
	No. Birds	% Infested	Avg. No. Flies	No. Birds	% Infested	Avg. No. Flies	No. Birds	% Infested	Avg. No. Flies
Goshawk	121	12	1.8	8	13	4.0	1	0	—
Sharp-shinned Hawk	1,828	1	1.1	0	—	—	32	9	1.2
Cooper's Hawk	128	5	1.0	0	—	—	101	0	—
Red-tailed Hawk	769	19	2.5	74	4	1.0	98	0	—
Red-shouldered Hawk	18	11	1.0	1	0	—	21	0	—
Swainson's Hawk	1	100	1.0	0	—	—	2	0	—
Marsh Hawk	104	0	—	1	100	1.0	203	0	—
Sparrow Hawk	68	1	1.0	0	—	—	102	0	—
Great Horned Owl	52	77	5.4	59	54	2.6	27	26	1.6
Barred Owl	10	33	1.0	0	—	—	0	—	—
Long-eared Owl	17	6	1.0	0	—	—	0	—	—

The persistence of adults in winter and spring suggests that pupae deposited during summer and early fall emerge before cold weather sets in; those deposited in late fall and winter remain dormant through the winter, emerging after a suitable period of warmer weather in spring and early summer. During late winter and spring the population decreases due to gradual mortality of adults, and a lower level of infestation is maintained until metamorphosis of pupae is completed or until sufficient numbers of infested migrants have returned. The coincidence of numbers of "*L. fusca*" on Broad-winged Hawks in spring might indicate the "importation" by hawks of a population of *L. americana* that lives year-round on birds of a more southern distribution.

According to Bequaert (1955), *L. americana* may not occur north of 48° 10′ north latitude, which is approximately the Canadian border in the central and western United States. We suspect that the range of this fly extends as far north as that of its hosts, which in the case of the Goshawk and Red-tailed Hawk is well north of the U.S.–Canadian border. There are few records of this fly from Mexico and farther south, and in western and southern states it is less common than *L. nigra* (Bequaert, 1955). The birds on which we found *L. americana* were, in fact, those which winter north of the Mexican border, and the only records we have for *L. nigra* are from the spring and from hawks that winter farther south.

Lynchia albipennis, L. angustifrons and *L. nigra* are tropical species (cf. Bequaert, 1955) that are occasionally introduced on spring migrants and apparently do not overwinter in a northern climate. *Microlynchia pusilla* is essentially tropical and rare north of the southwestern United States (Bequaert, 1955). Our specimen, taken from a Catbird in May, undoubtedly "migrated" north from Central America with its host.

Phoresy and Infestation by Mites

The attachment of chewing bird lice (Mallophaga) to Hippoboscidae is frequently cited as an example of phoresy, the wingless louse using the winged louse-fly as a means of transportation (references in MacArthur, 1948:385–387; Bequaert, 1952:163–174; Corbet, 1956a). This phenomenon is difficult to explain because each species of Mallophaga is believed to feed exclusively on feathers and epidermis of hosts of a given species. *Ornithomyia fringillina,* which is the most common carrier of the lice, is found on a variety of host species, and flies which have been experimentally marked for individual identification have been followed to individuals of several species of birds (Corbet, 1956b; Bennett, 1961). The lice would presumably not benefit from being transported to a host of a different species, and the louse-fly would not seem to be a good host for the lice to parasitize. Bequaert (1952:163) suggests that phoresy of Mallophaga by Hippoboscidae is "on the borderline of true parasitism".

The incidence of phoresy, at least by *O. fringillina,* is too high to be accidental. Bequaert (1952) reported phoresy by 6 per cent of some 500 *O. fringillina* and less frequently by a number of other species of Hippoboscidae, including *Ornithoica vicina, Ornithoctona erythrocephala, Lynchia americana,* and *Lynchia albipennis.* MacArthur (1948) found 14 cases, 4 per cent of the total flies examined, and Bennett (1961) reported phoresy by 22.8 per cent of *O. fringillina* collected in 1957, with the highest frequency in July and much less in late August and early September.

We found 30 cases (11.3 per cent) of phoresy by *O. fringillina* and one by our only specimen of *Microlynchia pusilla* (a female Brüelia on the fly taken from a Catbird on 4 May, 1965). Avian hosts for flies that carried lice were a Sharp-shinned Hawk, a Yellow-shafted Flicker and 11 species of Passeriformes. In view of the diversity of bird species, it is perhaps surprising that all lice were in the genus Brüelia and appeared to be of the same species; adult female lice predominated. All 30 cases of phoresy by *O. fringillina* in our collection occurred in summer and early autumn (2 in July, 1 in August, 23 in September, and 4 in October). The lice were firmly imbedded in the integument of the louse–flies by their mouth parts, and the lateral surfaces of the abdomen were preferred places of attachment; in only one case was a louse attached to the prothorax. All were facing in the same direction as the flies.

The infestation of Hippoboscidae by epidermoptid mites (Acarina) is considered true parasitism (cf. MacArthur, 1948:387; Bequaert, 1952:142–160). We found mite clusters on 52 *O. fringillina* (26.6 per cent) and on three *L. americana;* the latter is a species not previously recorded as parasitized by mites (cf. Bequaert, 1952). The mites were of the genera *Microlichus* and *Myialges.* Hosts for the *L. americana* which carried mites were two Broad-winged Hawks trapped in April and one unidentified hawk in October. The mite-infested *O. fringillina* were on 18 species of passerine birds and one Pigeon Hawk, all trapped during autumn migration (2 in August, 31 in September, 18 in October, and one sometime in fall). Mites preferred the underside of the wings in the vicinity of the large veins, and they were rarely found elsewhere on the flies, such as on the abdomen or the upper surface of the wings. Mites usually consisted of a cluster formed by a female and her eggs or young. Clusters were often present on the underside of both wings, and only the immature mites tended to stray to other parts of the fly's body.

SUMMARY

In the years 1955 through 1965 more than 5,000 hawks and owls and nearly 54,000 passerine birds were trapped alive in Wisconsin, and louse-flies were collected. Most birds were caught during autumn and spring migrations. A total of 1,281 individuals of eight species of Hippoboscidae was taken from 695 individuals of 60 species of birds. Only three species of louse-fly were common: *Ornithoica vicina, Ornihomyia fringillina,* and *Lynchia americana. O. vicina* was most frequently found in the ears of the Great Horned Owl. *O. fringillina* was found on a wide variety of passerines and on 6 raptorial species, with no obvious host preferences. *Lynchia americana* clearly preferred hawks and owls, especially those with large-feathered, loose plumage. Hawks returning from the south occasionally harbored other species of Hippoboscidae: *Lynchia nigra, L. albipennis, L. angustifrons* and *Ornithoctona erythrocephala.* One specimen of *Microlynchia pusilla* was found on a Catbird.

The winter climate is probably the most important factor affecting the occurrence of a given species of fly in Wisconsin. Those species which cannot tolerate cold during the pupal stage (e.g. *O. erythrocephala, L. albipennis, L. angustifrons, L. nigra,* and *M. pusilla*) occur in Wisconsin only as vagrants and have essentially no chance of becoming permanently established. The pupae of *O. vicina* and *L. americana* can tolerate cold with a temporary suspension in development, and *O. fringillina* has a true diapause that depends on a period of chilling in order for development to resume (cf. Bennett, 1961). Adults of *L. americana* may overwinter on resident hosts, even perhaps continuing to reproduce, but there is no supplementation of their numbers until spring migration brings in adults that have emerged in the south or until local temperatures become suitable for emergence of new flies. Adults of species infesting migratory birds travel south on their hosts in autumn and die with or without reproducing in the south.

Lice of a species of Brüelia (Mallophaga) were found attached to 11.3 per cent of the *Ornithomyia fringillina.* Phoresy was also found in one specimen of *Microlynchia pusilla.* Parasitic mites of the genera *Microlichus* and *Myialges* were found on the wings of three *Lynchia americana* and 26.6 per cent of the *O. fringillina.*

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References Cited

Bennett, G. F. 1961. On three species of Hippoboscidae (Diptera) on birds in Ontario. Can. J. Zool., 39:379–406.

Bequaert, J. C. 1952–53. The Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part I. Structure, physiology and natural history. Entomol. Amer., 32–33 (N.S.):1–442.

Bequaert, J. C. 1954–56. The Hippoboscidae or louse-flies (Diptera) of mammals and birds. Part II. Taxonomy, evolution and revision of American genera and species. Entomol. Amer., 34–36 (N.S.):1–611.

Corbet, G. B. 1956a. The phoresy of Mallophaga on a population of *Ornithomyia fringillina* Curtis (Dipt., Hippoboscidae). Ent. Mon. Mag. 92:207–211.

Corbet, G. B. 1956b. The life-history and host-relations of a Hippoboscid fly *Ornithomyia fringillina* Curtis. J. Anim. Ecol., 25:403–420.

Corbet, G. B. 1961. A comparison of the life-histories of two species of *Ornithomyia* (Diptera, Hippoboscidae). Entomol. Gaz., 12:24–31.

Hill, D. S. 1962a. Revision of the British species of *Ornithomyia* Latreille (Diptera: Hippoboscidae). Proc. Royal Ent. Soc. London, (B), 31:11–18.

Hill, D. S. 1962b. A study of the distribution and host preferences of three species of *Ornithomyia* (Diptera: Hippoboscidae) in the British Isles. Proc. Royal Ent. Soc. London, (A), 37:37–48.

Hill, D. S. 1963. The life history of the British species of *Ornithomyia* (Diptera: Hippoboscidae). Trans. Royal Ent. Soc. London, 115:391–407.

Hill, D. S., W. Hackman, and L. Lyneborg. 1964. The genus *Ornithomyia* (Diptera: Hippoboscidae) in Fennoscandia, Denmark and Iceland. Notulae Entomologicae, 44:33–52.

Maa, T. C. 1963. Genera and species of Hippoboscidae (Diptera): types, synonymy, habits and natural groupings. Pacific Insects Monog., 6:1–186.

MacArthur, K. 1948. The louse-flies of Wisconsin and adjacent states (Diptera: Hippoboscidae). Bull. Public Museum City Milwaukee, 8:367–440.

Mueller, H. C., and D. D. Berger. 1966. Analyses of weight and fat variations in transient Swainson's Thrushes. Bird-Banding, 37:83–112.

Mueller, H. C., and D. D. Berger. 1968. The relative abundance of species caught in mist-nets during fall migration at Cedar Grove. Passenger Pigeon, 29:107–115.

Woodman, W. J. 1954. Mallophaga of Wisconsin. (unpub.) PhD Thesis, Univ. of Wisconsin, Madison. 281 pp.

APPENDIX

(Scientific names of birds* infested with Hippoboscidae)

Goshawk	*Accipiter gentilis*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperii*
Red-tailed Hawk	*Buteo jamaicensis*
Red-shouldered Hawk	*Buteo lineatus*
Broad-winged Hawk	*Buteo platypterus*
Swainson's Hawk	*Buteo swainsoni*
Golden Eagle	*Aquila chrysaëtos*
Marsh Hawk	*Circus cyaneus*
Sparrow Hawk	*Falco sparverius*
Pigeon Hawk	*Falco columbarius*
Barn Owl	*Tyto alba*
Screech Owl	*Otus asio*
Great Horned Owl	*Bubo virginianus*
Barred Owl	*Strix varia*
Long-eared Owl	*Asio otus*
Saw-whet Owl	*Aegolius acadicus*
Yellow-shafted Flicker	*Colaptes auratus*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Eastern Kingbird	*Tyrannus tryannus*
Traill's Flycatcher	*Empidonax traillii*
Blue Jay	*Cyanocitta cristata*
Black-capped Chickadee	*Parus atricapillus*
Red-breasted Nuthatch	*Sitta canadensis*
Catbird	*Dumetella carolinensis*
Brown Thrasher	*Toxostoma rufum*
Robin	*Turdus migratorius*
Wood Thrush	*Hylocichla mustelina*
Veery	*Hylocichla fuscescens*
Hermit Thrush	*Hylocichla guttata*
Swainson's Thrush	*Hylocichla ustulata*
Gray-cheeked Thrush	*Hylocichla minima*
Ruby-crowned Kinglet	*Regulus calendula*
Cedar Waxwing	*Bombycilla cedrorum*
Solitary Vireo	*Vireo solitarius*
Red-eyed Vireo	*Vireo olivaceus*
Philadelphia Vireo	*Vireo philadelphicus*
Myrtle Warbler	*Dendroica coronata*
Bay-breasted Warbler	*Dendroica castanea*
Blackpoll Warbler	*Dendroica striata*
Ovenbird	*Seiurus aurocapillus*
Northern Waterthrush	*Seiurus novaboracensis*
Mourning Warbler	*Oporornis philadelphia*
Redstart	*Setophaga ruticilla*
Rusty Blackbird	*Euphagus carolinus*
Scarlet Tanager	*Piranga olivacea*
Cardinal	*Richmondena cardinalis*
Rose-breasted Grosbeak	*Pheuticus ludovicianus*
Evening Grosbeak	*Hesperiphona vespertina*

* American Ornithologists' Union. 1957. Checklist of North American Birds. American Ornithologists' Union, Baltimore, Md.

Purple Finch	*Carpodacus purpureus*
Pine Siskin	*Spinus pinus*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Slate-colored Junco	*Junco hyemalis*
Tree Sparrow	*Spizella arborea*
White-crowned Sparrow	*Zonotrichia leucophrys*
White-throated Sparrow	*Zonotrichia albicollis*
Fox Sparrow	*Passerella iliaca*
Lincoln's Sparrow	*Melospiza lincolnii*
Swamp Sparrow	*Melospiza georgiana*
Song Sparrow	*Melospiza melodia*

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