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MORPHOLOGY OF THE ALIMENTARY SYSTEM OF THE SNAIL *LYMNAEA STAGNALIS APPRESSA* SAY

MELBOURNE ROMAINE CARRIKER
Zoological Laboratory of the University of Wisconsin

INTRODUCTION

Knowledge concerning the details of the anatomy and histology of snails is becoming increasingly important as information accumulates regarding their role as vectors for parasites of man, domestic animals, wild game and fish. Although the host-parasite relations between the vertebrates and the helminths are frequently well known, the corresponding relations between the snail and the developmental stage of the parasite are less adequately understood. The pathological effect of the parasite on the invertebrate host is frequently difficult to ascertain because the normal microanatomy and histology of the organs of the mollusc are but poorly worked out.

In the present study an attempt has been made to assemble and integrate the scattered and often incomplete information available on the microanatomy of the alimentary system of the snail *Lymnaea stagnalis* (Suborder Basommatophora, Order Pulmonata), and by additional original investigation on *L. s. appressa* to reconstruct the form of this system in detail. Emphasis has been placed on the proper selection of anatomical terms, and where these have occurred in synonymy the synonyms have been carefully considered in the selection of an acceptable term. The introduction of some new terms has been necessary. The literature presents but few quantitative descriptions; for this reason in this paper average measurements are given of living organs wherever feasible. Emphasis is also placed on describing the organs in their natural spatial relations within the shell and soft parts. Studies already completed on the histology and physiology of the alimentary system of this snail will appear in other journals.

ACKNOWLEDGMENTS

This work was carried out largely at the University of Wisconsin (1939 to 1943) under the guidance of Prof. L. E. Noland whose assistance is herewith gratefully acknowledged. Thanks are due also to Prof. T. C. Nelson of Rutgers University under whose direction the writer worked during the summer of 1942 at Rutgers University and the New Jersey Oyster Research Laboratories.

CLASSIFICATION

According to the classifications of F. C. Baker (1902, 1911, 1928) there is question as to whether the subspecies of the snail here investigated is *appressa* or *jugularis*. However, Dr. Henry A. Pilsbry of the Academy of Natural Sciences has kindly clarified the matter of synonymy (by letter), explaining that the original identifications of *jugularis* by Say are doubtful and that such a dubious name is better discarded.

The following characters (of laboratory-cultured specimens 38 mm. or over in shell length) place this snail nearer *appressa* taxonomically than to any other variety. As reported elsewhere (Carriker, 1943b) a study of fifteen radulae disclosed the following limits of the number of teeth: laterals, 14–19; intermediates, 2–5; marginals, 21–30. Contrary to Baker's findings for this subspecies, the first laterals were found to be almost entirely tricuspid. Examination of 75 shells indicated that the spire length varies from very much shorter than, to equal to, to longer than the aperture length. The number of complete shell whorls varies from 6.5 to 8, the average number being 7. The maximum length of snails grown in the laboratory to date is 62.5 mm.

HISTORICAL REVIEW

Of the references cited here only seven are the results of research on American Lymnaeidae: Wetherby (1879), Whitfield (1882), F. C. Baker (1900, 1911, 1928), Colton (1908) and Faust (1920). These investigations, with the exception of that by Faust which treats of the histology of the liver, describe only the superficial gross anatomy of the alimentary system. The more exhaustive researches are almost entirely those of European investigators on European Lymnaeidae. Thus the American lymnaeids are still an open field for investigation.

The following are the more thorough morphological works performed on the various parts of the alimentary system of *Lymnaea:* on the radula: Rössler (1885), Schnabel (1903), and Hoffmann (1932); the radular cartilage: Dybowski (1885), Loisel (1893), Schafer (1913) and Baecker (1932); radular collostyle: Baecker (1932); salivary glands: Prenant (1923); stomach region: Heidermanns (1924); liver: Barfurth (1880, 1883), Frenzel (1886), Enriques (1902) and Faust (1920). Thus the buccal mass, the esophagus and intestine have received little attention. With the exception of some preliminary observations on the buccal musculature by Amaudrut (1898) and the thorough work of Heidermanns on the innervation and vascularization of the stomach region, the gross and detailed musculature, innervation and vascularization of the system also have been only superficially investigated.

The following reviews were very helpful on the morphology of the Lymnaeidae: Moquin-Tandon (1885), Griffiths (1892), Cooke (1913), Pelseneer (1906), F. C. Baker (1900, 1928), Simroth and Hoffmann (1908–1928), Pelseneer (1935) and Yonge (1936).

The research on the alimentary system of the remaining Basommatophora is represented by only a few papers. The more detailed contributions are those of Hurst (1927) on *Physa;* H. B. Baker (1925), *Lanx;* Schumann (1911) *Gadinia;* Häckel (1911), *Chilina;* and Hoff (1940), *Ferrissia.* Older minor papers are those of André (1893) on *Ancylus;* Buchner (1891) on *Planorbis;* and Hutton (1879) on *Amphibola.*

The outstanding investigations on the Pulmonata have been performed principally on the stylommatophoran *Helix.* The more recent of such works which have a bearing on the pulmonate alimentary system are mentioned here: on the radula: Spek (1921), Pruvot-Fol (1926); alimentary canal: V. Haffner (1923); morphology of musculature: Trappmann (1916); morphology of vascular system: Schmidt (1916); morphology of nervous system: Schmalz (1914); body membranes: Kisker (1923). In other stylommatophorans the alimentary canal is also treated at some length by Richter (1926) in *Cerion;* Hoffmann (1925), Vaginulidae; Argaud and Bounoure (1910), *Arion;* and Awati and Karandikar (1940), *Oncidium.*

MATERIALS AND METHODS

L. s. appressa was selected for the study in part because of its excellent response to laboratory culture. Additional advantages are found in the relatively large size of the snail as compared with other fresh-water pulmonates, its short life-cycle and its relatively thin, semitransparent shell.

Over 1,000 snails used in the investigation were raised entirely in the laboratory. The original snails were collected in Fox Lake, Wisconsin, in 1939. As some of these snails were probably parasitized, the following method was utilized to obtain parasite-free animals: snail egg masses, soon after oviposition, were isolated into separate aquaria. Each new culture was started in this way, hence transmission of infection was rendered very improbable. Repeated dissections of snails of succeeding generations have never revealed the presence of parasites.

The soft parts of the animal were most easily removed uninjured from the shell by breaking the whorls away from the columella by means of slight outward-twisting pressure exerted on curved forceps. The origin of the heavy columellar muscle thus exposed is readily dislodged with the points of the forceps, and the soft parts of the mollusc then may be gently twisted out of the remaining shell spire.

Relaxation of the soft parts through anesthetization was produced most satisfactorily by the use of nembutal. The variety used was the commercial veterinary product, pentobarbital sodium, Abbott; list number 8612; concentration: 1 grain per cc. dissolved in 10% alcohol. Injections were made with a 1-cc. hypodermic syringe. The site of injection causing the minimum contraction and distributing the hypnotic most rapidly throughout the body of the snail is the heart. A minute hole was picked on the left side of the body whorl over the lung. If the snail is held before a strong beam of light the outline of the organs within the shell can be distinguished. The point of the hypodermic needle was directed through the renal organ and into the pericardium. The injection was most effective when made directly into the auricle or ventricle, both of which are clearly seen dilating. The quantity of nembutal per unit of body weight required to produce hypnosis is over fifty times that used in human administration. The average net weight of adult *L. s. appressa* is 5 gms. (maximum wet weight found to date: 8.39

gms.) and the approximate dose for complete hypnosis is about 0.1 cc. Quantities below 0.03 cc. had little visible effect. Within the limits of 0.03 and 0.20 cc. the promptness with which hypnosis was obtained increased with increase in dosage. Doses of 0.5 cc. per snail were used for the relaxation of snails for morphological study. With a 0.1-cc. dosage of nembutal about an hour was usually required for hypnosis of the more easily anesthetized snails, and as long as two hours for the more refractory specimens. Smaller snails required proportionately less nembutal. At high temperatures (e.g., 30–35° C.) hypnosis occurred more rapidly.

Magnesium sulfate was tried but with less success. Urethane (ethyl carbamate), water at 60° C. and glacial acetic acid gave only moderately relaxed animals. Chloroform, ether and similar anesthetics produced violent contracture of the snail, even when the anesthetic was floated in watch glasses on the water over the snails.

Snails anesthetized with nembutal and injected with 2M magnesium sulfate did not give animals as well relaxed as with nembutal alone, but the animals did loose the irritability which is generally noted about the tentacles and the velum of snails anesthetized with nembutal alone. Cardiac administration of 0.2 cc. of nembutal and immersion in a small volume of water with a few crystals of chloretone produced a more deeply anesthetized snail in two to three hours than did the nembutal alone. Out of 25 snails thus treated only one had contracted into the shell. Excellent relaxation of the snails was obtained by asphyxiation in boiled water to which chloretone had been added, but it took two to three days to completely asphyxiate them. Concurrent asphyxiation of animals injected with nembutal is not advisable, as under the anaerobic conditions of the method, the tissues about the site of injection autolyze badly.

General dissection was carried out in both living and preserved snails. In the former, the animals were anesthetized with nembutal for about an hour and then dissected under a special *Lymnaea* physiological solution developed to approximate more closely the ionic concentrations of *Lymnaea* blood. An account of this solution will appear in a separate paper on the physiology of the alimentary tract of *L. s. appressa.* The above procedure left the organs very nearly in their natural form. Crystals of chloretone added to the dissecting medium kept the animals under anesthesia. For dissection of preserved specimens, snails were killed by asphyxiation in boiled water to which chloretone had been added, and after killing were preserved in a mixture of dilute alcohol and formalin. Neutral red and methylene blue in varying dilute concentrations were used to differentiate the tissues during the process of dissection.

Study of the shape of the lumen of the alimentary canal was facilitated by injecting the canal with pigmented latex or pigmented vinylite. The canals of some 50 snails were cleared of food material by five days of starvation. They were then relaxed by the nembutal-chloretone method described above. Turtox latex injection medium, diluted with tap water to a creamy consistency, was injected in a rubber-metal syringe. Similarly Synflex vinylite, diluted with acetone, was injected in a dry glass syringe. As water immediately sets the vinylite, excess water was blotted from tissues and objects touched by the syringe. The dorsal region of the heads of the anesthetized snails was opened longitudinally to expose the buccal mass; this made possible the passage of the needle through the mouth into the esophagus without puncturing these delicate structures. The buccal mass was pressed tightly about the needle with a pair of fine forceps during the actual injection. Pressure was exerted on the plunger of the syringe until the injection medium poured out the anus. Not infrequently injections were ruined by the rupturing of the delicate pyloric region of incompletely anesthetized snails. Specimens injected with latex were allowed to set in dilute acetic acid. With vinylite, water was used. The tissues of the vinylite-injected specimens were dissolved away from the injectant by the use of concentrated KOH or strong HNO_3. Some total specimens were cleared by the method described by Guyer (1936), p. 117. The method is satisfactory if air bubbles are removed by suction during the clearing.

For a study of the topography of the inner walls of the lumina of the alimentary canal, starved, anesthetized snails were injected orally with a deep blue solution of methylene blue. This technic distended the walls of the canal and accentuated the pattern of the inner walls. For a study of the relationship of the alimentary lumina to the alimentary tract the carmine-staining method advised by Lathrop (1937) was applied. The presence of chitin in the alimentary system was detected by the method of Campbell (1929). Portions of the tract were removed from narcotized snails and tested separately.

Methods for the preparation of the radulae for study have been described elsewhere (Carriker, 1943b).

By far the most satisfactory injection medium for the vascular system was Emery's aqueous carmine (Lee, 1921), supplemented by the use of approximately 0.5% of the vasodilator sodium nitrite ($NaNO_2$). Snails were relaxed by the cardiac injection of 0.3 cc. of nembutal or by immersion in chloretone solution. After about an hour the snails were sufficiently relaxed to take the injectant. A 1-cc. syringe was filled with the carmine solution and laid aside with the needle in damp cloth; a shallow support which would hold the needle at the level of the heart during injection was also made ready. The shell of the relaxed snail was removed as far back as the liver, exposing the heart and the aorta, care being taken that the columellar muscle was not freed from the remaining shell and that no portions of the snail body were ruptured. The pericardium was cut open exposing the heart. With fine forceps a short piece of fine thread was slipped under the ventricle and a loose overhand knot was tied about it; the syringe needle was then pressed into the ventricle and down the aorta a short distance. The thread was tied tightly about the ventricle and needle. Injectant was then slowly forced into the vascular system until the minute arteries of the ventral surface of the foot started showing red. The syringe was then withdrawn and the ventricle tied off tightly. The snail, though under the effect of the hypnotic, is stimulated chemically and probably mechanically by the injectant, and moves slightly, thus furthering the penetration of the injectant into the most minute arterioles. The snail was then placed in approximately 5% alcohol until it ceased movement, and then into 20–30% alcohol for hardening of the carmine. Stronger alcohol hardens the carmine more effectively, but so also the tissues, which is not desirable in dissection. The injections were carried out entirely under the binocular microscope with the snail lying on paper toweling and under a strong beam of light. It was necessary to moisten the animal repeatedly during injection. Even though anesthetization with chloretone was more time-consuming (approximately six hours), it was found more expedient, as there is always danger of puncturing the ventricle or aorta with the syringe in cardiac injection. Once the animal is punctured, it is of no further use for total vascular injection. In some instances well-injected snails were dissected to expose the arteries, then dehydrated in alcohol and cleared in xylol. Injection of the vascular system was also made with undiluted India ink, with strong concentrations of methylene blue, and with pigmented vinylite, but these methods were not as effective as the first method outlined above.

The topography of the gross nervous system was studied in (1) narcotized snails dissected under *Lymnaea* physiological solution, (2) relaxed snails immersed for several hours in 5% nitric acid, (3) in snails killed by asphyxiation in chloretone and preserved in dilute alcohol and formalin, (4) and in snails treated as in (3) but cleared in glycerine and dissected under water after removal of the excess glycerine. In all of these methods methylene blue was sometimes applied during dissection to further differentiate the tissues. Minute innervation of the organs of the alimentary tract was studied by the technic of Alexandrowicz (1932). Submerging of the tissues in the dye was decidedly more fruitful than injection of the dye into the living animal. Small pieces of tissue from anesthetized snails were spread flat on thin pieces of paraffin (approximately 2 mm. thick) and secured there by means of very small insect pins ("Minuten nadeln"). These preparations were then immersed in solutions of *Lymnaea* physiological solution to which the methylene blue had been added (2 drops of 0.5% methylene blue and 1 cc. of translucent paraffin plates, were placed under the compound microscope from time to time to note the extent of staining. The nerves of the salivary glands stained well in about six hours; the remaining parts of the tract took as long as 24 hours. Ganglionic cells of the alimentary system were followed in histological sections and by means of the method suggested by Heidermanns (1924).

GENERAL ORGANIZATION OF INTERNAL ORGANS

All measurements given in this paper will be those normal to 48 mm. snails, the average of adult laboratory animals: shell length, 48 mm.; greatest width, 23 mm.; length of aperture, 25 mm.; and width of aperture, 15 mm. F. C. Baker (1911, 1928) describes the shell and the external appearance of the soft parts of *L. s. appressa* in detail. Throughout the paper, right and left refer to the animal's right and left.

The general organization of the internal organs is illustrated in Figs. 1, 2, 3 and 4. The body cavity of the snail is divided into three major spaces: the cephalic and the visceral hemocoels and the lung. The cephalic hemocoel lies within the head and neck regions (fig. 2). The visceral hemocoel is placed dorso-posteriad the cephalic hemocoel and ventrad the lung and lies within the shell (fig. 1). The lung saddles the middorsal region of the animal, lying over the anterior third of the visceral hemocoel and in the posterior dorsal limits of the seventh body whorl.

That portion of the *diaphragm* constituting the anteroventral boundary of the lung is considerably depressed and makes connection with the ventral body wall by means of a diffuse fibrocellular septum. This separates the cephalic from the visceral hemocoel. The ducts of the reproductive system, nerves and arteries which pass between the two hemocoels are firmly bound in the septal connective tissue; the esophagus is permitted free egress through a small rounded passageway remaining in the left ventral portion. Lacaze-Duthiers (1872) first referred to the relationship of these "cervical" structures in *L. stagnalis* but did not define them very clearly. Moquin-Tandon (1885) in Gastropoda, Robson (1922) in *Paludestrina,* Brown (1933–34) in *Philine,* and Fretter (1939) in Tectibranchia make passing reference but do not describe similar septa. Kisker (1923) in a description of a similar structure in *Helix* suggests the name "Membrana transversa" but does not consider the esophageal opening. It is desirable to designate the interhemocoelic septum as the *cervical septum* and the esophageal conduit as the *esophageal iter.*

The buccal mass occupies the anterior third of the cephalic hemocoel (fig. 2) and is bounded on all but the posterior side by the strong muscular walls of the head. A delicate laminated membrane screens the buccal mass from the remainder of the hemocoel. This membrane passes from the central nervous system forward completely around the buccal mass, attaching circumferentially in the body wall a short distance behind the mouth. This lamination is generously perforated and appears to function in part as a baffle membrane in connection with the cir-

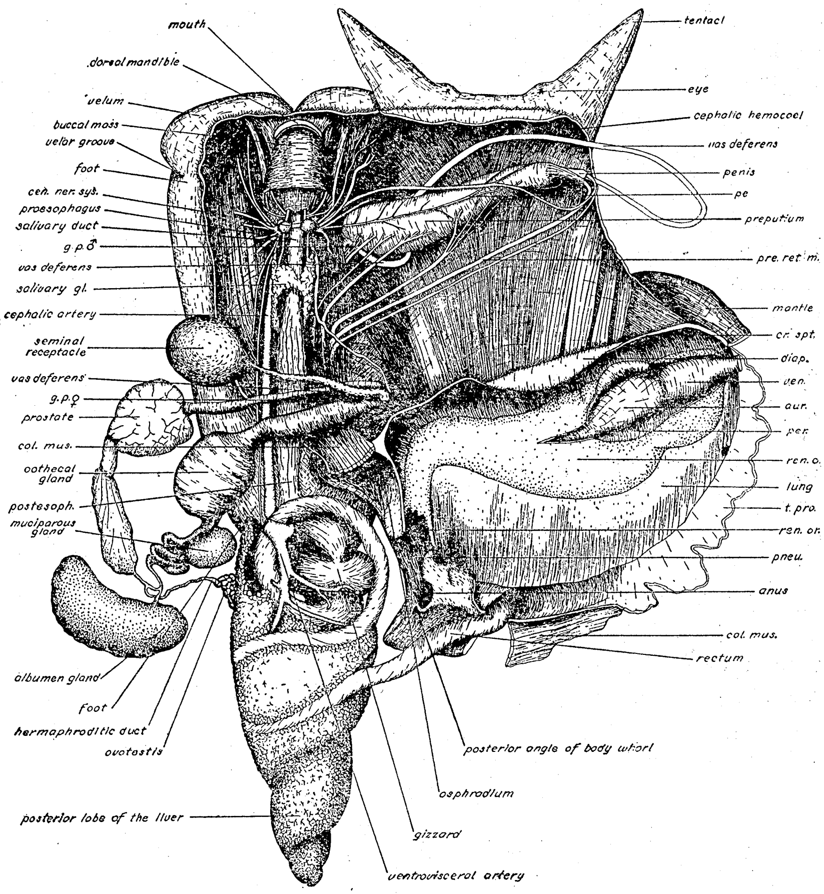

mouth
dorsal mandible
velum
buccal mass
velar groove
foot
cen. ner. sys.
proesophagus
salivary duct
g.p.♂
vas deferens
salivary gl.
cephalic artery
seminal receptacle
vas deferens
g.p.♀
prostate
col. mus.
oothecal gland
postesoph.
muciparous gland
albumen gland
foot
hermaphroditic duct
ovotestis
posterior lobe of the liver
tentacl
eye
cephalic hemocoel
vas deferens
penis
pe
preputium
pre. ret. m.
mantle
cr. spt.
diap.
ven.
aur.
per.
ren. o.
lung
t. pro.
ren. or.
pneu.
anus
col. mus.
rectum
posterior angle of body whorl
osphradium
gizzard
ventrovisceral artery

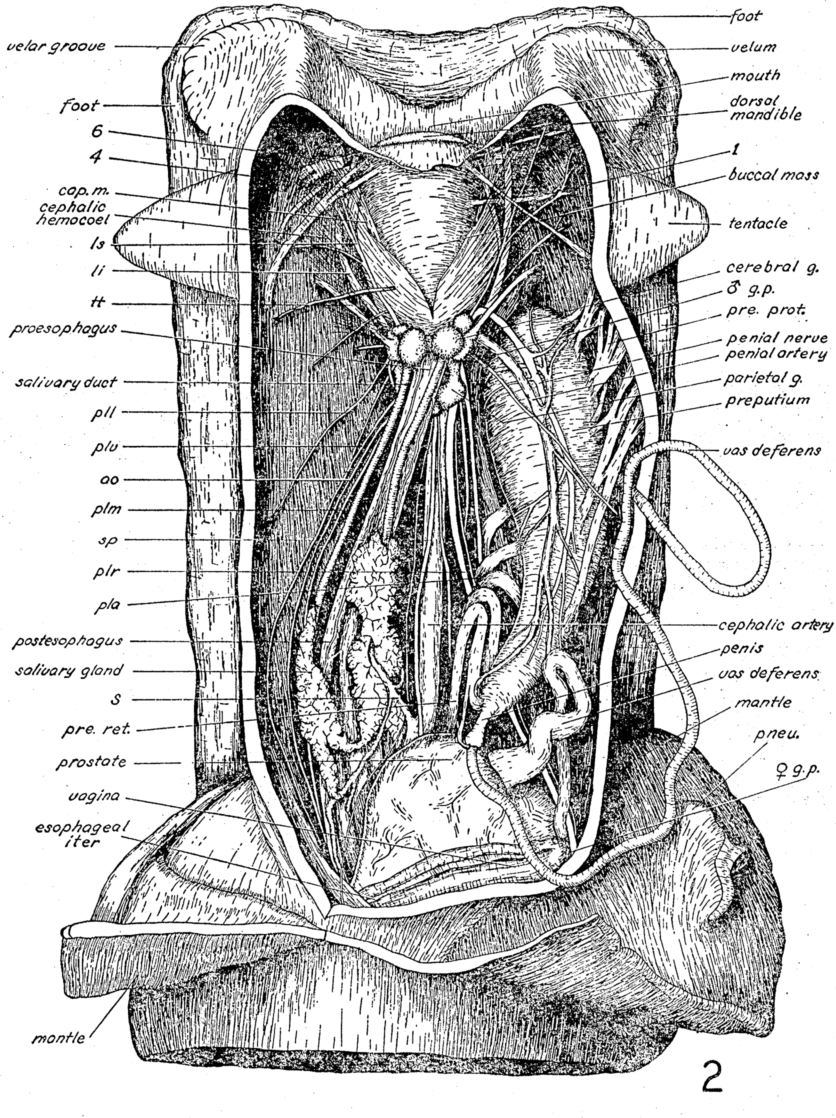
PLATE I

Explanation of Figure

Figure 1. Perspective line drawing of an entire *L. s. appressa* removed from the shell and opened along the left side. The dorsum has been flattened to the right and the organs spread for the sake of clarity. The stomach region and the posterior lobe of the liver have been turned on the longitudinal axis about one half turn to the right (compare with fig. 3). The midventral portion of the diaphragm and the tunica propria have been omitted. In the natural position the reproductive organs are closely grouped over the postesophagus, the lung covers the reproductive glands and some of the organs in the visceral hemocoel, the heart makes connection on the left ventral side with the aorta, the columellar muscle attaches to the columella of the shell. The length of the postintestine has been shortened. The configuration and nomenclature of the reproductive glands illustrated here are taken from Holm (1946). × 2.

Abbreviations

aur.—auricle
cen. ner. sys.—central nervous system
col. mus.—columellar muscle
cr. spt.—cervical septum
diap.—diaphragm
g. p. ♀—female genital pore
g. p. ♂—male genital pore
pe.—penial nerve
per.—pericardium
pneu.—pneumatopore
pre. ret. m.—retractor muscle of the preputium
ren. o.—renal organ
ren. or.—renal orifice
salivary gl.—salivary gland
t. pro.—tunica propria
ven.—ventricle


velar groove
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cap. m.
cephalic hemocoel
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salivary duct
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ao
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sp
plr
pla
postesophagus
salivary gland
S
pre. ret.
prostate
vagina
esophageal iter
mantle
foot
velum
mouth
dorsal mandible
1
buccal mass
tentacle
cerebral g.
♂ g.p.
pre. prot.
penial nerve
penial artery
parietal g.
preputium
vas deferens
cephalic artery
penis
vas deferens
mantle
pneu.
♀ g.p.

2

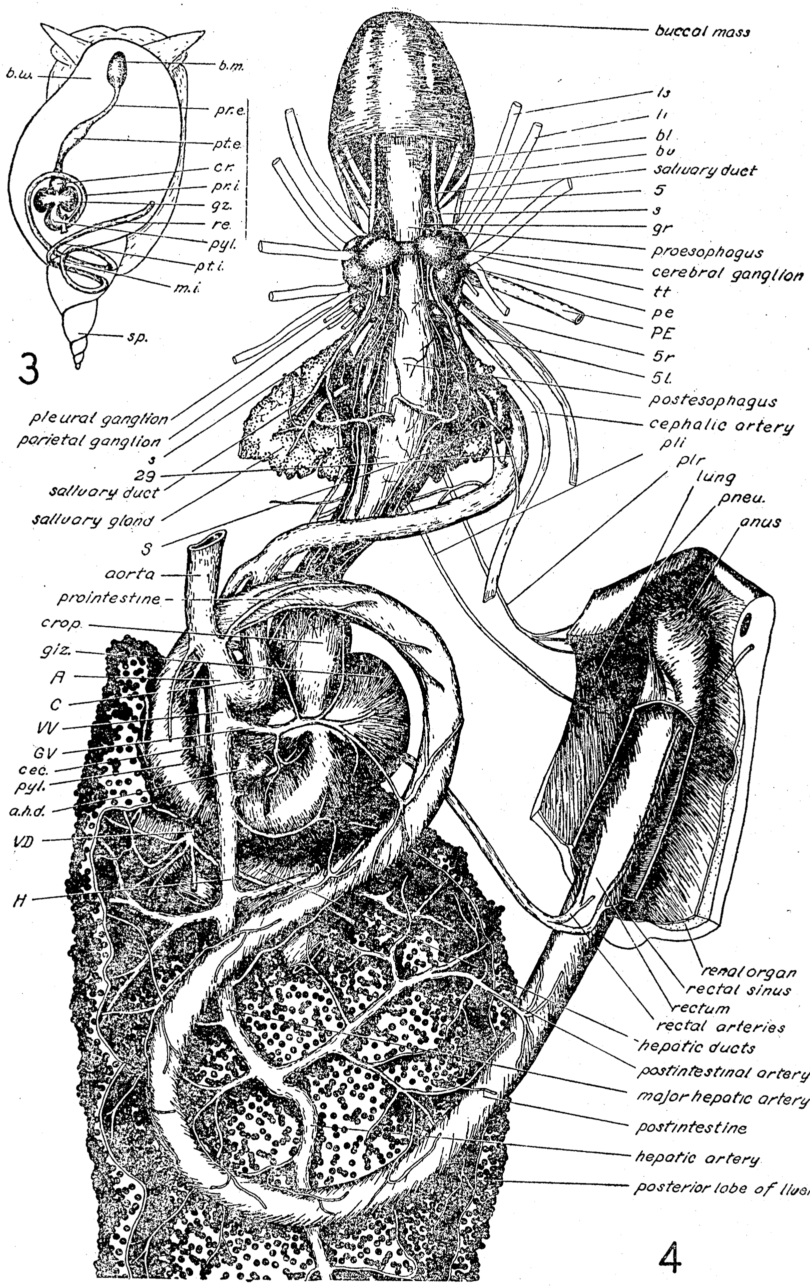
PLATE II

Explanation of Figure

FIGURE 2. Dorsal aspect of the natural position of the contents of the cephalic hemocoel. A median sagittal incision has been cut through the dorsum from the dorsal mandible to the mantle. Thus the velum has been bisected and the two resulting portions spread laterad. × 5.

Abbreviations

1—dorsolateral protractor muscle
2—preventral protractor muscle
4—dorsolateral retractor muscle
6—preventral levator muscle
ao—aortic nerve
cap m.—capitocerebral membrane
cerebral g.—cerebral ganglion
g. p. ♂—male genital pore
g. p. ♀—female genital pore
ls—superior labial nerve
li—inferior labial nerve
parietal g.—parietal ganglion
pla—anterior pallial nerve
pll—left pallial nerve
plm—median pallial nerve
plr—right pallial nerve
plv—ventropallial nerve
pneu.—pneumatopore
pre. prot.—protractor muscle of the preputium
pre. ret.—retractor muscle of the preputium
S—salivary artery
sp—splanchnic nerve
tt—tentacular nerve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b.m.
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pt.e.
cr.
pr.i.
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pyl.
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3

buccal mass
ls
li
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bu
salivary duct
5
s
gr
proesophagus
cerebral ganglion
tt
pe
PE
5r
5l.
postesophagus
cephalic artery
pli
plr
lung
pneu.
anus
pleural ganglion
parietal ganglion
s
29
salivary duct
salivary gland
S
aorta
prointestine
crop
giz.
A
C
VV
GV
cec.
pyl.
a.h.d.
VD
H
renal organ
rectal sinus
rectum
rectal arteries
hepatic ducts
postintestinal artery
major hepatic artery
postintestine
hepatic artery
posterior lobe of liver

4

PLATE III

Explanation of Figures

Figure 3. Outline of the organs of the alimentary tract as seen in their natural spatial relationship through the shell. × 1.

Figure 4. Detailed illustration of the alimentary system. The stomach region and the posterior lobe of the liver have been turned leftward one half turn so that the ventral surfaces of these parts are illustrated; the dorsal surfaces of the remainder of the tract are shown. The intestine has been much shortened. Vascularization of the posterior lobe of the liver is drawn; only the openings of the major hepatic ducts are indicated. The portion of the body wall about the rectum and anus has been retained. The portion of the liver which has been drawn has been uncoiled. The dorsal junction of the salivary glands is severed and the glands are spread laterad. × 5.

Abbreviations

5—buccal retractor muscle
5r—right buccal retractor muscle
5l—left buccal retractor muscle
29—salivary retractor muscle
A—aorta
a.h.d.—hepatic ducts, anterior lobe of the liver
bl—laterobuccal nerve
b.m.—buccal mass
bv—ventrobuccal nerve
b.w.—body whorl of shell
C—cephalic artery
cec.—cecum
cr.—crop
gr—right gastric nerve
GV—ventrogastric artery
giz.—gizzard
gz.—gizzard
H—hepatic artery
li—inferior labial nerve
ls—superior labial nerve
m.i.—midintestine
pe—penial nerve
PE—penial artery
pli—internal pallial nerve
plr—right pallial nerve
pneu.—pneumatopore
pr.e.—proesophagus
pr.i.—prointestine
pt.e.—postesophagus
pt.i.—postintestine
pyl.—pylorus
re.—rectum
s—salivary nerve
S—salivary artery
sp.—spire
tt—tentacular nerve
VD—dorsovisceral artery
VV—ventrovisceral artery

culation of the body fluids. Many of the large nerves passing to the velum and oral structures extend peripherally in the membrane. The term used for an analogous sheet in *Helix* by Kisker (1923), *capitocerebral membrane,* is adopted here for this membrane in *Lymnaea.*

The bulky preputium reaches posteriad from behind the base of the right tentacle, and crowding the esophagus and related organs to the left, occupies the middle third of the hemocoel. The large prostate gland lies in the right posterior two thirds of the cavity, and is pressed against the diaphragm and cervical septum. The ducts of the reproductive glands curve to the left behind the prostate gland and slip under the diaphragm through the connective tissue of the cervical septum into the visceral hemocoel beyond. The esophagus proceeds unhampered from the one hemocoel to the other by way of the esophageal iter, and lies to the left and partly under the left portion of the prostate gland.

The banded longitudinal muscles of the floor of the cephalic hemocoel run posteriad and dorsally into the shell clustering under the right side of the diaphragm as the *columellar muscle* (fig. 1). This passes slightly beyond and under the posterior boundary of the lung to its origin midway up the columella of the shell. The visceral coils within the shell are clothed by a thin transparent laminated muscular tunic, the *tunica propria,* which makes connection with the remainder of the body wall at the mantle collar.

The bulk of the reproductive glands are clumped in the anterior portion of the visceral hemocoel, somewhat to the left and partly over the columellar muscle. In the sexually mature animal they bulge prominently into the lung cavity under certain portions of the diaphragm.

Immediately behind the esophageal iter the esophagus runs parallel with and to the left of the columellar muscle, depressed between the oval spermatheca to the left and the large oöthecal gland to the right. Past these glands it drops gradually below the columellar muscle to join the *crop, gizzard* and *pylorus* ventrally. These names are those applied by English writers to the three regions of the middle section of the tract. The gizzard and pylorus are probably comparable to what some authors refer to as the "stomach." These digestive organs lie cupped in the midventral concavity outlined by the sixth and seventh shell whorls, at a point dorsad the angle of the shell aperture and partly under the columellar muscle. The albumen gland in adult snails noticeably crowds the stomach organs to the left; most of the other reproductive glands lie above and anteriad the stomach organs.

Shell whorls 1 to 5 and the greater part of 6 are filled by the massive dark brown *liver* which is located behind the stomach organs. The posterior half of the pylorus curves to the right and passes a short distance alongside the gizzard (fig. 3). It is followed by three coils of the intestine for which the terms *pro-, mid-* and *postintestinal loops* are offered. The prointestinal loop completely encircles the crop, gizzard and pylorus. The intestine then moves across the ventral surface of the viscera close behind the pylorus towards the right side of the sixth body whorl and mounts the external right contour of the dorsal surface of the liver. Here it bends back on itself in a graceful **U** curve, forming the midintestinal loop. This lies still in the sixth shell whorl. From this loop the intestine descends over the right contour of the liver, parallel to and but slightly posteriad the ascending portion. The descending portion is confined to the angle of the shell whorl. It turns under the liver again ventrally, still running alongside and posterior to the earlier lengths of the intestine. At the junction of the sixth and seventh shell whorls it passes immediately behind the pylorus and the prointestinal loop. Its course persists in the angle of the body whorl forming one last turn completely around the body whorl, the postintestinal loop. As the intestine passes behind the lung it gradually enlarges to form the *rectum* which terminates in the *anus*. The ovotestis lies embedded in the central spiral course of the liver, generally bordering on the columella of the shell.

The lung is an empty chamber unornamented by accessory respiratory structures (fig. 1). Midventrally the diaphragm is very thin and transparent, becoming more strongly muscled as it joins the cervical septum anteriad. The bright yellow-orange renal organ spreads thinly across the roof of the respiratory chamber from the pneumatopore on the right side to the pericardium on the extreme left ventral side of the body whorl. The pericardium is located over the parietal wall of the shell slightly behind the umbilical chink and encloses a single bright-yellow ventricle and light-yellow auricle.

GENERAL CONFIGURATION OF THE ALIMENTARY SYSTEM

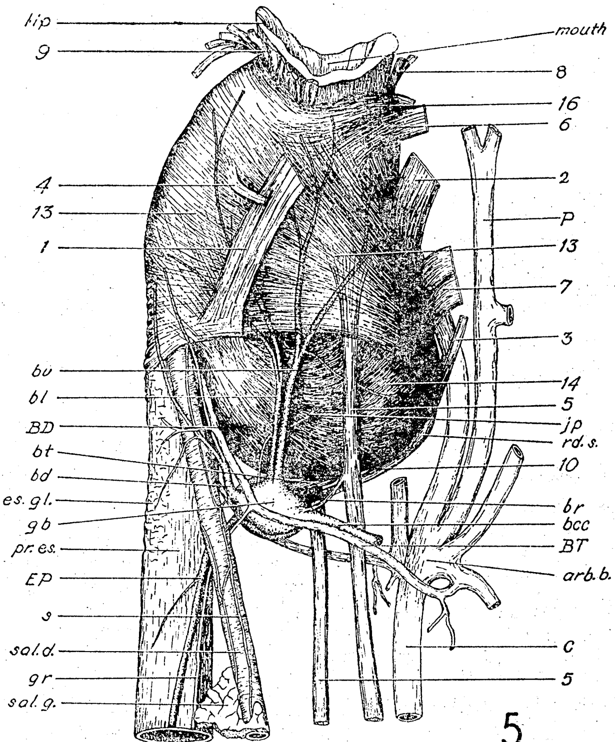
Buccal mass (figs. 5–12). This is a pyriform muscular organ whose muscles are colored a bright reddish-chestnut allegedly due to the presence of hemoglobin (Lankester 1872, Griffiths 1892, Bowell 1924, Hoffmann in Simroth and Hoffmann 1908–1928, Pelseneer 1935). It is 6.6 mm. long; 5.2 mm. through its greatest dorsoventral dimensions at the posterior end; 3.5 mm. through a dorsoventral plane directly behind the mandibles; 2.9 mm. wide at the dorsal mandible; and 4.9 mm. wide at the greatest width posteriorly.

In its simplest outline the buccal mass consists of two supporting structures, a large central *odontophoral cartilage* and a smaller cylindrical posterior *radular collostyle* (fig. 6).

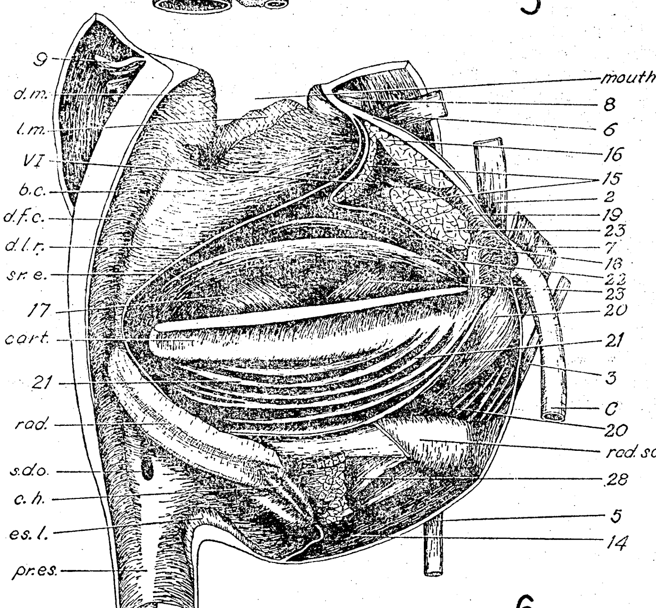
The odontophoral cartilage is an ovoid, spoon-shaped, vesiculo-muscular organ whose longer axis in the resting position runs dorsoventrad in the buccal mass. The sides curve back to such an extent that from the front it appears semicircular in cross section. When spread flat it measures 4.64 mm. in its greatest length, 4.06 mm. at the greatest width basally and 2.90 mm. at the dorsal width where it narrows to a truncated lip under the radular membrane. In thickness it varies from 1.16 mm. through the thickest lateral pillar-like portions to 0.70 mm. in the middorsal central portion, and 0.29 mm. in the thinner midventral central part. Thus a concavity is shaped in the posterior central dorsoventral plane of the cartilage which in part supports the radular sac (figs. 6, 8, 9, 12). The lateral swellings of the cartilage taper at each end, particularly in the dorsal position under the radula where the ends are approximately of the same thickness as the midventral portion. The odontophoral cartilage is not cartilagenous. Because analogous structures in some of the marine snails are composed of tissue very similar to mammalian cartilage and because of the continued application of this term for such radular supportive structures by malacologists, the term is now generally accepted for the Gastropoda. The number of so-called cartilages in different Gastropoda varies from a single one to many: in *Urosalpinx cinerea* (Carriker, 1943a) there exist two separate and distinct cartilages; in *Helix* *pomatia* (Trappmann, 1916) the single cartilage appears composed of two lateral parts which are held intimately together by the horizontal cartilage muscle; in *L. s. appressa* the cartilage exists as a single structure with a shallow groove running dorsoventrally in the rear midventral portion and is pigmented a faint reddish-chestnut color.

Nestled in the posterior hollow of the cartilage lies the *radular sac.* This is strengthened centrally by a cylinder of translucent milky-white supportive tissue, the *radular collostyle,* which is firm and of a gelatinous nature. The term collostyle is introduced here to replace the inaccurate name "papilla" which with many other terms has been applied to this structure. The collostyle is topped dorsally by a cap of epithelium and slightly pigmented muscle fibers. The term *collostylar hood* is suggested for the cap. The nascent portion of the radula passes around and envelopes most of the cylindrical collostyle, and is clothed externally by the radular sac. The latter measures 3.78 mm. from the ventral end to the collostylar hood. Ventrally it is 1.22 mm. in diameter; halfway between the ends, 0.98 mm.; and at the hood, 1.57 mm. (figs. 6, 9, 11).

The cartilage, radular sac and attendant muscles bulge as the *odontophore* under the buccal cavity epithelium in a gracefully rounded protuberance and amply fill most of the buccal cavity (fig. 7). The cartilage and muscles of the odontophore function synchronously as a cushion upon which the radula is carried, longitudinally directed. The buccal cavity epithelium is affixed to the subepithelial tissues on all but the ventral surfaces of the cavity. Here it rises freely over the cartilage and is connected with the odontophoral musculature principally at the sides and behind the odontophore. Consequently the cartilage is permitted considerable play under the cavity epithelium. Behind the crest of the odontophore the epithelium makes a deep tubular evagination which passes down into the odontophore between the cartilage and the radular collostyle to the ventral extremity of the collostyle. This tubular evagination is collapsed on itself and forms a double-layered trough which has come to fit closely and almost completely around the collostyle. It thus forms a two-layered cellular envelope around all but a narrow longitudinal band on the posterior surface of the collostyle (figs. 6, 9–11).


lip
9
mouth
8
16
6
2
4
13
P
1
13
7
3
bv
14
bl
5
BD
jp
rd. s.
bt
10
bd
es. gl.
br
gb
bcc
pr. es.
BT
EP
arb. b.
s
sal. d.
C
gr
5
sal. g.

5


9
mouth
d. m.
8
l. m.
6
VI
16
15
b. c.
2
d. f. c.
19
23
d. l. r.
7
18
sr. e.
22
23
17
20
cart.
21
3
21
C
rad.
20
rad. sac
s. d. o.
28
c. h.
5
es. l.
14
pr. es.
sal. d

6

PLATE IV

Explanation of Figures

Figure 5. Right lateral face of the buccal mass. Emphasis is placed on the external musculature, innervation and external vascularization. × 10.

Figure 6. Internal left half of the buccal mass which has been cut in a longitudinal sagittal plane. The arrangement of the intrinsic buccal muscles about the odontophoral cartilage and the radular sac is illustrated. The radula and radular sac have been left entire. × 10.

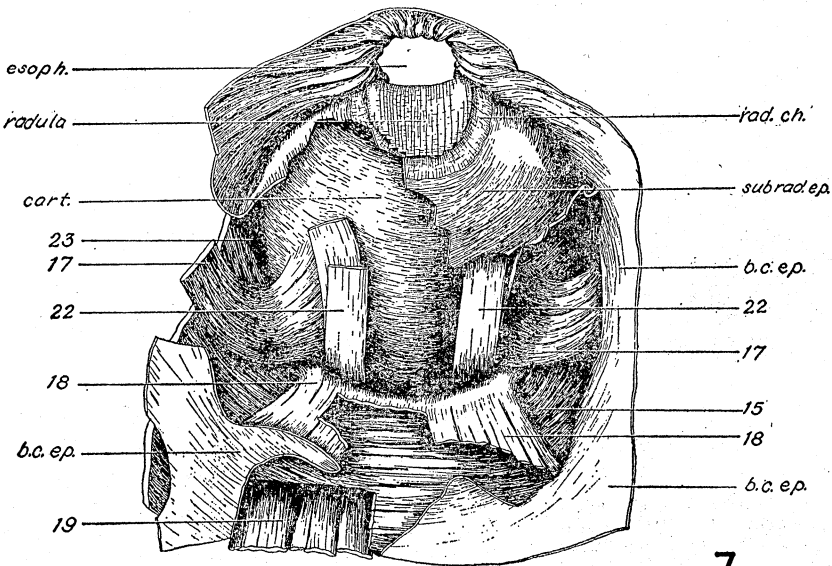
Abbreviations:

Muscles:

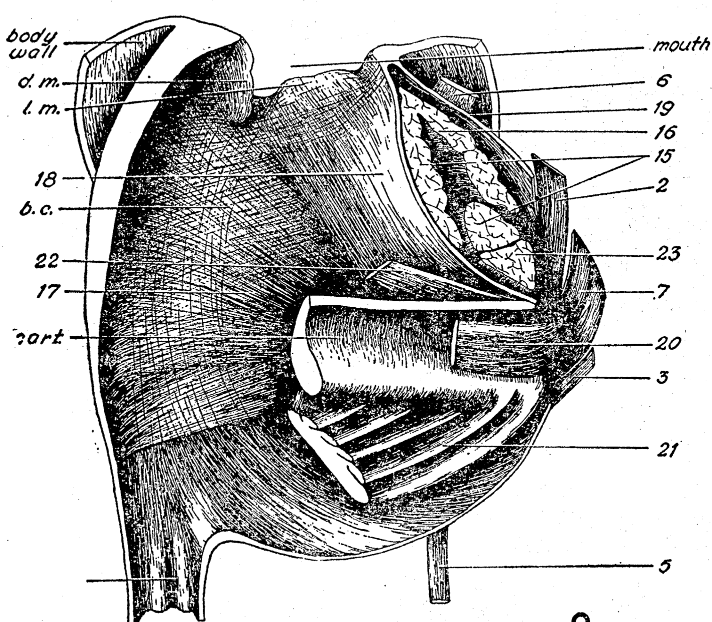
1—dorsolateral protractor
2—preventral protractor
3—postventral protractor
4—dorsolateral retractor
5—buccal retractor
6—preventral levator
7—postventral levator
8—suboral dilator
9—dorsomandibular dilator
10—suspensor of the radular sac
13—anterior jugalis
14—posterior jugalis
15—buccal sphincter
16—mandibular approximator
17—dorsal odontophoral flexor
18—ventral odontophoral protractor
19—infraventral odontophoral protractor
20—supramedian radular tensor
21—supralateral radular tensor
22—inframedian radular tensor
23—infralateral cartilage tensor
27—superior suspensor of the radular sac
28—tensor of the hood

Others:

arb.b.—buccal vascular arborescence
b.c.—buccal cavity
bcc—buccocerebral connective
BD—dorsobuccal artery
BT—postbuccal artery
bd—dorsobuccal nerve
bl—laterobuccal nerve
br—buccal retractor nerve
bv—ventrobuccal nerve
bt—postbuccal nerve
C—cephalic artery
cart.—cartilage
c.h.—collostylar hood
d.f.c.—dorsal food channel
d.l.r.—dorsolateral ridge
d.m.—dorsal mandible
EP—proesophageal artery
es.gl.—buccal glands of proesophagus
es.l.—ledge at entrance to proesophagus
gb—buccal ganglion
gr—right gastric nerve
jp—posterior jugalis nerve
l.m.—lateral mandible
P—pedal artery
pr.es.—proesophagus
rad.—radula
rd.s.—radular sac
s—salivary nerve
s.d.o.—salivary duct opening
sal. d.—salivary gland duct
sal.g.—salivary gland
sr.e.—subradular epithelium
VI—inner buccal valve


esoph.
radula
cart.
23
17
22
18
b.c. ep.
19
rad. ch.
subrad. ep.
b.c. ep.
22
17
15
18
b.c. ep.

7


body wall
d. m.
l. m.
18
b. c.
22
17
cart.
mouth
6
19
16
15
2
23
7
20
3
21
5

8

PLATE V

Explanation of Figures

Figure 7. Front view of the odontophore, surrounded by muscles of the buccal mass and portions of the buccal cavity epithelium. × 10.

Figure 8. Musculature of the left internal half of the buccal mass. The radular sac, distal portions of the odontophoral cartilage muscles, portions of the odontophoral cartilage and the epithelium of the buccal cavity have been removed. × 10.

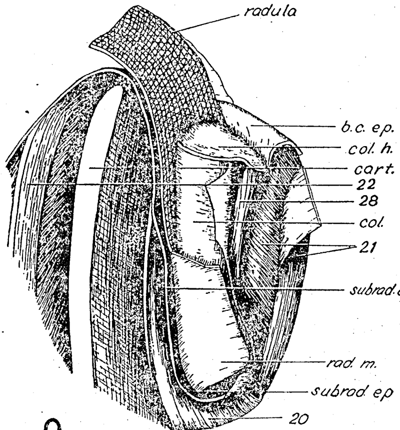
Abbreviations:

Muscles:

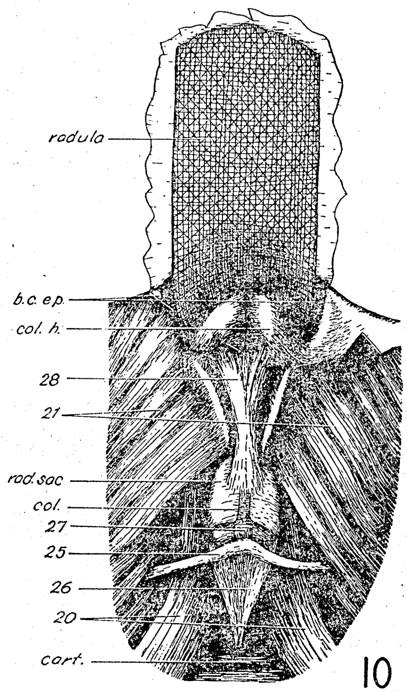
2—preventral protractor
3—postventral protractor
5—buccal retractor
6—preventral levator
7—postventral levator
15—buccal sphincter
16—mandibular approximator
17—dorsal odontophoral flexor
18—ventral odontophoral protractor
19—infraventral odontophoral protractor
20—supramedian radular tensor
21—supralateral radular tensor
22—inframedian radular tensor
23—infralateral cartilage tensor

Others:

b.c.ep.—buccal cavity epithelium
b.c.—buccal cavity
cart.—cartilage
d.m.—dorsal mandible
esoph.—esophagus
l.m.—lateral mandible
rad. ch.—chitinous membrane of the radula
subrad.ep.—subradular epithelium


radula
b.c. ep.
col. h.
cart.
22
28
col.
21
subrad. ep.
rad. m.
subrad. ep
20

9


radula
b.c. ep.
col. h.
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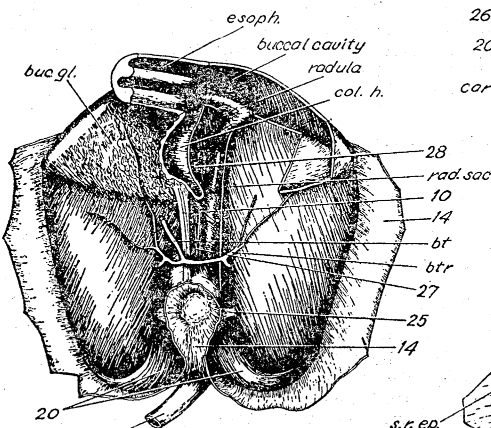
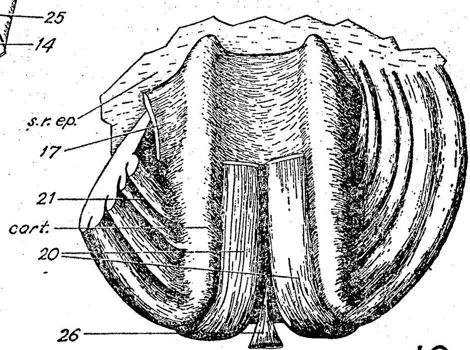
21
rad. sac
col.
27
25
26
20
cart.

10


esoph.
buccal cavity
buc. gl.
radula
col. h.
28
rad. sac
10
14
bt
btr
27
25
14
20
c

11


s.r. ep.
17
21
cart.
20
26

12

PLATE VI

Explanation of Figures

Figure 9. Posterior lateral view of the radular sac lying in its normal position against the posterior depression of the odontophoral cartilage. The left half of the odontophore and parts of the radula and the radular sac have been removed to expose the sinuses existing between these structures. × 12.

Figure 10. Posterior view of the radular sac and radula in the normal relation to the musculature of the odontophore. The radula has been lifted off of the anterior face of the odontophoral cushion and drawn in the same plane as that of the radular sac. The subradular epithelium has been cut away from the radular sac and the heavy supralateral radular tensor muscles. × 12.

Figure 11. Posterior aspect of the buccal mass. A segment of the right posterior half of the buccal cavity epithelium has been cut out; the laminated posterior jugalis muscle over the posterior portion of the buccal mass has been dissected to the sides; and the right posterior portion of the radular sac has been opened to expose the collostyle. × 10.

Figure 12. Posterior view of the odontophoral cartilage and some of its attendant muscles. × 10.

Abbreviations:

Muscles:

10—suspensor of the radular sac
14—posterior jugalis
17—dorsal odontophoral flexor
20—supramedian radular tensor
21—supralateral radular tensor
22—inframedian radular tensor
25—lateral suspensor of the radular sac
26—inferior suspensor of the radular sac
27—superior suspensor of the radular sac
28—tensor of the collostylar hood

Others:

b.c.ep.—buccal cavity epithelium
bt—postbuccal nerve
btr—right postbuccal nerve
buc.gl.—buccal glands
C—cephalic artery
cart.—cartilage
col.—collostyle
col.h.—collostylar hood
esoph.—esophagus
rad.m.—radular membrane
subrad.ep.—subradular epithelium
s.r.ep.—subradular epithelium

Of these epithelia Hoffmann (1932) and many previous workers name the membrane under the radula the basal epithelium and that over the radula the covering epithelium. The terms *subradular* and *supraradular epithelia,* respectively, as used by some workers, are thought here to give a clearer picture of the relationship of the parts. A final, external, thin connective tissue sheath forms a casing over the combined collostyle and epithelial layers.

The radula is produced by and between these two evaginated epithelial layers. As the radula passes out of the epithelial sac it unfurls and spreads anteriad over the buccal cavity epithelium, or subradular epithelium as it is better named. The radula thus roofs the crest of the odontophore, and in the resting position reaches a short distance over the anterior side of the odontophoral cushion. Throughout, the radula is affixed quite firmly to the subradular epithelium by means of the *subradular chitin* which is secreted by the epithelium. At its exit from the radular sac, the supraradular epithelium, before passing back into the buccal cavity epithelium, elevates and arches over the radular collostyle as the hood. This rests tightly against the unfurling radula (figs. 6, 9, 10). The entire radula is a chitinous ribbon approximately 6.0 mm. long by 2.5 mm. wide, surfaced by a uniform distribution of some 130 transverse and 100 longitudinal rows of glass-like posteriorly directed denticles. The posterior half lies securely fastened about the radular collostyle (fig. 9).

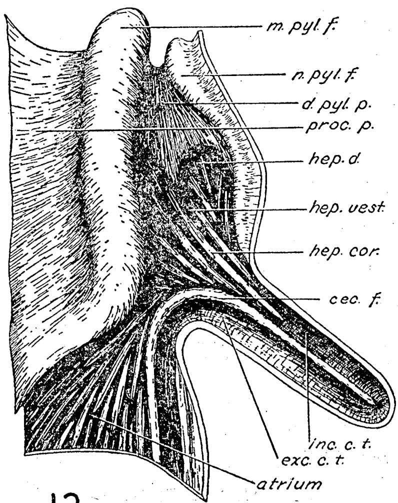
The epithelial covering of the mouth is lined dorsally by the heavy, hardened dorsal mandible, and at the sides by the two depressed lateral mandibles. The dorsal mandible is 1.57 mm. wide and 0.64 mm. high; and the laterals, 0.18 mm. wide and 0.87 mm. long. Ventrally the aperture is walled by deep longitudinal folds which permit expansion of the mouth to the diameter of the odontophore. The inner proximal margin of the dorsal mandible is projected its full width as a relatively thick layer some distance back under the roofing epithelium of the buccal cavity. A narrower extension of the layer continues far back directly over the path of the radula some 3.2 mm. and terminates at a point over the crest of the resting odontophore. The extension paves the anterior two thirds of a wide deep depression, the *dorsal food channel,* which is 0.75 mm. wide and 5.2 mm. long and passes from the dorsal mandible to the tapering of the dorsal part of the cavity into the esophagus (fig. 6). The dorsal portions of the sides of the buccal cavity bulge inwardly in the form of a shallow flattened elevation on each side, which may be called the *dorsolateral ridges.* The two salivary gland ducts make their entrance to the buccal cavity in the dorsolateral region, at a point in the posterior origin of the dorsolateral ridges (fig. 6). At the ventral boundary of the longitudinally folded opening of the esophagus there is present also a prominence or *esophageal ledge* which extends a short distance anteriad over the hood. This is usually deeply impressed by two or three longitudinal furrows which permit considerable expansion.

The living epithelium of the buccal cavity and its protective covering, with the exception of the radula and the mandibles, is very soft and of a velvety consistency. The mandibles, the entire radula and the cuticular lining of the anterior two thirds of the cavity gave a marked positive test for chitin. The radular denticles when stained with orange G after the treatment with the alkali appeared identical to normal untreated teeth, indicating the presence of a very high concentration of chitin.

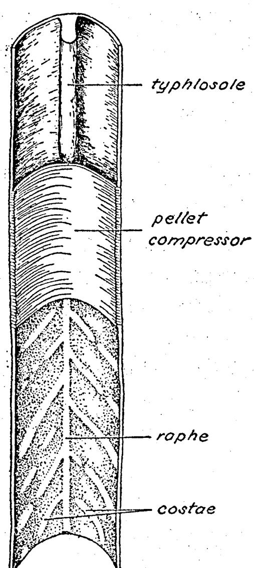
The greater part of the external walls of the buccal mass consists of muscle, connective tissue and buccal glands which lie between the muscle layers and the epithelium, and are distributed over most of the buccal mass and anterior portions of the esophagus. Over the rear dorsal portions of the mass the glands present a rough surface raised unevenly in irregularly distributed pustules (figs. 5, 11).

Esophagus (figs. 1–6, 8, 11, 15). On the basis of form, histology and function, the esophagus is distinctly divisible into an anterior and posterior esophagus. The anterior esophagus, for which is suggested the term *proesophagus,* passes out of the buccal mass as a smooth, straight, thin-walled, light cream-yellow tube approximately 1.16 mm. in diameter. It courses posteriad some 4.7 mm. from the buccal mass and suddenly widens into the posterior esophagus under the salivary glands. The posterior esophagus, here designated the *postesophagus,* retains its increased diameter of 1.35 mm. the full 16.5 mm. of its length. It is capable of distension to 5.0 mm. Its coloration varies from a translucent light cream to a gray-brown, furrowed by darker longitudinal stripes.

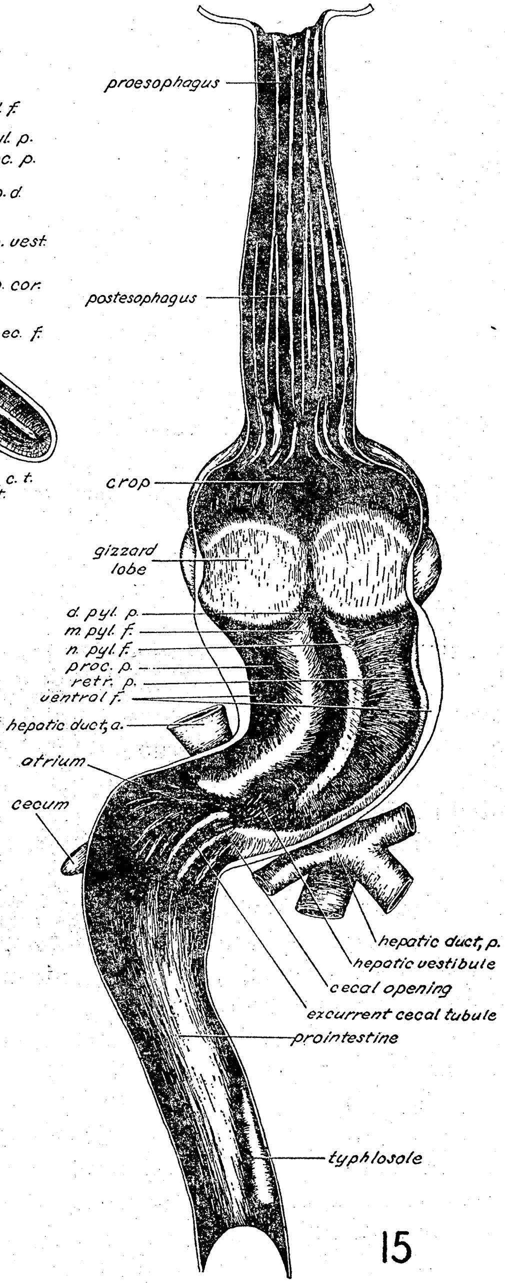
Internally the esophageal walls present a heavily corrugated surface (fig. 15). The folds run longitudinally. In the proesoph-


m. pyl. f.
n. pyl. f.
d. pyl. p.
proc. p.
hep. d.
hep. vest.
hep. cor.
cec. f.
inc. c. t.
exc. c. t.
atrium

13


typhlosole
pellet compressor
raphe
costae

14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postesophagus
crop
gizzard lobe
d. pyl. p.
m. pyl. f.
n. pyl. f.
proc. p.
retr. p.
ventral f.
hepatic duct, a.
atrium
cecum
hepatic duct, p.
hepatic vestibule
cecal opening
excurrent cecal tubule
prointestine
typhlosole

15

PLATE VII

Explanation of Figures

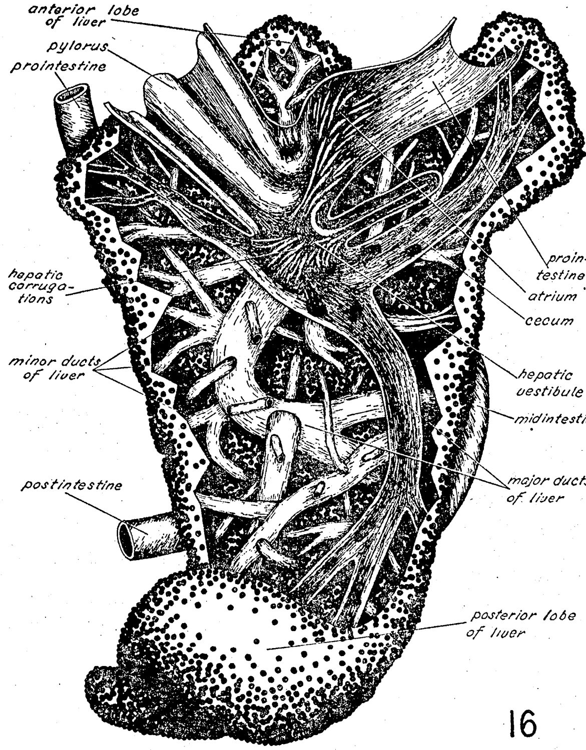
Figure 13. Detailed view of the internal contours of the cecum, hepatic duct openings into the pylorus, atrium and some of the pyloric folds and passages. The cecum has been bisected in the longitudinal axis of the alimentary tract, thus in the drawing only the right cecal fold is evident. The pattern of the atrial and hepatic vestibular corrugations is accented. × 6.

Figure 14. Detailed drawing of the anterior portion of the prointestine, showing the pellet forming area. The prointestine has been cut down the middorsal line and spread. × 5.

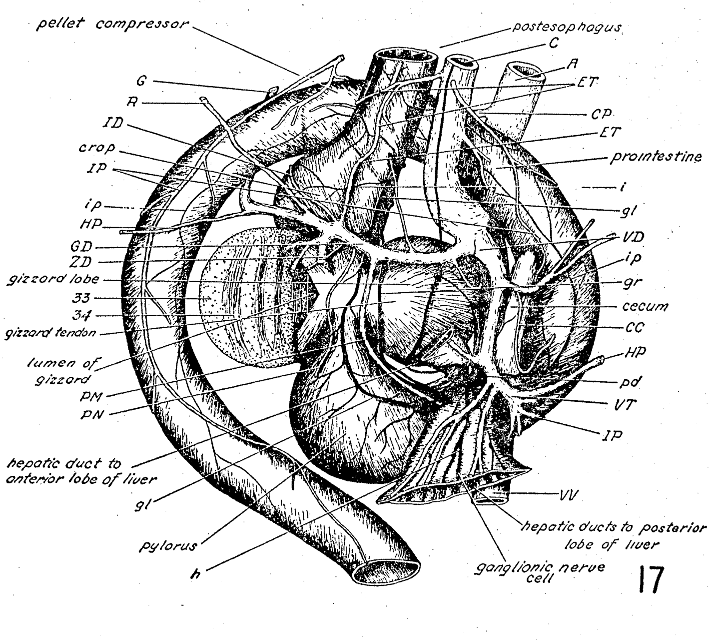
Figure 15. Detailed illustration of the dorsal internal surfaces of the esophagus, crop, gizzard, pylorus and a portion of the prointestine. A median longitudinal incision has been made to permit opening of the tract. × 5.

Abbreviations:

cec.f.—cecal fold
d.pyl.p.—dorsal pyloric passage
exc.c.t.—excurrent cecal tubule
hep.cor.—hepatic corrugations
hep.d.—hepatic duct
hepatic duct,a—hepatic duct of anterior lobe of liver
hepatic duct,p—hepatic duct of posterior lobe of liver
hep.vest.—hepatic vestibule
inc.c.t.—incurrent cecal tubule
m.pyl.f.—major pyloric fold
n.pyl.f.—minor pyloric fold
proc.p.—procurrent pyloric passage
retr.p.—retrocurrent pyloric passage
ventral f.—ventral fold


anterior lobe of liver
pylorus
prointestine
hepatic corrugations
minor ducts of liver
postintestine
prointestine
atrium
cecum
hepatic vestibule
midintestine
major ducts of liver
posterior lobe of liver

16


pellet compressor
G
R
ID
crop
IP
ip
HP
GD
ZD
gizzard lobe
33
34
gizzard tendon
lumen of gizzard
PM
PN
hepatic duct to anterior lobe of liver
gl
pylorus
h
postesophagus
C
A
ET
CP
ET
prointestine
i
gl
VD
ip
gr
cecum
CC
HP
pd
VT
IP
VV
hepatic ducts to posterior lobe of liver
ganglionic nerve cell

17

PLATE VIII

Explanation of Figures

Figure 16. Detailed drawing of the ductal system of the liver. The posterior lobe of the liver has been partly uncoiled. Those hepatic ducts lying in the first plane of the drawing and the cecum and the pylorus have been opened by an incision in the longitudinal axis of the structures. × 5.

Figure 17. Detailed drawing of the external dorsal aspect of the crop, gizzard, pylorus, cecum and prointestinal loop. The details of innervation and vascularization are accented. × 6.

Abbreviations:

33—gizzard compressor muscle
34—gizzard tensor
A—aorta
C—cephalic artery
CC—cecal artery
CP—compressor artery
ET—postesophageal artery
G—genital artery
GD—dorsogastric artery
gl—left gastric nerve
gr—right gastric nerve
h—hepatic nerve
HP—prohepatic artery
i—ingluvial nerve
ID—dorsoingluvial artery
ip—prointestinal nerve
IP—prointestinal artery
pd—dorsogastric plexus
PM—major pyloric artery
PN—minor pyloric artery
R—rectal artery
VD—dorsovisceral artery
VT—vestibular vascular arboresence
VV—ventrovisceral artery
ZD—dorsal gizzard artery

agus four such folds are present: two lie in the dorsolateral and two in the ventrolateral portions of the tube. The two dorsolateral folds pass into the buccal cavity as the dorsolateral buccal cavity ridges, and the two ventral lateral folds fade into the posteroventral buccal wall. At the initial flaring of the postesophagus the four folds of the proesophagus branch to give approximately fifteen smaller folds. These run back through the crop as far as the gizzard. The postesophagus is capable of great distension in which state the folds level out considerably; the proesophagus does not appear capable of such marked enlargement.

Salivary glands (figs. 1, 2, 4). The pair of salivary glands are conspicuous in the cephalic hemocoel in their brilliant yellow color, palmatifid form and very finely and uniformly textured surface. When spread flat each gland measures 6.9 mm. in length and 5.2 mm. in width. In their normal relationship to the anterior portion of the posteosphagus, each gland spreads posteriad over one lateral half of the esophagus in finger-like lobes. These adhere firmly to the esophageal walls by means of short strands of muscle and the vascular ramifications. The two glands are connected over and under the esophagus by bridge-like extensions of the marginal gland lobes, and thus completely encircle the esophagus.

The two salivary gland ducts are straight, smooth-walled, light-yellow tubes 7.0 mm. in length and 0.35 mm. in diameter. They pass, one to each side of the esophagus, from the rear dorsal surface of the buccal mass through the aperture in the central nervous system in company with the esophagus. Each duct branches many times in each gland; the diameter of each of the first branch ducts is 0.20 mm.

Yonge (1936) has suggested that the salivary glands in the Gastropoda be designated topographically, those emptying into the buccal cavity being called buccal glands. The fact that such a change in terms would confuse the true buccal glands in the walls of the buccal mass (see Häckel 1911, and later in the present paper) with the salivary glands, and the additional fact that the present term of "salivary" has been so long in use, indicate that no advantage is to be gained from such a change.

Crop (figs. 1, 4, 15, 17). The crop is indistinctly separated from the postesophagus and is distinguished from it only by its increased radial dimensions. It is a thin-walled bulbular pocket which connects the postesophagus with the gizzard and measures 2.3 mm. in length, 3.5 mm. in width and 4.4 mm. in depth. Internally the ventral portion is depressed in a rounded, shallow hollow below the floor of the gizzard and the walls bear continuations of the longitudinal folds from the postesophagus. There is no pronounced constriction of the postesophagus as it enters the crop, but the diameter at this junction usually remains small (fig. 15). Posteriorly the crop joins the gizzard with only a slight narrowing of its lumen, a constriction caused by the pulling in of the crop walls to meet the inner margins of the gizzard lobes. Externally and internally a sharp boundary is evident between the shallowly corrugated internal surface of the crop and the smooth, slightly elevated cuticulated surface of the gizzard pads. The external coloration of the crop varies in different individuals from ivory yellow to slate gray, accented with more intense stippled markings; a velvet-gray lining covers the internal surfaces of the crop as well as those of the esophagus.

Hoffmann (Simroth and Hoffmann, 1908–1928) was uncertain as to whether the crop should be considered a part of the stomach or a true esophageal crop. Structurally the crop of *L. s. appressa* appears more closely allied to the postesophagus.

Gizzard (figs. 1, 3, 4, 15, 17). This is a crushing organ consisting essentially of two very strong, laterally placed muscular cushions, the *gizzard lobes,* which are joined dorsally and ventrally by tough bands of silvery luster, the *gizzard tendons.* Both muscular lobes are colored a strikingly deep reddish-chestnut and in some individuals the surface bears added black stippled designs. The dimensions of the organ are as follows: length, 4.9 mm.; width, 6.5 mm.; and depth, 5.3 mm. Each lobe is globular and is rounded and narrowed medially on the dorsal and ventral sides to about one third of its length, where the two are strongly connected by the non-contractile gizzard tendons. The left lobe lies slightly behind the right.

Internally the lobes are represented by two ovoid, distinctly concave, slightly projected, flattened pads which face each other. These lie parallel and almost meet when the gizzard lumen is void of food and/or sand particles. The pads are firm and hard and protected by a relatively thick layer of cuticle which, by reason of the deeply pigmented musculature beneath, appears red. This cuticle when tested for chitin reacted negatively to all of the tests! Nor was chitin found in any other part of the digestive system with the exception of the buccal mass.

Possibly the first to describe this organ, but only superficially, were Cuvier (1806, 1817), and Stiebal (1815). More recent records are those of Goodsir (1840), Lacaze-Duthiers (1872), Gartenauer (1875), Wetherby (1879), Whitfield (1882), Moquin-Tandon (1885), F. C. Baker (1900, 1911), Colton (1908) and Heidermanns (1924). In the illustrations of some of these investigators the stomach parts are shown upside down (Lacaze-Duthiers 1872, Wetherby 1879, F. C. Baker 1900). According to F. C. Baker, Whitfield was the first to correctly describe the stomach region in American *Lymnaea.* Heidermanns believes that the gizzard tendons are to be compared in their functions to the tendons of vertebrate muscle.

Pylorus (figs. 1, 4, 15–17). The morphology of the basommatophoran pylorus has been neglected, except for the work of Heidermanns (1924), which was principally on cellular physiology. He mentioned briefly, but did not name, the three longitudinal folds which partially block the opening into the liver and which swell to partly occlude the opening into the gizzard lumen. In the following paragraphs an attempt is made to describe and name those structures most significantly correlated with the function of the pylorus.

Immediately behind the gizzard the alimentary canal continues as a tapering tube, the pylorus, which curves to the right around the right gizzard lobe. The two hepatic ducts and the cecum empty into the rear middorsal part and make the site of greatest constriction (fig. 15). At the junction of the pylorus and the gizzard, the pyloric walls narrow slightly, accommodating the posterior opening of the gizzard. Directly behind the opening of the cecum into the pylorus and existing as a modified prolongation of the pylorus, the digestive canal widens into a flaring rounded chamber whose dorsal and lateral walls appear palmately ribbed, the main stem passing from the proximal posterior base of the cecum. The term *atrium* first applied to a similar structure in *Ferrissia* by Hoff (1940) is adopted here for this structure in *L. s. appressa,* but because of its function it is more rightfully considered as a part of the pylorus than of the intestine. The efferent ends of the two hepatic ducts approach each other from opposite sides and converge broadly over the rear dorsum of the pylorus. Here a common antechamber, for which the term *hepatic vestibule* is offered, some 0.46 mm. across, is interposed. The cecum passes out of its posterior portion and the vestibule itself makes connection with the pyloric lumen (figs. 15, 17). The dimensions of the pylorus vary considerably with the extent of muscular dilation and with the content of nutriment. A relaxed, moderately filled, straightened pylorus measures about 2.3 mm. in its greatest diameter just behind the gizzard; 1.5 mm. in its least diameter immediately in front of the hepatic vestibule; 4.9 mm. from the gizzard to the hepatic vestibule; and 7.5 mm. from the gizzard to the atrium. The atrium is 2.5 mm. across and 2.4 mm. in length from its posterior margin to the posterior base of the cecum. The pylorus is usually translucent and colored a straw yellow.

Two principal channels pass down the length of the pylorus, for which the terms *dorsal* and *ventral pyloric passages* are proposed (figs. 13, 15, 16). The dorsal passage leads along the dorsal third of the pylorus from the gizzard to the hepatic vestibule. It is a smooth, deep, narrow groove making connection between the gizzard lumen and the liver by way of the hepatic ducts and the hepatic vestibule. The ventral pyloric passage runs in the ventral two thirds of the pylorus. It is the more spacious channel and constitutes the connection between the gizzard lumen and the intestine. The two passages are almost completely separated by two ridges of tissue, the *major* and the *minor pyloric folds*. These are located in the dorsolateral walls of the pylorus and meet along their distal crests. The major fold extends along the right dorsolateral wall from the right gizzard pad to the atrium, passing under and to the right of the hepatic vestibule. It increases somewhat in bulk as it advances, and terminates in a flattened protruding bulge partly under the opening of the hepatic vestibule. The minor fold reaches posteriad along the left dorsolateral portion of the pylorus parallel to the major fold. It is a flattened, less conspicuous, fold which becomes reduced and disappears slightly to the rear of the left wall of the hepatic vestibule. The major and minor folds thus may effect complete closure of the hepatic vestibule from the ventral pyloric passage. Passing down over the midventral wall of the ventral passage is found the low, wide, ventral pyloric fold. This extends from the ventral junction of the gizzard pads to the left ventral margin of the atrium and the excurrent cecal ridges located there. It is thickened into a prominent muscular elevation directly behind the gizzard pads and partly occludes the ventral passage from the gizzard cavity. The fold gradually diminishes in bulk posteriad. In the living animal the folds are relatively turgid and smooth; in the dissected specimen they become wrinkled and convoluted; and in histological sections they shrink markedly.

The ventral pyloric passage is thus partly divided into two smaller passages by the ventral pyloric fold. Because of the direction of the ciliary currents in these two conduits, the terms *procurrent* and *retrocurrent passages* are suggested for them. The former lies to the right and the latter to the left of the ventral fold. The procurrent passage is narrower than the retrocurrent and becomes smaller further down the pylorus, finally passing out into the intestine ventrally beneath the atrium. The retrocurrent passage has no direct outlet to the intestine, and its walls are capable of marked distension. The three pyloric folds are faintly pigmented a light reddish-chestnut color, as was first observed by Heidermanns (1924). No references can be found on the investigation of the hemoglobin content of these folds or of the gizzard lobes.

The atrium flares widely to the rear of the hepatic vestibule and the cecum, as a flattened inflation in the dorsal and lateral portions of the rear of the pylorus. The procurrent pyloric passage after passing down the right lateral side of the pylorus, swings gradually to the midventral side and empties into the intestine across the vacancy left by the discontinuation of the atrium in the ventral pyloric wall. The connection between the atrium and the anterior portion of the pylorus may be completely occluded by constriction of the pylorus at this point and the consequent approximation of the major and minor pyloric folds.

The efferent ends of the hepatic ducts are lined internally by a corrugated epithelium. The furrows so formed commence in the hepatic ducts as minute longitudinally directed grooves which coalesce progressively into large gutters in their course toward the hepatic vestibule. In the hepatic vestibule there are finally present only some twelve such grooves and ridges, where their longitudinal axes are pointed in the direction of the cecal opening (fig. 13). Two or three furrows of the same proportions as those in the vestibule arise in the passage leading from the vestibule to the atrium and run into the latter, in a direction at an obtuse angle from that of the grooves in the vestibule. The few larger grooves branch into an extensive system of progressively smaller depressions which flare out fan-like over the inner walls of the atrium. This ramiform pattern originates at the opening of the cecum into the vestibule and produces the palmate design visible externally.

Cecum (figs. 4, 13, 15–17). For some time this organ was entirely overlooked by morphologists and was considered to be absent in the Lymnaeidae. By Wetherby (1879) and F. C. Baker (1900) it was referred to as the "pancreas." Heidermanns (1924) calls attention to the cecal folds but does not describe in any detail the structure of the organ.

The cecum in *L. s. appressa* arises as a dorsal evagination of the hepatic vestibule and extends horizontally anteriad over and between the right lobe of the gizzard and the early part of the prointestinal loop. It is a cylindrical, slightly tapering, blind tube 4.4 mm. long, with a proximal diameter of 1.2 mm. and a distal diameter of 0.6 mm. Numerous branching blood vessels secure it to the intestine and gizzard and it is well hidden by the anterior lobes of the liver. This fact, combined with the fact that the cecum is an inconspicuous, watery, translucent, straw-yellow structure, readily explains why early workers entirely missed it. The cecal lumen is divided longitudinally into two channels by the *cecal folds*. By reason of the function of these two conduits, the terms *incurrent* and *excurrent cecal tubules* are offered for them. The cecal folds exist as two flattened ledges of tissue which extend from the posterior borders of the hepatic vestibule along the lateral walls of the cecum. The projected folds meet along their distal extremities and pass almost to the distal tip of the cecum where they flatten out. Thus they leave there a small opening which connects the distal portions of the incurrent and excurrent tubules. The incurrent tubule originates in the posterodorsal portion of the hepatic vestibule. One of the minute ridges in the epithelium of the vestibule passes about one third of the distance into the incurrent tubule midway between the two cecal folds; and two others accompany it to either side about half this distance. The remainder of the tubule is smooth-walled. The excurrent tubule is entirely smooth-walled and is more spacious than the counterpart. At the base of the cecum the excurrent tubule narrows slightly, turns posteriad and empties by way of a furrow running across the atrium into the pro-intestine, a groove outlined by the cecal folds which at the same time thicken basally (fig. 15).

Liver (figs. 1, 4, 16). This exists as two distinct, racemose, compound-tubular outpocketings of the pylorus, the *anterior* and *posterior liver lobes,* whose terminal ducts end blindly in minute clustered *follicles.* The whole branching complex is supported by a meshwork of connective tissue, blood vessels and nerves. Externally it is enveloped in the thin muscular *tunica propria.* Slight tenacious strands of connective tissue and muscle and some of the peripheral blood vessels bind the tunica to the liver. The coloration of the liver varies from a delicate salmon pink in partly starved animals to a greenish-brown in animals feeding heavily on lettuce. According to Sorby (1876) the reddish pigmentation of the liver of *Lymnaea* is caused by a secreted fluid composed in part of hematin. A white, irregularly distributed mottling is evident over the surface of the liver, as well as over all the other organs of the body. This is caused by the presence in the connective tissue of white *calciferous concretions* similar to those found in *Helix* by Kisker (1923) and by v. Haffner (1923).

In newly matured snails the liver is roughly one third the size of the soft parts of the animal. In old snails, however, it atrophies markedly. The anterior (morphologically the right one) lobe is roundly triangular and measures about 4.5 mm. by 5.0 mm. on its peripheral surface and is 3.5 mm. deep. It lies ventrally, closely bounded by the contours of the gizzard and the pylorus. The posterior (morphologically the left) lobe constitutes the greater part of the first six whorls of the shell and when coiled within the shell measure 25.0 mm. in length and 12.0 mm. in its greatest diameter anteriorly. When removed from the shell and uncoiled, the lobe is fully 37 mm. long. Both lobes are thickly penetrated by a multibranching ramification of blind *hepatic ducts.* The anterior lobe possesses only one such many-branching conduit; the posterior lobe is filled by several. The spire is reached principally by one large median duct which spirals in the gland across the winding contour of the columella; a second large tube passes spireward along the periphery of the whorls; two smaller ducts push anteriad into the forward projections. These ducts coalesce in the middle anterior portion of the lobe, behind the flexure of the pylorus, forming a large, short vessel which in turn discharges into the left end of the hepatic vestibule. A similar smaller duct from the anterior lobe enters the vestibule from the right end. The hepatic ducts, with the exception of the short corrugated portions emptying into the hepatic vestibule, are smooth, thin-walled vessels. The openings of the larger ones are about 1 mm. in diameter—but slightly smaller than that of the intestine. The liver, when considered in terms of internal surface area of its ramiform tubular complex, exposes a relatively vast surface of epithelium which in comparison dwarfs the inner surface dimensions of the remainder of the alimentary canal.

Little attention has been given to the macroscopic morphology of the liver. The work of Pelseneer (1906) and Faust (1920) may be mentioned, but their descriptions are cursory. The liver of the gostropods has been known by so many different appellations that the present use of the term "liver" deserves explanation. In the gastropod literature of the past century such English terms as liver, digestive gland, digestive diverticulum, hepatic gland, hepatopancreas, gastric gland, and liver mass are extant. German names encountered are "Leber" and "Mitteldarmdrüse"; French designations, "foie", etc. Liver is most generally accepted. It is of course obvious that the gastropod liver and the vertebrate liver are not homologous either structurally or functionally, but there is similarity in general position and function, and the term liver has been used so universally for this organ in the gastropods that acceptance of the designation is justified.

Intestine and rectum (figs. 1, 3, 4, 14, 15, 17). The intestine and rectum together measure 70 mm. in length. The entire alimentary canal is 115 mm. long. If the total length of the evaginations of the canal (salivaries and ducts, liver and ducts and cecum) were considered, the total length would exceed 170 mm. Thus the intestine and rectum together constitute about 41% of the total length of all the parts of the alimentary system. The intestine varies roughly from 1.3 to 1.5 mm. in diameter. The rectum is some 15 mm. long and 1.5 to 2.0 mm. in diameter. Both the intestine and rectum are very thin-walled and easily ruptured in dissection. The former passes imperceptibly into the latter. The rectum, after passing to the right behind the lung, reaches the anus by means of a tubular passage, the rectal sinus, made for it through the heavy musculature of the posterior angle of the mantle.

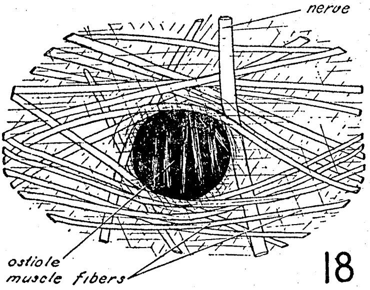
No mention of the specialization of the prointestine in the Basommatophora were encountered in the literature examined. The anterior half of the prointestinal loop may be referred to as the *pellet-molding region* which has developed two structures for this function: The first is the *intestinal typhlosole* and the second may be named the *pellet-compressor.* The typhlosole arises as an infolding of the ventral muscular wall of the intestine and projects at right angles about 0.6 mm. into the intestinal lumen. It is 0.4 mm. wide proximally and projects gradually from the intestinal wall some 2.4 mm. behind the atrium. It is 3.4 mm. long, is placed along the longitudinal axis of the prointestine and slowly reaches its maximum size at the posterior extremity (figs. 14, 15). This end stops abruptly as a rounded prominence. The pellet-compressor consists essentially of a specialized circular band of the intestine, 3.4 mm. wide. It lies adjacent to and at the anally directed end of the typhlosole and consists of a slightly thickened wall of circular muscle which is lined internally by approximately 40 distinctly outlined, thick epithelial annulations. These are conspicuous in their yellowish brown coloration and circular uniformity. They are not always parallel, branching and coalescing at intervals (fig. 14). The compressor generally lies in that portion of the prointestinal loop passing over the postesophagus.

The typhlosole persists as a slight ridge of muscle beneath the annulations of the pellet-compressor. It is not evident there unless the epithelial layer is removed. Posterior to the pellet-compressor the ridge is visible again and can be followed a short distance down the intestine as a low, narrow elevation covered by a raised band of epithelium which runs down along the same side of the intestine. The term *intestinal raphe* is offered for this raised band of epithelium. The inner lining of the intestine and rectum, beyond the pellet-compressor, is ribbed by bands which pass obliquely around the intestinal circumference from the raphe (fig. 14). The bands are low, narrow, flattened elevations of the epithelium, similar in width and height to the raphe, and meet opposite the raphe, tending to form a continuous longitudinal band down the intestine and raphe. This second band opposite the raphe may be referred to as the *pseudoraphe.* The term *intestinal costae* is suggested for the obliquely running bands.

H. B. Baker (1925) describes "plicae" in the intestinal epithelium of *Lanx.* The intestinal costae of *L. s. appressa* could hardly be called plicae as they are not true folds. Häckel (1911) noted that the entire intestine of *Chilina* is covered within by epithelial "folds," which according to his description, are distributed similarly to those in its near relative, *L. s. appressa.*

MUSCULATURE OF THE ALIMENTARY SYSTEM

Buccal mass (figs. 5–12, 27). The musculature of this specialized organ is the most complicated in the entire animal, and indeed, one of the most intricate muscular structures in the invertebrate group. Loisel (1893) gave an early, though rather confused, description of some of the muscles of *L. stagnalis.* Amaudrut (1898) offered the first really comprehensive study. His work was concerned mostly with *Helix,* with but occasional references to *Lymnaea,* and has formed the basis for some of the terminology of the more recent investigators. He states that the buccal retractor muscles are missing altogether in *Lymnaea.* They are always present in *L. s. appressa,* however, and F. C. Baker (1900, 1911, 1928) also found these muscles in all the Lymnaeidae investigated. As Hoffmann (Simroth and Hoffmann, 1908–1928) states, little accurate work has as yet been done on the basommatophoran buccal musculature. The best work yet published on the musculature of the pulmonate buccal mass is that by Trappmann (1916) on *Helix pomatia.* Other good gastropod papers in this connection are those of Herrick (1906) on *Sycotypus,* Richter (1926) on *Cerion,* and Crofts (1929) on *Haliotis.* The terminology adopted for the muscles of the buccal mass of *L. s. appressa* is based wherever homology warrants it on the works cited above, principally on that of Trappmann. The intrinsic musculature of *L. s. appressa* has been found to be almost identical with that of *Helix pomatia,* although *Helix,* possibly as a result of its terrestrial habitat, possesses stronger, bulkier, more developed muscles. Amaudrut



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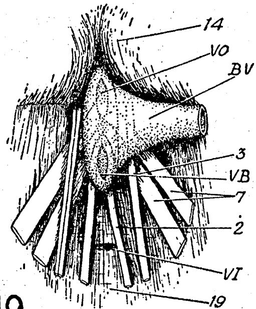

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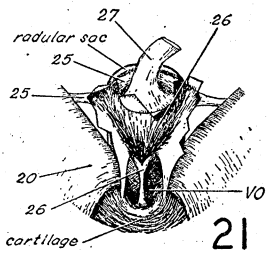

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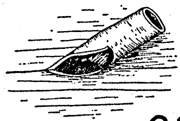
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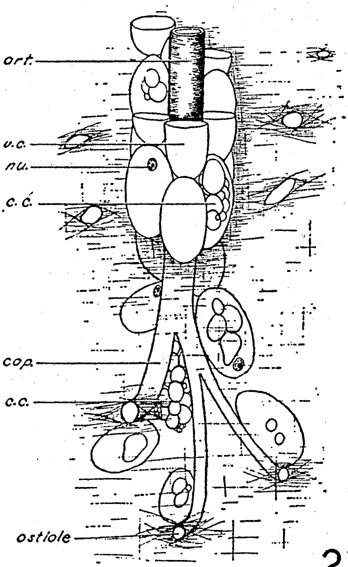

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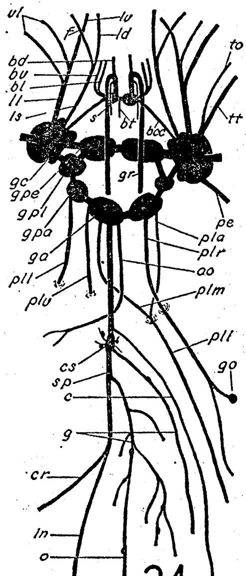

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PLATE IX

Explanation of Figures

Figure 18. Typical ostiole in the surface tissue of the postesophagus. × 200.

Figure 19. Ventral view of the buccal mass showing the mode of attachment of the ventrobuccal artery and extrinsic muscles, and the location of the arterial valves. The location of the inner buccal valve is indicated by the dark oval mark (VI) and is seen only in dissection of the mass. × 10.

Figure 20. Inner buccal valve. × 12.

Figure 21. Anteroventral aspect of the inferior suspensor muscle of the radular sac. The outer, flaring, hollow portion of the suspensor has been opened medially. × 12.

Figure 22. Penetration of the right gizzard lobe by the right dorsal gizzard artery. The proximal portion of the artery has been cut away. × 10.

Figure 23. Capillary, showing its terminations in the surface of the postesophagus in ostioles. Before it plunges into the tissue, the capillary is thickly covered with vesicular cells. × 100.

Figure 24. Central nervous system and principal nerves of the buccal, cerebral, parietal and abdominal ganglia. × 4.

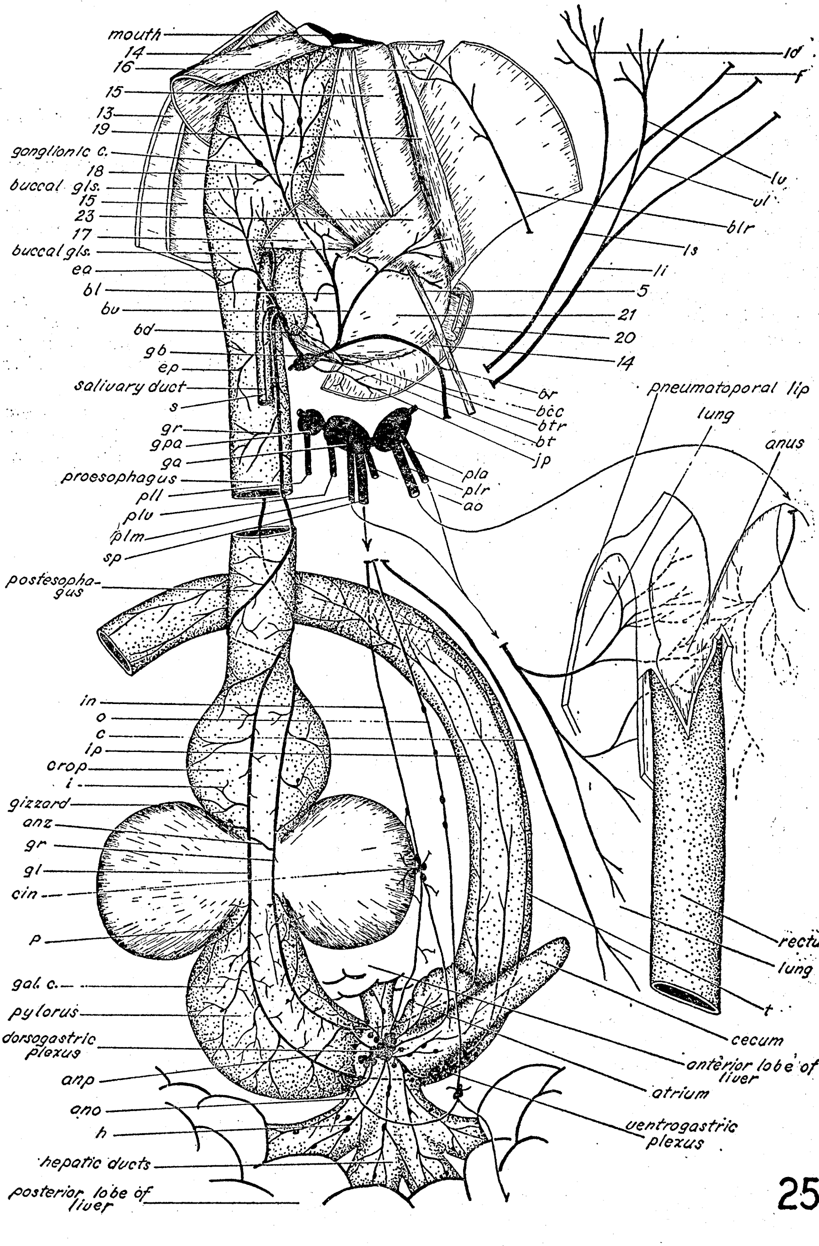
Abbreviations:

Muscles:

2—preventral protractor
3—postventral protractor
7—postventral levator
14—posterior jugalis
19—infraventral odontophoral protractor
20—supramedian radular tensor
25—lateral suspensor of the radular sac
26—inferior suspensor of the radular sac
27—superior suspensor of the radular sac

Others:

ao—aortic nerve
art.—arteriole
bd—dorsobuccal nerve
bcc—buccocerebral connective
bl—laterobuccal nerve
bt—postbuccal nerve
bv—ventrobuccal nerve
BV—ventrobuccal artery
c—columellar nerve
c.c.—calciferous concretion
cap.—capillary
cr—cardiac nerve
cs—splanchnic complex
f—frontal nerve
g—genital nerve
ga—abdominal ganglion
gc—cerebral ganglion
go—osphradial ganglion
gpa—parietal ganglion
gpe—pedal ganglion
gpl—pleural ganglion
gr—right gastric nerve
in—intestinal nerve
ld—dorsolabial nerve
li—inferior labial nerve
ls—superior labial nerve
lv—ventrolabial nerve
nu.—nucleus of vesicular cell
o—gonadal nerve
pe—penial nerve
pla—anterior pallial nerve
pll—left pallial nerve
plm—median pallial nerve
pli—internal pallial nerve
plr—right pallial nerve
plv—ventropallial nerve
s—salivary nerve
sp—splanchnic nerve
to—optic nerve
tt—tentacular nerve
VB—outer buccal valve
v.c.—vesicular cell
vl—velar nerve
VI—inner buccal valve
VO—odontophoral valve


mouth
14
16
15
13
19
ganglionic c.
18
buccal gls.
15
23
17
buccal gls.
ea
bl
bv
bd
gb
ep
salivary duct
s
gr
gpa
ga
proesophagus
pll
plv
plm
sp
postesophagus
in
o
c
ip
crop
i
gizzard
anz
gr
gl
cin
p
gal. c.
pylorus
dorsogastric plexus
anp
ano
h
hepatic ducts
posterior lobe of liver
ld
f
lv
vl
blr
ls
li
5
21
20
14
br
bcc
btr
bt
jp
pla
plr
ao
pneumatoporal lip
lung
anus
rectum
lung
t
cecum
anterior lobe of liver
atrium
ventrogastric plexus

25

PLATE X

Explanation of Figure

Figure 25. Innervation of the alimentary system. Portions of the postesophagus and of the intestine have been omitted. The stippled surfaces indicate areas of relatively less developed musculature. Arrows indicate the continuity of the nerves. × 6.

Abbreviations:

Muscles:

5—buccal retractor
13—anterior jugalis
14—posterior jugalis
15—buccal sphincter
16—mandibular approximator
17—dorsal odontophoral flexor
18—ventral odontophoral protractor
19—infraventral odontophoral protractor
20—supramedian radular tensor
21—supralateral radular tensor
23—infralateral cartilage tensor

Others:

ano—anastomosis of dorsogastric plexus and gonadal nerve
anp—anastomosis of gastric nerves over pylorus
anz—anastomosis of gastric nerves over gizzard
ao—aortic nerve
bcc—buccocerebral connective
bd—dorsobuccal nerve
bl—laterobuccal nerve
blr—branch of laterobuccal nerve
br—buccal retractor nerve
bt—postbuccal nerve
btr—right postbuccal nerve
buccal gls.—buccal glands
bv—ventrobuccal nerve
c—columellar nerve
cin—intestinal complex
ea—anterior esophageal nerve
ep—proesophageal nerve
f—frontal nerve
ga—abdominal ganglion
gal. c.—ganglionic nerve cell
gb—buccal ganglion
gl—left gastric nerve
gr—right gastric nerve
gpa—parietal ganglion
h—hepatic nerve
i—ingluvial nerve
in—intestinal nerve
ip—prointestinal nerve
jp—posterior jugalis nerve
ld—dorsolabial nerve
li—inferior labial nerve
ls—superior labial nerve
lv—ventrolabial nerve
o—gonadal nerve
p—pyloric nerve
pla—anterior pallial nerve
pll—left pallial nerve
plm—median pallial nerve
plr—right pallial nerve
plv—ventropallial nerve
s—salivary nerve
sp—splanchnic nerve
t—typhlosolic nerve
vl—velar nerve

observed a great uniformity throughout the Pulmonata as regards the buccal mass.

In the following compilation each muscle is given a number which corresponds to similar numbers designating the muscles in the illustrations. In addition to the number, there is listed for each muscle: the name (in italics), the origin and insertion, and a brief description including function where the name is not self-explanatory.

Extrinsic muscles, from body wall to buccal mass:

1. *Dorsolateral protractors* (fig. 5). Origin: body wall at the sides of the oral aperture. Insertion: external posterior dorsolateral surfaces of buccal mass. Two wide, thin bands on either side of the buccal mass.

2. *Preventral protractors* (figs. 5, 6, 8, 19). Origin: anterior ventral surface of the body wall immediately behind oral aperture. Insertion: anterior ventral external wall of buccal mass directly about buccal valve of the ventrobuccal artery (see section on vascularization). A pair of thin bands, passing forward somewhat obliquely.

3. *Postventral protractors* (figs. 5, 6, 8, 19). Origin: ventrolateral body wall just behind oral aperture. Insertion: posteroventral external wall of buccal mass in ventral surface of and to either side of buccal artery. Usually two thin bands.

4. *Dorsolateral retractors* (fig. 5). Origin: lateral body wall on level with rear of buccal mass. Insertion: anterior dorsolateral external surface of buccal mass. A pair of narrow, thin ribbons to either side of the mass.

5. *Buccal retractors* (figs. 2, 4–6, 8). Origin: columellar muscle in ventral wall of cephalic hemocoel just in front of cervical septum. Insertion: external lateral surfaces of buccal mass over the cartilage. Two slender muscle bands passing between the ganglia of the central nervous system. The *left buccal retractor,* because of the salivary glands (figs. 2, 4), where the salivary muscle detaches, passes along the right ventral side of the esophagus. The *right buccal retractor* extends posteriorly somewhat farther to the right of the esophagus and does not branch.

6. *Preventral levators* (figs. 5, 6, 8). Origin: lateral body wall opposite the middorsal portion of the buccal mass. Inser-

tion: anterior ventral external surface of buccal mass. Flattened broad bands on each side of the buccal mass which elevate the anterior portion of the buccal mass on the rasping stroke of the radula.

7. *Postventral levators* (figs. 5, 6, 8, 19). Origin: usually same as preventral levators. Insertion: posteroventral external surface of buccal mass beneath the cartilage, between the odontophoral and the buccal valves of the ventrobuccal artery. Usually two flattened broad bands on each side of the ventrobuccal artery. The pre- and postventral levators suspend the buccal mass as in a double sling; the latter in part raise the rear of the mass on the forward stroke of the odontophore, thus helping to bring the odontophore into the position for rasping.

8. *Suboral dilators* (figs. 5, 6). Origin: across the ventral body wall, midway under the buccal mass. Insertion: across the anterior ventral wall of the buccal mass, immediately behind its attachment to the body wall. A number of fine bands which depress the anterior wall of the buccal cavity during the protrusion of the odontophore.

9. *Dorsomandibular dilators* (figs. 5, 6). Origin: across the dorsal body wall. Insertion: across the dorsal attachment of the dorsal mandible. A large number of fine bands which function, in conjunction with the suboral dilators, in opening the mouth, and which draw the dorsal mandible upwards and backwards.

10. *Suspensor of the radular sac* (fig. 5). Origin: commissure of the buccal ganglia at base of esophagus. Insertion: external distal end of radular sac. A stout muscle serving to suspend the distal end of the radular sac, and passing over the stout postbuccal nerve.

11. *Labial retractors.* Origin: within body wall. Insertion: lip, entirely around oral aperture. These exist as a large number of small fibers within the body wall which radiate from the lip. They draw the lip away from the mouth during protrusion and early retraction of the odontophore.

12. *Labial sphincter.* A circular diffuse band of a large number of fine fibers located in the body wall at that point where the buccal mass attaches to it, and which entirely surround the oral aperture, serving to close the mouth.

Intrinsic muscles in buccal wall, from cartillage to mandible:

13. *Anterior jugalis* (fig. 5). Origin: median dorsal surface of buccal mass and corners of dorsal and lateral jaws. Insertion: ventrolateral ends of cartilage. The conspicuous external muscular yoke passing over the anterior two thirds of the top and sides of the buccal mass from the base of the cartilage, and continuous over the top of the mass. Functions in suspending, elevating, and protracting the odontophore.

14. *Posterior jugalis* (figs. 5, 6, 11). Origin: along attachment of dorsal mandible in the buccal mass and body wall. Insertion: distal tip of radular sac and over the ventrolateral external surfaces of cartilage. A bursiform, thin, muscular sheet enveloping the rear of the buccal mass and extending forward under the anterior jugalis and the buccal sphincter over the dorsal wall of the mass. The envelope thickens to the sides of the radular sac and as it passes forward over the sides of the esophagus. This muscle pulls the ventral end of the odontophore posteriad, upward and forward, while others draw the dorsal end anteriad, downward and forward thus shifting the central axis of the odontophore from a dorsoventral resting direction to the anteroposterior one which it must assume before passing out of the mouth.

15. *Buccal sphincter* (figs. 6–8). A broad, thick band of muscle encircling the buccal mass, and lying between the anterior margins of the cartilage and the mouth. It is covered by the anterior jugalis, and dorsally covers the posterior jugalis.

16. *Mandibular approximator* (figs. 6, 8). Insertion: lateral corners of dorsal mandible and attachment of lateral mandibles. A broad band of muscle lying directly in front of and adjacent to the buccal sphincter, and passing between the mandibles by way of the ventral wall of the buccal mass. In contraction it depresses the dorsal mandible and approximates the lateral mandibles about the receding radula.

17. *Dorsal odontophoral flexor* (figs. 6–8, 12). Origin: lateral corners of dorsal mandible and anterior dorsum of buccal mass. Insertion: dorsal third of the lateral extremities of the cartilage. A pair of inconspicuous, wide, flat bands which flare dorsoanteriad on either side of the cartilage. The muscles lie next under the anterior portion of the posterior jugalis and the buccal sphincter, and partly adjacent the buccal cavity epithelial

lining. They function, in conjunction with the posterior jugalis, in orienting the longitudinal axis of the odontophore in an anteroposterior direction; in keeping the cartilage spread and the radula tensed, and in drawing the odontophore forward to and partly out of the mouth.

18. *Ventral odontophoral protractor* (figs. 6–8). Origin: lateral mandibles and ventral lip. Insertion: across the anterior ventral base of the cartilage. A wide, thin sheet, thicker laterally, which spreads under the epithelial lining of the ventral wall of the buccal cavity, and meets the dorsal odontophoral flexor laterally. It serves to draw the odontophore forward.

19. *Infraventral odontophore protractors* (figs. 6–8). Origin: ventral floor of the mouth, and mandibular approximator. Insertion: ventral base of cartilage. A pair of flat bands constituting the external wall of the buccal mass, and continuous with the anterior jugalis laterally. The ventral portions of the circularly directed mandibular approximator, buccal sphincter, and infralateral radular tensor (see below) lie sandwiched between the infraventral and the ventral odontophoral protractors.

Intrinsic muscles, from cartilage to radula and radular sac:

20. *Supramedian radular tensors* (figs. 6, 8–12). Origin: ventral outer extremities of the cartilage. Insertion: dorsal anterior face of the radular sac. Are two strong, flattened bands which fit snugly in the posterior depression of the cartilage between the radular sac and the cartilage.

21. *Supralateral radular tensors* (figs. 6, 8–12). Origin: outer ventral and lower lateral extremities of cartilage. Insertion: (1) middle posterolateral surface of the radular sac, (2) the under lateral margins of the subradular epithelium along those portions at the mouth of the radular sac where the radula begins to curve inward, (3) the under surfaces of the buccal cavity epithelium at areas over, to the sides, and behind the dorsolateral portions of the cartilage. This pair is the bulkiest in the odontophore. They lie on either side of the supramedian radular tensors and may be seen externally at the rear of the buccal mass through the posterior jugalis. Dorsoposteriorly, a laminated outer layer of muscle fibers pass medially from the supralateral radular tensors over the radular sac, and thus bind

the supralateral muscles, the cartilage, and the radular sac together (fig. 11).

22. *Inframedian radular tensors* (figs. 6–8). Origin: anterior ventrolateral base of cartilage. Insertion: under side of subradular epithelium, a pair over each lateral third of the cartilage. These reach over the curved anterior surface of the cartilage, each lateral muscle band branching once before attaching to the epithelium. The anteriormost muscles draw the buccal epithelium posteroventrad when the odontophore is protruded; and the other posterior pair are larger and function more in pulling the epithelium over the cartilage, in antagonism to the supramedian radular tensors. The supramedian, supralateral and inframedian radular tensors hold the radula tightly over the surface of the cartilage and draw the radula back and forth over it during rasping.

23. *Infralateral cartilage tensor* (figs. 6–8). An arc-like, semicircular muscle band passing over the curved ventral anterior surface of the cartilage and fastening in the lateral edges of the cartilage. Anteroventrally it is set adjacent to the buccal sphincter. It serves in spreading the cartilage, especially on the retractor stroke of the odontophore, when the supramedian and supralateral radular tensors, in exerting the necessary pull to stretch the radula, tend to collapse inward the outer margins of the cartilage.

24. *Intracartilage tensors.* A mat of fibers passing throughout the cartilage at right angles to the anterior and the posterior surfaces of the cartilage. The fibers situated in the lateral pillar-like portions of the cartilage are arched outward slightly. The cartilage spaces between the muscle fibers are filled with the turgid vesicular cells (see later) which act in part as antagonists to the fibers. When the straight fibers in the medial portion of the cartilage contract the result is a flattening out, compressing and consequent slight laterad expansion of this part; with the contraction of the curved fibers in the lateral pillars the result is a drawing mediad and a slight bulging of the lateral extremities of the cartilage. This specialization is of the utmost importance in rasping, where it is the dorsal truncated tip and the posterior dorsal surfaces of the cartilage, under the effective rasping portion of the radular, which function in transmitting the forces exerted by the muscles of the buccal mass to the radula.

Intrinsic muscles, passing outward from the radular sac:

25. *Lateral suspensors of the radular sac* (figs. 10, 11, 21). Origin: median posterior surface of the supralateral radular tensors. Insertion: distal base of the radular sac. Two short, thin bands horizontally directed.

26. *Inferior suspensor of the radular sac* (figs. 10, 12, 21). Origin: posteroventral median surface of the cartilage in the cartilage groove. Insertion: distal base of the radular sac. A short, laminated sheet which flares from its origin to its insertion, and whose slender anterior portion lies directly in the opening of the odontophoral valve of the buccal artery.

27. *Superior suspensor of the radular sac* (fig. 11). Origin: posterior ventral boundary of the buccal cavity epithelium, down behind the odontophore. Insertion: distal base of the radular sac. Thin, flattened band, vertically directed. The lateral, inferior and superior suspensors of the radular sac hold the distal end of the radular sac securely suspended in the posterior ventral portion of the buccal mass, between the bulky supralateral radular tensors.

28. *Tensor of the hood* (figs. 6, 10, 11). Origin: posterior ventral surface of radular sac. Insertion: under surface of the collostylar hood. A small hour-glass-shaped muscle serving in the holding of the collostylar hood during the rasping stroke and, indirectly, also probably in preventing the forward passage of the hood with the radula as it grows out of the radular sac.

Homologies for some of the muscles described above have not been described in the pulmonate literature. The extrinsic muscles, with the exception of the suboral and the dorsomandibular dilators and suspensor of the radular sac, are but slight variations of similar muscles described for other pulmonates. The suboral and the dorsomandibular dilators (Nos. 8, 9, 10), however, are not mentioned before. Trappmann gives the name of "anterior protractor muscles" to muscles in the same region in *Helix*, but there is no such function for these muscles in *L. s. appressa*. The suspensor of the radular sac has also gone undescribed. Of the intrinsic muscles, the labial retractors and labial sphincter (Nos. 11, 12), the mandibular approximator (No. 16), the ventral odontophoral and the infraventral odontophoral protractors (Nos. 18, 19), the intracartilage tensors (No. 24), the lateral suspensors of the radular sac (No. 25), and the tensor of the hood (No. 26), appear to be described here for the first time. In *Helix* Trappmann seems to include the mandibular approximator as a part of the buccal sphincter; however, in *L. s. appressa* they are distinct. He also considers the infraventral odontophoral protractors as a ventral continuation of the anterior jugalis.

The muscle of the dorsum of the buccal mass is a composite of the muscles passing dorsad from the ventrum and sides, and of those connecting the rear of the mass with the dorsal mandible and of the short radial muscles which extend peripherad from the basement membrane of the cuticulated epithelium. A conspicuous portion is composed of the large vesicular cells and other connective tissue which lie between the muscle fibers and provide the turgidity which characterizes the dorsum.

Salivary glands. A slender muscle for which the term *salivary retractor* (No. 29) is suggested, has its insertion in the ventral surface of the salivary glands. It extends to and becomes a part of the left buccal retractor (fig. 4). At its insertion, the salivary retractor also sends a smaller muscle anteriorly and another posteriorly over the esophagus. The glands are fastened to the esophagus by numerous slender strands, which may be named the *salivary connectives* (No. 30).

Esophagus. The entire tube is composed of an outer layer of very thin circular muscle and an inner layer of equally thin longitudinal muscle which rises into and thickens in the longitudinal folds. The muscle layers of the proesophagus are slightly thicker than those of the postesophagus. The longitudinal muscular ridges become slightly larger in the posterior region of the postesophagus and do not flatten out with extreme dilation of this part. The two longitudinal muscular ridges lying under the two gastric nerves are conspicuously larger than the others. They swing around to the topographically dorsal side of the crop and gizzard in company with the nerves and other folds, suggesting torsion of this part of the tract.

Crop. The outer circular muscle layer of the esophagus becomes the inner layer in the crop, and passes to the gizzard, still bearing, though in modified form, some of the longitudinal ridges of the esophagus. The crop walls are strengthened primarily by a new external layer of muscle passing over it from the gizzard. A slightly thickened, diffuse band of muscle, for which the term *ingluvial constrictor* (No. 31) is suggested, encircles the opening of the postesophagus into the crop. On each side of the crop slightly thicker bands run from the ventral to the dorsal ends of the gizzard lobes, following the curvature of the gizzard lobes. The designation of right and left *anterior gizzard constrictors* (No. 32) is offered for these muscular bands. Ventrally the bands arise partly in their respective lobes, and partly in the opposite lobes, interweaving medially where they cross. The remaining wall of the crop bears loose, somewhat more slender, fibers which spread from the ventral junction of the gizzard lobes to the crop constrictor and permit considerable inflation of the crop.

Gizzard (fig. 17). The lobes of this organ are composed of strong muscular layers running at right angles to each other: four circularly directed layers and four layers running in the long axis of the alimentary tract. The terms *gizzard compressors* (No. 33) and *gizzard tensors* (No. 34), respectively, are suggested for these layers. The compressors reach circumferentially from the middorsal to the midventral tendons, and extend laterally to the anterior and posterior margins of the lobes. The tensors are sandwiched between the compressors, and their ends terminate among the fibers of the compressors anteriorly and posteriorly. Dorsally and ventrally the tensors decrease in bulk, finally disappearing as the compressors merge into single muscles connecting with the gizzard tendons.

Heidermanns (1924) found but six muscular layers in the European *L. stagnalis,* and points out that the number cannot be ascertained with consistency as it shows a tendency to diminish with increase in the size of the animal. His description of the gizzard musculature of the European *L. stagnalis,* with the exception of the number of compressor and tensor layers, fits that of *L. s. appressa* very closely.

Pylorus. The same thin sheet of circular muscle found in the crop is continued in the pylorus as the inner lining. Also present are the companion muscle bands to the anterior gizzard constrictors, the *posterior gizzard constrictors* (No. 35), which are placed as are the anterior pair, although the interweaving of the ventral portions of the muscles is more marked. The remainder of the pyloric wall is composed mostly of loose, spongy, circular muscle, with the exception of the folds which are strengthened by small fibers running in all directions in connective tissue. The muscular wall of the retrocurrent passage is markedly thinner than that of the procurrent passage. The external wall of the minor passage is thin and is supported by relatively little muscle. The circular muscle remains of uniform thickness as far as the atrium, where strong fibers are particularly evident in the boundary between the hepatic vestibule and the atrium. In the latter the muscular wall becomes exceedingly thin and transparent, with faint thickenings suggestive of the atrial corrugations.

Liver. The hepatic ducts are supported by a relatively strong muscular wall which passes about one third of the distance into the liver in the principal ducts. The fibers in the ducts are found to run in several directions, although the circular ones predominate. The corrugations of the principal hepatic ducts are supported by corresponding, slight ridges of muscle and connective tissue. The thickness and frequency of the fibers decrease as the ducts pass peripherally in the liver and decrease in size. Muscular elements are distributed even as far as the terminal liver follicles. Under high magnification single fibers are evident circumventing the liver follicles, and in living mounts, movement of small groups of such liver cells may be observed.

Cecum. This is composed of a relatively thin outer layer of circular muscle and some inner longitudinal fibers, most of which are found in the cecal folds.

The *intestine* and *rectum* are encircled principally by a very thin layer of circular muscle. The circular muscle layer in the pellet-molding region and in the rectum is slightly stronger, particularly in the pellet-compressor and anus. The *typhlosolic muscle* (No. 36), as the muscular support of the intestinal typhlosole may be called, is composed principally of circular muscle which has invaginated in a thick longitudinal fold. In the direction of the anus, the muscular wall of the rectum thickens and the circular and longitudinal muscular elements become more distinct. At the anus the circular muscle reaches considerable size as the strong *anal sphincter* (No. 37). Longitudinal muscle passes radially out of the rectum and into the musculature of the pneumatoporal lip, and because of its service as the *anal dilator* (No. 38), may be so named. In the anal wall and in the surrounding pneumatoporal lip, the longitudinal and circular muscles are closely intertwined and further strengthened by minor muscles running obliquely.

In its entire course over the surface of the liver the intestine is held firmly to it by strong slender strands. In the rectal region these become bulkier and more numerous, and extend from the rectal walls, by way of the rectal sinus which surrounds the rectum, to the walls of the rectal sinus. For the former strands the term *intestinal connectives* (No. 39) is offered; and for the latter, *rectal connectives* (No. 40).

Summary of the Muscles of the Alimentary System of *L. s. appressa*
(new terms in italics)

I. Extrinsic muscles: buccal mass to body wall:

1. dorsolateral protractors
2. *preventral protractors*
3. *postventral protractors*
4. *dorsolateral retractors*
5. buccal retractors
6. preventral levators
7. postventral levators
8. suboral dilators
9. dorsomandibular dilators
10. suspensor of the radular sac
11. *labial retractors*
12. *labial sphincter*

II. Intrinsic muscles: in buccal wall from cartilage to mandibles:

13. anterior jugalis
14. posterior jugalis
15. buccal sphincter
16. *mandibular approximator*
17. dorsal odontophoral flexor
18. ventral odontophoral protractor
19. infraventral odontophoral protractors

III. Intrinsic muscles: from cartilage to radula and radular sac:

20. supramedian radular tensors
21. supralateral radular tensors
22. inframedian radular tensors
23. infralateral cartilage tensor
24. *intracartilage tensors*

IV. Intrinsic muscles: outward from the radular sac:
25. *lateral suspensors of the radular sac*
26. inferior suspensor of the radular sac
27. superior suspensor of the radular sac
28. *tensor of the hood*

V. Muscles of the remainder of the tract:
29. *salivary retractor*
30. *salivary connectives*
31. *ingluvial constrictor*
32. *anterior gizzard constrictors*
33. *gizzard compressors*
34. gizzard tensors
35. *posterior gizzard constrictors*
36. *typhlosolic muscle*
37. *anal sphincter*
38. *anal dilator*
39. *intestinal connectives*
40. *rectal connectives*

VASCULARIZATION OF THE ALIMENTARY SYSTEM

In *L. s. appressa* the organs are supplied with blood by means of an extensive multiramous system of arteries which ultimately branch richly as minute capillaries over the organs. From the capillaries the blood empties directly into the large hemocoels where it bathes the organs. The venous system has lagged far behind the arterial system in specialization, and consists only of series of connected passages. These lack also the special muscular coat which lines the arteries. The alimentary system receives the greatest volume of arterial blood; the reproductive system, the next largest amount.

The blood itself is a moderately clear, faint milky-colored, watery fluid lacking hemoglobin, but containing hemocyanin and amebocytes. The wandering cells display considerable activity, are moderately numerous, and float freely in the body fluid; in the contracted state they are delicate highly translucent spheres about 8μ in diameter; when expanded they extend variably shaped pseudopodia and may cover an area fully five times the original. Cuénot (1892) described the phagocytic activity of these cells in *L. stagnalis*.

Thorough work on the topography of the circulatory system of the Basommatophora, with the exception of that of Heidermanns (1924), is entirely lacking; and the latter paper is concerned only with the circulation in the gizzard lobes of some Lymnaeidae. Faust (1920), F. C. Baker (1900), and Lacaze-Duthiers (1872) make but passing mention of the principal vessels to be found in various *Lymnaea.* In the stylommatophoran pulmonates the detailed work of Schmidt (1916) on the topography of the vascular system of *Helix pomatia* is still the best account. Jourdain (1879) described the terminal openings of the capillaries in *Arion rufus.*

In the first part of this description the general topography of the arteries leading to the various organs of the alimentary system will be presented. The arteries, where homologous, will be named in accordance with previous pulmonate nomenclature, particularly that of Schmidt (1916) on *Helix pomatia.* Each artery where designated by specific name, will also be denoted by a parenthetical capital letter which corresponds with similar designations in the illustrations. Later, the specific vascularization of each of the organs of the system will be considered.

General topography of the arteries (figs. 1, 2, 4–6, 17). The two-chambered heart is located in the left ventral wall of the lung, and lies directly over and slightly to the left of the umbilical chink in the shell. The *aorta* (A) leaves the ventricle and passes the short distance to the prointestinal loop and is readily seen lying over the tunica propria ventrally (fig. 4). It runs under the foremost portion of the prointestinal loop and branches immediately into the three principal arteries of the body: the *cephalic* (C) which supplies the organs of the cephalic hemocoel and the foot (figs. 1, 2, 4); the *dorsovisceral* (VD) which penetrates the dorsal areas of the organs in the visceral hump (fig. 17); and the *ventrovisceral* (VV) which runs through the ventral portions of the visceral hump (fig. 4).

From its origin just behind the prointestinal loop and to the right of the esophagus, the *cephalic artery* (C) passes over the loop and turns sharply leftward to make a complete turn around the esophagus. This brings it back to the right side of the esophagus again, whence it continues cephalad in company with the esophagus. The artery passes through the bulk of the genital organs beneath the lung, and at the cervical septum plunges through and is bound securely by the connective tissue there. In the cephalic hemocoel it passes under the esophagus and finally courses through the central nervous system to branch into several smaller arteries under the base of the buccal mass (fig. 2). The following arteries are given off by the cephalic artery in its course forward:

Over the anterior arc of the prointestinal loop, one or two *compressor arteries* (CP), in company with two compressor arteries given off by the aorta, are passed to the pellet-compressor of the prointestine. The *typhlosolic artery* (T) spreads over the typhlosole. Minor vessels, the *prointestinals* (IP), pass to other portions of the prointestine (fig. 17).

Just in front of the junction of the crop and the postesophagus one or more *postesophageal arteries* (ET) are given off to the postesophagus.

Three *genital arteries* (G) are extended to the spermatheca, the upper prostate, and the lower prostate from the cephalic artery as it passes beneath the diaphragm of the lung. The cephalic artery is here bound firmly to the reproductive glands by connective tissue.

In the cephalic hemocoel the large *salivary artery* (S) passes off to the left supplying the midventral portion of the salivary glands. It there divides into five smaller vessels, two *salivary arteries* (S) and three *midesophageal arteries* (EM). The former branch richly over the inner surfaces of the salivary glands, one to each gland, and send some smaller vessels to the esophagus (fig. 4).

At the central nerve ring the cephalic artery passes first under the abdominal and parietal ganglia and then over the pedal ganglia. Minute *cerebral arteries* (CE) are extended out around the ganglia (figs. 2, 4). Just in front of the central nerve mass and at the posterior base of the buccal mass, the cephalic artery forks many times, forming a *cephalic arborescence*. One fork, the *penial* (PE), passes to the right over the preputium. A *right* and *left cephalic artery* (CR, CL) extend forward under the sides of the buccal mass to the anterior cephalic body wall. Here each sends a vessel, the *probuccal artery* (BP), mediad and around the oral aperture; the principal vessels of the right and left cephalics pass to the velum. Two unpaired branches, the *ventrobuccal artery* (BV) and the *pedal artery* (P), run straight forward under the buccal mass; the pedal plunges into the foot, and the ventrobuccal turns dorsad, penetrating the buccal mass. Finally, the paired *dorsobuccal arteries* (BD) pass dorsally over the rear of the buccal mass from the lateral extremities of the arborescence (fig. 5). They follow, one on each side, the path of the buccocerebral commissures, pass along the outer sides of the buccal ganglia, and run anterior at the sides of the proesophagus, over the buccal mass. One *proesophageal artery* (EP) is given off on each side to the esophagus and one *postbuccal artery* (BT) extends on each side over the rear of the buccal mass and under the proesophagus. The last tributaries of the dorsobuccals are a pair of *salivary duct arteries* (SD) which run posteriad over the ducts of the salivary glands. Occasionally only one duct will be supplied from the dorsobuccal to one of the lobes of the salivary glands, in which case the other will be vascularized by a branch from the salivary arteries.

The *dorsovisceral artery* (VD) arises just behind the anterior arc of the prointestinal loop, runs posteriad over the middorsal surface of the gizzard and pylorus and closely alongside the cecum as far as its base (fig. 17). The following arteries branch from the dorsovisceral artery:

The *dorsogastric* (GD) passes to the left over the midregion of the gizzard and sends two *dorsoingluvial arteries* (ID) anteriorly over the dorsolateral portions of the crop; two principal *dorsal gizzard arteries* (ZD) into the lobes of the gizzard; the *minor pyloric artery* (PN) posteriorly over the dorsal flexure of the pylorus; one of the largest of the *genital arteries* (G) to the left and upward into the genital organs; and a large *rectal artery* (R) which passes also to the left, then swings dorsad and to the right over the columellar muscle which partly roofs the stomach organs. At this muscle the rectal artery branches thickly, then continues to the right and upward where it meets the posterior intestine. Here it bifurcates and the two *rectal arteries* then pass along the rectum within the rectal sinus almost to the anus. The genital artery passes a single *esophageal artery* (IT) to the crop and esophagus.

In the vicinity of the cecum two or more *cecal arteries* (CC) pass from the dorsovisceral artery to the cecum (fig. 17). Branches of these extend to the right portion of the prointestinal loop as *prointestinals* (IP) and into the anterior lobules of the posterior liver lobe as *hepatics* (H). At the base of the cecum the dorsovisceral artery branches extensively, forming a dense *vestibular arborescence* over the junction of the hepatic ducts in the hepatic vestibule. From this center of ramification one or more *atrial arteries* (AT) spread over the atrium branching profusely. One of these branches passes on as a prointestinal over the prointestine. Many minute *vestibular arteries* (VT) vascularize the dorsal walls of the hepatic vestibule. The principal branches from this arborescence, some four main *prohepatics* (HP), run posteriorly into the anterior lobules of the posterior liver lobe by way of the hepatic ducts; smaller arteries are also passed into the anterior liver lobe. Many of the prohepatics send prointestinals out of the anterior liver lobules over the posterior portions of the prointestinal loop.

The ramifications of the *ventrovisceral artery* (VV) are more extensive than those of the dorsovisceral artery. It continues as a straight extension of the aorta into the spire as follows (fig. 4):

First, several small *prointestinals* (IP) advance to the lateral portions of the prointestinal loop from the area under the gizzard.

Next, the *ventrogastric artery* (GV) arises under the right lobe of the gizzard and proceeds to the left under the gizzard, giving off two *ventroingluvial arteries* (IV) to the gizzard lobes; one *major pyloric artery* (PM) over the right side of the pylorus; and one *propyloric* (PP) over the left anterior bulge of the pylorus. A branch of the major pyloric artery, the *minor hepatic* (HN), penetrates the anterior lobe of the liver.

A short distance behind the origin of the ventrograstric artery, the *ventral pyloric artery* (PV) forks from the ventrovisceral, and presses over the ventral surface of the pylorus (fig. 4).

Beyond the ventral pyloric artery, the ventrovisceral artery continues as the *major hepatic* (HM) which vascularizes the bulk of the posterior liver lobe and penetrates to the very tip of the spire. It follows closely over the internal curvature of the columella of the shell, and directs numerous *hepatic* (H) branches to the various lobules of the liver. Many of these ramifications pass to the dorsointestinal loop where they spread about the intestine as the *midintestinal arteries* (IM). Some of the anterior hepatic arteries send prointestinals to the posterior portion of the prointestinal loop. The largest branch artery of the major hepatic, the *postintestinal* (IT), arises in the midregion of the liver and passes peripherally to the posterior part of the intestine at that point where the intestine runs off of the liver into the postintestinal loop. The postintestinal artery follows the postintestine as far as the rectal artery and the rectum. One or two prointestinal arteries are found jumping from the post-intestinal artery onto the prointestine at that point where the postintestine circles parallel to a portion of the prointestinal loop. An artery to the ovotestis, the *gonadal artery* (GO), arises from the major hepatic artery near the origin of the post-intestinal artery.

Some variability is found in the origin of the minor arteries, but the particular portion of tissue being vascularized remains constant. Of the terms employed for the arteries, the following are adopted from those used in previous works: aorta, cephalic, salivary, penial, pedal, right and left cephalics, rectal and hepatic. The terms visceral, esophageal, intestinal and buccal, also used in earlier works, have been modified for use in the present description.

Specific Vascularization

Buccal mass (figs. 5, 6, 19–21). This is vascularized by the paired probuccal, single ventrobuccal, paired postbuccal and paired dorsal buccal arteries (fig. 5). The probuccals pass about the oral structure, and especially between the fibers of the buccal sphincter and the mandibular approximator muscles. The dorso-buccal penetrates the dorsal part of the mass, passing beneath the anterior jugalis muscle alongside the posterior jugalis muscle, and sends special arterioles into the buccal glands in the dorsolateral wall. The postbuccal vascularizes the rear dorsal part of the mass, in particular the portions of the buccal gland there. Throughout the glandular tissue and adjacent connective tissues these arteries pass terminally into minute and thickly distributed capillaries, some of which measure only three micra in outer diameter (carmine injected).

The principal passage of blood into the mass is by way of the ventrobuccal artery which enters directly under the cartilage, at that point where the extrinsic ventral buccal muscles have their insertion (figs. 5, 6, 19). The artery enlarges broadly at its site of attachment. Blood penetrates the buccal mass by way of two valves which exist as two longitudinal slits in the surface musculature of the mass and within the anterior and posterior limits of the attachment of the artery (fig. 19). There is no specialization of the valves in *L. s. appressa* as there appears to be in the single buccal valve described for *Helix pomatia* by Schmidt (1916). In *L. s. appressa* the valves consist each of two slight lateral ledges of tissue which project mediad and meet tightly when force is brought to bear on the surrounding tissues. The term *odontophoral valve* is suggested for the posterior valve. This leads into the space lying between the cartilage and the radular sac and the subradular epithelium. For the anterior valve the designation of *outer buccal valve* is offered; this leads into the spaces lying between the muscles in the anterior ventrolateral portions of the mass, and is surrounded on all but the anterior border by the insertion of the two extrinsic preventral protractor muscles. The insertion of the postventral levator muscles lies between the two valves, and that of the postbuccal protractor muscles in the anterior borders of the odontophoral valve. These extrinsic muscles are all so placed with respect to the valves, that their contraction along with the contraction of other principal muscles in the forward stroke of the odontophore forces the valves to gape open. On the other hand, the intrinsic supramedian and supralateral radular tensor, the infralateral cartilage tensor, the buccal sphincter, and the extrinsic buccal retractor muscles and possibly others, are so oriented with respect to the valves that the valves close upon the contraction of these muscles. This occurs on the retracting stroke of the odontophore when the rear ventral portion of the buccal mass is constricted to the point where the lateral pillars of the cartilage are partly collapsed on themselves, clamping the valves shut.

The outer buccal valve leads into extensive, broadly continuous spaces lying about the ventral and lateral portions of the mandibular approximator, buccal sphincter, infralateral cartilage tensor, and other muscles. The name *buccal sinuses* is offered for these spaces. They pass in the lateral walls about the muscles as far as the more compact tissues lying over the dorsal channel of the buccal cavity, and back in the lateral walls to the rear of the mass. An extensive honey-comb system thus supplies these muscles with body fluid. The cavity lying about the cartilage and the radular sac and delimited by the subradular epithelium dorsally, the circular muscles anteriorly, the lateral radular tensors laterally, and the posterior jugalis muscle posteriorly, may be called the *odontophoral sinus.*

A third valve, which may be designated the *inner buccal valve,* makes connection between the odontophoral and the buccal sinuses. This valve is merely a smooth transverse slit-like opening in the midventral portion of the buccal sphincter muscle. It is about the same size as the other valves and closes readily upon the contraction of the circular muscles of the buccal mass.

All of the muscles of the mass, particularly the buccal sphincter and mandibular approximator and the supralateral radular tensor, are perforated by small numerous slit-like passages which extend between the muscle fibers from the sinuses. These vary much in length, average about 70μ, and behave very much like the inner buccal valve in controlling the passage of blood. Thus the blood trapped in the odontophoral and buccal sinuses passes out into the hemocoel by way of these openings during the relaxation or early contraction of the muscles. Portions of the posterior jugalis covering the rear of the mass are composed in part of a laminated musculo-connective membrane which is also perforated. These openings are rounded or oval and the smaller measure about 15μ. Emery's aqueous carmine when injected into the relaxed buccal mass by way of the ventrobuccal artery readily extravasates through these openings. In an injected animal which has partly recovered from anesthesia, these same openings become tightly closed. The aqueous carmine solution does not appear immediately toxic to the injected snail, as muscles of such snails when retained in *Lymnaea* physiological solution remain irritable for over twenty-four hours. When carmine is suspended over the external valves from which the ventrobuccal artery has been removed, it may be seen to enter the valves upon relaxation of the buccal musculature; but it does not pass back out again when the musculature contracts. The likeness of the odontophoral, the inner and outer buccal valves, to the less specialized slits in the musculature is striking. Possibly these valves were developed from the simple slit-like openings in the evolution of the buccal musculature.

The distal portion of the radular sac which contains the radula-forming odontoblasts is supplied with fresh blood from the ventrobuccal artery through a notable specialization of the *inferior suspensor muscle of the radular sac* (fig. 21). This muscle originates as a slender thread-like structure in the ventral portion of the posterior cartilage groove. A short distance away from its origin it flares broadly into a small triangular-shaped inclosure of spongy connective tissue making its insertion in the distal extremity of the radular sac. The insertion passes about and partly surrounds the insertion of the superior suspensor muscle of the radular sac in the central distal tip of the radular sac. At the initial flare of the inferior suspensor of the radular sac, a relatively large opening is evident, the anterolateral margins of which make connection with the cartilage. Thus the suspensor acts as a baffle membrane intercepting a fraction of the blood passing into the odontophoral sinus and directing it to the radular sac. In injected specimens this sac is always heavily charged with the injectant.

A study of the minute anatomy of the buccal mass, combined with observations on its movements, suggests the following course of the blood through the mass: In the resting position of the odontophore, the odontophoral and outer buccal valves are open and the blood flows freely throughout the mass. During the forward stroke of the odontophore, the extrinsic ventral muscles in their contraction continue to hold the valves in an open state. At the first phase of rasping the entire musculature of the mass tenses, in particular that of the rear ventral part, and effects complete closure of the valves, preventing resurgence of the blood from the sinuses. It is quite probable also that, with the initial tensing of the muscles, the slit-like openings leading from them are also pressed shut. Thus the blood in the odontophoral sinus becomes imprisoned and affords a turgor pressure about the cartilage and under the radula at the rasping and retracting strokes of the radula when the greatest expenditure of energy occurs. In the retraction of the odontophore, the mandibular approximator and the buccal sphincter muscle constrict markedly after the receding odontophore, forcing outward some of the blood in the buccal sinuses. At the termination of the retracting stroke the musculature relaxes and the remaining blood in the odontophoral sinus, being under pressure, is forced out through the openings in the muscles. The rate of beating of the heart is faster than the rate or protraction of the odontophore (at ordinary summer temperatures), so that the blood tends to accumulate in the ventrobuccal artery while the buccal valves are closed.

Esophagus (figs. 4, 5). The proesophagus is vascularized by a pair of proesophageal arteries arising from the dorsobuccal arteries, and by some four proesophageal arteries passing anteriad from the salivary and from the midesophageal arteries. The principal site of penetration of the tissue by both sets of vessels is along the four proesophageal folds, into which the larger arteries pass and fork many times.

The postesophagus receives, on the average, eleven midesophageal arteries from the salivary artery. Each of these passes posteriad embedded in one of the postesophageal folds, specifically vascularizing these more muscular regions and sending smaller vessels out into the thinner tissue between the folds. The main arteries extend posteriad almost to the crop. The posterior portions of the postesophagus are penetrated by one or more arteries from the cephalic artery, by a branch of the genital artery passing from the dorsovisceral branch, and by terminal ramifications of the ventro- and dorsoingluvial arteries in the crop.

Capillaries (figs. 18, 22, 23). Just as Jourdain (1879) describes for *Arion,* the arterioles in *L. s. appressa* ultimately terminate in capillaries which spread out over the tissues in a fine ramification. These then end at the external surface of the organs in truncated oval openings through which the blood empties into the hemocoels. This applies to the entire alimentary canal with the exception of the very muscular portions of the buccal mass and the gizzard. In these, as already described for the buccal mass, the body fluids empty outward through slit-like passages between the muscle fibers. These passages and slits appear to be but modifications of the condition existing in the remainder of the tract. Because of the thinness and slight muscularity of the walls, the postesophagus affords a good place in which to observe the capillaries.

As represented in Figure 23 the smaller arteries usually extend over the external surface of the organs before plunging into the tissues. The capillaries spring from these arterioles and reach in all directions through the connective tissue, musculature and along the epithelium for variable distances. They vary greatly in diameter, those of 10μ being common, but both larger and smaller ones being almost as abundant. Beyond its final branching, each capillary retains a moderately uniform diameter, and ultimately directs its course towards the external surface of the organ, there terminating in a slightly flaring aperture. These *capillary ostioles,* as the capillary exits may be designated, are also extremely variable as to size, those as small as 6μ having been observed. Each ostiole is surrounded by a dense network of fine muscle fibers (fig. 18) which are so oriented that upon contraction the ostiole may be completely occluded. Muscle fibers are found along the entire length of the capillary situated in the wall of the organ. The carmine solution, when injected intravascularly in thoroughly anesthetized snails, was never observed to pass any appreciable distance down those lengths of capillary lying in the tissue; it was stopped abruptly probably by constriction of the muscle fibers surrounding the vessels. Conversely, when snails recently killed by asphyxiation were injected, the injectant was sometimes found to pass considerable distances down the capillaries and extravasate into the surrounding tissues. This extravasation was undoubtedly made possible by the complete relaxation and the initiation of autolysis in the cells, as it never occurred in anesthetized snails. However, the fact that the carmine solution, even though heavily charged with a vasodilator, is blocked by constrictions in the capillaries of anesthetized snails, indicates that the muscle fibers surrounding the tubules are extremely sensitive to chemical stimulation, and probably play a significant role in the control of the passage of blood through the tissues.

The course of the arteries and capillaries everywhere may be readily followed under low magnification by the presence along the course of the vessels of large numbers of white *calciferous concretions.* These are discussed under varying names in the pulmonates by such authors as Cuénot (1892), Kisker (1923), v. Haffner (1923), Nold (1924), Hoffmann (Simroth and Hoffmann, 1908–1928) and Baecker (1932). Some of the concretions lie in the large vesicular cells (cells of Leydig) and others, intercellularly. It would seem from the fact that all transitional stages from a few small to many large concretions are observable in the vesicular cells, that the concretions are formed within them. These cells measure about 50μ in diameter and their nuclei are readily seen in living tissues stained with methylene blue (fig. 23). The outer, relatively thick wall of the larger arteries is composed almost entirely of these vesicular cells, the majority of which do not contain the calciferous concretions.

In cross section the arteries exhibit two distinct layers of tissue: a thick outer sheath of vesicular cells and a thin inner tube of muscle fibers. In the cephalic and visceral arteries the outer sheath may be composed of as many as three layers of the large vesicular cells. The number of cell layers decreases in the smaller arteries and in the smallest arterioles the arterial lumen becomes encircled by a single layer of only three or four cells in cross section. In capillaries lying within the tissues, vesicular cells no longer form the usual external sheath but lie sparsely and irregularly scattered over the course of the tubule (fig. 23).

In the largest arteries the muscular layer is approximately 5μ in thickness and is composed almost entirely of circularly directed muscle fibers. Very few longitudinal fibers are evident. In the arterioles the circular layer is composed of only a one- or two-cell layer of muscle and the longitudinal fibers are entirely absent. In many of the smaller capillaries buried in the tissues, the capillaries are devoid of any special capillary wall and give the appearance of tubular spaces tunneled in the muscle fibers and connective tissue, delimited only by the cells around them. Nold (1924) and Baecker (1932) describe a similar condition for the arteries of such Stylommatophora as *Helix,* with the exception that in the larger arteries the longitudinal layer of muscle is well developed, and the smaller arteries bear an internal lining of endothelium-like, flattened muscle cells.

The type of capillary vascularization described above for the postesophagus is found in all parts of the alimentary system where the organ walls are relatively thin, as in the proesophagus, crop, pylorus, intestine and rectum. The number of fibers surrounding the capillary ostioles varies with the muscularity of the tissues: for example, those ostioles in the wall of the anterior portion of the proesophagus, which is relatively less muscular, are not delimited by as many fibers as those in portions of the crop constrictor muscle. Then again, the degree to which the capillaries taper in diameter is correlated with the relative thickness, the complexity, and the glandular nature of the tissues in question. Thus in the tissues of the buccal glands, the salivary glands and the liver, the capillaries are found to diminish to an outer diameter of 3μ. In these glandular regions the capillaries spread over individual groups of cells. In the liver the capillary network embraces the individual liver follicles. In the salivary glands, where the cells are so large, sometimes the capillary network covers groups of only a few cells. Even in the glandular areas, however, the capillaries open to the hemocoels by way of capillary ostioles.

Salivary glands (fig. 4). These are supplied by the two principal salivary arteries which spread out fan-shape over the inner surfaces of the glands and send minute capillaries throughout the glands between the cells.

Crop and Gizzard (figs. 4, 17). The crop is vascularized by the four ingluvial arteries and a part of the postesophageal artery extending from the genital branch of the dorsovisceral artery. These branch most abundantly over the crop constrictor and anterior gizzard constrictor muscles. The four large dorsal and ventral gizzard arteries pass almost directly from the dorso- and the ventrovisceral arteries into the dense musculature of the gizzard lobes. They penetrate the dorsal and ventral portions of the lobes near the tendons, and pass through slit-like openings (fig. 22) about the muscle layers within. In well-injected specimens dehydrated in alcohol and cleared in xylol, the clearly outlined arteries may be seen to pass first through the outer gizzard compressor to the gizzard tensor muscle layer, and so on into the innermost layers, en route passing branches to all areas of the lobes between the muscular layers. Smaller arteries also penetrate the lobes along the anterior and posterior sides of the gizzard and in the tendons. Within the lobes the arteries open into small sinuses which lie about the muscle fibers, particularly between the muscle layers. These sinuses in turn lead to the exterior by way of the usual slit-like ostioles between the muscle fibers. The ostioles are most numerous in the anterior and posterior margins of the gizzard along the anterior and posterior gizzard constrictors. The slit-like openings through which the arteries plunge into the lobes act as "valves" which close upon the contraction of the muscles, much as do the ostioles.

Carmine injected into the dorsal gizzard arteries of a "pithed" snail, by way of the dorsogastric artery, passed readily into all the larger arteries and sinuses of the lobe, but did not extravasate. Similar injections in thoroughly relaxed snails flowed out freely through the ostioles. The passage of the blood in the living gizzard appears to be as follows: blood runs into the relaxed lobes, propelled by the pumping of the heart. Upon contraction of the gizzard the entrances of the gizzard artery are blocked and some of the blood within the lobes is forced out the ostioles. Upon relaxation the openings to the gizzard arteries part and the blood in the arteries, under greater pressure than that in the relaxed gizzard, flows into the gizzard. Also the expanding gizzard muscles tend to form a partial vacuum which augments the flow of blood from the arteries and causes an inflow of blood from the hemocoel through the ostioles. When active, the gizzard lobes undergo a continuous contraction and relaxation, so that they undoubtedly act also as a kind of pump which keeps the blood flowing through the gizzard musculature.

Heidermanns (1924) in his work on the gizzard of *Lymnaea* found essentially the same picture as presented above for *L. s. appressa.* He does not believe that the blood passes freely through the gizzard. However, the anatomy of the gizzard alone indicates that in the relaxed gizzard the blood may flow freely through it.

Pylorus and Cecum (figs. 4, 17). The ventral fold of the pylorus is vascularized by the ventropyloric artery; the major and minor folds by the major and minor pyloric arteries; the interior external portion of the retrocurrent passage wall by the propyloric artery; the corrugations of the vestibule and the atrium by branches of the multiramous vestibular and atrial arteries, respectively. The enlarged posterior portion of the major pyloric fold which occludes the hepatic vestibule also receives smaller vessels from the vestibular arborescence. The intervening thinner walls are penetrated by capillaries branching from the principal arteries. The cecal arteries pass externally over and vascularize principally the cecal folds.

Liver (fig. 4). The anterior lobe of the liver is penetrated by a minor hepatic artery branching from the major pyloric artery, and by one or more very small minor hepatic arteries which leave the vestibular arborescence and pass up the hepatic duct. The principal mass of the posterior lobe is vascularized by the major hepatic artery which enters the anteroventral portion of the lobe, and by it s offshoot, the postintestinal artery.

The anterodorsal portions of the lobe are entered by the numerous prohepatic arteries which arise in the vestibular arborescence and pass into the liver lobules by way of the hepatic ducts. In contrast to the prohepatic arteries which pass into the liver from a common source in palmate forking fashion, the hepatic arteries from the major hepatic branch along the main stem of the artery as it passes to the tip of the spire.

Intestine and Rectum (fig. 4). In the prointestinal loop the principal sites of vascularization are the pellet-compressor and the typhlosole. To the former pass three or more compressor arteries which form sprays of arterioles completely around the circumference of the compressor. To the latter passes usually a single typhlosolic artery which sends branches in opposite directions over the typhlosole. These in turn direct branching arterioles down into the musculature of the typhlosole where the capillaries diffuse. The remainder of the prointestinal loop is moderately supplied with prointestinal arteries. The mid- and postintestines have no special points of vascularization but are densely and uniformly covered by numerous branching midintestinal and postintestinal arteries which pass arterioles completely about the entire tube. The more numerous capillaries pass over the intestinal costae. The two lateral rectal arteries course anad over those portions of the rectal wall which support the raphe and the pseudoraphe, an artery to each. From these, branch arteries spread over the rectum, though not as profusely as do the arteries over the midintestine. The rectum lies in the rectal sinus.

Generalizations. Certain generalizations with regard to the vascularization of the alimentary system may be appropriately stressed. The organs most abundantly vascularized are those performing the most physical work. In order of their decreasing activity these are: the buccal mass, the gizzard, pylorus, and liver. Of these organs, with exception of the buccal mass and the gizzard, the parts most generously supplied with blood vessels are the muscular folds and epithelial corrugations. The arterioles pass into capillaries which may terminate in either the rounded ostioles of the esophagus, crop, pylorus, intestine, rectum, liver and salivary glands; or the slit-like ostioles between the muscle fibers of the buccal mass and the gizzard. Passage of blood through the organs is impelled not only by the action of the heart, but is greatly facilitated, as well as probably controlled, by the muscular activity of the organs themselves. The rich vascularization of the mid- and postintestines is suggestive of a function other than peristaltic.

The arterial source of each vessel named and described in the previous paragraphs is indicated in the following outline:

Summary of the Arteries Supplying the Alimentary System of *L. s. appressa*

1. aorta, A
    1. compressors, CP
    2. cephalic, C (arborescence)
        1. right cephalic, CR
        2. left cephalic, CL
            1. probuccal, BP
        3. ventrobuccal, BV
        4. pedal, P
        5. penial, PE
        6. cerebral, CE
        7. dorsobuccal, BD
            1. proesophageal, EP
            2. salivary duct, SD
            3. postbuccal, BT
        8. salivary, S
            1. midesophageal, EM
        9. prostatic, GP
        10. genital, G
        11. spermathecal, GS
        12. postesophageal, ET
        13. typhlosolic, T
        14. prointestinal, IP
    3. dorsovisceral, VD
        1. dorsogastric, GD
            1. dorsoingluvial, ID
            2. dorsal gizzard, ZD
            3. rectal, R
                1. columellar, CO
            4. minor pyloric, PN
            5. hepatic, H
            6. genital, G

2. cecal, CC
3. atrial, AT
4. prointestinal, IP
5. prohepatic, HP
6. vestibular, VT (arborescence)

4. ventrovisceral, VV
    1. prointestinal, IP
    2. ventrogastric, GV
        1. ventroingluvial, IV
        2. ventral gizzard, ZV
        3. ventropyloric, PV
        4. major pyloric, PM
        5. minor hepatic, HN
        6. propyloric, PP
    3. major hepatic, HM
        1. midintestinal, IM
        2. postintestinal, IT
        3. hepatic, H
        4. prointestinal, IP
        5. gonadal, GO

INNERVATION OF THE ALIMENTARY SYSTEM

Central nervous system and principal nerves (figs. 1, 2, 4, 5, 11, 17, 24, 25). Bargmann (1930) in a comparative reinvestigation of the morphology of the central nervous systems of the Pulmonata has clarified the terminology of the central nervous ganglia. According to her classification of eight different types of pulmonate central nervous systems, *L. stagnalis* falls in the basommatophoran group. This is the most unspecialized group, in which the minimum concentration of the ganglia is evident, and all nine ganglia are separated by definite connectives (fig. 24).

As far as can be ascertained, the only extensive descriptions of the principal nerves in the Lymnaeidae is that of Lacaze-Duthiers (1872). The topography of these nerves, as far as that author follows them, is in agreement with that found in *L. s. appressa.* F. C. Baker (1900, 1911) gives brief descriptions of the principal nerves in the Lymnaeidae. There is so little agreement in the literature as to the terminology, and in some cases the course, of the principal nerves of the visceral chain, that an effort is made here to adopt a logical nomenclature based as much as possible on that of such investigators as Bargmann (1930), Merker (1913), F. C. Baker (1900, 1911), Lacaze-Duthiers (1872), Simroth and Hoffmann (1908–1928) and Schmalz (1914). The work of Schmalz on the morphology of the nervous systems of *Helix pomatia* is probably the most detailed of any on the Pulmonata, although he does not follow it out to the minute innervation of the organs.

Of the ganglia in the visceral chain, the pleural ganglia do not send out nerves; the two parietal and the single abdominal ganglia together extend seven principal nerves to the mantle and to the visceral organs. The terms suggested here for these nerves are given below (fig. 24). Throughout this section the parts of the nervous system will be designated in parentheses in lower case letters which correspond to similar notations in the illustrations.

Right parietal ganglion (gpar): (1) The *anterior pallial nerve* (pla) anastomoses with the (2) *median pallial nerve* (plm) from the abdominal ganglion to form a single nerve, the *internal pallial* (pli) which passes in the floor of the lung in the direction of the pneumatoporal lip and the anus. It is questionable whether the term internal pallial of Merker and anterior pallial of Bargmann, F. C. Baker and Lacaze-Duthiers is synonymous to the usage here adopted of anterior pallial, internal pallial, or to a combination of both. The median pallial is synonymous with what Merker designates as anal, and Bargmann as pallial. (3) The right pallial (plr) innervates the mantle over the roof of the lung and sends one large nerve to the *osphradial ganglion* (go) and smaller ones in the direction of the anus. There is no disagreement over this nerve, although Merker adds the word external to distinguish it from his right internal pallial.

The *left parietal ganglion* (gpal) sends out only one nerve, (4) the *left pallial* (pll), which innervates the left portion of the mantle. There is also general agreement on this nerve.

Abdominal ganglion (ga): There is no confusion over the (5) *aortic nerve* (ao) which passes along the cephalic artery to the left body wall. The median pallial (plm) was discussed above. (6) The *ventropallial nerve* (plv) reaches posteriad to the portion of the mantle running under the columellar muscle.

Bargmann refers to it only as a pallial nerve, F. C. Baker as the anterior mantle, and Merker as the cutaneous. (7) The last nerve, the genital of Bargmann and Lacaze-Duthiers, intestinal of Merker and subintestinal of F. C. Baker, passes posteriad between the median pallial and the aortic nerves. Beyond the cervical septum it branches into about five large branches which innervate the reproductive system, the columellar muscle, the pericardium and the digestive system. Because this nerve supplies so many of the visceral organs, the new term *splanchnic nerve* (sp) is suggested for it, and the older terms for it are given to the appropriate branches, as follows: that passing over the columellar muscle, the *columellar nerve* (co); two nerves arising from a knotty enlargement of the splanchnic nerve in the cervical septum and spreading over the reproductive organs, the *genitals* (g); that passing into the pericardium, the *cardiac nerve* (cr); and that passing from the splanchnic enlargement and along the cephalic artery to the stomach region, the *intestinal nerve* (in). A branch of one of the genital nerves also passes back dorsally along the hermaphroditic duct, the *gonadal nerve*. The term *splanchnic complex* (cs) is suggested for the enlargement of the splanchnic nerve in the vicinity of which arise the intestinal and genital nerves.

The principal nerves passing forward from the *cerebral ganglia* (gc) into the head region have been described for *Lymnaea* by Lacaze-Duthiers (fig. 24). (1) A pair of *buccocerebral connectives* (bcc) extend to the *buccal ganglia* (gb) located at the rear of the buccal mass under the esophagus; (2) a *penial nerve* (pe) to the preputium; (3) paired *tentacular nerves* (tt) to the tentacles; (4) paired *optic nerves* (to) to the eyes; (5) paired *superior labial nerves* (ls) which extend over the dorsolateral surface of the buccal mass and branch once, sending the *dorsolabial nerves* (ld) to the dorsal portion of the lips, and the *frontals* (f) outward to the base of the tentacles; (6) and paired *inferior labial nerves* (li) which pass over the ventrolateral surfaces of the buccal mass and branch into three smaller nerves: the inner nerves, the *ventrolabials* (lv), innervate the ventral portion of the lips; the two outer branches, the *velar nerves* (vl), penetrate the outer portions of the velum. Lacaze-Duthiers names only the main stems of the nerves, calling them the inferior labials and the superior frontolabials. The names of the ramifications of these nerves have been taken in part from this author's terms for the principal nerves.

Specific innervation of the alimentary system (figs. 4, 5, 11, 17, 24, 25). With the exception of Heidermanns' work (1924) there has been no intensive work on the innervation of these organs in the Lymnaeidae. Meager descriptions are given by Lacaze-Duthiers (1872), Amaudrut (1898) and F. C. Baker (1911). The detailed structure of the nervous system of such Stylommatophora as *Helix* has been investigated by such workers as Smidt (1899, 1901), Baecker (1932) and others.

Principally concerned in the innervation of the alimentary system of *L. s. appressa* are the right and left buccal, the right and left cerebral, the right parietal and the single abdominal ganglion.

The oral aperture, the lips, the muscles about the mouth (the suboral and the dorsomandibular dilators and the labial retractors and sphincter) are innervated by the *dorso-* and *ventrolabial* (ld, lv) nerves (branches of the superior and inferior labials, respectively) which pass through this region. These nerves were not found to pass into the buccal mass (fig. 24).

The musculature of the anal region, including the anal sphincter and the anal dilator, receives the *anal nerves* (figs. 4, 25), from the right pallial nerves. These nerve endings constitute a fine system of branchings in the pneumatoporal lip, the angle of the mantle and the anal region. No nerves, however, could be traced over the rectum itself. Other branches from the internal pallial nerve, and from the splanchnic nerve extend over the columellar muscle into the ventral wall of the rectal sinus, but again no nerve branches could be traced to the rectum. With more refined technics, nerves could undoubtedly be found on the rectum, since like the intestine it exhibits peristaltic movements.

The paired *buccal ganglia* (gb; figs. 5, 25) send out the principal nerves innervating the greater part of the alimentary system. These ganglia are two small oblong inconspicuous bodies connected to each other by the *buccal connectives* (bc; figs. 24, 25) and lie under the esophagus at its point of entrance into the buccal mass. Union with the cerebral ganglia is accomplished by means of two lateral *buccocerebral connectives* (bcc). In addition to the connectives, six principal nerve paths pass from the buccal ganglia: (1) the postbuccal, (2) ventrobuccal, (3) laterobuccal, (4) dorsobuccal, (5) salivary and (6) gastric nerves; all are paired with the exception of the postbuccal nerve and this splits as soon as it passes into the buccal mass.

(1) The *postbuccal nerve* (bt; figs. 5, 11, 25) arises as a single nerve from the midventral portion of the buccal connective and passes ventrally to the posterior lower surface of the radular sac, penetrating through the posterior jugalis muscular sac. It forks once over the radular sac sending the *right* and *left postbuccal nerves* (btr, btl) laterad. The right and left branches fork symmetrically in three directions: the principal branch, the *collostylar nerve* (pp), passes down onto the radular sac, innervates the hood tensor muscle, then swings up along the radular sac, extending small nerves to the supralateral radular muscle. It terminates along the junction of the supralateral radular muscle and the subradular epithelium. The two smaller branches of the right and left postbuccals reach in a dorsolateral direction over the supralateral radular muscles, innervating these muscles and the epithelium and glandular tissue about the entrance of the proesophagus in the buccal mass. In many specimens ganglionic cells are found along these outer nerves. The ramifications of the postbuccal nerve are only exposed when the posterior jugalis muscle is removed from the buccal mass.

(2) The *ventrobuccal nerves* (bv; figs. 5, 25) emerge from the lateral ends of the buccal ganglia and run in a ventrolateral direction, sometimes in company with the buccocerebral connectives. Over the cartilage several nerves are extended into the origin of the supralateral, supramedian and inframedian radular and infralateral cartilage muscles and into the cartilage itself. A subsidiary nerve continues anteroventrad, passing under the anterior jugalis muscle and branching under the infralateral cartilage muscle in the direction of the odontophoral and buccal valves. The ventrobuccal nerves thus innervate the cartilage and all those muscles passing about and from the cartilage.

(3) The *laterobuccal nerves* (bl; figs. 5, 25) extend forward over the lateral surfaces of the buccal mass a short distance with the ventrobuccal nerves, and then alone, as the ventrobuccal nerve swings ventrad. The laterobuccal nerves on each side of the buccal mass branch in three directions: the ventral branch sometimes arises from the ventrobuccal nerve and passes in the anterior jugalis muscle to the lateral region immediately about the oral aperture, especially into the mandibular approximator and buccal sphincter muscle. The median branch passes directly into the first lengths of the dorsal odontophoral flexor muscle as it leaves the cartilage. The dorsal branch plunges forward beneath the anterior jugalis, the anterior extensions of the posterior jugalis, and the buccal sphincter muscles. It splits profusely over and through the buccal glands lying in the dorsolateral, anterior portion of the buccal mass and directly adjacent the buccal cavity epithelium. Numerous nerve branches continue into the region directly about the mouth and the buccal cavity epithelium. Two or three conspicuous ganglionic cells are found along some of the branches of this last nerve.

(4) The *dorsobuccal nerves* (bd; figs. 5, 25) originate in the dorsomedial surface of the buccal ganglia and pass over the buccal mass to the sides of the proesophagus, innervating the glandular and epithelial regions, as well as the portions of the posterior jugalis, anterior jugalis, buccal sphincter and odontophoral flexor muscles found over the dorsum of the mass. No branches could be traced to the mouth. An *anterior esophageal nerve* (ea) passes on the median side of each dorsobuccal nerve over the dorsal surface of the proesophagus as it enters the buccal mass.

(5) The *salivary nerves* (s; figs. 5, 25) pass forward as a part of the dorsobuccal nerves for a short distance before they run onto the salivary ducts. A single nerve extends over each duct to the salivary glands, branching generously along its course. Three or four fine threads fork from the parent nerve stem and penetrate the principal lobules of each salivary gland in relatively sparse ramifications. The nerve sheath described for the nerves of the stomach region by Heidermanns (1924) is very clearly observed in the salivary ducts and glands. Here by the methylene-blue technic of Alexandrowics (1932) the prin-

cipal nerves may be seen *in vivo* enclosed in relatively large sheaths, in which the branch nerves travel some distance before passing into the surrounding tissues.

Before the last of the principal buccal nerves is described, two minor buccal nerves will be mentioned. The first of these are the paired *posterior jugalis nerves* (jp; figs. 5, 25) which pass, one from each of the buccal ganglia, to the rear lateral surfaces of the posterior jugalis muscles. The second, the small paired *buccal retractor nerves* (br), extend, one from each bucco-cerebral connective, to the buccal retractor muscles, where the latter run near the connectives.

(6) The *right* and *left gastric nerves* (gr, gl; figs. 4, 5, 17, 25) also run forward from the buccal ganglia as part of the dorsobuccal nerves for a short distance, then jump to the lateral sides of the proesophagus, to extend along almost the entire length of the alimentary tract. The gastric nerves, and the splanchnic nerve from the abdominal ganglion, are the most extensive and the longest nerves in the snail body. The two gastric nerves pass down the esophagus in the two largest lateral esophageal folds, branch profusely over the esophagus and form a fine network of *pro-* and *postesophageal nerves* (ep, et) over the surface of the tube. As the alimentary tube is followed posteriad, it is evident from the course of the gastric nerves over it, and from the complete turn of the cephalic artery about it, that the tube undergoes a clockwise torsion (as seen from the front), or a turning to the animal's left, at the postesophagus and crop in its development. The torsion appears to have involved one complete turn of the tube (360°), so that the topographically dorsal surface of the alimentary tube posteriad the site of torsion is also the true morphologically dorsal surface. At the site of torsion the left gastric nerve turns gradually ventrad and makes a turn under and around the crop to the right, emerging finally on the left dorsal surface of the gizzard between the two gizzard lobes (figs. 17, 25). It continues rearward over the left pyloric fold. The right gastric nerve swings over the post-esophagus and completes a full turn about it, emerging ultimately on the right dorsal surface of the gizzard. It reaches posteriad over the right pyloric fold. Heidermanns (1924) writes that the left nerve makes a turn of 180° and the right one, 360°. In *L. s. appressa* the left gastric nerve makes almost a 270° turn.

The crop is heavily innervated by *ingluvial* (i) ramifications of the gastric nerves which form an extensively ramifying network over this organ (fig. 25). The principal branches pass down over the ingluvial and the anterior gizzard constrictor muscles. Nerves from the crop and from the pylorus pass into the muscular layers of the gizzard lobes. The pylorus is even more thickly innervated than the crop by *pyloric* (p) nerves branching from the gastric nerves. The denser nerve patterns occur over and in the major, minor and ventral folds, and the posterior gizzard constrictor muscle. Particularly heavy innervations are found about the vestibular region and the enlargement of the major fold there.

From the pylorus the gastric nerves pass down over the intestine to either side of the proximal base of the cecum. The left nerve runs on the left dorsal side of the pylorus and under the hepatic duct of the posterior liver lobe; the right nerve hugs the right dorsal side of the pylorus reaching beneath the hepatic duct to the anterior liver lobe, and extends over the atrium into the intestine. Both nerves undergo considerable ramification as they spread out over the walls of the pro- and midintestines, becoming, respectively, the *prointestinal* (ip) and the *midintestinal nerves* (im). A large branch of the left gastric nerve, the *typhlosolic nerve* (t), inserts itself into and follows through the tissue of the typhlosole and the intestinal raphe. The prointestinal pellet-compressor is fully innervated by the prointestinal nerves as they pass down the intestine. Branches of the gastric nerves could be traced only into the anterior lengths of the postintestine with the technics employed; nor could branches of the genital, columellar, or internal pallial nerves which penetrate the rectal sinus, be found reaching over the postintestine or rectum.

Innervation of the remaining gastric regions is brought about by nerves leading from the *dorsogastric nerve plexus* (dp; fig. 25); this is a nerve center composed of a large number of giant intestinal ganglionic cells and nerve fibers and is located on the vantage position of the hepatic vestibule, slightly to the front of the proximal base of the cecum. The plexus makes connection with the gastric nerves by means of two stout nerves. It sends one nerve also out over the ventral pyloric fold, others over the vestibule, the atrium and the cecum. Most numerous and conspicuous are those nerves sent posteriad into the lobules of the posterior liver lobe. This heavy ramification spreads over the surface of the duct and is soon lost in the glandular mass of the liver. Smaller nerves are sent also to the anterior liver lobe. The ganglionic cells of the plexus are most concentrated directly over the vestibule and diminish in number out over the hepatic ducts and pylorus. They exist in varying numbers throughout the pylorus, liver, gizzard, crop, esophagus, buccal mass, and intestine. In the gizzard, as found also by Heidermanns (1924), these cells are most numerous in the subepithelial connective tissue layer between the epithelium and the muscle layers. The largest cells are found in the dorsogastric plexus embedded in the vestibular vascular arborescence and measure about 80μ in diameter. A second nerve center, the *ventrogastric nerve plexus* (pv; fig. 25) is found on the ventral efferent external surface of the hepatic duct leading from the posterior liver lobe, and partly adjacent to the posteroventral proximal base of the cecum. This plexus is relatively inconspicuous and is composed of noticeably smaller ganglionic cells and nerve threads which lie in the path of the left gastric nerve. The plexus is in communication with the dorsogastric plexus by means of the complex network of nerves which interlace throughout this heavily innervated stomach region. The gastric nerves also intercommunicate by anastomoses which may occur anywhere between them over the crop, gizzard or pylorus. The nervous picture found in the stomach region of *L. s. appressa* is in agreement with that described by Heidermanns (1924), with one major exception: Heidermanns states that both gastric nerves pass directly into the liver; in *L. s. appressa* this was not found to be the case.

The dorsogastric plexus anastomoses with the central nervous system by way of ramifications of the splanchnic nerve: the *intestinal nerve* (in) and the *gonadal nerve* (o; fig. 25). The intestinal nerve passes to the rear along the cephalic artery, and after sending off the *cardiac nerve* (cr) to the pericardium, reaches the junction of the cephalic, dorsovisceral, ventrovisceral and aortic arteries. At a point where this arterial branching presses against the right lobe of the gizzard the intestinal nerve enters a small group of ganglionic cells, comprising the *intestinal complex* (ci). The complex sends minute nerves out over the arteries, to the gizzard lobe, into the connective tissue, and two large intestinal nerves rearward to the dorsogastric plexus. One of these intestinal nerves passes along the pylorus, and the other by way of the cecum. The gonadal nerve arises from the genital nerves and extends posteriad over the hermaphroditic duct to the ovotestis, passing over the prointestinal loop and the connective tissue of the dorsal surface of the stomach region. Several ganglionic cells are evident along its course. At a point over the pylorus, it sends a fine nerve ventrad which anastomoses with the dorsogastric plexus. Several ganglionic cells are present at the source of the anastomosing nerve.

Discussion. Schmalz (1914) gives the names of anterior, median, and posterior buccal to the buccal nerves in *Helix pomatia.* These do not appear to fit the case in *L. s. appressa,* and probably correspond as follows with the terms which have been suggested here for *L. s. appressa:* dorsobuccals, laterobuccals and ventrobuccals, respectively. The two gastric nerves he terms the posterior gastric nerves. The anterior companions to the posterior gastrics he refers to as the anterior gastrics, which in *L. s. appressa* correspond either with the anterior esophageal or the dorsobuccal nerves. Other terms here introduced to designate nerves described in this section are: collostylar, anterior esophageal, posterior jugalis, proesophageal, postesophageal, ingluvial, pyloric, vestibular, dorso- and ventrogastric plexi, typhlosolic, intestinal, intestinal and splanchnic complexes, prointestinal, midintestinal and gonadal.

Unquestionably the densest nerve patterns of the alimentary system in *L. s. appressa* are found in the stomach region, particularly about the pylorus. This is perhaps indicative of the significant role played by this portion of the digestive tract. The second densest innervation is that located in the buccal mass. This could be anticipated from the complexity of the musculature and the intricacy of the movement of this organ in food getting.

SUMMARY OF THE NERVES PASSING TO THE ALIMENTARY SYSTEM OF *L. s. appressa*

(arranged according to the source of the nerves)

1. Cerebral Ganglia, gc
   a. buccal ganglia, gb
      1. gastric, gr, gl
         a. proesophageals, ep
         b. postesophageals, et
         c. ingluvials, i
         d. pyloric, p
         e. hepatic, h
         f. vestibular, v
         g. dorsogastric plexus, pd
         h. ventrogastric plexus, pv
         i. prointestinals, ip
         j. typhlosolic, t
         k. midintestinals, im
      2. salivary, s
      3. anterior esophageals, ea
      4. dorsobuccals, bd
      5. posterior jugalis, jp
      6. laterobuccal, bl
      7. ventrobuccal, bv
      8. buccocerebral connective, bcc
      9. buccal connective, bc
         a. buccal retractor, br
      10. postbuccal, bt
         a. right postbuccal, btr
         b. left postbuccal, btl
            1. collostylar, pp
   b. superior labials, ls
      1. frontals, f
      2. dorsolabials, ld
   c. inferior labials, li
      1. ventrolabials, lv
      2. velars, vl
   d. tentaculars, tt
      1. optics, to
   e. penial, pe

2. Right Parietal Ganglion, gpar
   a. anterior pallial, pla
      1. internal pallial, pli
         a. anal, a
   b. right pallial, plr
3. Left Parietal Ganglion, gpal
   a. left pallial, pll
4. Abdominal Ganglion, ga
   a. aortic, ao
   b. splanchnic, sp
      1. columellar, c
      2. genitals, g
         a. gonadal, o
      3. cardiac, cr
      4. intestinal, in
         a. intestinal complex, cin
   c. median pallial, plm
      1. internal pallial, pli (anastomosis)
   d. ventropallial, plv

DISCUSSION

Embryological evidence for the specialization and differentiation of the simple embryonic alimentary tube to give the fully developed alimentary system of the mature snail is supplemented by information obtained from a study of the configuration, vascularization, innervation and particularly the muscularity of the adult system. This is in keeping with Amaudrut's theory (1898) that the complex buccal mass arose from a simple invagination of the cephalic integument, and Heidermanns' suggestion (1924) that the gizzard developed in front of the first flexure of the midgut. The fact that the thin cuticular layer covering the gizzard lobes internally is not chitinous in contrast to the thicker chitinous layers of the buccal cavity, may suggest the relatively more recent phylogenetic appearance of the gizzard as compared to that of the buccal mass. The various coilings of the intestine about the other organs attest the extent to which this part of the alimentary system has followed the spiral turning of the visceral hump over the foot in the embryological development of the individual. Torsion of the tract itself at the crop and postesophagus is made conspicuous by the course of the esophageal folds, the gastric nerves and the cephalic artery over this region.

SUMMARY

1. The alimentary system of *L. s. appressa* is composed of the following morphologically (histologically and functionally—see later papers) distinct parts: buccal mass, buccal glands, salivary glands, proesophagus, postesophagus, crop, gizzard, pylorus, liver lobes, cecum, prointestine, midintestine, postintestine and rectum.

2. Forty morphologically distinct muscles are described for the alimentary tract. The majority of these are concerned with the manipulation of the complex mouth parts of the buccal mass. The stomach region is next in muscular complexity, but does not compare with the buccal mass in the intricacy of muscular specialization.

3. The arterial system of *L. s. appressa* is composed of a much-branching system of arteries and capillaries. About fifty distinct arteries are described. The capillaries pass over the walls of the organs and empty into the hemocoels surrounding them by means of ostioles. The venous system is composed of successive series of open sinuses, the largest being the cephalic and the visceral hemocoels. The alimentary system receives the greatest number of arterial vessels and consequently the largest volume of blood of any of the body organs.

4. The alimentary system is innervated by a densely ramifying system of nerves and by variously distributed giant ganglionic nerve cells. The pair of gastric nerves passing from the buccal ganglia supply the majority of the nerves from the buccal mass to the intestine. The large splanchnic nerve from the abdominal ganglion sends an intestinal nerve to the pylorus where it anastomoses with the gastric nerves in the gastric plexuses. These are conspicuous concentrations of the ganglionic nerve cells and mark the site of greatest innervation of the alimentary system. Some fifty separate nerves are described.

5. Morphological study indicates that torsion of the gut has occurred at the crop and postesophagus.

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MAPLE SUGAR: A BIBLIOGRAPHY OF EARLY RECORDS. II.*

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A continuation of the search of early American narratives of travel and books on natural history, inclusive of diaries, journals and official communications, in the rich collection of the State Historical Society of Wisconsin has uncovered sufficient material to warrant publication of another communication on the subject of a typically American food. It is quite apparent that a chronology of maple sugar records as observed in the voyages of exploration, missionary activities, colonization with its economic problems, the botanizing travels of Bartram, Nuthall, Michaux, and Kalm, Indian lore, the Lewis and Clark expedition, the slavery issue, technological advancement, and the rise of food adulteration, is in a sense a segment of North American history itself.

Observation of maple trees in Canada during the sixteenth century is attributed to Cartier (1540), discoverer of the St. Lawrence river. Champlain (1603) unquestionably observed these trees and Hariot reported them in Virginia in 1590.

The fact that maple trees were tapped for their sap was mentioned early in the seventeenth century but the production of sugar was not recorded until much later in the century. The question of whether the Indians made sugar or even syrup is controversial. The writings of Thornton (1684), an anonymous author (1685), Beverly (1722), Keating (1824), Lahontan (1703), and Verwyst (1744) permit the assumption that sugar-making was probably a native art. Charlevoix (1721), on the

* For Part I see *Trans. Wisconsin Acad. Sci.* 29:1935, 209–236.

other hand, contended that while they made constant use of the sap, the Indians learned from the white man how to make sugar. If this is true the knowledge certainly spread among the natives with great rapidity as did modifications in the process of concentrating sap, such as freezing or the addition of hot stones.

Interest in maple sap as a significant source of supply of sugar was particularly marked around 1800. The production of maple sugar was encouraged as a means of freeing the country of the need to import cane sugar from the West Indies. As the slavery issue became acute maple sugar production was cited as a means of combatting slavery.

Chemical interest is first noted in the records of Boyle (1664), but not until late in the ninteenth century do chemical analyses appear. Scientific investigation became necessary at this time when food adulteration became so flagrant that control legislation became essential.

73. Cartier, Jacques 1535

Bref recit, & succincte narration, de la nauigation faicte es yles de Canada, Hochelage & Saguenay & autres, auec particulieres meuers, langaige, & cerimonies des habitans d'icelles: fort delectable â veoir. Paris, 1545, (a) p. 14; Richard Hakluyt, The Principal Navigations, Voyages, Traffiques, and Discoveries of the English Nation. London, 1600. Reimpression verbatim by Edmund Goldsmid. Edinburgh, 1889, Vol. XIII ii, (b) p. 109; J. P. Baxter, A. Memoir of Jacques Cartier, Sieur de Limoilou. His Voyages to the St. Lawrence. New York, 1906, (c) p. 145; H. P. Biggar, The Voyages of Jacques Cartier. Publications Public Archives Canada, No. 11, 1924, (d) p. 123.

a. (No mention of the maple in Cartier's book)

". . . Nous nommasmes ledict lieu saincte Croix, par ce que ledict iour y arrivasmes. Aupres d'iceluy lieu ya ung peuple, dont est seigneur ledict Donnacona, & y est sa demeurance qui se nomme Stadacone, qui est aussi bonne terre qui'l soit possible de veoir & bien fructiferete, pleine de fort beaulx arbres de la nature & sorte de France. Comme chesnes, ormes, fresnes, noyers, yfz, cedres, vignes, aubespines, qui portent le fruict aussi gros que prunes de damas, aultres arbres; . . ."

b. (The maple mentioned in Hakluyt's English version of Cartier's second voyage)[1]

"... we named it the holy Crosse, for on that day we came thither. Neere vnto it, there is a village, whereof Donnacona is Lord, and there he keepeth his abode: it is called Stadacona, as goodly a plot of ground as possibly may be seene, and therewithall very fruitfull, full of goodly trees euen as in France, as Okes, Elmes, Ashes, Walnut trees, Maple tres, Cydrons, Vines, and white Thornes, that bring foorth fruit as bigge as any damsons, ..."

c. (Occurrence of the maple in Canada revealed in a contemporary Cartier manuscript)

"... We named the said place St. Croix because we arrived there the said day. Near this place there is a people of whom the said Donnacona is lord, and there is his dwelling place, which is called Stadacone, which is as good land as it is possible to behold, and very fruitful, full of exceeding fair trees of the nature and kinds of France, as oaks, elms, ashes, nuts, plum-trees, maples, cedars, vines, white thorns, which bear fruit as big as damson plums."

d. (Occurrence of maple not revealed in copy of original Cartier manuscript)

"... Nous nommasmes ledict lieu *saincte Croix* pource que ledict jour y arrivasmes. Aupres d'icelluy lieu y a vng peuple dont est seigneur ledict Donnacona, et y est sa demeurance, lequel se nomme Stadacone, qui est aussi bonne terre qu'il soit possible de veoyr, et bien fructifferante, plaine de moult beaulx arbres, de la nature et sorte de France, comme chaisnes, hourmes, frennes, noyers, prunyers, yfz, seddrez, vignes, aubespines, qui portent

[1] The accounts of Cartier's first voyage to Canada, in 1534, all fail to record observation of the maple tree (érable, arable). An account of the second voyage, made a year later, was first published in book form in 1545 under the title *Bref recit.* This was translated into Italian and published, along with an account of the first voyage, in Ramusio's *Navigationi et Viaggi* (Venice, 1556). *Bref recit* apparently disappeared from circulation about this time. The only known existing copy was discovered in the British Museum more than two centuries later.

The source for Hakluyt's version of the first two voyages appears to be an English translation of Ramusio's book which he induced John Florio to make in 1580.

Baxter had access to three manuscripts, believed to be Cartier originals, in the Bibliothèque Nationale in Paris. He found none of them in exact agreement with *Bref recit* which he believed was printed from the one numbered 5653. He translated the one numbered 5589. Biggar used these same manuscripts, publishing a verbatim copy of 5589 as well as a translation. At the same time he collated the manuscript with 5653, 5644, and *Bref recit.* His work indicates that the maple tree was not mentioned in any of these works by Cartier.

fruict aussi groz que prunes de Damas, et aultre arbres, . . ."

74. Cartier, Jacques 1540

The third voyage of discouery made by Captaine Iaques Cartier, 1540. unto the Countreys of Canada, Hochelaga, and Saguenay. Richard Hakluyt. *Ibid.*, p. 149; H. S. Burrage, Editor. Early English and French Voyages. Chiefly from Hakluyt. 1534–1608. New York, 1906, p. 97.

(Earliest existing version of the third voyage records the maple in Canada)[2]

". . . Moreover there are great store of Okes the most excellent that ever I saw in my life, which were so laden with Mast that they cracked againe: besides this there are fairer Arables, Cedars, Beeches, and other trees than grow in France."

75. Alphonse of Xanctoigne, Jean 1542

Richard Hakluyt. *Ibid.*, p. 163. Here followeth the course from Belle Isle, Carpont, and the Grand Bay in Newfoundland vp the Riuer of Canada for the space of 230. leagues, obserued by Iohn Alphonse of Xanctoigne chiefe Pilote to Monsieur Roberval, 1542.

(The chief pilot of a colonizing party reports arables in Cartier's Canada)

". . . and in all these Countreys there are okes, and bortz, ashes elmes, arables, trees of life, prusse trees, ceders, great wall nut trees, and wilde nuts, hasel-trees, wilde peare trees, wilde grapes, and there have been found redde plummes."

76. Thévet, André 1575

La cosmographie universelle. Paris, 1575, pp. 1008–1016.

(Maple trees noted in Canada)

"Entre autres s'en trouve un, qu'ils nomment *Cotony*,[3] lequel est de la grosseur d'un gros noyer pardeçà. Cest arbre a esté long temps inutile & sans aucun proffit, iusques à ce que quelcun des nostres le voulans coupper, dés

[2] Cartier's third voyage of 1540 and the records of Jean Alphonse, chief pilot of Roberval's colonizing expedition in 1542, have come down to the present only through the English version of Hakluyt. He was chaplain to the British Ambassador in Paris in 1583 and, according to Biggar, possibly had access to original French manuscripts which have since been lost.

[3] Rousseau from whose monograph, La Botanique canadienne à l'époque de Jacques Cartier, (*Contributions du Laboratoire de Botanique de l'Universite de Montreal*, No. 28:1937, p. 29) these lines are quoted, opines that Thévet refers to the sugar maple.

tité; laquelle estant goustee, fut trouvee de si bon goust, que plusieurs l'esgalloient à la bonté du goust de vin, de sorte que plusieurs recueillerent de ceste liqueur en abondance, & ayda à rafraischir les nostres: Et pour voir & experimenter dont procedoit la source de ceste boisson, ledit arbre fut scié, le tronc duquel estant par terre, fut trouvé comme chose miraculeuse au coeur de l'arbre, une Fleur de lys bien effigiee. . . Les Canadeens n'oubliront pas l'excellence de ceste liqueur, & se souviendront tousiours de ceux qui en trouverent l'usage, veu la bonté de ce breuvage, meilleur pour vray, que celuy duquel auparavant ils usoient, comme plusieurs de leurs voisins."

77. Hariot, Thomas 1590

A briefe and true report of the new found land of Virginia. Franckfort, 1590, p. 23.

Of commodities for building and other necessary vses

"*Maple,* and also *Wich-hazle,* whereof the inhabitants vse to make their bowes."

78. Champlain, Samuel de 1603

Des Savvages, ou, Voyage de Samvel Champlain, de Brovage, fait en la France novvelle l'an mil six cens trois. Paris, 1603, Vol. I, Chap. VIII; H. P. Biggar, Editor, The Works of Samuel de Champlain. Toronto, 1922, Vol. I, p. 144.

(Maple trees observed in Richelieu River region)

". . . I went in a canoe to the south Shore, where I saw a number of islands, very productive of fruits, such as grapes, walnuts, hazelnuts, and a kind of fruit like chestnuts, cherries, oaks, aspens, poplars, hops, ash, maple, beech, cypress, very few pines and fir trees."

79. Smith, John 1616

A Description of New England: or the Observations, and Discoveries, of Captain *Iohn Smith* (Admirall of that Country) in the North of *America,* in the year *of our Lord* 1614: *with the successe of sixe Ships, that went the next yeare* 1615; *and the* accidents befell him among the *French men of warre.* London, 1616. *Coll. Mass Hist. Soc.,* [3] 6, 120 (1837).

(Maple tree not noticed)

Oak is the chief wood, of which there is great difference in regard of the soil where it groweth, fir, pine, walnut, chestnut, birch, ash, elm, cypress, cedar, mulberry, plum-tree, hazel, sassafras, and many other sorts.

80. Lescarbot, Marc 1617

Histoire de la Nouvelle-France. Paris, 1866, new ed., Vol. III, (a) p. 750, (b) p. 815; W. L. Grant, The History of New France. Toronto, 1914, Vol. III, (a) p. 194, (b) 256.

a. (Sap as thirst-quencher)

". . . And we in France are troubled when we have lost our way ever so little in some great forest. If they are tormented with thirst, they have the skill to suck certain trees, whence tricles a sweet and very pleasant liquor, as I myself have sometimes proved."

b. (Forest trees)

"As for the trees of the forests, the most common in Port Royal be oaks, elms, ashes, birch (very good for joiner's-work), maples, sycamores, pine-trees, fir-trees, whitethorns, hazel-trees, willows, bay-trees, and some others besides which I have not yet marked."

81. Sagard, Gabriel 1632

Le Grand voyage du pays des Hurons situé en l'Amerique vers la mer douce, ès derniers confins de la Nouvelle France dite Canada. Paris, 1632, pp. 102 and 331; W. F. Ganong. The Long Journey to the Country of the Hurons. Toronto, 1930, (a) p. 82, (b) p. 240.

a. (Beech sap as a tonic)

". . . In the season when sap is rising in the trees we would sometimes make an incision into the bark of some big beech, and holding a bowl underneath get the juice and liquid which dropped from it; this served us as a tonic for the digestion whenever we were indisposed in that way. It is, however, a very crude remedy and of little effect, which sickens rather than strengthens, and the reason we employed it was the lack of any other substance more suitable and better. . . ."

b. (Forest trees)

"In the woods there are many cedars, called *Asquata,* very fine large oaks, beeches, maples, wild cherry trees, and a great number of other trees of the same species as ours, . . ."

82. Boucher, Pierre 1664

Histoire véritable et natvrelle des moevrs et Prodvctions dv pays de la Novvelle-France vvlgairement dite le Canada. Paris, 1664; B. Sulte, 1896. Pierre Boucher et son livre. *Proc. Trans. Roy. Soc.* Canada, [2] 2 i, 134.

(Water from the maple)

"Il'y a vne autre esspece d'arbre, qu'on apelle Herable, qui vient fort gros & haut: le bois en est fort beau, nonobftant quoy on ne s'en fert à rien qu'a brüler, ou pour emmancher des outils, à quoy il est trespropre, à cause qu'il est extremémet doux & fort. Quand on entaille ces Herables au Printeps, il en dequote quantité d'eau, qui est plus douce que de l'eau détemplée dans du sucre; du moins plus agreable à boire."

83. Boyle, Honourable Robert 1664

Some considerations Touching the Vsefvlness of Experimental Natural Philosophy. Oxford, 1664, 2 ed. p. 102.

(Sugar from trees in Massachusetts)

"Since the writing of these last lines, being visited by an ancient *Virtuoso,* Governour to a considerable Colony in the Northern *America,* and inquiring of him, among other particularities touching his *Countrey,* something in relation to the thoughts I had about the making of several kinds of Sugar, he assured me, upon his own Experience, that there is in some parts of *New England,* a kind of Tree, so like our Walnut-trees, that it is there so called; whose juice, that weeps out of its Incision &c. if it be permitted slowly to exhale away the superfluous moisture, doth congeal into a sweet and saccharine substance: and the like was confirmed to me, upon his own knowledge, by the Agent of the great and populous Colony of the Masathusets."

84. Hubbard, William 1680

A General History of New England from the discovery to MDCLXXX. Boston, 1815. *Coll. Mass. Hist. Soc.*, [2] 5, 24 (1815).

(Maple trees in colonial New England)

"... the same trees, plants and 'shrubs', roots, herbs and fruits being found either naturally growing here that are known to do in the northern countries of the like climate of Europe, and upon trial have been found as effectual in their operation, and do thrive as well when transplanted; as the oak, walnut, ash, elm, maple. . . ."

85. Hennepin, Louis 1698

A Continuation of the New Discovery of a Vast Country in America, Extending above Four Thousand Miles, between New France and New Mexico with a Description qu'il l'eut touché au vif, en feit sortir une liqueur en quan-of the Great *Lakes, Cataracts, Rivers, Plants,* and *Animals.* London, 1698, (a) Bon ed., p. 147; (b) Tonson ed., p. 153.

a. (Maple sap a sovereign remedy)

". . . Our common Drink was fair Water, which we took out of the Springs, Rivers or Lakes; but if any of us were indisposed at the time when the Trees were in Sap, more especially if he were afflicted with an Oppression or Weakness of the Stomach, we usually made a Cleft in the Bark of a Maple-Tree; out of which issued forth a kind of sweet Liquor, which was receiv'd into a Dish made of Birch-Tree Bark: This Liquor was drank as a Sovereign Remedy, altho in reality the effects of it were not very considerable. There are great store of Maple-Trees growing in the Vast Forests of those Countries, and Distill'd Waters may be drawn from them: Insomuch that having caus'd them to boil for along time, we made a Reddish sort of Sugar, much better than that which is taken from the ordinary Canes in the *Islands* of *America.*"

b. (A kind of reddish sugar from maple sap)

". . . Our ordinary Drink was Water. If any of us was indisposed, while the Sap was up in the Trees, we made a hole in the Bark of a Maple, and there dropt out a sweet Sugar-like Juice, which we saved in a Platter made of the Bark of a Birch-tree; we drank it as a Souvereign Remedy, tho it had but small effects. There are in the Vallies of those Forests great store of Maples, from whence may be drawn distill'd Waters. After a long boiling, we made of it a kind of reddish Sugar, much better than that which is drawn from the ordinary Cane in the Isles of *America.*"

86. Penicaut 1701

Relation de Penicaut. Pierre Margry, Decouvertes et Etablissements des Francais dans l'ouest et dans le sud du L'Amerique Septentrionale (1614–1754) Memoires et Documents Originaux. Paris, 1883, Vol. V, p. 417; R. G. Thwaites, Editor, The French Regime in Wisconsin. 1634–1729. *Wisconsin Hist. Coll.,* 16, 196 (1902).

(Maples near Le Seuer's fort on the Mississippi)

"There are also more different species of trees than are found on the lower river—for instance, of the wild cherry, maple, and *plaine,* (red or swamp maple, *Acer rubrum.* ed.) and of the poplar, a tree which grows so large that some specimens of it are five brasses in circumference. As for the trees called "maple" and *plaine,* incisions are made in them early in March, and a tube is placed in each incision to catch the sap; this passes through the tube and falls into a vessel, which is placed underneath to receive it. These trees flow abundantly during three months, from the first of March to the end of May; the Water which they distill is very sweet; to preserve it, this is boiled until it becomes a syrup, and if it is boiled longer it turns to sugar."

87. Neville, Ella H., Sarah G. Martin, and Deborah B. Martin 1703

Historic Green Bay. Green Bay, 1893, p. 70.

(Louis baron de Lahontan honored)

"A marvelous banquet was served by the Indians in the baron's honor, at which the guests were seated in oriental fashion on the green sward, under the lofty trees.

Successively they partook of whitefish boiled in water, cutlets of the tongue of buck, followed by hazel hen—a fowl fattened on nuts—a bear's paw, and, greatest delicacy of all, the tail of a bear. Then came a bouillon prepared from a variety of meats, the whole washed down by what the baron calls a most delicious liquor, made of maple sugar, beaten up with water."

88. Dièreville 1708

Relation du Voyage du Port Royal de L'Acadie ou de Lanouvelle France. Rouen, pp. 108–110; L. U. Fontaine, Voyage du Sieur de Diéreville en Acadia. Quebec, 1885, p. 61; John C. Webster, Relation of the Voyage to Port Royal in Acadia or New France. Toronto, 1933, pp. 117 and 270.

(Strawberries and maple sugar)

". . . Strawberries are no less plentiful in the fields everywhere, one has the pleasure of eating them with a Sugar produced in the Country.

Instead of Canes, whose Pores secrete
White Sugar, brought from afar,
Nature, for the Acadian, with kind
Forethought, has put some in the Sycamore.[4]
When Springtime comes, this tree gives forth
A sweetish liquor from its bark,
And this, in each vicinity,
The Settlers all collect with care.
This seemed a pleasant brew to me
In copious draughts I drank it down;
And Lemons only did we need
To make it into Lemonade.

To obtain this sweet Liquor, which is as clear as Spring water, a hole, fairly deep, shaped like a trough, is made in the tree with an axe, a frame of bark is joined to this reservoir, so that the sap, as it flows, may drop into it. When it is full, which occurs quickly enough, for the sap at this time is in its greatest vigour, the fluid runs by means of a little scupper attached to the trough,

[4] This is an incorrect designation as the true sycamore did not grow in Acadia. Dièreville means the sugar maple. Europeans used the term sycamore maple, to designate a native species, *Acer psuedo-platanus*.

into a vessel at the base of the tree. Several trees are treated in this way at the same time, so that a quantity of fluid is obtained, which is carefully collected each day as long as it is forthcoming. It is boiled in a large cauldron until the drying point is reached; as it condenses little by little, it becomes a Syrup, & then a reddish Sugar which is very good."

89. Byrd Family, Member of 1729

Letters of the Byrd Family. *Virginia Mag. Hist.*, **36**, 117 (1928).

(The sugar tree in Virginia)

"To Mr. Warner in England July, 1729 (Virginia)

"As it was our Fortune to pass over all sorts of ground, we saw many new plants, the most remarkable of which was, the Sugar Tree, which grows as tall, as an Elm, and big in proportion. By Tapping this Tree in the Spring, a Liquor issues out of it, which may be boiled into good sugar. I shall endeavor to get you one of these, against the return of the Ships, and every thing else, that I believe may be agreeable."

90. Anon. 1730

Observations Botaniques III.

Histoire de l'Academie Royale des sciences, Paris, 1730, 65; l'Abbé Laflamme, Michael Sarrazin: Matériaux pour servir à l'histoire de la science en Canada. *Proc. Trans. Roy. Soc. Canada,* 5, iv, 21 (1887).

(A report on the maple tree)

"M. Sarrazin, Medecin de Quebec, Correspondant de l'Academie, a trouve dans l'Amerique Septentrionale quatre especes d'Erable qu'il a envoyees au Jardin Royal, apres leur avoir impose des noms. La 4^{me} qu'il appelle *Acer Canadense Sacchariferum, fructu minori. D. Sarrazin,* est un arbre qui s'élève de 60 à 80 pieds, dont la sève qui monte depuis les premiers jours d'Avril jusqu'a la moitié de Mai est assez souvent sucrée, ainsi que l'ont aisément reconnu les Sauvages & les François. On fait à l'arbre une ouverture, d'ou elle sort dans un vase qui la reçoit, & en la laissant évaporer, on a environ la 20^{me} partie de son poids, qui est de véritable sucre propre à être employé en confitures, en sirops, &c. Un de ces arbres qui aura 3 ou 4 pieds de circonférence, donnera dans un printemps, sans rien perdre de sa vigueur, 60 à 80 livres de seve. Si on en voulait tirer davantage, comme on le pourrait, il est bien clair qu'on affoibliroit l'arbre, & quo'on avanceroit sa vieillesse.

"Cette sève pour être sucrée demande des circonstances singulières, qu'on ne devineroit pas, & que M. Sarrazin a remarquées par ses expériences. 1°. It faut que dans le temps qu'on la tire, le pied de l'arbre soit couvert de neige, & il y en faudroit apporter, s'il n'y en avait pas. 2°. Il faut qu'ensuite cette neige soit fondue par le soleil, & non par un air doux. 3°. Il faut qu'il ait gelé la nuit précédente. Cette espèce de manipulation, dont la nature se sert pour faire le sucre d'Erable, ressemble assez à quelques opérations délicates de Chymie, où l'on fait des choses qui paroissent opposées, où celles qui paroissent le plus semblables ne sont pas équivalentes pour l'effet.

"Encore une remarque curieuse de M. Sarrazin, c'est que le sève de tel Érable qui ne sera point bonne à faire du sucre, le deviendra une demi-heure, ou tout au plus une heure après que de la neige, dont on aura couvert le pied de l'arbre, aura commencé à fondre. Cette neige s'est donc portée dans les tuyaux de l'Érable, & y a opéré avec une grande vîtesse."

91. Bartram, John 1743

Observations on the Inhabitants, Climate, Soil, Rivers, Productions, Animals, and other Matter Worthy of Notice in his Travels from Pensilvania to Onondago, Oswego and the Lake Ontario. London, 1751, (a) p. 28, (b) p. 39, (c) p. 71.

a. (Sugar maple in Pennsylvania)

"The 15th, we set out a N.E. course, and passed by very thick and tall timber of beach, chestnut, linden ash, great magnolia, sugar-birch, sugar-maple, poplar, . . ."

b. (Sugar maples along the Susquehanah river)

". . . we descended easily for several miles, over good land producing sugar-maples many of which the *Indians* had tapped to make sugar of the sap, . . ."

c. (Parched corn and maple sugar)

". . . They take the corn and parch it in hot ashes, till it becomes brown, then clean it, pound it in a mortar and sift it, this powder is mixt with sugar."

92. Verwyst, Chrysoston 1744

Historic sites on Chequamegon Bay. *Wisconsin Hist. Coll.*, 13, 429 (1895).

(Maple sugar made by Indians along the Swamp River)

"Mashki-Sibi (Swamp River, misnamed Bad River): About two miles up this river are pictured rocks, now mostly covered with earth, on which in former times Indians engraved in the soft stone the images of their dreams, or the likenesses of their tutelary manitous. Along this river are many maple groves, where from time immemorial they have made maple-sugar."

93. Kalm, Peter 1749

Travels into North America. J. R. Forster, trans. London, 1772, Vol. II, 2 ed., p. 411.

(Sugar from the juice of the maples and the sugar-birch)

They boil a good deal of sugar in *Canada* of the juice running out of the incisions in the sugar-maple, the red maple, and the sugar-birch; but that of the first tree is most commonly made use of. The way of preparing it has been more minutely described by me in the Memoirs of the Royal Swedish Academy of Sciences.

94. B., J. C. 1751–1761

Voyage au Canada, dans le nord de l'Amerique Septentrionale, fait depuis l'an 1751 a 1761; H. R. Casgrain, Editor. Quebec, 1887; Travels in New France, S. K. Stevens, D. H. Kent, Emma F. Woods, Editors. Pennsylvania Historical Survey, Harrisburg, 1941, p. 93.

(A most remarkable tree in the Ohio Country)

"The maple is the most remarkable of all these trees, because every year, in February and March, there exudes from this tree an abundant flow of a delicious, sweet and clear liquid which is fragrant and very wholesome. The tree will die, however, if it is used too often.

"Maple sap can be drawn from the same tree for five or six consecutive days, if care is taken to make new grooves every day always on the side toward the noonday sun. This must be, too, when it has been cold the night before, and when there is bright sunshine without a cold, fierce wind. It can be determined that the tree contains no more sap when the sap appears whitish and runs slowly.

"When it is at that stage, vinegar or a drink like cider can be made from it, if you go on extracting, but it still must be boiled down into sugar.

"Maple sap must be cooked for two full hours to make syrup, and two more hours to make sugar, which is always brown. It is very good for the lungs and never causes heartburn. Maple sugar is made into small cakes like chocolate so that it can more easily be carried on trips. It keeps a long time if dry, otherwise becoming moldy, spoiling because of dampness. Maple trees usually have large growths on them, which are cut and dried in the sun, making a sort of touchwood which Canadians call *tondre.*

"The plane-tree, the wild cherry, the ash, and the walnut, also produce sap which yields sugar. But as the flow is much less and the sugar not so good, it is almost never made. Maple sugar, therefore, is most used in Canada, as much as white sugar is used. . . . Maple sugar is very easily digested."

95. Barney, George 1755

The history of the Town of Swanton in Franklin County. Vermont Historical Gazetteer, Vol. IV, p. 957 (1882).

(Indians made maple sugar at Missisqoi)

". . . From Dr. Belknap's History of New Hampshire we learn that in 1755, the Indians in the vicinity of Missisqoi were in the habit of tapping the maples in spring, and making sugar. This perhaps was no more than they had been accustomed to do for many years. . . ."

96. Dodge, J. R. 1755

Red Men of the Ohio Valley. Springfield, O., 1860, (a) p. 30, (b) p. 85.

a. Their Character and Customs

"Impelled by hunger, a supply of wild fowl, fat raccoons, deer and bears, was secured; at the proper season, a quantity of maple sugar made; then, with hominy, which became a luxury with a dressing of bear's fat and sugar, the feast would be prolonged, day after day, till all was gone; . . ."

b. Narrative of Colonel James Smith

"This Wyandot encampment consisted of eight hunters, and thirteen squaws, boys and children. . . . In February, they commenced sugar making. First, the squaws, finding an elm that would strip at this season, cut it down, and with a crooked stick, broad and sharp at the end, took the bark from the tree, and of this bark curiously wrought vessels holding about two gallons each, making more than a hundred in number. In the sugar-tree, they cut a sloping notch, at the lower extremity of which they struck a tomahawk, and, in the cut, drove a long chip to convey the sap to the vessels. They notched only the trees of two feet or more in diameter, so plenty and large were they. They had bark vessels of four gallons each, two brass kettles of fifteen gallons each, and, as they could not boil the sap as fast as collected, they had large vessels of bark, holding about one hundred gallons each.

"Their mode of using sugar was by putting it on bear's fat, until the fat was almost as sweet as the sugar itself, and in this was dipped the roasted venison—by no means an unpalatable morsel."

97. Gautier, Jean François 1755

Histoire du sucre d'érable. *Acad. Roy. Sciences, Mem. math. phys.*, 2, 378–392 (1755).

(Adulterated maple sugar)

Described is not only the preparation of syrup and sugar in Canada from the sap of the maple (*Acer canadense, folio tridenato*) but also experiments in support of the observations that the optimum meteorological conditions for the flow of sap are warm, sunny days with the wind blowing from the southwest, on which side of its trunk the tree should be tapped.

The addition of wheat flour to the syrup or sugar is a frequently practiced form of adulteration. Because the syrup prepared from the sap obtained at the end of the season is of poor quality, it is often flavored with an extract of maiden hair fern.

Maple sugar is used in the preparation of foods in the home; as a medicine it is deemed to be pectoral and emollient.

98. Alden, Timothy 1756

An Account of the Captivity of Hugh Gibson among the Delaware Indians of the Big Beaver and the Muskingum, from the latter part of July 1756, to the beginning of April, 1759. Boston, 1837. *Coll. Mass. Hist. Soc.*, [3] 6, 147 (1837).

(Indian Sugar Camp)

"Gibson and a little boy, of twelve years of age, went on a hunting expedition, were absent three days, killed two turkeys, and returned; but Bisquittam, whether suspecting the plan or not is unknown, was still at the place. He, with the little boy, again took a tour into the woods. They reached an Indian sugar camp the first evening, stole a horse and a bag of corn, rode several miles to a cranberry swamp, tarried there seven days, parched and ate their corn, threw away their bag, killed one turkey, and returned to the sugar camp."

99. Henry, Alexander 1760+

Travel and Adventures in Canada and the Indian Territories between the Years 1760-1765. New York, 1809, (a) p. 68, (b) p. 216, (c) p. 217.

a. (Sugar-making near the Sault de Sainte-Marie)

"The lands, between the Bay of Boutchitaouy and the Sault, are generally swampy, excepting so much of them as compose a ridge, or mountain, running east and west, and which is rocky, and covered with the rock or sugar maple, or sugar-wood (*Acer saccharinum*). The season for making maple-sugar was now at hand; and, shortly after my arrival at the Sault, I removed, with some other inhabitants, to the place at which we were to perform the manufacture. . . .

"The next day was employed in gathering the bark of white birch-trees, with which to make vessels to catch the wine or sap. The trees were now cut or tapped, and spouts or ducts introduced into the wound. The bark vessels were placed under the ducts; and, as they filled, the liquor was taken out in buckets and conveyed into reservoirs or vats of moose-skin, each vat containing a hundred gallons. From these, we supplied the boilers, of which we had twelve, of from twelve to twenty gallons each, with fires constantly under them, day and night. While the women collected the sap, boiled it, and completed the sugar, the men were not less busy in cutting wood, making fires, and in hunting and fishing, in part of our supply of food.

"The earlier part of the spring is that best adapted to making maple-sugar. The sap runs only in the day; and it will not run unless there has been a frost the night before. When in the morning there is a clear sun, and the night has left ice of the thickness of a dollar, the greatest quantity is produced.

". . . we hunted and fished, yet sugar was our principal food, during the whole month of April. I have known Indians to live wholly upon the same, and become fat."

b. (Sugar maples at Michipicoten)

"The country, immediately contiguous to my wintering-ground, was mountainous in every direction; . . . On the summits of some of the mountains there were sugar-maple trees; but, with these exceptions, the uplands had no other growth than spruce-firs and pines, nor the low-lands than birch and poplar."

c. Maple-sugar making

"In the beginning of April, I prepared to make maple-sugar, building for this purpose a house, in a hollow dug out of the snow, the house was seven feet high, but yet was lower than the snow.

"On the twenty-fourth, I began my manufacture. On the twenty-eighth, the lands below were covered with a thick fog. All was calm, and from the top of the mountain not a cloud was to be discovered in the horizon. Descending the next day, I found half a foot of new-fallen snow, and learned that it had blown hard in the valleys the day before; so that I perceived I had been making sugar in a region above the clouds.

"Sugar-making continued till the twelfth of May. On the mountain, we eat nothing but sugar, during the whole period. Each man consumed a pound a day, desired no other food, and was visibly nourished by it."

100. Anon. 1765

The Annual Register, or a View of the History, Politics, and Literature for the Year 1765. London, 1778, 2 ed., Vol. VIII, Chronicles, p. 141.

(New method of obtaining sugar and melasses)

"A very singular method of obtaining sugar and melasses has been lately introduced in New England, especially at a place called Bernardston, almost twenty miles from Athol; and as the vegetable, from which that valuable article may be obtained by this new method, grows in the coldest climates, it promises great advantages to mankind, especially in those countries, which, like New England, are already plentifully stocked with it by the hand of nature. This vegetable is no other than the maple-tree. The process in Bernardston is as follows. Having chosen out a large tree, suitable for the purpose, they with an axe box it, much after the same manner, that they box that kind of fir, which produces turpentine. This being done, they prepare a kind of trough, extending from the trunk of the tree on each side, in order to retain the sap as it runs down. By this means they have obtained upwards of thirty gallons from one tree in a day; which, being treated like the syrup proceeding from the sugar cane, produces a sugar equal in fineness of grain to the Jamaica sugar, and as pleasant to the taste; and the makers insist that it is a medicinal, and very popular to give children for the chin-cough, at this time very prevalent in New England. This sugar produces melasses, or treacle, very little, if anything, inferior to West Indian melasses. Of this sugar, above 600 lb. was made by one man during the last season, that is, from February last to April last inclusive; and several hundred weight of it were in July last brought for sale to Boston in New England, from various towns situated on the eastern and western parts of that province."

101. Pond, Mrs. Nathan G. *ca.* 1765

Journal of "Sir" Peter Pond. *The Conn. Magazine,* 10, (a) 244, (b) 245 (1906).

a. (Maple sugar traded at Mackinac)

". . . Hear I Met with a Grate meney Hundred People of all Denominations . . . Sum trading with the tribes that Came a Grate Distans with thare furs, Skins & Mapel Suga &c to Market."

b. (Maple sugar made near Mackinac)

". . . Most of the frenchmens wives are white women. In the spring they made a Grate Quantity of Maple Suga for the youse of thare families & for sale som of them."

102. Rogers, Robert 1765

A Concise Account of North America. London, 1765, p. 251.

(Loaf sugar from maple sap)

"The Indians, in the months of February and March, extract the juice from the maple-tree; which is wholesome and delicious to the palate. The way they extract it is by cutting a notch in the body of the tree, and by means of a piece of wood or quill, convey the juice from the tree to a vessel placed to receive it. The same tree may be tapped for several years successively. The liquor is as clear as spring-water, and is very refreshing. It is accounted a very good pectoral; and was never known to hurt any one, tho' he drank ever so freely of it. The liquor will not freeze; but, when kept any time, becomes excellent vinegar. The Indians, by boiling it, make from it a kind of sugar, but is milder, and answers all the ends of sugar for sweetening; and, no doubt, was it properly manufactured, might be rendered equal to that extracted from sugar-cane. A manufactory is begun in the Province of New York, near South Bay; which, I am told, answers very well; and produces considerable quantities of powder and loaf sugar."

103. Grignon, Augustin 1766–1816

Seventy-two years' recollections of Wisconsin. *Wisconsin Hist. Coll.*, 3, 255 (1857).

(Maple sugar used in fur trade at Green Bay)

"The early commerce of the country deserves a passing notice. . . . There was some considerable quantity of deer's tallow, saved by the Indians and sold to the traders, taken to Mackinaw, and some maple sugar; . . . But as there was much sugar manufactured around Mackinaw, not much was sent there to market; the Indians made large quantities as far back as I can remember. To the traders passing into the Indian country, cattle for beef were sold, sugar and tallow, potatoes and other vegetables. . . ."

104. Anon 1767

A New Collection of Voyages, Discoveries and Travels, etc. London, 1767, Vol. II, (a) p. 138, (b) p. 179.

a. (Beverage of the Souties or Attawawas)

"They, as yet, make very little use of spiritous liquors, nor do they manufacture any kind of drink, except the juice of the maple-tree, of which they likewise make sugar."

b. (Properties of maple sap)

"The Indians, in the months of February and March, extract the juice from the maple-tree, which is wholesome and delicious to the palate. The way they extract it is by cutting a notch in the body of the tree, and, by means of a piece of wood or quill, convey the juice from the tree to a vessel placed to receive it. The liquor is as clear as spring-water, and is very refreshing. It is accounted a very good pectoral, and was never known to hurt any one, though he drank ever so freely of it. The liquor will not freeze, but, when kept any time, becomes excellent vinegar. The Indians, by boiling it, make from it a kind of sugar, which has a taste very much like honey, but is milder: A manufactory of this kind of sugar is begun in the province of New York, near South Bay, which is said to answer very well; and produces considerable quantities of powder and loaf-sugar.

105. Crevecoeur, St. John de 1770–1774

Henri L. Bourdin, Ralph H. Gabriel and Stanley T. Williams, Editors. Sketches of Eighteenth Century America. More "Letters from an American Farmer," by St. John de Crevecoeur. New Haven, 1925, p. 98.

(Careful "bleeding" prolongs life of the tree.)

"In clearing his farm my father very prudently saved all the maple trees he found, which fortunately are all placed together in the middle of our woodland; and by his particular caution in bleeding them, they yield sap as plentifully as ever. The common method is to notch them with an axe. This operation, after a few years, destroys the tree entirely. That which my father followed is much easier, and gives these trees wounds which are almost imperceptible. The best time to make this sugar is between the months of March and April, according to the season. There must be snow on the ground, and it must freeze at night and thaw in the day. These three circumstances are absolutely requisite to make the sap run in abundance. But as my trees are but a little way from my house, I now and then go out and try them, and, as soon as the time is come, then I bring all my hands, and we go to work. Nothing can be simpler than this operation. I previously provide myself with as many trays as I have trees. These I bore with a large gimlet. I then fix a spile made of elder through which the sap runs into the trays. From them it is carried into the boiler which is already fixed on the fire. If the evaporation is slow, we are provided with barrels to receive it. In a little time it becomes of the consistency of syrup. Then it is put into another vessel and made to granulate. When in that state we cast it into little moulds made according to the fancy of the farmer. Some persons know how to purify it, and I am told that there are some people at Montreal who excel in this branch. For my part, I am perfectly well satisfied with the colour and taste which Nature has given it. When the trees have ceased to run we stop the holes with pegs made of the same wood. We cut them close to the bark, and in a little time the cicatrice becomes imperceptible. By these simple means our trees will afford sugar for a long time, nor have I ever observed that it impaired their growth in the least degree. They will run every year, according to the seasons, from six to fifteen days until their buds fill. They do not yield every year the same quantity, but as I regularly bleed two hundred trees, which are all I have, I have commonly received six barrels of sap in twenty-four hours which have yielded me from twelve to eighteen (pounds of sugar).

"Thus without the assistance of the West Indes, by the help of my trees and of my bees, we yearly procure the sweetening we want, and it is not a small quantity, you know, that satisfies the wants of a tolerable American family."

106. Le Page du Pratz **1774**

The History of Louisiana or of the Western Parts of Virginia and Carolina. T. Becket, translator. London, 1774, new ed., p. 240.

(An excellent stomachic)

"The maple grows upon declevities in cold climates, and is much more plentiful in the northern than southern parts of the colony. By boring it they draw from it a sweet syrup which I have drunk of, and which they allege is an excellent stomachic."

107. Buchanan, James *ca.* 1775

Sketches of the History, Manners, and Customs of the North American Indians. New York, 1824, Vol. I, p. 163.

(An episode at an Indian sugar-camp)

". . . One hope, however, still remained. The sugar-making season was at hand, and they were shortly to remove to their sugar camps, where he flattered himself his wife would not be followed by the disturber of his peace, whose residence was about ten miles from thence. But this hope was of short duration. They had hardly been a fortnight in their new habitation, when, as he returned one day from a morning's hunt, he found the unwelcome visiter at his home, in close conversation with his faithless wife. This last stroke was more than he could bear; without saying a single word, he took off a large cake of his sugar, and with it came to my house, which was at the distance of eight miles from his temporary residence."

108. Ansbury, Thomas 1776

Travels through the Interior Parts of America; in a Series of Letters. London, 1791, new ed., Vol. I, p. 80.

(Maple sugar used as a pectoral)

QUEBEC, November 5th 1776

"MY DEAR FRIEND,

. . .

"The maple tree yields in great quantities a liquor which is cool and refreshing, with an agreeable flavor. The Canadians make a sugar of it, a very good pectoral, and used for coughs. There are many trees that yield a liquor they can convert into sugar, but none in such abundance as the maple. You will, no doubt, be surprised to find, in Canada, what Virgil predicted of the Golden Age, *Et durae quercus subabunt roscida mella.*"

109. Askin, John 1778

Fur-trade on the upper lakes – 1778–1815. *Wisconsin Hist. Coll.*, 19, p. 243 (1910).

(Letter to Benjamin Frobisher mentions sugar)

"St. Cir arrived last night. I have delivered him the Canoes, all your Corn, Sugar, Gum, Bark & Watap now remaining here shall be delivered him to Day, all the rum coming up in the Canoes he shall also have. . . ."

110. Broadhead, Daniel 1780

Letters from Col. Daniel Broadhead. Pennsylvania Archives, Vol. XII, p. 212 (1856).

(Murders at sugar camp)

FORT PITT, March 8th, 1780

"DEAR GENERAL,

The savages have already begun their hostilities—last Sunday they killed five men at a Sugar Camp on Racoon Creek, Youghaghany County, and took prisoners three girls and three lads. It is generally conjectured that the Delawares perpetrated this Murder, but it is possible that it may have been Done by other Indians. . . .

Most Obed't Serv't.

DANIEL BROADHEAD

Directed
To His Excellency General Washington
By Mr. D. Duncan"

111. Alexander, M.T.C. 1784

Vermont Historical Gazetteer. Burlington, 1876, Vol. I, (a) p. 313, col. 1; (b) col. 2

a. Danville – to 1860

In recalling the activities of Capt. Charles Sias, a pioneer settler, the author states:

"... In three days more the effects were all removed, and the lone family began their hard labors upon the wilderness. They commenced by tapping the maples, which stood thick around them in the most beautiful groves, affording them sugar in abundance, and supplied, in a great degree, the lack of other food."

b. (Maple sugar an emergency food)

A too rapid increase in population caused a scarcity of provisions in 1789. In describing the conditions existing at that time, the author states:

"The sufferings of that time were very severe. Maple sugar formed the chief article of food. Like the manna of the ancient Hebrews, it was really a providence in the time of hunger and famine. No doubt, those stern old fathers blessed the forest trees that gave them food and life."

112. Brissot de Warville, J. P. 1788

Nouveau Voyage dans les Etats-Unis de L'Amerique Septentrionale, fait en 1788. Paris, 1791, Vol. II, p. 41; New Travels in the United States of America, including the Commerce of America. London, 1792, p. 301.

On replacing the Sugar of the Cane by the Sugar of the Maple

"On this continent, my friend, so polluted and tormented with slavery, Providence has placed two powerful and infallible means of destroying this evil. The means are, the societies of which we have been speaking, and the sugar-maple.

"Of all vegetables containing sugar, this maple, after the sugar-cane, contains the greatest quantity. It grows naturally in the United States, and may be propagated with great facility. All America seems covered with it, from Canada to Virginia; it becomes more rare at the southward, on the east of the mountains; but it is found in abundance in the back country.

"Such is the beneficent tree which has, for a long time, recompensed the happy colonists, whose position deprived them of the delicate sugar of our islands.

"They have till lately contented themselves with bestowing very little labour on the manufacture, only bringing it to a state of common coarse sugar; but since the Quakers have discerned in this production, the means of destroying slavery, they have felt the necessity of carrying it to perfection; and success has crowned their endeavors.

"You know, my friend, all the difficulties attending the cultivation of the cane. It is a tender plant, it has many enemies, and requires constant care and labour to defend it from numerous accidents: add to these, the painful efforts that the preparation and manufacture costs to the wretched Africans; and, on comparing these to the advantages of the maple, you will be convinced, by a new argument, that much pains are often taken to commit unprofitable crimes. The maple is produced by nature; the sap to be extracted, requires no preparatory labour; it runs in February and March, a season unsuitable for other rural operations. Each tree, without injury to itself, gives twelve or fifteen gallons, which will produce at least five pounds of sugar. A man aided by four children, may easily, during four weeks running of the sap, make fifteen hundred pounds of sugar.

"Advantages, like these, have not failed to excite the attention of the friends of humanity; so that, besides the societies formed for the abolition of slavery, another is formed, whose express object is to perfect this valuable production.

"Whenever these shall form from North to South a firm coalition, an ardent emulation to multiply the produce of this divine tree, and especially when it shall be deemed an impiety to destroy it, not only America may supply herself, but she may fill the markets of Europe with a sugar, the low price of which will ruin the sale of that of the islands—a produce washed with the tears and blood of slaves.

"What an astonishing effect it would produce, to naturalize this tree through all Europe! In France we might plant them at twenty feet distance, in a kind of orchard, which would at the same time produce pasture, fruits. and other vegetables. In this manner an acre would contain 140 trees, which, even when young, would produce three pounds of sugar a-year. This would give 420 pounds the acre, which, at threepence sterling the pound, and deducting one half for the labour, would yield annually 52 £. 6s. sterling, clear profit; besides other productions, which these trees would not impede. . . .

"Thus we should obtain a profitable production in Europe, and diminish so many strokes of the whip, which our luxury draws upon the blacks. Why is it, that, in our capital where the delicacy of sentiment is sometimes equal to that of sensation, no societies are formed, whose object should be to sweeten their coffee with a sugar not embittered by the idea of the excessive tears, cruelties and crimes, without which these productions have not been hitherto procured?—an idea which cannot fail to present itself to the imagination of every humane and enlightened man. Our devotees, our ignorant and inhuman priests, who never fail to be great lovers of coffee and sugar, would, by these means, be saved from the horrible part which they take in the most enormous crime on which the sun ever shown. In consuming these articles, do they not encourage those whose guilt is more direct in the operation of producing them? and yet, with what coldness, with what culpable indifference, do these pious men look upon our Society of the Friends of the Blacks."

113. Anon. **1792**

A plan for moderating the price of sugar. *The Bee, or Literary Weekly Intelligencer,* 7, 330.

(Sugar from the maple for Britain?)

"The present extravagent price of sugar has attracted the attention of every class of persons in this island, and has brought forward many plans for remedying that evil, some of which will no doubt take effect at some *future* period; but there is reason to suspect, that the nation must submit to the hardship for a good while, before things can be brought to bear.

"Among the first plans that was suggested for this purpose, was that of manufacturing sugar from the maple tree, in America. It has been long known, that the juice of one kind of maple, common in most of the American states, can afford a grained sugar, without any other process than that of evaporating the watery parts by boiling; but the quantity of water that requires to be dissipated, renders that process so tedious and expensive, in a country where labour is very high, as gives reasons to fear the assistance that can be derived from thence will be but very inconsiderable."

114. Biggs, Benj. 1793

Calendar of Virginia State Papers. Sherwin McRae, Editor. Richmond, 1886, Vol. VI, p. 307.

(Sugar making near Marietta, Ohio)

"I just Received authentick Intelligence of the capture of Major Goodall by the Savage, which happened near Bellspray on the Ohio, a small distance below Muskingum. About seven days previous to the capture a number of Kittles were taken from the Sugar Camp, within a small distance of Mariatta."

115. Allen, William 1794

The History of Norridgewock. Norridgewock, 1849, p. 99.

(Rum and maple sugar)

"In the summer of 1794, the meeting house was erected, and among other things preparatory to the raising, it was 'Voted to get one barrel of good W. I. Rum, and one-hundred pounds of maple sugar, to be used at the raising of the meeting house'."

116. Coxe, Tench 1794

A View of the United States of America, in a Series of Papers, Written at Various Times, between the Years 1787 and 1794. Philadelphia, 1794, (a) p. 65, (b) p. 77, (c) p. 453, (d) p. 455; Dublin, 1795, (a) p. 54, (b) p. 65, (c) p. 386, (d) p. 388.

a. (Sugar from the maple trees of Pennsylvania)

". . . A new article is added to the list of our productions, which is a well-tested and wholesome sugar, made of the maple tree. It has been proved, by many fair and careful experiments, that it is in the power of a substantial farmer, who has a family about him, easily to make twelve hundred weight of this sugar every season, without hiring any additional hands, or utensils, but those which are necessary for his family, and farm use. The time, in which it can be made, is from the middle of February to the end of March, when farmers in this country have very little to do, as it is too early to plough or dig. The price of sugar being lower here than in Europe, this article may be reckoned at one hundred and fifty dollars per annum, to every careful and skilful farmer, who owns land bearing the sugar maple. Of these there are some millions of acres in Pennsylvania and the adjacent states. It seems also highly probable, that this valuable tree may be transplanted, and thus be obtained by almost any farmer in the state; and that men of property, who will purchase kettles, and hire hands for the above short period, may make larger quantities."

b. (The possible value of maple sugar in certain parts of the United States)

". . . The easy and profitable practice of making sugar from the sap or juice of the maple tree, had prevailed for many years in the northern and eastern states. The facility and advantages of this pleasing branch of husbandry, had attracted little attention in Pennsylvania, though a few of its inhabitants were in the habit of manufacturing small quantities of this kind of sugar. In the year 1790, it became more generally known to the Pennsylvanians that their brethern in the eastern and northern parts of the union, had long made considerable quantities, with their family utensils, and without the expense of hiring assistance, that the same tree might be carefully tapped without injury for many successive years; that the process was simple and very easy, and only required to be carried on between the middle of February and the end of March when the farmer has little to do, and that a very large proportion of the unsettled lands of the state abound with this valuable tree. The great and increasing dislike to negro slavery, and to the African trade among the people of that state, occasioned this new prospect of obtaining a sugar, not made by the unhappy blacks, to be particularly interesting to them. The following estimate, which was founded on the best materials obtainable at that time, was published among other things to elucidate the subject."

c. A method of clearing a farm lot of new woodland, easily practicable by persons having no more money or provisions than are sufficient to provide the food and clothing of their families, during the first year of their settlement.

". . . If he has sugar maple trees on his land, he may also obtain money, by making sugar in February and March, and felling or bartering, it for cash, or goods to be laid out in like manner, in hiring hands the next season. If money is scarce in a new settlement, and he barters pot ash or maple sugar, for strong trowsers, shirts, hats or jackets, he will find it easy to procure laborers for such necessaries."

d. (The valuable maple)

"The United States have been brought, by slow degrees, to their present knowledge of the value of their wood and timber. The value of the maple sugar tree is not yet universally known. . . ."

117. Wansey, Henry 1794

An Excursion to the United States of America. Salisbury, 1798, 2 ed., (a) p. 43, (b) p. 47, (c) p. 47, (d) p. 262.

a. (Maple sugar served in Hartford, Conn.)

"At Frederick Bull's tavern, where I lodged, we had excellent provisions: beef, mutton, and veal, as good as in England; tea and coffee of the best kind; three sorts of sugar brought always to the table;—the muscovado, the fine lump sugar, and the maple; from the novelty of it, I preferred the last, though I could not find much difference in the taste of it."

b. (England forbids importation of maple sugar)

"At breakfast I was offered by one of the passengers five hundred weight of it, for fourpence halfpenny sterling per pound, but it is contrary to the laws of England to import it."

c. (Maple groves in Dunham township, Conn.)

"Under many of the maple trees, I observed many of the wooden troughs remaining, and the taps still in the trunks, although the sap season had been over about six weeks, being only while the sap is rising. A frosty night always makes a plentiful distillation next morning. A passenger told me that a barrel of juice made six quarts of molasses, which produces ten or eleven pounds of sugar."

d. (Granulated maple sugar)

"The sugar maple, is a tree that I should suppose would grow in this country as well as in many parts of Europe. In Connecticut, it is exposed to as severe winters as any in this island. I have a tree in my garden, seven feet high, that has stood the severe winter of 1794. The chief thing to attend to, is to see it planted in good rich soil. Those settlers in America, who clear the lands, always begin with cutting down the sugar maples, because they are generally found on the richest and best land.—This is one reason why America will not be sufficient to supply its own sugar.

"I was given the following as the method in which they make it: Draw off the sap into wooden vessels, by wooden taps fixed in the bark, seven feet from the ground. Boil it away next day;—provide three kettles of different sizes—say, of fifty, sixty, and seventy gallons; boil it first in the large kettle, adding as much lime as will make the liquor granulate; as it boils, take off the scum, encreasing the heat, till it evaporates to sixty gallons; then strain it through a woolen cloth into the sixty gallon kettle. This must be boiled and skimmed in the same manner, till it is reduced to fifty, and then be strained into the fifty gallon kettle. And each kettle must be continued in succession, till you have boiled your whole quantity—say two hundred gallons.

"When it is boiled enough, which is known by its becoming ropy between the finger and thumb, it is turned out into a wooden cooler, and stirred with a kind of wooden paddle, till it granulates; and then it is put into earthen moulds, in the same manner as the West-Indian planters practice."

118. La Rochefoucault-Liancourt, Duke de 1795

Travels through the United States of North America, the Country of the Iroquois, and Upper Canada in the Years 1795, 1796, and 1797. London, 1799, Vol. I, (a) p. 79, (b) p. 96, (c) p. 107, (d) p. 125, (e) p. 153, (f) p. 283.

a. (Maple sugar at Fishing Creek, Penn.)

". . . This was the first place, where we used maple sugar, which we found excellent. Abraham Miller sells yearly about five or six barrels of this sugar. He buys it at thirteen pence a pound, and sells it at fifteen; the brown moist sugar of the colonies he sells at fourteen pence."

b. (Maple Sugar made at Asylum, Penn.)

". . . Maple-sugar is made here in great abundance. Each tree is computed to yield, upon an average, from two pounds and half to three a year. Melasses and vinegar are also prepared here. I have seen Messrs. De Vilaine and Dandelot make sugar in this place, which much surpasses any of the same kind, which has hitherto come under my observation."

c. (Price of maple sugar at Painted Post, N. Y.)

". . . There are however few sugar-maple trees. The price of this sugar at the beginning of last spring was one shilling per pound."

d. (Maple sugar production at Genessee)

"The whole country abounds in sugar-maple trees (*Acer saccharinum,* Lin. called by the Indians Ozeketa. - *Trans.*), and very considerable quantities of this sugar are made here. The following is the substance of the information, which we were able to procure on this head:

"1. The medium produce of a tree, standing in the midst of a wood, is three pounds of sugar.

"2. The average produce of trees, standing on ground which has been cleared of all other wood, is from five to seven pounds per tree.

"3. A barrel of the first juice, which comes from the maple-tree, will yield seven pounds of sugar, if the tree stand single, and four, if it stand in the midst of other wood. This sugar is sold at one shilling per pound.

"4. A barrel of the second juice will yield three gallons and a half of treacle.

"5. Four or five barrels of the third juice will yield one barrel of a good and pleasant vinegar.

"6. The vinegar is found to be better, in proportion as it is more concentrated. This is the case with Robinson's vinegar, who, from ten barrels of the third juice, brews but one barrel of vinegar.

"7. To clarify the vinegar, it must be boiled with leaven.

"8. The third juice, which is not used for vinegar, yields cyder of an excellent flavour, when mixed with an equal quantity of water.

"9. The longer the first juice is boiled, the better and finer the sugar will become.

"10. In order that the trees may continue productive, they require to be tapped with extraordinary care; i.e. the fissures must be neither too deep, nor too wide, so that no water may settle in them, after the juice is extracted, and that the wood may close again in the space of a twelvemonth.

"11. During the time the juice is flowing out, which lasts about six weeks, and generally begins on the 1st of February, all the days on which it freezes or rains are lost, so that the number of days on which the business can be pursued to advantage is frequently, from these circumstances, much diminished.

"12. Maple sugar, however, is already obtained in sufficient quantities, to form a respectable article of trade, as during the above time two persons can frequently make from five to six hundred pounds of it, and this quantity will be increased in proportion to the number of workmen employed. As the maple-tree, wherever it goes, multiplies with astonishing rapidity, we found, almost everywhere on our journey, no want of excellent sugar. At Robinson's it was better and finer than we had met with any where else; although in general it was not so white here as at Asylum, where Messrs. de Villaine and D'Andlau refine it with the yolks of eggs. . . ."

e. (Maple sugar production at Genessee Flats)

". . . Maple-sugar, of which great quantities are usually obtained in this neighbourhood, has not answered this year, from the uncommon wetness of the season. It is sold for one schilling a pound."

f. (Production neglected at Kingston, Canada)

". . . The farmers make but little maple-sugar, though the woods abound with the trees, from which it is produced. The Indians import about two or three thousand pounds, and sell it to the retail traders for one shilling a pound. Maple-sugar is prepared in much larger quantities in Lower Canada. The Canadians eat it here on bread, or make cakes of it, mixed up with flour of wheat, or Indian corn. . . ."

119. Weld, Isaac, Jr. 1795

Travels through the States of North America, and the Provinces of Upper and Lower Canada, during the years 1795, 1796 and 1797. London, 1799, pp. 219–224.

Observations on the Manufacture of Sugar from the Maple-tree

"The variety of trees found in the forests of Canada is prodigious, . . . ; the sugar maple tree is also found in almost every part of the country, a tree never seen but upon good ground. There are two kinds of this very valuable tree in Canada; the one called the swamp maple, from its being generally found upon low lands; the other, the mountain or curled maple, from growing upon high dry ground, and from the grain of the wood being very beautifully variegated with little stripes and curls. The former yields a much greater quantity of sap, in proportion to its size, than the other, but this sap does not afford so much sugar as that of the curled maple. A pound of sugar is frequently procured from two or three gallons of the sap of the curled maple, whereas no more than the same quantity can be had from six or seven gallons of that of the swamp. . . .

"The maple is the only sort of raw sugar made use of in the country parts of Canada; it is very generally used also by the inhabitants of towns, whither it is brought for sale by the country people who attend the markets, just the same as any other kind of country produce. The most common form in which it is seen is in loaves or thick round cakes, precisely as it comes from the vessel where it is boiled down from the sap. These cakes are of a very dark colour in general, and very hard; as they are wanted they are scraped down with a knife, and when thus reduced into powder, the sugar appears of a much lighter cast and not unlike West Indian muscovada or grained sugar. If the maple sugar be carefully boiled with lime, whites of eggs, blood, or any of the other articles usually employed for clarifying sugar, and properly granulated, by the draining off of the melasses, it is by no means inferior, either in the point of strength, flavour, or appearance to the eye, to any West Indian sugar whatsoever: simply boiled down into cakes with milk or whites of eggs it is very pleasing to the taste. . . ."

120. Winterbotham, W. 1795

An Historical, Geographical, Commercial, and Philosophical view of the American United States, and of the European Settlements in America and the West Indies. London, 1795, Vol. III, (a) p. 498, (b) p. 500.

An extended report on maple sugar in America. The first part deals with the occurrence of the maple tree in New York and Pennsylvania. The tree is described. Factors which influence the flow of sap are discussed along with methods of concentrating the sap by freezing, spontaneous evaporation and boiling. The possibility of large scale manufacture is considered.

a. (Maple sugar is clean and not made by slaves.)

"The quality of this sugar is necessarily better than that which is made in the West-Indies. It is prepared in a season when not a single insect exists to feed upon it, or to mix its excrements with it, and before a particle of dust or of the pollen of plants can float in the air. The same observation can not be applied to the West-India sugar. The insects and worms which prey upon it, and of course mix with it, compose a page in the nomenclature of natural history. We shall say nothing of the hands that are employed in making sugar in the West-Indies, but that men who work for the exclusive benefit of others are not under the same obligations to keep their persons clean while they are employed in this work, that men, women and children are, who work exclusively for the benefit of themselves, and who have been educated in the habits of cleanliness. The superior purity of the maple sugar is farther proved by its leaving a less sediment when dissolved in water than the West-India sugar.

"It has been supposed that the maple sugar is inferior to the West-India sugar in strength. The experiments which led to this opinion we suspect to have been inaccurate, or have been made with maple sugar prepared in a slovenly manner. Dr. Rush examined equal quantities by weight of both the grained and loaf sugar, in hyson tea, and in coffee, made in every respect equal by the minutest circumstances that could affect the quality of taste of either of them, and could perceive no inferiority in the strength of the maple sugar. The liquors which decided this question were examined at the same time by Alexander Hamilton, Esq. secretary of the treasury of the United States, Mr. Henry Drinker, and several ladies, who all concurred in the above opinion."

b. (Maple sugar in relation to alcoholic liquor)

". . . The sap of the maple is moreover capable of affording a spirit, but we hope this precious juice will never be prostituted by American citizens to this ignoble purpose. Should the use of sugar diet become more general in America, it may tend to lessen the inclination or supposed necessity for spirits, for a relish for sugar in diet is seldom accompanied by a love of strong drink. It is the sugar which is mixed with tea which makes it so generally disagreeable to drunkards."

121. Thwaites, R. G. 1797–98

Narrative of Andrew J. Vieau, Sr. *Wisconsin Hist. Coll.*, **11**, (a) 223, (b) 231 (1898).

a. (Maple sugar at Milwaukee, Wisconsin)

". . . Each spring, after packing up the winter's peltries and buying all the maple sugar available from the Indians, father would start out with his family and goods on his return to Mackinaw. . . . Upon his return down the lake, father would stop at his various jack-knife posts and collect their furs and maple sugar. . . ."

b. (A venture in maple sugar)

"In the spring of 1839, I closed up my post, bought a lot of sugar from the Indians, loaded up a boat with the sugar and furs that I had collected and went up to Milwaukee, where I disposed of my venture, having had an excellent winter's trade."

122. Adams, George *ca.* 1798

History of Enosburgh, Franklin County. Vermont Historical Gazetteer, Vol. II, p. 135 (1871).

(Wooden faucets for drawing off sap)

"Sugar is something of an article of revenue. Since the high prices occasioned by the war, great improvements have been made in the process of manufacture. Two considerable sugar orchards are in use: one by Virgil Bogue, and one by James Kidder, where grain was once grown. Among all the improvements in this business, whether in theory or practice, the most novel is in that of tapping, proposed by one of our first settlers, Isaac B. Farrar, who settled on the lot on which V. Bogue lives. Mr. Farrar was a son of Priest Farrar, of New Ipswich, N. H. — had a liberal education, and doubtless thought it best to bring his knowledge to bear on his business, and pursue a kind of 'scientific farming.' He brought with him a large quantity of wooden faucets. When inquired of what he designed these for, said 'he had formed a favorable opinion of the manufacture of maple sugar; and, upon inquiry, thought the method then pursued of tapping with an axe, gouge and split spouts, must occasion great waste, as well as hurry in gathering and boiling, when it run rapidly.'

Said his 'plan was to obviate both difficulties, by tapping with an auger, and putting in a faucet; and when he wanted sap, to draw a pailful, and take it leisurely.' He afterwards moved to Fairfax, and established himself in the pottery business. Whether his improved manner of tapping was generally introduced, I have never learned."

123. Stuart, John 1798

Narrative of Col. John Stuart, of Greenbrier. *William and Mary College Quart. Hist. Mag.*, 22, 234 (1914).

(Sugar trees in Virginia)

"I here hazard a conjecture that has often occurred to me since I inhabited this place, that nature has designed this part of the world a peaceable retreat for some of her favorite children, . . . mines pragnant with saltpeter, & forrests of sugar trees so amply provided and so easily acquired . . ."

124. French, Samuel 1799

History of the Town of Hardwick, Caledonia County. Vermont Historical Gazetteer, Vol. I, p. 325 (1876).

(Sugaring at Hardwick)

"The last of March the snow lay 4 feet deep on a level, but the weather was mild, and we prepared for sugaring; but there came two feet more of snow, and not a tree was tapped until the 15th of April. We gathered our buckets the 15th of May. Snow-banks were visible the 9th of June."

125. Smith, James 1799

An Account of the Remarkable Occurrences in the Life and Travels of Col. James Smith, during his Captivity with the Indians, in the Years 1755, '57, '58 and '59. Lexington, 1799, (a) p. 15, (b) p. 16, (c) p. 22, (d) p. 23, (e) p. 27, (f) p. 39, (g) p. 41, (h) p. 45.

a. (Sugar maples in Pennsylvania)

"On the head waters of this branch, and from thence to the waters of Canesadooharie, there is a large body of rich, well lying land—the timber is ash, walnut, sugar-tree, buckeye, honey-locust and cherry, intermixed with some oak, hickory, . . ."

b. (Results of the winter hunt)

"As the Indians on their return from their winter hunt, bring in with them large quantities of bear's oil, sugar, dried venison, &c. at this time they have plenty, and do not spare eating or giving . . . thus they make way with their provision as quick as possible. . . ."

c. (Sugar tubs of elm bark)

See Drake. (Pt. I, ref. 42a of this bibliography)

d. (A load of maple sugar)

"When all things were ready we moved back to the falls of Canesadooharie. In this route the land is chiefly first and second rate, but too much meadow ground, in proportion to the up land. The timber is white ash, elm, black-oak, cherry, buckeye, sugar-tree, lynn, mulberry, beech, white-oak, hickory, wild apple-tree, red-haw, black-haw, and spicewood bushes. There is in some places, spots of beech timber, which spots may be called third rate land. Buckeye, sugar-tree and spice wood, are common in the woods here. . . .

"On our arrival at the falls, (as we had brought with us on horse back about two hundred weight of sugar, a large quantity of bears oil, skins, . . .) the canoe we had buried was not sufficient to carry all, therefore we were obliged to make another one of elm bark. . . ."

e. (Homony, bear's oil and maple sugar)

"At this time homony plentifully mixed with bears' oil and sugar; or dried venison, bears oil and sugar, is what they offer to every one who comes in any time of the day; and so they go on until their sugar, bears oil and venison, is all gone. . . ."

f. (Concentration of maple sap by freezing)

See Drake. (*Ibid.*, 42b)

g. (Sugar camp on Big Beaver Creek)

"From our sugar camp on the head waters of Big Beaver creek, to this place is not hilly, and some places the woods are tolerably clear: but in most places exceeding brushy. . . ."

h. (Forest trees near Fort Detroit)

"There is plenty of good meadow ground here, and a great many marshes that are overspread with water. . . . The timber is elm, sugar-tree, black-ash, white-ash, abundance of water-ash, oak, hickory, and some walnut."

126. Draper, Lyman C. 1800–1809
Antoine Le Clair's statement. *Wisconsin Hist. Coll.*, **11**, 241 (1888).

(Maple sugar made in Milwaukee)

"The Indians at Milwaukee had no fruit trees, except wild plums, which were plenty; there were blackberries, grapes and strawberries, but no raspberries. There were no nuts,—no pecans, no persimmons. The Indians manufactured large quantities of maple sugar for their own use, and for sale; they would live on it fast, and sell to the traders,—the rule in this, as in other things, being first a feast, then a famine. . . ."

127. Sumner, Samuel *ca.* 1800
History of the Town of Troy, Orleans County. Vermont Historical Gazetteer, Vol. III, p. 319 (1877).

(Sugar maples yield a luxury)

"The sugar maple was a blessing to the early settlers of Vermont. Those beautiful groves yielded an abundant supply of sugar, affording to the indigent settler a necessary and luxury of life which the wealthy in older countries could scarce afford, whilst the cheerful fires of this wood, which, in our infancy, we saw blazing in the old stone-backed chimneys, call up recollections of an enjoyment we cannot now find in the dull invisible warmth of an air-tight stove, and the ashes of this generous tree, when manufactured into potash or pearlash, furnished an article for exportation, and almost the only one which would warrant the expense in transporting it to the then distant markets."

128. Michaux, F. A. 1802
Travels to the Westward of the Allegany Mountains. London, 1805, Vol. II, p. 81.

(The sugar maple in southwestern Pennsylvania)

"The sugar maple is very common in all that part of Pennsylvania, which is watered by the Monogahela and the Allegany. This tree thrives best in cold, humid, and mountainous countries, and its sap is more abundant, as the winter has been more severe. The sugar obtained from it has as dark a colour as that of the clayed sugar of the first boiling, it is sold in loaves of 6, 8, or 10 pounds, at seven pence per pound. The inhabitants only make it for their own use, most of them have tea or coffee every day, but they only use it in the state in which it is obtained from the first evaporation of the sap: they do not refine it because of the great loss which it sustains in this operation."

129. Curot, Michel 1804

A Wisconsin fur-trader's journal, 1803-04. *Wisconsin Hist. Coll.*, 20, (a) 449, (b) 457 (1911).

a. (Sugar made by Indians near Jaune, or Yellow, River)

"Friday 9. (March) Mr. Sayer sent his wife this morning to the Savages' lodges to make sugar. 4 Men went with her to carry her Baggage and provisions."

b. "Tuesday 27th. (March) Mr. Sayer sent yesterday with Kitchinimiscoutte, & Payechgigue who brought him a Mocock of about 30 lbs. of sugar, two of his men and a 3 Gallon Keg of Pure H. W. . . . His wife (Savoiard's) went to the Lodges to make sugar with her sister. Ataowabe came to the fort with them bringing nothing but about Two Livres of sugar that he gave me."

130. Lewis, Merriweather, and George Rogers Clark 1804

Original Journals of the Lewis and Clark Expedition, 1804-1806. R. A. Thwaites, Editor. New York, 1904, (a) Vol. I, p. 8; (b) p. 291; (c) Vol. VI, p. 169.

a. (Extra ration of whiskey for sugar makers)

"DETACHMENT ORDERS
CAMP RIVER DUBOIS, Feb^r^. 20^th^, 1804

"LEWIS:

"The four men who are engaged in making sugar will continue in that employment untill further orders, and will receive each a half a gill of extra whiskey p[r]. day and be exempt from guard duty.

MERRIWEATHER LEWIS CAP[t].
1[st]. U. S. Reg[t]. Infty."

b. (Maple in bud – Mandan to Yellowstone)

"9th of April Tuesday 1805.

"Set out this morning verry early under a gentle breeze from the S.E. at Brackfast the Indian deturmined to return to his nation. I saw a Musquetor to day great numbers of Brant flying up the river, the Maple, & Elm has buded & cotton and arrow wood beginning to bud. . . ."

c. (Meteorological observation for February, 1804)

"11th. The Sugar Maple runs freely, Swans pass from the North."

131. Malhiot, François Victor 1804

A Wisconsin fur-trader's journal – 1804–05. *Wisconsin Hist. Coll.*, 19, (a) 174, (b) 232 (1910).

a. (Maple sugar exchanged for a gum)

"He did me the favor of giving me a keg of sugar for a keg of gum, which had been given me at Kamanaitiquoya instead of a keg of sugar."

b. (Mococks of maple sugar sold)

"1 A Mocock of Sugar. . . ."

132. Pike, Zebulon Montgomery 1805–1806

An Account of a Voyage up the Mississippi River, from St. Louis to its Source. Compiled from Mr. Pike's journal. (Washington, 1807 ?), (a) p. 49. Elliott Coues, Editor. The Expeditions of Zebulon Montgomery Pike, To Headwaters of the Mississippi River, through Louisiana Territory, and in New Spain, During the years 1805–6–7. New York, 1895, new ed., (b) Vol. I, pp. 184–186.

a. (Visit to camp of Thomas, the Fols Avoine chief)

" . . . The camp was situated in one of the finest sugar groves imaginable. They were received in a truly patriarchal style: the chief pulled off Mr. Pike's moccasins, assigned him the best place in the lodge, and offered dry cloths. After being presented with the syrup of the maple to drink, the chief asked his guest which he preferred, beaver, swan, elk or deer, to eat. . . . they were presented with something to eat; at one a bowl of sugar,—at another the tail of a beaver: generally, with what was esteemed a delicacy by their Indian friends.

"The next morning Mr. Pike purchased two baskets of sugar; . . ."

b. (Visit to Thomas sugar camp)

"*Mar. 18th.* We marched (up Spunk river), determined to find the (Menomonee) lodges. Met an Indian whose track we pursued through almost impenetrable woods for about 2 1/2 miles to the camp. Here there was one of the finest sugar-camps I almost ever saw, the whole of the timber being sugar-tree. . . . He then presented us with syrup of the maple to drink, and asked whether I preferred eating beaver, swan, elk, or deer; . . . We were presented with something to eat; by some, with a bowl of sugar: . . ."

"*March 19th.* This morning purchased two baskets of sugar. . . ."

133. Dubuque, J. 1807

Fur-trade on upper lakes. 1778–1815. Operations of Dubuque. *Wisconsin Hist. Coll.*, 19, 319 (1910).

(Sugar at Prairie du Chien)

"As for the Accounting that you ask me for, I make it the same as to what I owe as you and every one does. But there are some small differences in regard to the price made on sugar, rum, and powder; and after these are settled I will adjust the Balance whenever you wish."

134. Grignon, Pierre 1807

Fur-trade on the upper lakes – 1778–1815. Grignon accounts 1806–1807. *Wisconsin Hist. Coll.*, 19, 321 (1910).

A typical invoice

"1807 Rentree de L'envoice Oliva
Par diverses agrets
1000 lvs de Sucre .10 500"

135. Askin, Jno., Jr. 1808

Fur-trade on the upper lakes – 1778–1815. *Wisconsin Hist. Coll.*, 19, 325 (1910).

(Son sends father maple sugar from St. Joseph's Island)

"I send Mr. J. & Mrs. Barthe Sen[r] a Mocouts of sugar addressed to your Care. One for Mr. Badishon w[h] Madelain & my comp[s], a Mocouts marked I P for Mr Peltier & a Bundle. You'll receive One Mocouts Sugar, a Bundle of Mats, & a mocout of dryed Huckleberrys which you'll please accept of. The sugar is very clean I believe having received it from a clean woman."

136. Smith, J. P. *ca.* 1810

History of the Town of Newark, Caledonia County. Vermont Historical Gazetteer, Vol. I, p. 357.

(Maple sugar production in Newark)

"This town is also celebrated for its large productions of maple sugar. The original growth of timber upon two-thirds of its area, consisted of maple, beech and birch, maple being in the excess; many beautiful groves of this usefull tree have been cut down, but many yet remain. The eastern slope of a mountain which extends from East Haven to the centre of the town (a distance of three miles), is covered for two miles or more with a continuous forest of sugar-maple. Many tons of sugar are made here annually."

137. Tyrrel, J. B. *ca.* 1810

David Thompson's Narrative of his Explorations in Western America. 1784-1812. Toronto, 1916, (a) p. 274, (b) p. 275, (c) p. 283.

a. (Diet of wild rice and maple sugar)

". . . Proceeding five miles over the Lake we came to the trading house of Mr. John Sayer, a Partner of the North West Company, and in charge of this Department, . . . Mr. Sayer and his Men has passed the whole winter on wild rice and maple sugar, which keeps them alive, but poor in flesh: . . ."

b. (Indian family property rights to maple groves)

"In the Spring the Natives employ themselves in making Sugar from Maple Trees, the process of doing which is well known. The old trees give a stronger sap than the young trees; The Canadians also make a great quantity, which when the sap is boiled to a proper consistence, they run into moulds where it hardens. But the Indians prefer making it like Muscovado sugar, this is done simply by stirring it quickly about with a small paddle. The Plane Tree also makes a good sugar, the sap is abundant, and the sugar whiter, but not so strong. Both sugars have a taste, which soon becomes agreeable, and as fine white loaf sugar can be made from it as from that of the West Indies. The natives would make far more than they do if they could find a Market. . . . The Natives here call themselves 'Oochepoys' and for some years have begun to give something like a right of property to each family on the maple sugar groves, and which right continues in the family to the exclusion of others. But as this appropriated space is small in comparison of the whole extent; any, and every person is free to make sugar on the vacant grounds. The appropriation was made by them in a council, in order to give to each family a full extent of ground for making sugar, and to prevent disputes that would arise where all claim an equal right to the soil and its productions. And as in the making of sugar, several kettles and many small vessels of wood and birch rind for collecting and boiling the sap are required, which are not wanted for any other purpose, (they) are thus left in safety on their own grounds for future use."

c. *(Sugar from the juice of the ash-leaved maple)*

"He had traded 16 Cwt. of Maple Sugar from the Natives; this was packed in baskets of birch rind of 28 to 68 lbs. each. The Sugar appeared clean and well made; that of the Plane Trees, looked like the East India Sugars, and (was) much the same in taste: In this article I have always noticed the supply is greater than the demand."

138. Wakefield, Priscilla. 1810

Excursions in North America, described in Letters from a Gentleman and his Young Companion, to their Friends in England. London, 1806, 2 ed., (a) p. 56, (b) p. 191, (c) p. 295.

a. (Maple trees in Virginia)

". . . Virginia is intersected by numerous rivers and creeks, and in many parts covered with forests of maples, pines, cedars, the climbing trumpet-flower tree, the Carolinian allspice, cornel trees, walnuts, laurels, bay-trees, tulip trees, poplars, oaks, sumachs, acacias, and many others: . . ."

b. (The red maple in Maine)

". . . The black fir, the Weymouth pine, the red cedar, the common fir, the red maple, the Pennsylvania ash, the black birch, and the dwarf birch, are also common. . . ."

c. (The sugar maple in Canada)

". . . The sugar maple grows in all parts of the country, and is a very useful tree; as not only sugar may be made from it, but vinegar, table beer, and an excellent spirit. The country people pierce these trees with an augur, and put a vessel beneath, to catch the sap as it falls, which they refine by boiling till it is converted into sugar, and a sufficient quantity is procured to nearly supply the inhabitants, who seldom use any other."

139. Lambert, John 1814

Travels through Canada and the United States. London, 1814, p. 83.

(Quality of Canadian maple sugar)

"Large quantities of maple sugar are sold at about half the price of the West India sugar. The manufacturing of this article takes place early in the spring, when the sap or juice rises in the maple trees. It is very laborious work, as at that time the snow is just melting, and the Canadians suffer great hardships in procuring the liquor from an immense number of trees dispersed over many hundred acres of land. The liquor is boiled down and often adulterated with flour, which thickens, and renders it heavy: after it is boiled a sufficient time, it is poured into tureens, and, when cold, forms a thick hard cake of the shape of the vessel. These cakes are of a dark brown colour, for the Canadians do not trouble themselves about refining it. The people in Upper Canada make it very white; and it may be easily clarified equal to the finest loaf sugar made in England.

"It is very hard, and requires to be scraped with a knife when used for tea, otherwise the lumps would be a considerable time dissolving. Its flavour strongly resembles the candied horehound sold by the druggists in England, and the Canadians say that it possesses medicinal qualities, for which they eat it in large lumps. It very possibly acts as a corrective to the vast quantity of fat pork which they consume, as it possesses a greater degree of acidity than the West India sugar. Before salt was in use, sugar was eaten with meat in order to correct its putrescency."

140. Baird, Eliz. T. *ca.* 1815

Reminiscences of early days on Mackinac Island. Green Bay Gazette, Dec. 4, 1886; Nov. 19, 1887; *Wisconsin Hist. Coll.*, 14, 29 (1898).

(An American forest scene – maple sugar-making)

"A visit to the sugar camp was a treat to the young folks as well as the old. In the days I write of, sugar was a scarce article, save in the Northwest, where maple sugar was largely manufactured. All who were able, possessed a sugar camp. My grandmother had one on Bois Blanc Island, about five miles east of Mackinac. About the first of March, nearly half of the inhabitants of our town, as well as many from the garrison, would move to Bois Blanc to prepare for the work. Our camp was delightfully situated in the midst of a forest of maple, or a maple grove. A thousand or more trees claimed our care, and three men and two women were employed to do the work.

"The 'camp',—as we specifically styled the building in which the sugar was made, and the sugar-makers housed, —was made of poles or small trees, enclosed with sheets of cedar bark, and was about thirty feet long by eighteen feet wide. On each side was a platform, about eighteen inches high and four feet wide. One side was intended for beds, and each bed when not in use was rolled up nicely, wrapped in an Indian mat, then placed against the wall; the bedroom then became a sitting room. The walls on the inside were covered with tarpaulin, also the floor. The women's bedding was placed at one end of the platform. The platform at the other side served as a dining floor, one end of which was enclosed in cedar bark, forming a chest for the dishes and cooking utensils. The dishes consisted of some crockery, tin plates and cups, and wooden dishes and ladles. The wing was added at one end, for the men's bedroom.

"At either end of the camp were doors, made large to admit heavy logs for the fire. The fire-place was midway between the two platforms, and extended to within six feet of the doors. At each corner of the fire-place were large posts, firmly planted in the ground and extending upward five feet or more. Large timbers were placed lengthwise on top of these posts, and across the timbers extended bars from which, by chains and hoops, were suspended large brass kettles, two on each bar. On the dining-room side, half way up the wall, ran a pole, horizontally. This was to hold in place hemlock branches, which were brought in fresh every evening. The place between the fire and the platforms was kept very heat by a thick, heavy broom, made of cedar branches, cut off evenly on the bottom, and with a long handle. These brooms are still used by semi-civilized Indians.

"The hanging of the kettle was quite a test of skill, requiring three persons to perform the task. The fire had to be burning when the hanging began. It was the duty of one person to hang the kettle properly; of the second, to pour in immediately a small quantity of sap to keep the kettle from burning; of the third, to fill it with sap. The peak of the roof was left open to allow the smoke to escape,—and at night to let in the stars, as was my childish fancy. . . .

"Now for the work; All of the utensils used in the making of sugar were of that daintiest of material, birch-bark. The *casseau,* to set at the tree, to catch the sap, was a birch-bark dish, holding from one to two gallons. The pails for carrying the sap were of the same material, and held from three to four gallons. The men placed a *gauje* or yoke on their shoulders, then a bucket would be suspended on each side. The women seldom used this yoke, but assisted the men in carrying the buckets, doing so in the usual manner. The mocock, in which the sugar was packed, was also of birch-bark and held from thirty to eighty pounds. The bark was gathered in the summer at Bark Point. The name was afterward done in French as 'Point aux Ecorces,' meaning 'bark point'. The sailors now miscall it, 'Point au Barques.'

"The *gouttière* or spout, which was made of basswood, had to be cleaned each spring, before it was placed in the tree; the birch-bark of the *casseau* was cleaned by taking off a layer of the inner bark and then washing it. The buckets were made by sowing the seams with *bast* (which is taken from the inner bark of bass-wood), then gummed over with pine pitch. They also were carefully washed and dried before use. As a matter of course, the large vessels to receive the sap were barrels made of oak. No pine was ever used about the camp, as that would impart a disagreeable taste. The strainers were made of a particular kind of flannel, of very coarse thread and not wooly, brought especially for this purpose by the merchants. I remember well, the cleaning of these. After they had been used, they were put in a tub of hot water and washed (without soap); or pounded, rather, with a *battoir* or beetle, then rinsed in many waters.

"By this time the sap must be boiling. It takes over twenty-four hours to make the sap into syrup, and the boiling is usually begun in the morning. The fire is kept bright all day and night. Two women are detailed to watch the kettles closely, for when the sap boils down nearly to syrup, it is liable to bubble over at any moment. The women therefore stand by with a branch of hemlock in hand; as soon as the liquid threatens to boil over they dip the branch in quickly, and, it being cool, the syrup is settled for a while. When at this stage, it requires closest watching. When the sap has boiled down about one-half, the women have to transfer the contents of one kettle, which would spoil all. As fast as a kettle is emptied it will be filled with water and set aside, awaiting the general cleaning. The kettles require the utmost care, being scoured each time emptied, keeping one woman employed nearly all the time. Sand and water are the cleansing agents used.

"All this time, if the weather favors the running of the sap, it is brought as fast as possible, and the boiling goes on. At this period, my grandmother would send me my little barrel full of syrup. The miniature barrel I still have in my possession. The barrel bears the date 1815, and is now dark and polished with age, and is a rare memento of those halcyon days. It holds less than a pint, and was made by an Ottowa Indian, out of a solid piece of wood, sides and ends all one, the interior being ingeniously burned out through the bung hole. The receipt of this was the signal that the time had come when I too might visit the camp.

"When made, the syrup is put in barrels, awaiting the time when it can be made into sugars of various kinds, the *modus operandi* thus: A very bright brass kettle is placed over a slow fire (it can not be done at boiling time, as then a brisk fire is required),—this kettle containing about three gallons of syrup, if it is to be made into cakes; if into *cassonade,* or granulated sugar, two gallons of syrup are used. For the sugar cakes, a board of basswood is prepared, about five or six inches wide, with moulds gouged in, in forms of bears, diamonds, crosses, rabbits, turtles, spheres, etc. When the sugar is cooked to a certain degree, it is poured into these moulds. For the granulated sugar, the stirring is continued for a longer time, this being done with a long paddle which looks like a mushstick. This sugar has to be put into the mocock while still warm, as it will not pack well if cold. The work is especially difficult; only a little can be made at a time, and it was always done under my grandmother's immediate supervision.

"The sugar-gum, or wax, is also made separately. Large wooden bowls, or birch-bark *casseaus,* are filled with snow, and when the syrup is of the right consistence it is poured on the snow in thin sheets. When cooled, it is put into the birch-bark, made into a neat package, and tied with bast. The syrup made for table use is boiled very thick, which prevents its souring. For summer use it is put into jugs and buried in the ground two or three feet deep, where it will keep for a year, more or less.

"One time, a party of five ladies and five gentlemen were invited to the camp. Each lady brought a frying-pan in which to turn *les crêpes* or pancakes, which was to be the special feature and fun of the occasion. All due preparation was made for using the frying-pans. We were notified that no girl was fitted to be married until she could turn a *crêpe*. Naturally, all were desirous to try their skill in that direction, whether matrimonially inclined or not. The gentlemen of the party tried their hand at it, as well as the ladies. It may not be amiss here to explain what turning a *crêpe* meant; when the cake was cooked on one side, it was dexterously tossed in the air, and expected to land, the other side up, in the pan. Never did I see objects miss so widely the mark aimed at. It seemed that the *crêpes* were influenced indeed by the glee of the party; they turned and flew everywhere, but where wanted. Many fell into the fire, as if the turner had so intended. Some went to the ground, and one even found its way to the platform, over the head of the turner. One gentleman (Henry S. Baird) came up to Mrs. John Dousman, and holding out his nice fur cap, said, 'Now turn your cake, and I will catch it.' Mrs. Dousman was an adept at turning, and before the challenger had time to withdraw his cap, with a toss she deftly turned the cake and landed it fairly into the cap. You may imagine the sport all this afforded. In due time, a nice dinner was prepared. We had partridges roasted on sticks before the fire; rabbits and stuffed squirrel, cooked French fashion; and finally had as many *crêpes*, with syrup, as we desired. Every one departed with a bark of wax, and sugar cakes."

141. Heckewelder, John 1817

History, Manners and Customs of the Indian Nations who once Inhabited Pennsylvania and the Neighboring States; *Memoirs Historical Society Penn.*, 12, 194–195 (1876).

Food and Cookery

". . . In the dough of this kind of bread they frequently mix boiled pumpkins, green or dried, dry beans, or well pared chestnuts, boiled in the same manner, dried venison well pounded, whortle berries, green or dry, but not boiled, sugar and other palatable ingredients.

"The Indians have a number of manners of preparing their corn. They make an excellent pottage of it, by boiling with fresh or dried meat (the latter pounded), dried pumpkins, dry beans, and chestnuts. They sometimes sweeten it with sugar or molasses from the sugar-maple tree. . . .

". . . They make an excellent preserve from the cranberry and crab-apple, to which, after it has been well stewed, they add a proper quantity of sugar or molasses. . . ."

142. Evans, Estwick 1818

A Pedestrious Tour of Four Thousand Miles through the Western States and Territories. Concord, 1819, p. 171; R. G. Thwaites, Editor, Early Western Travels 1748–1846. Cleveland, 1904, Vol. 8, p. 275.

(Maple sugar production)

". . . Several millions of pounds of mapel sugar are made here annually; . . ."

143. Michaux, F. A. 1819

The North American Sylva, or a Description of the Forest Trees of the United States, Canada and Nova Scotia. Paris, 1819, Vol. I, (a) p. 216, (b) p. 218, (c) p. 221, (d) p. 223, (e) p. 228, (f) p. 237.

a. White Maple (Acer eriocarpum)

"In the Atlantic parts of the United States, this species is often confounded with the Red Maple which it nearly resembles; west of the Mountains, they are constantly distinguished, and the *Acer eriocarpum* is known by no other name than White Maple.

"Some of the inhabitants on the Ohio make sugar of its sap, by the same process which is employed with the Sugar Maple. Like the Red Maple, it yields about half the product from a given measure of sap; but the unrefined sugar is whiter and more agreeable to the taste than that of the Sugar Maple. The sap is in motion earlier in this species than in the Sugar Maple, beginning to ascend about the 15th of January; so that the work of extracting the sugar is sooner completed. The cellular integument rapidly produces a black precipitate with sulphate of iron."

b. Red Flowering Maple (Acer rubrum)

"Different names are given to this tree in different parts of the United States; east of the Alleghany mountains it is called Red flowering Maple, Swamp Maple and Soft Maple; in the Western Country, simply Maple. The first denominations, which is most generally in use, is also most appropriate, as the young shoots, the flowers, and the fruit are red. . . ."

c. (Sugar from the red maple, or plaine)

"The French Canadians make sugar from the sap of this Maple, which they call *Plaine,* but, as in preceding species, the product of a given measure is only half as great as is obtained from the Sugar Maple."

d. Sugar Maple (Acer saccharinum)

"This species, the most interesting of the American Maples, is called Rock Maple, Hard Maple, and Sugar Maple. The first of these names is most generally in use, but I have preserved the last, because it indicates one of the most valuable properties of the tree.

"The Sugar Maple covers a greater extent of the American soil than any other species of this genus. It flourishes most in mountainous places, where the soil though fertile is cold and humid. Besides the parts which I have particularly mentioned, where the face of the country is generally of this nature, it is found along the whole chain of the Alleghanies to their termination in Georgia, and on the steep and shaly banks of the rivers which rise in these mountains."

e. (Manufacture of maple sugar)

Descriptive.

f. Black Sugar Tree (Acer nigrum)

"In the Western States, and in the parts of Pennsylvania and Virginia, which lie between the mountains and the Ohio, this species of Maple is designated by the name of Sugar Tree, and frequently, by the more characteristic denomination of Black Sugar Tree; probably, on account of the dark colour of its leaves, in comparison with those of the true Sugar Maple, which sometimes grows with it. In the extensive country of Genesee both species are indiscriminately called Rock Maple and Sugar Maple. This confusion seems to have arisen from the country's being settled principally by emigrants from the Eastern States, who, finding the Black Sugar Tree applicable to the same uses with the other, and equally productive of sugar, have given it the same name. The two species have also been confounded by Botanists, in describing the vegetable productions of America."

144. Childs, Ebenezer 1820

Recollections of Wisconsin since 1820. *Wisconsin Hist. Coll.*, 4, (a) 161, (b) 175 (1858).

a. (Maple-sugar making at Green Bay)

"There were quite a number of very respectable French families residing at the Bay when I arrived there. . . . They caught large quantities of sturgeon and trout, and they made immense quantities of maple sugar. At the proper season in the spring, the entire settlement would remove to their sugar-campe, often remain two months, each family making eight to ten hundred pounds of the finest sugar I ever saw."

b. (Barter with maple sugar at Green Bay, Wis.)

"I furnished the Indians with provision that fall and winter; they paid me in furs and maple sugar. I purchased some six tons of sugar of them."

145. Doty, James Duane 1820

Northern Wisconsin in 1820. *Wisconsin Hist. Coll.*, 7, 199 (1876).

(Indians make maple sugar at Rice Lake)

". . . Their families being left at home in this hunt, repair to the sugar camps, and are engaged in manufacturing sugar during the absence of the men, of which they make large quantities."

146. Doty, James Duane 1820

Official Journal, 1820. Expedition with Cass and Schoolcraft. *Wisconsin Hist. Coll.*, 13, 207 (1897).

(Indian sugar camp near Sandy Lake)

". . . Thus far the land has been low,—timber birch, maple, bass wood, and elm. Next we steered S. 20 west 6 miles over a ridge one half (the first covered chiefly with pine the residue the sugar maple). The Indians had a large establishment in this wood, this last spring where from every appearance they must have made great quantities of sugar."

147. Irwin, M. 1820

Fur trade and factory system at Green Bay. 1816–21. Letter of M. Irwin, U. S. Factor, to Doctor J. Morse. *Wisconsin Hist. Coll.*, 7, 286 (1876).

(Maple sugar traded for whiskey)

". . . He adds, 'I will venture to say, that out of two hundred barks of sugar taken, not five have been purchased with any other commodity than whiskey. I have not been able to procure a pound (of sugar) from the Indians, but can get a supply from the traders at ten cents a pound.'

"Independent of the known veracity of Mr. Varnum, the fact that private traders can sell sugar at ten cents a pound, is pretty conclusive evidence of the manner in which they obtain it."

148. Locke, John 1820

On the manufacture of sugar from the river maple (*Acer eriocarpum of Linnaeus*). *Am. J. Sciences, Arts,* 2, (a) 258, (b) 261.

a. (Sugar from the river maple)

"It seems not to be generally known, that sugar is afforded in any considerable quantity, by any other species than the sugar maple, (*Acer saccharinum*); but I have found that in some parts of New-England, more sugar is made from the river, than from the sugar maple.[5]

"A peculiar method of tapping is practiced in Fryeburg. The incision from which the sap issues is made by driving a gouge a little obliquely upward, an inch or more into the wood. A spout or tap about a foot long, to conduct off the sap, is inserted about two inches below this incision with the same gouge. . . . One principal

5 The author bases his statements upon observations made in Fryeburg, Maine, on the Saco river, where large quantities of maple sugar were annually made. The sap of the river maple was generally deemed there to be sweeter than that of the sugar maple; its sugar whiter and of a better quality.

advantage of this method is, that the wound in the tree is so small that it is perfectly healed or 'grown over' in two years, the tree sustaining little or no injury. The other common methods of tapping are two. 1. With an axe. An oblique incision three or four inches long, is made in such a manner that all the sap will be conducted to the lower corner, where it passes into a spout inserted with a gouge as above. Disadvantages of this method. The surface being much exposed to the air and sun, is presently dried, so as to diminish very much the quantity of sap. The wound in the tree is extensive and a ruinous decay is often the consequence, the tree becoming rotten-hearted. 2. With an auger. The tree is perforated an inch or more with an auger three fourths of an inch diameter, and a tube made of elder or sumach is inserted to conduct off the sap. The end of the tube is made tapering so as to bear only at the outer edge of the tube. Disadvantage. The tap presses upon the external grains so as to obstruct the flow of sap from them; and it is from these *external* grains that most of the sap is obtained. The method tapping with the gouge is undoubtedly superior to either of the others, but in a sugar maple there might be difficulty in inserting the gouge to a sufficient depth on account of its superior hardness.

"It seems that the superiority of the river over the sugar maple is not universal; for Micheaux says, that on the Ohio only one half the quantity is obtained from the river, that is afforded by the sugar maple."

*b. (Lin*es *to the maple tree)*

"In a poem written in Fryeburg called 'The Village' the following lines are bestowed upon it.

'More sacred than the thunder chosen oak,
'Let not the maple feel the woodman's stroke.
'Fair maple! honours purer far are thine
'Than Venus's myrtle yields, or Bacchus's vine;
'Minerva's olive consecrated tree,
'Deserves not half the homage due to thee.
'The queen of trees, thou proudly towerist on high,
'Yet wave thy limbs in graceful pliancy.'"

149. Morse, Jedidiah 1820

Report to the Secretary of War of the United States. New Haven, 1822, Appendix p. 50.

(Maple products made at Green Bay, Wis.)

In commenting upon the activities of the half-breed population at Green Bay, the author states, "These people, and the Menominees with whom, by the ties of relationship, they are connected, make from the maple tree about one hundred pounds of sugar annually; and from three to four hundred gallons of molasses. These, with their skins, etc. are nearly all sold for whiskey, at an immense sacrifice."

150. Finley, J. B. 1821

History of the Wyandott Mission. Cincinnati, 1840, (a) p. 124, (b) p. 125, (c) p. 126, (d) p. 128.

a. (Sugar-making season)

"In February, nearly all of the Indians went to the woods, to trap and make sugar. They seldom return from these expeditions until the first of April."

b. (Sugar-flavored boiled raccoon meat)

"Soon we had placed before us a kettle filled with fat raccoons, boiled whole, after the Indian style, and a pan of good sugar molasses. These we asked our heavenly Father to bless, and then each carved for himself, with a large butcher knife. I took the hind quarter of a raccoon, and holding it by the foot, dipped the other end in the molasses, and eat it off with my teeth. Thus I continued dipping and eating until I had pretty well finished the fourth part of a large coon."

c. (Troughs as sap containers)

"The troughs in which they catch their sugar water, are made of bark, and hold about two gallons. They have a large trough, made like a bark canoe, into which they gather from the small ones. The women make the sugar, and stretch all the skins. The men trap and hunt."

d. (War-time rations of the Indian)

"Deer meat is sliced thin; and dried over the fire, until it can be easily pounded in a mortar. This, mixed with sugar and dipped in bear's oil, is the greatest luxury of an Indian table. This, with corn parched in a kettle, and pounded to meal, then sifted through a bark sieve, and mixed with sugar, makes the traveling provision of an Indian in time of war."

151. Grignon, L. 1821

Fur-trade in Wisconsin. Letter to Robt. Stuart, Michimilimackinac from La Bay verte 7 June 1821. *Wisconsin Hist. Coll.*, 20, 200 (1911).

(Sugar supplies plentiful in Green Bay)

"There is much sugar here but few Peltries, . . ."

152. Nuttall, Thomas 1821

A Journal of Travels into the Arkansas Territory. Philadelphia, 1821, p. 113; R. G. Thwaites, Editor, Early Western Travels 1748–1846. Cleveland, 1905, Vol. XIII, p. 161.

(Low-cost sugar)

". . . Sugar and Coffee are also high priced articles, more particularly this year. There is a maple in this country, or rather, I believe, on the banks of the White river, which has not come under my notice, called the sugar-tree (though not, as they say, the *Acer Saccharinum*), that would, no doubt, by a little attention afford sugar at a low rate; . . ."

153. Deane, Samuel 1822

The New England Farmer; or Georgical Dictionary. Boston, 1822, 3 ed., p. 262.

(Observations on making sugar from the sap of the rock-maple)

This is an edited quotation from the *American Museum,* vol. 6, pp. 98–101 for which see reference 28, part 1, of this bibliography.

154. Ellis, Albert G. 1822

Fifty-four Years' Recollections of Men and Events in Wisconsin. *Wisconsin Hist. Coll.,* 7, 1876, (a) 220, (b) 222.

a. (Sugar-making at Green Bay)

"The product of the *sucreries* of the better class of the French, was a fair article of sugar, of ready sale, and in some respects preferable to the best muscovado. They had learned to use the utmost neatness and caution to keep out all impurities, and had attained to great perfection in the purifying process. All the sap was strained through a fine sieve into the kettles—the syrup was strained twice before granulating; and here came in the product of the chickens, to wit, the eggs, the whites of where were broken in the boiling syrup, when all impurities immediately came to the surface and were removed. The sugar, when strained off and cooled, was quite fair and pure. Some of the more enterprising and forehanded, bought syrup and coarse sugar of their Indian retainers, and their less able neighbors, and went into the purifying process on a large scale, and thus largely increased their product for the season. A few families of this class had a preference in the sugar market at the frontier trading posts, their mococks, branded with their names, always being sought, at advanced prices.

"As before stated, the Easter festival was generally celebrated at those *sucreries;* for this reason those who had the chickens, and could do it, took them into the woods, made houses for them, and saved a store of eggs for this festival. Then it was that their friends at the settlement, the Americans and army officers, were invited to visit them, and the invitations were rarely declined. The American citizens, the gentlemen and ladies of the army, found no greater enjoyment than one of these spring festivals in the depth of the great maple woods, in their commodious sugar-houses. . . . These frolics were often enlivened by an old-fashioned 'candy-pull', when the French girls presented their sweet-hearts, on parting, with a cake of candy, folded in a strip birch-bark, which they called their 'billet doux'."

b. (Maple sugar not accepted in trade)

". . . the natives, as well as the French inhabitants, made quantities of maple sugar; this was not current at New York, for payment of goods, as peltries were; and so not much cared for by the old traders. The Indians resorted with it to the United States factor, Major Irwin, who bought large quantities of it; and had many thousand pounds in store at the time of our arrival in 1822. . . ."

155. Moore, Jacob B. 1822

Topographical and historical sketch of Andover, N. H. Farmer and Moore's Historical Collections, Vol. I, p. 12.

(A neglected branch of domestic economy)

". . . The growth of wood, in the other parts of the town, is principally oak, beach and sugar-maple. . . . From its first settlement until within a few years of the inhabitants have anually supplied themselves with sugar from their own farms; but the trees now beginning to decay, and little pains being taken in their preservation, this branch of domestic economy is almost wholly neglected."

156. Woods, John 1822

Two Years' Residence in the Settlement on the English Prairie in the Illinois Country, United States. London, 1822, (a) p. 235, (b) p. 306, R. G. Thwaites, Editor, Early Western Travels 1748-1846. Cleveland, 1904, Vol. X, (c) p. 312, (d) p. 354.

a. (Maple trees tapped near Harmonie, Indiana)

"In passing some woods, we saw some sugar-maple trees that were tapped, with the liquor then running into; we dismounted, and had a good draught or two of the liquor; it was pleasant-tasted."

b. (Sugar made in Illinois)

". . . This year some sugar has been made near us, from the white maple, and it appears to answer nearly as well as the sugar-maple. I suppose, another season, it will be made in considerable quantities."

157. Hunter, John D. 1823

Manners and Customs of Several Indian Tribes Located West of the Mississippi. Philadelphia, 1823, p. 269.

(Indian beverage)

"Their usual drink is pure cold water; though sometimes they mix maple sugar with it, or honey, which they procure in considerable quantities from the stores of honey bees, deposited in hollow trees; . . ."

158. Schoolcraft, Henry R. **1823**

Personal Memoirs of a Residence of Thirty Years with the Indian Tribes on the American Frontiers. Philadelphia, 1851, p. 162.

(Sugar-making season at hand)

"It is now the season for making sugar from the rock maple by the Indians and Canadians in this quarter. And it seems to be a business in which everyone is more or less interested. Winter has shown some signs of relaxing its iron grasp, although the quantity of snow upon the ground is still very great, and the streams appear to be as fast locked in the embraces of frost as if it were the slumber of ages. Sleighs and dog trains have been departing for the maple forests, in our neighborhood, since about the tenth instant, until but few, comparatively, of the resident inhabitants are left. Many buildings are entirely deserted and closed, and all are more or less thinned of their inhabitants. It is also the general season for sugar making.

"I joined a party in visiting one of the camps. . . . We found a large temporary building, surrounded with piles of ready split wood for keeping a fire under the kettles, and large ox hides arranged in such a manner as to serve as vats for collecting the sap. About twenty kettles were boiling over a central elongated fire."

159. Anon. **1824**

Topographical sketch of Salisbury, New-Hampshire. Farmer and Moore's Historical Collections, Vol. III, p. 297.

(Forest trees at Salisbury)

". . . The hilly lands in their natural state, were covered with a heavy growth of the sugar maple, white maple, beech, birch, elm, ash and red oaks; the valleys were interspersed with ever-greens. . . ."

160. Lawe, John **1824**

Fur-trade in Wisconsin. Letter to Jacques Porlier, Portage, Green Bay 25th April 1824. *Wisconsin Hist. Coll.*, 20, 338 (1911).

(Sugar abundant at Green Bay)

"... Sugar will be somewhat abundant but there is so many purchasers we stand but a small chance of geting our share & they estimate it so high that it will cost us more than the first cost of our Goods to pay for it."

161. Evelyn, John 1825

Silva: or, A Discourse of Forest-Trees. London, 1825, Vol. I, 5 ed., p. 199.

(Maple sugar—refined in Normandy)

"The Savages in Canada, when the sap rises in the Maple, by an incision in the Tree, extract the liquor; and having evaporated a reasonable quantity thereof, (as suppose seven or eight pounds) there will remain one pound as sweet and perfect sugar as that which is gotten out of the cane; part of which sugar has been for many years constantly sent to Rouen in Normandy, to be refined: There is also made of this sugar an excellent syrup of Maiden-hair and other capillary plants, prevalent against the scurvy; though Mr. Ray thinks otherwise by reason of the saccharine substance remaining in the decoction."

162. McKenney, Thomas L. 1826

Sketches of a Tour to the Lakes, of the Character and Customs of the Chippeway Indians, and of Incidents connected with the Treaty of Fond Du Lac. Baltimore, 1827, (a) p. 192, (b) p. 193.

a. (Trade in maple sugar at Sault de St. Marié)

"The staples of the place, are the white fish and maple sugar, and some few, but not many furs."

b. (Mococks of maple sugar)

"Sugar is the next great staple. It is made from the maple, and principally by the Indian women. You know the manner of tapping the tree, and boiling the sap, and fining the sugar, and therefore it is not necessary that I should trouble you with an account of it. Henry tells us the earlier part of the spring is that best adapted to make maple sugar. The sap runs only in the day, and it will not run unless there has been a frost the night before. When, in the morning, there is a clear sun, and the night has left ice the thickness of a dollar, the greatest quantity is produced. Three families in this neighborhood, of which my old friend Mr. J . . .'s is one, make generally *four tons* of sugar in a season. Some of it is very beautiful. I have some *mococks* of it given to me by Mrs. Johnson, of her own make. It is as white as the Havanna sugar, and richer. A mocock is a little receptacle of a basket form, and oval, though without a handle, made of birch bark, with a top sewed on with *wattap,* (the fine roots of the red cedar, split) the smaller ones are ornamented with porcupines' quills, died red, yellow, and green. These ornamented mococks hold from two to a dozen table spoons full of sugar, and are made for presents, or for sale, to the curious. The larger ones, also of birch bark, are not ornamented, and contain from ten to thirty pounds of sugar. This is an article of exchange with those who make it. They give for labour, for goods, &c. and generally at about ten cents per pound. Indians often live wholly upon it; and Henry tells us he has known them to grow fat upon this sugar alone."

163. Doty, James Duane 1827

Letter to The Honorable James Strong, Chn. of the Comt. on Territories, Dec. 25, 1827. *Wisconsin Hist. Coll.,* 13, 245 (1897).

(Sugar exported from "that part of the Michigan Territory which lies to the north and west of Lakes Huron and Michigan")

"The exports from this Territory have been usually estimated to consist annually of Furs and Peltries, valued at 300,000$—White fish 800 to 1000 barrels.— Sugar 200,000 lbs. and Lead 10,000,000 lbs.

164. Lockwood, James H. 1827

Early times and events in Wisconsin. *Wisconsin Hist. Coll.,* 2, 156 (1856).

(Sugar-making in Iowa)

". . . he went with his family up the Yellow or Painted Rock Creek, above twelve miles above the Prairie, on the Iowa side of the Mississippi River, to make sugar. . . ." (cf. Snelling, 1827)

165. (Snelling, Wm. J.) ? 1827

Early days at Prairie du Chien. *Wisconsin Hist. Coll.*, 5, 126 (1868).

(Sugar-making by white men in Iowa)

". . . Every one knows that, in the Western country, French people make maple sugar in the spring. M. Methode chose to set up his sugar camp at the mouth of the Yellow River, two miles from Prairie du Chien. . . ."

166. Smith, Thomas and John O. Charles 1828

The Origin and History of Missions. Boston, 1837, Vol. II, p. 389.

(A penitent interpreter of dreams among the Ojibway Indians)

The Rev. Wm. M. Ferry, the founder of the mission at Mackinaw, wrote of an "excessively intemperate" Indian woman of Ojibway blood who, because of influential connections, had been selected to become an interpreter of dreams. In about 1825 "her serious attention to religion commenced, the amount of which for some length of time was very fluctuating." In one of her drunken orgies she "lost her sack." Repentance followed. Of her it was stated: "During the spring, while at the sugar camp, she says she was greatly distressed during the whole time. When gathering sap, she often had feelings like these – Here I am going the same round daily from tree to tree, and can find no relief – I must always carry this wicket heart, and when I die, be miserable forever."

167. Macauley, James 1829

The Natural, Statistical, and Civil History of the State of New York. New York, 1829, p. 536.

Remarks on some of the trees, etc.

"The Indians in this State and Canada are said to have made sugar anterior to the colonization. The quantity made lessens as the woods are cut down. There are many districts, in which large quantities were formerly made, which, at present, do not afford a pound. In general, no attention has been paid to the preservations of the trees. In addition to this, the snow, where the lands are cleared, go off much earlier, and the seasons have become shorter and more irregular: hence, the trees do not afford so much sap as formerly. . . ."

168. Sheppard, W. 1829

Observations on the American Plants described by Charlevoix. *Trans. Literary Hist. Soc. Quebec,* 1, 223, (1829).

(Erable à fleurs rouges)

"Acer rubrum. Red maple. Called by the Canadians, Plane. A large tree growing commonly about Quebec, and in common with the other maples yields a saccharine sap; but the sugar made from it, is inferior in quality to that obtained from Acer saccharinum and nigrum. It is surprizing that Charlevoix should mention this species only, out of the nine found in America."

169. Stambaugh, Samuel 1831

Report (to Secretary of War) on the quality and condition of Wisconsin Territory, 1831. *Wisconsin Hist. Coll.,* 15, (a) 408, (b) 413, (c) 415 (1900).

a. (Brothertown Indians settle on Menominie land east of Fox River)

". . . I assured the Menominies that the removal of the stranger Indians upon this land would not impair their treaty stipulations with the United States, nor diminish the kind feeling entertained toward them by the government, but that, should the Treaty be ratified by the Senate, all its provisions would be carried into effect. With this assurance the Chiefs left me apparently satisfied, although some of their finest sugar Camps are on the land occupied by the Brothertown Indians, which will be much injured if not entirely destroyed by their settlement."

b. (Maple groves near Oconto Falls)

". . . There are exuberant groves of Maple and Beech in the neighborhood of these falls, which is the best evidence of the fertility of the soil; and a short distance below, on the south side of the mill, the Indians have Sugar Camps, at which they manufacture large quantities of sugar. . . . The land is covered with a thriving growth of Oak, Beech and Maple. . . ."

c. (Sugar camps near Little Kaccalin)

"There are several sugar camps in the neighborhood, where large quantities of sugar are manufactured from large and beautiful Maple groves."

170. Anon. 1832

History of the Delaware and Iroquois Indians formerly Inhabiting the Middle States. Philadelphia, 1832, p. 89.

(The great value of the sugar maple tree)

"Of all the productions of the earth, however, with which the Indians were familiar, none was better esteemed, or more interesting than the *Sugar maple tree,* so called because of the sap which runs from it at a particular season of the year, from which they make a quantity of delightful sugar. This sap is found in greatest plenty in the spring of the year. At this time they make an incision into the tree; and through this hole the sap is received, by means of a funnel, into wooden troughs or vessels. It is then boiled over a slow fire in kettles, and becomes as good as any sugar in the world. The flowing season lasts generally one or two months.

"Sugar boiling is chiefly the employment of women. A kettle holding between sixty or seventy quarts, with two of a smaller size, for ladles, will boil, with ease, two hundred pounds of sugar in one season, besides furnishing a large quantity of molasses. Instances have been known of one tree producing above three hundred quarts of good sap for sugar, and as much for molasses. About thirty-five or forty quarts of sap produce one pound of sugar. Thus about eight pounds of sugar, and as many of molasses, may be collected from one tree, and the trees last eight or nine years. A large quantity of maple sugar is made every year in the United States. Dr. Rush, who wrote on this subject of sugar maple, which he regarded as a peculiar gift of a benevolent providence, calculates that the cultivation of these trees would furnish support to many thousand families, and even become an important branch of revenue to the government."

171. Ferrall, S. A. 1832

A Ramble of Six Thousand Miles through the United States of America. London, 1832, p. 173.

(Sugar Maple in Indiana)

"The farmers use, almost exclusively, the sugar of the maple (*acer saccharinum*) which they manufacture themselves. The space in which a number of these trees are found, they call a 'sugar camp.' The process of manufacturing is as follows: – After the first frost, the trees are tapped, by perforating the trunk in an ascending direction. A spout of alder is inserted in the perforation, and the sap drips through this conduit into a trough of wood. The sap is then boiled with a spoonful of slaked lime, the white of an egg or two, and about a pint of milk, to every fifteen gallons. An ordinary tree commonly gives four pounds of good course brown sugar, which when refined can be made equal to superior lump sugar."

172. Hudson, Charles 1832

History of the Town of Westminster, Mendon, Mass., 1832, p. 6.

(Sugar-making in Massachusetts)

". . . It is a good grazing township. The growth of wood is beech, maple, birch, oak, chestnut, ash, hemloc, and pine. Beech and rock maple, are the most abundant. From the latter sugar for family consumption, is made in considerable quantities."

173. Radcliff, T. 1832

Authentic Letters from Upper Canada. Dublin, 1833, p. 229.

(Shuggar from the "maypole")

"But what flogged all that I had ever seen, was making sugar out of a tree, Mary – not a word of a lie do I tell you; you take a big gimlet and make a hole in the tree, (the *maypole* I think they call it,) and out comes the shuggar, like sweet water thick like, and you boil it, and you—but where's the use of my telling you any thing about it, as you have no sugar trees at home.

"I remember when you and I thought a shuggar stick, a mighty good sort of thing, never thinking I'd lay my eyes on a *sugar tree*."

174. Flint, Timothy 1833

History and Geography of the Mississippi Valley. Cincinnati, 1833, Vol. I, 3 ed., p. 43.

("Country sugar" and cane sugar)

"The sugar maple is very abundant in the northern and middle regions of this valley. . . . In different parts of Ohio, Kentucky, Tennessee, Illinois, and Missouri, it is made, not only for consumption, but for sale. . . . The season of making it is generally one of festivity and high holiday. We have tasted sugar loaf made from it, which could in no way be distinguished from that made from the cane. The cheapness of the latter kind, the abundance and excellence of its growth in the lower country, and the diminished expense of transporting it to the upper states, in consequence of the multiplication of steam boats, has diminished the demand for what is called 'country sugar,' and the manufacture of it has decreased, since the use of steam boats."

175. Porter, Jacob 1834

Topographical Description and Historical Sketch of Plainfield, in Hampshire County, Massachusetts. Greenfield, 1834, (a) p. 11, (b) p. 12.

a. (Native timber)

"The native timber of our forests consists principally of maple, (of which we have four species,) beech, birch, hemloc, spruce, fir, and cherry. From the sugar maple large quantities of sugar are manufactured. . . ."

b. (Plantings of sugar maple)

"Several years since the practice of setting out that very beautiful and useful tree, the sugar maple, by our road sides, was introduced by the writer of this article. Several of our streets are now ornamented in this way; and it is highly desirable that the practice should become general. . . ."

176. Catlin, George 1835

Letters and Notes on the Manners, Customs, and Condition of the North American Indians. Philadelphia, 1859, p. 604; Thos. Donaldson, The George Catlin Indian Gallery. Report of the U. S. National Museum. 1885, Pt. V, p. 240.

(A Chippeway gift of maple sugar)

"Through this curious scene I was strolling a few days since with my wife, and I observed the Indian women gathering around her, anxious to shake hands with her and shew her their children, of which she took especial notice; and they literally filled her hands and her arms with *muk-kuks* of maple sugar, which they manufacture and had brought in, in great quantities for sale."

177. Featherstonhaugh, Geo. Wm. 1835

A Canoe Voyage up the Minnay Sotor. London, 1847, Vol. I, (a) p. 327, (b) 338.

a. (Maple sap restores Indians' strength)

"The banks of the river were generally low, but occasionally immense bluffs of granite came jutting in, maple, oak, poplar, and willow abounding. Milor informed me that the sugar-maple was a great blessing to the Indians; for that often in the spring, before the snow has melted, and they are almost reduced to starvation, they watch the maple-tree, and as soon as the sap begins to run in March, drink it and soon recover their strength."

b. (Maple sugar camp near Lac qui Parle)

". . . At 9 A.M. we stopped in a clump of sugar maple trees to breakfast, where we found a great number of little wooden troughs, which the Indians, after making an incision in the trees, place beneath them to collect the sap. . . ."

178. Fitch, Martha E. 1839

A little girl of old Milwaukee. *Wisconsin Mag. Hist.*, 9, 84 (1925).

(A "sugaring off" along the Menominee River)

"Whenever they came to a maple tree they stopped and chopped a small piece of wood from it, pressed a shingle into the cavity to carry the sweet maple sap that was ready to flow into the bucket that they had left under each tree. They found a nice open space for the great kettle and put it on a chain, supported by rods, and later built from the fallen trees a great fire under it. In a day or two they commenced gathering the sugar sap, as it was called. The men drove to all the trees and emptied the buckets into a barrel, and then drove to the fire, emptying the barrels into the big kettle. We could drive around with them or sit on a log and watch the boiling kettle, just as we pleased. There was a long table with tin cups and plates, and a long dipper to stir the syrup, and the nice men would give us a cupful of the syrup, which we cooled in the snow and it was just like candy. When the syrup was boiled down sufficiently we had a 'sugaring off.' The neighbors were invited. It was in the evening and the moon was bright as day, and the big bonfire blazed and glowed, and made us all warm and 'comfy.' The neighbors came, some in sleighs and some on horseback, and boys and girls, too. They could have all the sugar they wanted to eat. . . . And that is the way we made our maple sugar."

179. Trego, Charles B. 1843

A Geography of Pennsylvania. Philadelphia, 1843, p. 60.

Maple

"Of the Sugar Maple we have two kinds; the true Sugar maple (Acer *saccharinum*) and the Black Sugar tree, or Black maple (*Acer nigrum*). The former is most abundant in the northern parts of the State, and along the elevated range of the Allegheny table land, where the soil, though fertile, is cold and moist. . . . The Black maple is more common in the low rich soils along the western rivers. . . . Both of these species of maple yield the sap from which sugar is made. . . . In February, or the beginning of March, when the sap begins to ascend, holes are bored in the tree from one to two feet from the ground, and tubes of elder or sumach inserted to conduct the sap into a trough or vessel placed to receive it. The sap is collected and boiled to a syrup, after which it is cooled and is strained through a cloth to separate impurities. It is then boiled again, until the syrup is reduced to the proper consistency for graining or pouring into the moulds. The colour and quality of the sugar depend much upon the care and judgment with which the process is conducted. The sap continues to flow for several weeks, but gradually becomes less abundant and less rich in saccharine matter. About four gallons of sap are estimated to yield a pound of sugar, and a single tree, having twenty tubes inserted has been known to yield twenty-three gallons of sap in a day. Large quantities of maple sugar are still made in the northern and western counties by the farmers, who sell that which they do not require for their own use to the shopkeepers of the neighbouring towns."

180. Marshall, Josiah T. 1845

The Farmer's and Emigrant's Hand-Book. New York, 1845, 2 ed., p. 359.

(To make maple sugar)

In a letter to the Committee on Maple Sugar of the New-York State Agricultural Society, Joel Woodworth describes his method of making and clarifying the sugar for which he received the Society's first premium. As clarifying agents he uses for one hundred pounds of sugar "the whites of four or five eggs well-beaten, about one quart of new milk, and a spoonful of saleratus, all mixed with the syrup before it is scalding hot."

181. Beckley, Hosea 1846

The History of Vermont; with Descriptions, Physical and Topographical. Brattleboro, 1846, p. 311.

(A salute to the sugar-maple)

"The sugar maple is the glory of the Vermont forests, so rich and beautiful in their great variety of trees and shrubbery, and to the different heights to which they grow, and shapes which they assume. The color of their bark and lines and tinges of their foliage are almost endless in their diversities. The form of the maple and the intenseness of its foliage, the first to bud and leave out in the spring, and the first to fade in autumn, renders it a pleasing object of contemplation in itself. But the increasing use made of it for sugar and molasses, must greatly enhance its value and comeliness in the eyes of the Vermonters, on whose soil it stands pre-eminent and most frequent.

"Pre-eminent and most frequent, this is true as a state; although in some parts of New York, particularly the high-lands of Schoharie county, this noble tree is found in magnitude and height and frequency equal to any part of this state. Such significant names of neighborhoods and villages are found as *sap-bush-hill,* and *sap-hollow,* where and on *dutch-hill,* the writer has seen as noble specimens of this tree as those given by Dr. Williams in early periods of green mountain history; five feet in diameter and from one to two hundred feet high."

182. Butterfield, Consul W. 1848

History of Seneca County. Sandusky, 1848, p. 69.

(A Seneca festival)

"Large kettles of soup ready prepared, in which maple sugar, profusely added, made a prominent ingredient, thus forming a very agreeable saccharine coalescence. All were invited, and all were made welcome; indeed, a refusal to partake of their bounty was deemed disrepectful, if not unfriendly."

183. Goodrich, S. G. 1848

Manners and Customs of the American Indians. Boston, 1848, p. 204.

(Food of the North American Indian)

"They extracted sugar from the maple tree, and used it to sweeten their cakes which were made of ground corn mixed with chestnuts, beans and berries."

184. Allen, William 1849

The History of Norridgewock. Norridgewock, 1849, (a) p. 57, (b) p. 73.

a. (Forest trees at Norridgewock, Maine)

"There was formerly a considerable quantity of pine timber in the town which was distinguished for its size. The hard wood growth originally consisted of beech, sugar maple, yellow and white birch, white and brown ash, intermixed with evergreens, of which hemlock predominated; spruce and cedar were also found, and in some swampy places, hackmatack. . . . The margin of the river was lined with trees of various kinds, and the intervales were covered with the white and sugar maple, the elm, the birch, the butternut, and the basswood; balm of Gilead and poplars were found in some places."

b. (Source of sugar)

"The surrounding maples furnished them with sugar; . . ."

185. Clark, Joshua V. H. 1849

Onondaga; or Reminiscences of Earlier and Later Times. Syracuse, 1849, Vol. I, p. 54.

(Rites and ceremonies)

"The first of these festivals is held in spring, directly after the season for making sugar is past. They give thanks for the abundance of sap, and for the quantity of sugar they have been permitted to make."

186. Eastman, Mary 1849

Dahcotah; or Life and Legends of the Sioux around Fort Snelling. New York, 1849, p. 159.

(Sugar-feast is part of the Indians religious rites)

"After the scalp-dance had been performed long enough, the Dahcotahs of the villages turned their attention to making sugar. Many groves of sugar trees were in sight of their village, and on this occasion the generous sap rewarded their labors.

"Nor were they ungrateful; for when the medicine men announced that they must keep the sugar-feast, all left their occupations, anxious to celebrate it. Neither need it be concluded that this occasioned them no loss of time; for they were all occupied with the construction of their summer wigwams, which are made of bark trees, which must be peeled off in the spring.

"But every villager assembled to keep the feast. A certain quantity of sugar was dealt out to each individual, and any one of them who could not eat all that was given him was obliged to pay leggins, or a blanket, or something valuable, to the medicine man. On this occasion, indeed on most occasions, the Dahcotahs have no difficulty in disposing of any quantity of food."

187. (Cooper, Susan Fennimore) 1850

Rural Hours. New York, 1850, (a) p. 23, (b) p. 27, (c) p. 28.

a. (The maple sugar scene in New York)

"Saturday, April 1st.—Fresh maple sugar offered for sale today; it is seldom brought to the market as early as this. A large amount of this sugar is still made in our neighborhood, chiefly for home consumption on the farms. In the villages, where foreign groceries are easily procured, it is eaten more as a dainty than in any other way; the children are very fond of it, and most grown persons like a bit now and then, its peculiar flavor making it pleasant when taken by itself, though it becomes a defect when used for sweetening food. In the spring, a little of it is not thought unhealthy, from a fancy that it purifies the blood; probably it is neither better nor worse in this respect than any other sugar. With our farmers, however, it is a matter of regular household consumption, many families depending on it altogether, keeping only a little white sugar for sickness; and it is said that children have often grown up in this country without tasting any but maple sugar. Maple molasses is also very much used, some persons preferring it to that of the cane, as it has a peculiar flavor which is liked with puddings, or buckwheat cakes."

b. ("Year-round" production)

"A story is told in the village of a Scotch stocking-weaver, who some years since bought a farm near the lake, and the first spring after his arrival in the country was so successful with his maple trees, that in the midst of his labors he came into the village and gave large orders for sap-buckets, pans, furnaces, &. The good folk were rather surprised at the extent of these preparations, and inquiries were made about this grand sugar-bush. They were told by their new neighbor that as yet he had tapped only a small number of trees, but he intended soon to go to work in earnest among the maples, and, indeed, had quite made up his mind, 'canny Scot,' as he was, to 'give up farming altogether, and keep to sugar-making all the year round'; . . ."

c. (Other trees yield saccharine sap)

"Many other trees are tapped for their juices . . . they prepare from the sap of the Palm of Chili, a syrup of the consistency of honey. . . In Crimea, the Tartars regularly make sugar from the fine walnut-trees on the shores of the Black Sea. So says Dr. Clarke in his Travels. The lime or basswood also yields a saccharine fluid. Our own hickory is thought to have the sweetest and richest sap of any tree in the woods, and we have heard of superior sugar being made in small quantities from it by certain New England housewives. It would not be generally available for the purpose, however, as the amount of sap yielded is very small."

The entry concludes with some production figures for the various states.

188. Thatcher, B. B. 1854

Indian Traits: being Sketches of the Manners, Customs, and Character of the North American Natives. New York, 1854, Vol. I, p. 66.

(Maple sugar in Indian cookery)

"If ripe and dry, it was pounded as fine as possible in the mortar, kneaded into dough, and made up into flat cakes, which they were careful to bake on hot and clean ashes. With this dough they frequently mixed boiled pumpkins, green or dried, beans, chestnuts, dried venison pounded to a powder, berries, and other things. Sugar, made from the juice of the maple-tree, was in many sections used to sweeten the rest."

189. Myrtle, Minnie 1855

The Iroquois; the Bright Side of Indian Character. New York, 1855, p. 49.

(Maple festival)

"The first festival was held in the spring when the sap began to flow, to return thanks to the maple for its sweet juices, and also to God for having given it to his red children. . . ."

190. Thoreau, Henry David 1856

Early Spring in Massachusetts. From the Journal of Henry David Thoreau. Edited by H. G. O. Blake. Boston, 1893, p. 199.

(Sugar from the red maple)

"*March* 21, 1856. 10 A.M. To my red maple sugar camp. Found that after a pint and a half had run from a single tube after 3 P.M. yesterday afternoon, it had frozen about half an inch thick, and this morning a quarter of a pint more had run. Between 10½ and 11½ A.M. this forenoon I caught two and three quarters pints more from six tubes at the same tree, though it is completely overcast, and threatening rain,—four and one half pints in all. The sap is an agreeable drink like iced water, by chance, with a pleasant but slightly sweetish taste. I boiled it down in the afternoon, and it made one and one half ounces of sugar, without any molasses. This appears to be the average amount yielded by the sugar maple in similar circumstances, *viz.*, on the south edge of a wood, and on a tree partly decayed, two feet in diameter. It is worth while to know that there is all this sugar in our woods, much of which might be obtained by using the refuse wood lying about, without damage to the proprietors, who use neither the sugar nor the wood. I put in saleratus and a little milk while boiling, the former to neutralize the acid, and the latter to collect the impurities in a scum. After boiling it till I burned it a little, and my small quantity would not flow when cool, but was as hard as half-done candy, I put it on again, and in a minute it was softened and turned to sugar. Had a dispute with father about the *use* of my making this sugar when I knew it could be done, and might have bought sugar cheaper at Holden's. He said it took me from my studies. I said I made it my study and felt as if I had been to a university. The sap dropped from each tube about as fast as my pulse beat, and as there were three tubes directed to each vessel it flowed at the rate of about one hundred and eighty drops a minute into it. One maple, standing immediately north of a thick white pine, scarcely flowed at all, while a smaller one, farther in the wood, ran pretty well. The south side of a tree bleeds first in the spring. Had a three-quarter inch auger. Made a dozen spouts five or six inches long, hole as large as a pencil, and smoothed with one."

191. Lapham, I. A. 1857

The forest trees of Wisconsin. *Trans. Wisconsin State Agr. Soc.*, 4, 207 (1854–7).

(Acer Saccharinum, of Waugenheim. Sugar Maple)

"This well known and highly valuable tree forms dense groves in many places, but more especially in the eastern and northern parts of the State. Some of these groves, called 'maple openings,' are among the most beautiful and interesting of our forest scenery. These groves often occupy the sites of deserted Indian villages,—thousands of the trees are annually 'tapped' to draw sap for the manufacture of 'maple sugar.' Over six hundred thousand pounds of this sugar are annually made in Wisconsin."

192. Hardy, Campbell 1869

Forest Life in Acadie. London, 1869, p. 41.

(Sugaries, maple honey, maple molasses)

"Before leaving the woods, however, we may not omit to notice those characteristic trees of the American forest, the maples, particularly that most important member of the family, the rock or sugar maple – Acer saccharinum. Found generally interspersed with other hardwood trees, this tree is seen of largest and most frequent growth in the Acadian forests on the slopes of the Cobequid hills, and other similar ranges in Nova Scotia, often growing together in large clumps. Such groves are termed 'Sugaries', and are yearly visited by the settlers for the plentiful supply of sap which, in the early spring, courses between the bark and the wood, and from which the maple sugar is extracted. Towards the end of March, when winter is relaxing its hold, and the hitherto frozen trees begin to feel the influence of the sun, the settlers, old and young, turn into the woods with their axes, sap-troughs, and boilers, and commence the operation of sugar-making. A fine young maple is selected; an oblique incision made by two strokes of the axe at a few feet from the ground, and the pent-up sap immediately begins to trickle and drop from the wound. A wooden spout is driven in, and the trough placed underneath; next morning a bucketfull of clear sweet sap is removed and taken to the boiling house. Sometimes two or three hundred trees are tapped at a time, and require the attention of a large party of men. At the camp, the sap is carefully boiled and evaporated until it attains the consistency of syrup. At this stage much of it is used by the settlers under the name of 'maple honey, or molasses'. Further boiling; and on pouring small quantities on to pieces of ice, it suddenly cools and contracts, and in this stage is called 'maple-wax' which is much prized as a sweetmeat. Just beyond this point the remaining sap is poured into moulds, in which as it cools it forms the solid saccharine mass termed 'maple sugar'. Sugar may also be obtained, though inferior in quality, from the various birches, but the sap of these trees is slightly acidulous, and is more often converted into vinegar."

193. McAfee, H. H. 1870

The maple family of trees for cultivation. *Trans. Wisconsin State Agr. Soc.*, 9, 288 (1870).

(Economic value of the maple)

An appraisal of the maple tree as a source of sugar and of wood.

194. Fisk, E. A. 1874

Maple Sugar. Vermont State Board Agriculture, Manufacturing and Mining, *Second Biennial Report*, 1873–74, (a) p. 713, (b) p. 717.

a. (Maple sugar production poorly understood)

". . . Perhaps there is no branch of farming in which more improvement has been made within the last thirty or forty years than in the manufacture of maple sugar; and there is probably none in regard to which there is more general ignorance among people who do not live where it is made. I will not vouch for the truth of the story of the man who on immigrating to Vermont, thought he would follow sugaring the year round as he had heard that it was a profitable business. But only a few days ago I heard of two intelligent men within the limits of New England who had a warm dispute whether maple sugar was made in the fall or spring, and referred it to a Vermonter for decision. How many pounds of sugar can you make from a cord of maple wood? is also an authentic question."

b. (Factors which influence quality)

". . . The location of the sugar place may have some influence upon the quality of sugar produced, and if there are many spruces or hemlocks to cast their leaves into the sap, it cannot improve it any, and it is probable that impurities in the soil may in some cases affect the sugar. . . . In one case a pile of spent tan bark was placed near the roots of the maple, and the sap of that tree became the color of weak lye, but afterwards it was removed, and the sap has since appeared to be pure. In another case which came under my own observation, the sap was evidently affected by impure substances in or on the soil; but making allowances for all this, I think that much of the difference in sugar is in making."

195. Foster, A. M. 1874

Sugar Making. Vermont State Board Agriculture, Manufacturing and Mining, *Second Biennial Report,* 1873–74, p. 724.

(Production and marketing of maple sugar)

A report dealing with contemporary apparatus, manufacturing processes, marketing, and care of sugar tools.

196. Willard, J. E. 1874

History of the Town of Sutton, Caledonia County. Vermont Historical Gazetteer, Vol. V, iii, p. 159 (1891).

(Sutton, the banner maple sugar town)

"Sutton, it is understood, is the largest maple-sugar producing town in the State, and perhaps, the largest in the United States. In the spring of 1874, more than 140,000 pounds was made, and one year since, the produce was larger than in 1874.

"In School District No. 6 of 12 families more than 28,000 pounds have been made in a single season."

(Maple sugar in spirituous liquor)

"Our sugar is made nearly all of it in this County, dry or what is known as stirred so that it is put into flour barrels and headed up, and is now shipped to Chicago. What they do with so much maple sugar is somewhat of a mystery. Some say it is used in spirituous liquor, especially for brandy which it gives the look of age, others that it is used in glucose."

197. Daily, Josiah 1882

Flavoring-Extract for Sirup and Sugar. United States Patent 261,315. July 18, 1882.

Described as an "improved" sirup or sugar, claimed to have a flavor which "cannot be distinguished from genuine maple-sirup." To prepare it, a decoction of the outside bark of the shell-bark hickory or wood—the sap of this tree may be used if available—is added to a sirup made from any kind of sugar, or the sirups "ordinarily found on the market."

198. Wiley, H. W. 1885

Composition of maple sugars and syrups. *Chem. News*, 51, 88 (1885).

(Various forms of adulteration found)

The paucity of recorded analyses of maple sugars and syrups led to a study of market samples of these products with the discovery, as had long been suspected, that the commercial products were largely adulterated. Admixture with starch sugar, or glucose, substitution of colored cane sugar syrup for the genuine article, and the use of the sap of the butternut tree as the source of a syrup, are examples of the forms of adulteration revealed by this survey.

199. Wiley, H. W. 1885

The Sugar Industry of the United States. Maple Sugar. U. S. Dept. Agric., Chem. Div., *Bull.* 5, iv, (a) p. 209, (b) p. 213.

This publication summarizes the then known chemical information on maple saps, sugars, and sirups. Extensive new analytical data are recorded. Of special interest are the following items.

a. (A "Jersey" among maples?)

"The highest percentages of sucrose are found in tree No. 3, April 24, viz., 9.88 per cent., and in tree No. 14, April 20, viz., 10.20 per cent. In both of these cases the flow of sap was small, being 128 and 227 grams, respectively.

"The study of the sap from such a tree as No. 3 offers also the interesting suggestion that it may be quite possible to increase the percentage of the sugar in the sap of future maples by planting the seed of such trees as show the largest percentage of sucrose. . . . There is every reason to believe that a race of maples, yielding a large percentage of sugar, could be developed as easily as a race of cows, yielding large quantities of butter.

"Among the maples there may yet be a race of Jerseys."

b. (Manufacturing notes)

Descriptive.

200. Schultz, J. C. 1887

The Great Mackenzie Basin: A Summary of the Reports of the "Schultz Committees" of the Senate of Canada. Edited by F. J. Chambers. Ottawa, 1908, p. 16.

(Sugar from the ash-leaved or Red river maple)

"Prof. Bell explained that although the ordinary sugar maple does not grow in the Northwest, there is a tree there which yields sugar—the ash-leaved maple, sometimes called the Red river maple. It is a very pretty tree, grows rapidly and yields a rich sap. This tree grows native in all the more southern parts of the northwest country along the rivers, and Prof. Bell had seen it cultivated by the missionaries where it does not grow naturally. It is cultivated at Lac la Biche, some three hundred miles northwest of its natural northern limit. The missionaries at Lac la Biche cultivate it for the purpose of getting sugar from it. This sugar is capable of being refined. The sap contains two and a half per cent of sugar to its weight. The Indians boil down the sap of this tree to make sugar. It is the maple sugar of the Northwest."

201. Sargent, C. S. 1891

Silva of North America. Boston and New York, 1891, Vol. II, (a) p. 99, (b) p. 101.

a. (Sugar-making an Indian art)

". . . the making of maple-sugar was an established industry of the Indians during the last half of the seventeenth century, and before the discovery of the upper

Mississippi River by Europeans (1673). Bossu, a French officer of much intelligence who traveled in America between 1756 and 1771, states explicitly that the French learned the method of sugar-making from the Indians; and the testimony of earlier travelers point to the same conclusion."

b. (Early botanists overlook the sugar maple)

"The Sugar Maple, strangely enough, escaped the attention of the early botanists who examined the forests of North America, and it was not known to Linnaeus. . . ."

202. Wiley, H. W. 1892

Foods and Adulterants. Sugar, Molasses and Sirup, Confections, Honey and Beeswax. U. S. Dept. Agric. Div. Chem., *Bull.*, 13, vi, (a) p. 645, (b) p. 675, (c) p. 710.

a. (Adulterated maple sirup from Ohio)

". . . Among the 17 samples of maple molasses 6 were found to be adulterated with commercial glucose. This fact was a surprise to the writer, since two years ago the dairy and food commission of Ohio had succeeded in driving all of these spurious brands of maple sirup from the State. . . . some of the (remaining) samples have a considerable proportion of reducing sugars, and at the same time a low content of ash. In the manufacture of maple sirup and sugar, the salts contained in the sap are not separated from the finished product. . . . It would seem . . . that some of the samples not adulterated with glucose were contaminated with cane sugar or sirup. . . ."

b. (Maple sugar valued for its flavor)

". . . The price of maple sugar, as is well known, is out of all proportion to the saccharine matter which it contains, and is due to its peculiar and pleasant taste, derived presumably from some ethereal matter exuded with the sap. The nature of this substance has not . . . been definitely determined. It is not wholly volatile, since it remains in the sugar and molasses after they have been kept for a long time at a high temperature during the process of concentration. . . ."

c. (Maple sirup widely adulterated)

"It has long been known that a large part of the maple sirup sold in the market is made from glucose, understanding by this term the liquid product of the conversion of starch into sugar. It is also well known that large quantities of maple sirups are sold on the market which are fabrications made up of other sweets, to which a little maple molasses is added for the purpose of giving it flavor, or, as is often the case, being entirely free from any addition of maple product whatever. The maple flavor is imparted to sirups by mixing with them an extract of hickory bark, and this product has been made and sold under the term of 'mapleine.'" It is safe to say that perhaps the greater quantity of maple molasses or sirup sold on the market is an adulteration in the true sense of the word. . . ."

203. Hoffman, W. J. 1893

The Menomini Indians. Smithsonian Institution. Bur. Ethnology, 14 *Ann. Report,* 14, (a) p. 173, (b) p. 288, (c) p. 315.

a. (Menomini tale about the origin of maple sugar)

"When Manabush returned empty-handed from his hunting trip . . . he and his grandmother, Nokomis, gathered together all their effects, moved away from the place where they had dwelt, and built a new wigwam among the trees in the new locality.

"These trees were maples, and the grandmother of Manabush said to him, 'Now, my grandson, you go into the woods and gather for me some pieces of birchbark; I am going to make sugar.' So Manabush went into the woods and gathered some strips of birchbark to make vessels to contain the sugar.

"The grandmother of Manabush then went from tree to tree, cutting a small piece of wood over which the sap ran into the vessels placed beneath. Manabush followed his grandmother from tree to tree, watching her and looking for the sap to drop into the vessels, but none was to be seen. When she had gone around among the trees, and cut holes for as many vessels as she had made, Manabush went back and looking into the vessels saw that all of them had suddenly become half full of thick syrup.

"Manabush dipped his finger into the syrup and tasted it. Finding it sweet, he said, 'My grandmother this is all very good, but it will not do to have these trees produce sirup in this manner. The people will not have any work if they make sugar so easily; they must cut wood to boil the sirup for several nights, and to keep them occupied that they may not get into bad habits; I will change all this.'

"So Manabush climbed to the very top of one of the trees, when he took his hand and scattered water all over the maples, like rain, so that the sugar should dissolve and flow from the trees in the form of sap. This is why the uncles of Manabush and their descendants always have to work hard when they want to make sugar. Wood must be cut, vessels must be made, and the sap that is collected must be boiled for a long time, otherwise the people would spend too much time in idleness."

b. (The sugar-making season)

The season for sugar-making came when the first crow appeared. This happened about the beginning or middle of March, while there was yet snow on the ground. This period of the season was looked forward to with great interest, and, as among the Minnesota Ojibwa today, became a holiday for everybody. Each female head of a household had her own sugar hut, built in a locality abounding in maple trees—the *Acer saccharinum*—which might or might not have been convenient to her camp, but which was the place always resorted to by her, and claimed by right of descent through her mother's family and totem.

c. (English-Menomini vocabulary)

Cake sugar, Bakwatenekan; maple sugar molded in the shape of small cakes; served to visitors and friends, and also deposited in grave boxes of friends and relations as an offering. Hard maple, Sheshikima—*Acer saccharinum;* the species used for sugar-making; sap of maple, Shopomakwopo.

204. Burroughs, John 1895

Winter Sunshine. Boston, 1895, (a) p. 89, (b) p. 93.

a. A March chronicle

". . . The moment the contest between the sun and frost fairly begins, sugar weather begins; and the more even the contest, the more the sweet. I do not know what the philosophy of it is, but it seems a kind of see-saw, as if the sun drew the sap up and the frost drew it down; and an excess of either stops the flow. Before the sun has got power to unlock the frost, there is no sap; and after the frost lost its power to lock up again the work of the sun, there is no sap. But when it freezes soundly at night, with a bright, warm sun next day, wind in the west, and no signs of a storm, the veins of the maples fairly thrill. Pierce the bark anywhere, and out gushes the clear, sweet liquid. But let the wind change to the south and blow moist and warm, destroying the crispness of the air, and the flow slackens at once, unless there be a deep snow in the woods to counteract or neutralize the warmth, in which case the run may continue till the rain sets in. . . ."

b. (The charm of sugar-making)

"I think any person who has tried it will agree with me about the charm of sugar-making, though he have no tooth for the sweet itself. It is enough that it is the first spring work, and takes one to the woods. The robins are just arriving, and their merry calls ring through the glades. The squirrels are now venturing out, and the woodpeckers and nuthatches run briskly up the trees. The crow begins to caw, with his accustomed heartiness and assurance; and one sees the white rump and golden shafts of the high-hole as he flits about the open woods. . . . I sympathize wtih that verdant Hibernian who liked sugar-making so well that he thought he should follow it the whole year. I should at least be tempted to follow the season up the mountains, camping this week on one terrace, next week on one farther up, keeping just on the hem of Winter's garment, and just in advance of the swelling buds, until my smoke went up through the last growth of maple that surrounds the summit."

205. Jenks, Albert Ernest 1899

The Bear Maiden. An Ojibwa Folk-Tale from Lac Courte Oreille Reservation, Wisconsin. *J. American Folklore,* 15, 34 (1904).

(Maple sugar in Indian folk-tale)

"He asked the little Bear whether she could bring back the sun. She said: 'Yes, give me two handsful of maple-sugar and your oldest son.' With the maple-sugar she went to the wigwam of the old woman, and, climbing up to the top, threw the sugar into a kettle of wild rice which the old woman was cooking. When the old woman tasted the rice she found it too sweet, so she went away to get some water to put in the kettle, and the little Bear jumped down, ran into the wigwam, grabbed up the hidden sun, and threw it into the sky. . . ."

"Again the old chief got sick and he asked the little Bear whether she could get him his lost horse which was all covered with bells. She answered: 'Yes, give me two handsful of maple sugar and your youngest son.'"

206. Pokagon, Chief Simon 1899

O-gi-maw-kwe-mit-i-gwa-ki (Queen of the Woods). Hartford, Mich., 1899, (a) p. 124, (b) p. 143.

a. (Corn cake and maple syrup)

"After eating our simple morning meal of 'manda-min' (corn cakes) in 'gi-wa-ga-mis-i-gan' (maple syrup) dipped. . . ."

b. (God's kettle)

"That kettle is still kept among us, and is now called Man-i-to au-kick (God's kettle), and is used for boiling on-si-ban sho-po-maw (maple sap into sugar). . . ."

207. Parker, Arthur C. 1910

Iroquois Uses of Maize and Other Food Plants. N. Y. State Museum, *Museum Bull.,* 144, (a) p. 102, (b) p. 104.

a. (Iroquois' veneration of the maple)

"The maple tree was one of the trees venerated by the Iroquois. It was in fact the goddess of trees and the only one to which a stated ceremony was dedicated and to which offerings were made. Pine, hemlock, elm and basswood were esteemed, but the maple was a special gift of the

Creator and every spring at the foot of the largest maple tree in each village a ceremonial fire was built and a prayer chanted by the Keeper of the Maple Thanksgiving ceremony as he threw upon the embers pinches of sacred incense tobacco. The maple tree started the year. Its returning and rising sap to the Indian was the sign of the Creator's renewed covenant.

"The Iroquois will ever remember the maple tree, but few now even remember the tradition of how it was during the maple sap season, that the Laurentian Iroquois struck their blow for freedom from Adirondack domination and fled into northern and central New York. (One Mohawk tradition relates that the women flung hot maple sap into the faces of the Algonquin Chiefs and thus helped their people in the fight for independence)."

b. (Iroquois vocabulary)

"Maple, *wat da;* sap, syrup, *owa no gi;* sugar, *owa no;* boiling sap, *goste do;* sap runs, sap time, *o ga not;* he taps, *ha ge o ta;* sap spout, *nio geoda kwa.*"

208. Barbeau, C. M. 1912

Huron and Wyandot Mythology. Canada Geol. Surv., *Memoir* 80, No. 11, *Anthropological Series,* 1915, p. 110.

The maple and the woman

"The Sugar-tree-top, transfigured into a human form, once appeared to a woman who was engaged in making maple sugar.[6]

"The sweet sap from a maple-tree was changed at once, as it still lay by the tree, into a sugar lump, as big as a large round pebble. When the woman found it on the wooden chip that she had driven into the tree for conveying the sap into a bark tray, she picked it up and started to eat it. A person whom she did not know suddenly [appeared and] stood beside her, saying, 'I wish to bring you good-luck. You must not eat the sugar-lump but keep it in a box, so that it may not be spoilt. And whenever you are making maple sugar, you may use it for gathering as much syrup as you will desire. The only

[6] "The Iroquoian tribes knew how to make maple syrup before the coming of the whites. It is not certain whether the Wyandots belonging to the western band made any maple sugar since they left the neighbourhood of Detroit, Ohio, in the course of the eighteenth century."

thing for you to do, when the sap is boiling, is to make a mark in the big kettle with the [treasured] sugar-lump; and the syrup will fill the kettle up to that spot. Keep this charm forever, and I will give you good fortune.' "

209. Skinner, A. B. 1913

Social Life and Ceremonial Bundles of the Menomini Indians. New York, 1915. Am. Museum Nat. Hist., *Anthropological Papers,* 13, vi, (a) p. 6, (b) p. 21, (c) p. 51, (d) p. 62, (e) p. 66, (f) p. 148.

a. Home life of the Menomini

"... In early spring, too, there was the annual sugar-making festival at the camps when the toil of reducing maple sap was lightened by merriment, dances, and buffoonery."

b. Social organization

"If a man met his totem animal he would often give it tobacco or some of its favorite food. For instance, if a bear, he would give it a piece of maple sugar."

c. (A Menomini dream)

"Shanapow, when a young boy commenced fasting for his fortune. He lived with his parents on the side hill opposite Keshena Falls or Kakapakato. He fasted eight days without eating, till he got very weak. On the eighth night he dreamed that one of the sacred monsters who lived in the falls appeared and told him, 'Look yonder and you will see something laced there as your reward for fasting,' indicating a rock in the center of the falls. The whole earth looked transparent and he went to the rock island, going over ice. When he got there, he discovered a sacred kettle which was bright as fire. It was a bear kettle from the underneath god to fetch from when a sacrifice feast was given. 'Now,' said the god, 'go a short distance and you will find there what is granted you. You will then break your fast and eat.' So Shanapow went and found a large bear which he killed and made a sacrifice of, and then ate with others whom he invited.

"The sacred kettle was to be hidden at first, for it was too great and sacred to be seen. When maple sugar is made it is the first thing to be placed in the sacred kettle, and it should be in it till a feast is made in its honor. Then the feasters eat it in honor of the monster below the falls. A song is then sung which is: 'All of the chiefs have given me to know this song.' This kettle is called a bear god kettle and is sacred. Every spring, maple sugar is put in it because all bears like sweet sugar, especially the king bear beneath this great falls. The dreamer Shanapow was told that he must keep a tiny bear to fulfil his dream. He always kept a bear cubskin to set up on a stick during the sacrifices."

d. Months and seasons

April Sopomakwin keso Sugar-making moon

e. Burial customs

". . . Should the relatives of the deceased be so fortunate as to have an unusually luxurious meal, or, in the sugar season, when there is an abundance of sweets, some tid-bits are placed in a tiny wooden bowl which is hung up in the memory of the dead relative who is supposed to come and eat it. . . ."

f. Hunting customs

"When it drew near spring the parents of the lost girl were making maple sugar at their sugar bush. Only a little snow remained here and there, and in the evenings the owls began to whoop and sing to show that they are at last awake, for the Indians know that winter is but a short night to all the Sacred Powers.

"In the meantime the parents of the little girl had given her up as lost, but the owl said to her grandchild, 'Now I will take you home, and land you at the limits of your parent's work on the trees they have tapped, surrounding their sugar camp. Stand there silently until your mother comes and finds you. Don't allow her to touch you at all for four days. Then you must tell her to go and prepare a tiny wigwam for you to remain in for four days. This must be away from the sugar camp in a clean place where no one has done any trampling on the ground, and you shall remain there, silent.'

"The mother ran back to the sugar camp to tell her husband and they both went back and met the girl."

210. Barbeau, C. M. 1915

Huron and Wyandot Mythology. Canada Geol. Surv., *Memoir* 80, No. 11, *Anthropological Series,* p. 45.

(Maple in Wyandot myth regarding the origin of the world)

"The Good One . . . made all kinds of trees covered with savory fruits, just within one's hand's reach. . . . The maple was made so that syrup would just drip out when the tree was tapped. Then came the Evil One. Finding the bushes too luxuriant and the fruits too sweet and juicy, he spoiled them. . . . Into the maple tree he poured some water and in that way 'thinned' the syrup into sap, which could not be reduced into syrup without exacting labour and trouble."

211. Skinner, A. B., and J. V. Satterlee 1915

Folklore of the Menomini Indians. New York, 1915. Am. Museum Nat. Hist., *Anthropological Papers,* 13, iii, 298.

(Tales of the culture hero)

"Once in one of Manabus' walks he followed up a stream along the bank until he came to where a pair of mated partridges were making maple sugar. They had two children, little partridges, who were seated near their nest and beside the sugar kettle. . . . Then said Manabus, 'How do you eat your maple sugar? Let me see you, do.' So both little birds flew to the rim of the kettle and sat there while they commenced to eat maple sugar. Then Manabus pushed them in and killed them. . . .

"In the meantime the old partridges returned and when they saw their young ones in the kettle of syrup they said: 'Manabus must have come here.'"

212. Barrus, Clara 1916

The Life and Letters of John Burroughs. Boston, 1925, Vol. II, p. 230.

("Lock jaw", a maple sugar confection)

The author uses the colloquial name of "lockjaw" in referring to the sugar-gum, or wax, whose preparation from the hot syrup before it had reached the crystallization stage was usually part of every maple sugar picnic.

The art of making this confection by pouring thin sheets of syrup of the right consistency upon clean snow had been known for at least one hundred years.

213. Waugh, F. W. 1916
Iroquois foods and food preparation. Canada Geol. Surv. *Memoir* 86, No. 12. *Anthropological Series,* p. 140.

Saccharine foods: Maple Syrup and sugar

"The sap of the maple, birch, and several other trees was employed prehistorically. Besides its use as a beverage, it was boiled and thickened somewhat, though its manufacture into sugar must have been exceedingly difficult, if not impossible, with the crude utensils at hand."

214. Schafer, Joseph 1922
The Yankee and the Teuton in Wisconsin. *Wisconsin Mag. Hist.,* 6, 129 (1922).

(Maple forests in Wisconsin)

"And here we find that the distinguishing fact marking off the region in which Germans abounded from most of the other settled or partially settled areas of the state was its originally thickly wooded character. In a way almost startling, and superficially conclusive, the German settlements coincided with the great maple forest of southeastern Wisconsin, spreading also through the included pine forest on Lake Michigan south of Green Bay."

215. Smith, Huron H. 1923
Ethnobotany of the Menomini Indians. *Bull. Public Museum Milwaukee,* 4, 61 (1923).

(An important Menomini food)

"Hard Maple (*Acer saccharum* Marsh.) 'sopoma tik', . . . Maple sugar, 'sopoma tik sopomo', is one of the most important Menomini foods. . . ."

216. Smith, Huron A. 1928
Ethnobotany of the Meskwaki Indians. *Bull. Public Museum Milwaukee,* 4, 255, (1928).

(Sugar making in Wisconsin by the Meskwaki Indians)

"Sugar Maple (*Acer saccharum* Marsh.), 'sena mish' (cold timber). There are not many sugar trees on the

Meskwaki reservation; hence but little sugar is made, but they recall with considerable longing the sugar that they used to make in Wisconsin. Most of their cooking, even of meats, in the olden days was done with maple sugar as the seasoning instead of salt, but now they have to depend mostly upon salt."

217. Jenness, Diamond 1929

The Ojibwa Indians of Parry Island, Their Social and Religious Life. Canada Dept. of Mines, National Museum of Canada, *Bull* 78, *Anthropological Series,* No. 17, 1935, (a) p. 12, (b) p. 13.

a. Sugar-making moon

sizbakudikegizis, sizubakudikegizis

b. (Indian's method of concentrating sap)

". . . The Indians then packed their possessions to the maple groves and tapped the trees for their syrup. . . . The women had few idle hours though their work was comparatively easy. They directed the flow of the maple sap over a large sheet of birch bark, where the warm sun hardened it to the consistency of treacle. To harden it still further they used several methods. A hot sun alone would reduce it to a sort of toffee, or it could be evaporated at night before the fire. More often, perhaps, the women boiled it in clay pots directly over the fire, or else in vessels of birch bark by the use of hot stones. Impatient members of the family sometimes dipped into the syrup heated cones made of a soft, greenish stone, when the syrup crystallized on the stone and could be scraped away with a knife. . . ."

218. Smith, Huron H. 1932

Ethnobotany of the Ojibwe Indians. *Bull. Public Museum Milwaukee,* 4, 394 (1932).

(Maple sugar and the Ojibwa Indians)

"Sugar Maple (*Acer saccharum* Marsh.), 'inena tig' (indian tree) and 'adjagobi min.' Both names come from the Pillager Ojibwe, and although the trees were scarce on the Flambeau Reservation, they also call it 'inena tig,' and gather quantities of the sap somewhere south of the reservation. Maple sugar is one of their most important foods and is used in almost every kind of cookery. Maple sap is saved to drink as it comes from the tree, sometimes with the added sap of the Box Elder or Yellow Birch. Again it is allowed to become sour to make a vinegar 'ciwabo' used in their cookery of venison, which, when afterwards sweetened with maple sugar, corresponds to the German fashion of sweet-sour meat. Before they had the salt of the white man, maple sugar took its place and still does when they can get it. There are many interesting legends about the tree, its discovery and sugar making, as related in Mr. Alanson Skinner's 'Material Culture of the Menomini.' The Ojibwe garner their sugar crop much the same way as they did years ago, except that they have used large iron kettles since the coming of the white man. The sugar camps are rather permanent affairs, and the framework of the boiling house with its upright poles around the fire place to hold the kettles is left intact. A bark-covered wigwam is used to store the tools of sap gathering, and granulation. Most of the sap vessels and storage vessels are made of birch bark, sewed with boiled basswood fiber or the core of the Jack Pine root. The vessels are rendered waterproof by the application of pitch secured by boiling Jack Pine cones.

"In early April, the Ojibwe visit their camps, the men to repair the camps and the storage vats of hollowed logs, and to cut fire wood, the women to see that the sap buckets and mokoks are scrupulously clean and watertight. If some can not be repaired, rolls of birchbark are there to make new ones. The whole family then move to the camp and live in the large wigwam, while they make sugar for a month. During the sap flow, a man can chop holes and set taps into from two to three hundred trees a day. The first flow of sap is best, and it gets to be of a rather poor quality by the end of the flow. The Ojibwe will not use the night flow of the sap, which they say is bitter, so they cease collecting an hour before dark. Gathered sap is stored in hollowed basswood log vats, and covered over with birch bark to keep it clean. Boiling in the iron kettles
birch bark to keep it clean. Boiling in the iron kettles
is done much as the white man does it, except that foam

is dissipated by stirring with a fresh brush of a spruce branch. The syrup is strained through a cloth and recooked in two or three quart quantities until it is ready to sugar. Then, while still warm, it is poured into a wooden trough, where it is pounded and crushed with a heavy wooden paddle as it hardens. It is stored in covered birch bark baskets called mokoks, of from twenty-five to seventy-five pounds capacity. The sugar is graded according to whiteness and stored away. Sap is often added to the dregs in the kettles and a second grade sugar is secured. To waste or spill any of the sap is considered an affront to their deities, who punish such an act by causing the sugar to shrink after it is made."

219. Smith, Huron H. 1933

Ethnobotany of the forest Potawatomi Indians. *Bull. Public Museum Milwaukee,* 7, (a) p. 92, (b) p. 93 (1933).

a. (Potawomi name for maple)

" 'Kisinamic' (cold tree of timber). This name connotes medicinal rather than food use. The name of the tree when it is spoken of as food, is 'inina tig' (Indian tree). . . . The sugar maple and the black sugar maple are found all over Wisconsin and were the most valuable trees to our aboriginal brothers of any in the forest because they furnished them their seasoning material. . . .

"In February or March sugar camp among the Indians was one of the high spots of the year. While everybody had to work, they all derived a good deal of pleasure from it, especially the children who made taffy as the white children do, cooling it in the snow, . . ."

b. (Maple sap boiled in birch bark vessels)

". . . The boiling of sap in birch bark vessels was quite a difficult thing to do. In those days, the original fire had to be fed with bark of the tamarack tree. . . . The flame must never be allowed to come in contact with the birch bark, but the intense heat of the coals made the sap boil.

"Indian pottery was not much better than the bark 'mokoks,' for it was rather fragile and would not stand rough handling or overheating."

SUBJECT INDEX.[7]

[7] This index covers not only the quotations cited but unquoted portions of the reference as well.

8 The name *Acer saccharinum*, L. is used to designate the soft, white, or silver maple. The correct term for the hard, rock, or sugar maple is *Acer saccharum*, Marsh. first used by Humphry Marshall in his *Arbustrum Americanum: The American Grove* (Philadelphia, 1785). *Acer saccharinum* has been erroneously used to designate the true sugar maple as well as the silver maple and the references cited apparently refer to the true sugar maple.

ACIDITY OF SOIL AND WATER USED IN CRANBERRY CULTURE

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That cranberries are grown in Wisconsin under a much wider variety of conditions than in the eastern states has long been recognized. In no way is this more strikingly evidenced than in the range of acidity of the soil and water used in their culture. This is clearly shown in Figure 1 which is based in part on data assembled by the late L. M. Rogers. It will be noted that the pH of soil planted to cranberries ranges from 3.6 to 6.8 and that of the water used in flooding from 5.0 to 8.5. The chart also shows that while in general acid soil and acid water tend to be found together, there are some exceptions. In one case a marsh having soil of pH 4.0 used water with pH 7.8. Another marsh (only a few years old) having soil with pH slightly over 5.0 uses water with a pH above 7.5.

In striking contrast to this C. S. Beckwith, who was for many years in charge of the Cranberry Substation of the New Jersey Experiment Station, informed me in a personal conversation in April, 1943, that the pH of 90 per cent of New Jersey's cranberry soils is between 4.0 and 5.0 with a maximum alkalinity of about 5.5 and that the water used for flooding cranberries in that state is very uniform at about 4.5.

In 1940 attention was called to the apparently harmful effects of the use of alkaline water on cultivated cranberries in Wisconsin (1). Continued observation in that state added further evidence of the importance of this relation (2). The economic importance in Wisconsin and the general scientific interest of this subject should assure a serious experimental study of the whole problem. A desirable preliminary, however, seemed to be to determine whether any comparable conditions exist in southeastern Massachusetts, by far the most important cranberry producing region in the world. For this purpose a survey of water supplies used in flooding cranberries in Massachusetts was made during July and August, 1945. Through the generous assistance of the workers at the Cranberry Station, H. F. Bergman, H. J. Franklin, and J. L. Kelley, and the officers of the New England Cranberry Sales Company, it was possible to reach bogs widely scattered through the cranberry growing area even during the period of gasoline rationing.

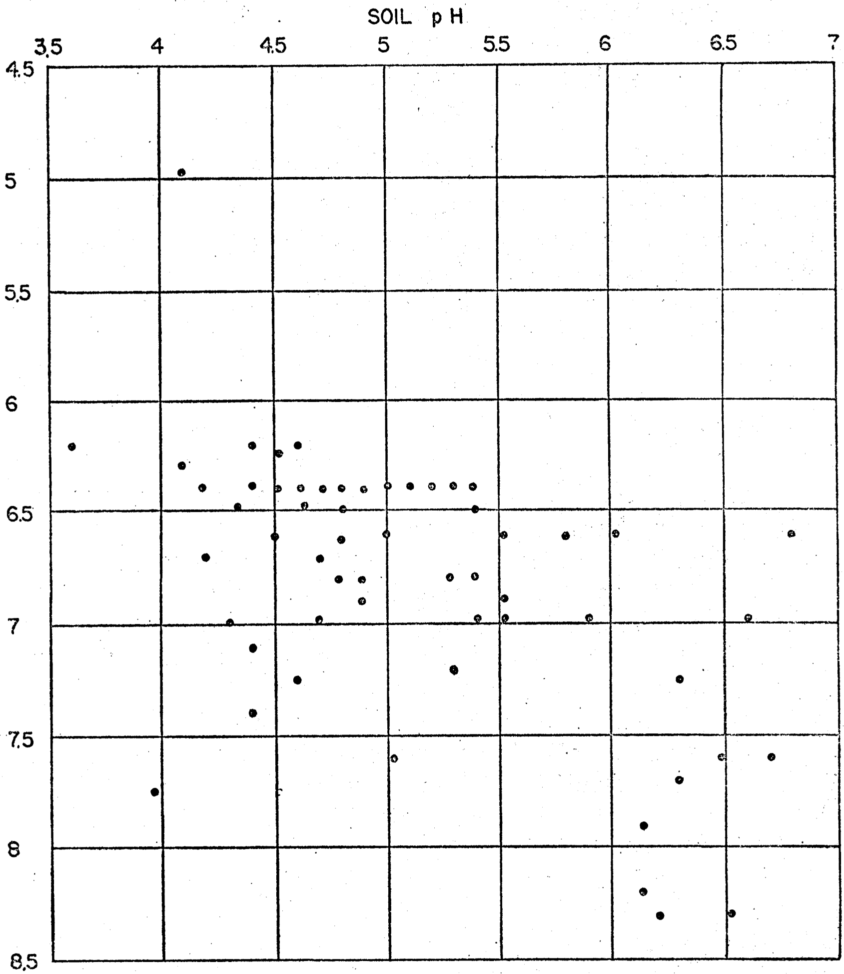

FIG. 1.—The approximate pH of soil and flooding water of Wisconsin cranberry properties.

TABLE 1

COMPARISON OF FLOODING WATER USED ON CRANBERRIES IN WISCONSIN AND MASSACHUSETTS

pH	Number of Properties using Water of the pH Indicated		Range of Hardness of Water in the Classes Indicated Expressed as Bound CO_2	
	Wis.	Mass.	Wis.	Mass.
4.2–5.0	13	5	....	1–3
5.1–6.0	16	35	5–10	2–6
6.1–7.0	43	56	6–23	2–6
7.1–7.5	10	4	17–23	3–6
7.6–7.9	14	....	30–55	....
8.0–8.7	6	....	35–80	....

During the summer water from about 150 sources was tested. The number of cranberry bogs on which the water is used would be much larger since water from certain ponds and streams is used on several different bogs. Information gathered during the past seven years was available regarding flooding water used in approximately 100 cranberry properties in Wisconsin. Direct comparison between these and the first 100 samples taken in Massachusetts is made in Table 1. (3) It will be noted in columns 1, 2, and 3 that the largest number in both regions falls in the category having pH 6.1 to 7.0. The similarity ends there, however, for while all but four of the water samples in Massachusetts have a pH of 7.0 or below, the remaining waters in Wisconsin are almost equally distributed between those below pH 6.1 and those above pH 7.0. In all fairness it should be said that a number of the Wisconsin bogs listed as having water of high alkalinity have been abandoned for some years.

The contrast in water between eastern Massachusetts and Wisconsin is even more strikingly shown in columns 4 and 5 which give the range of bound carbon dioxide (4) in the water of the two regions. It is obvious that all the flooding water thus far tested in southeastern Massachusetts is very low in carbonates. Exactly one half of the first 100 water supplies on which these Massachusetts data are based showed a bound carbon dioxide content of three parts or less per million. All except 11 have five parts per million or less and would thus fall in the category "very soft," as set up by Professor Juday, and widely used in Wisconsin.

Two comments may be added. Water sources falling in Juday's classes "medium hard" and "hard" were found in southern Vermont and adjacent Massachusetts but so far as could be learned these have never been used in cranberry culture.

The foregoing information tends to show why none of the cranberry problems which are believed to be associated with the use of hard water in Wisconsin have been recognized in Massachusetts.

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1. Stevens, N. E., L. M. Rogers, and H. F. Bain. 1940. Alkaline flooding water in cranberry growing. Trans. Wisconsin Acad. Sci. 32:351–360.
2. Stevens, N. E. 1944. Further observations on alkaline flooding water in cranberry growing. Trans. Wisconsin Acad. Sci. 36:395–397.
3. Stevens, N. E. 1946. Observations on flooding waters used in cranberry culture. Mass. Agr. Exp. Sta. Bull. 433:37–51.
4. Birge, E. A. and Chancey Juday. 1911. The Inland Lakes of Wisconsin. Wisconsin Geological & Natural History Survey. Bull. 22, 259 pp.

PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. XXXIII.* RANUNCULACEAE

NORMAN C. FASSETT

These data are based on the material in the herbaria of the University of Wisconsin and the Milwaukee Public Museum, and much of the Wisconsin material in the Chicago Museum of Natural History. Another source of information has been also used for the aquatic species; Mr. Neil Hotchkiss has sent me the records of his collections in Wisconsin made in connection with his work for the Fish and Wild Life Service. On a few maps open circles indicate sight records by Mr. Hotchkiss.

The numbering of genera follows that of dalla Torre & Harms.

Much of the work in preparing this paper was done under a grant from the Wisconsin Alumni Research Foundation.

NYMPHAEACEAE. Water Lily Family

a. Petiole attached at the middle of the blade
- *b.* Blades round, 20–40 cm. in diameter................2508. *Nelumbo.*
- *b.* Blades oval, 10 cm. or less in diameter..............2510. *Brasenia.*

a. Petiole attached at the base of a deep notch
- *c.* Flowers white or pinkish; veins of leaf radiating from attachment of petiole........................2513. *Nymphaea.*
- *c.* Flowers yellow; veins coming from the midrib........2514. *Nuphar.*

2508. NELUMBO. American Lotus

N. LUTEA (Willd.) Pers. In sloughs and pools along the Mississippi River north to the mouth of the Chippewa River, and elsewhere in ponds in the southern and western part of the state. The most northern station, in Polk County, is not along the St. Croix River but on East Lake some five miles from the river. The range in Wisconsin has doubtless been extended by the Indians. Map 1.

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* Mr Kruschke's Preliminary Report on the Boraginaceae in Volume 36 was erroneously numbered XXXI; the number should have been XXXII.

The name *Nelumbo pentapetala* (Walt.) Fernald, Rhodora 36:23. 1934, has recently been substituted for *N. lutea*. The Lotus in Wisconsin has many petals and they are so definitely yellow that it is easy to recognize a colony of Lotus in flower from a distance of several miles by color alone, when seen from a bluff overlooking the Mississippi River; if Walter's *Nymphaea pentapetala,* with 5 white petals, was the same species as that of the Middle West it must have been, as Jones, Fl. Ill. 132. 1945, has suggested, based on a monstrosity.

2510. BRASENIA. Water Shield

B. SCHREBERI Gmel. In lakes, mostly northward, coming south in the eastern half of the state. Map 2.

2513. NYMPHAEA. Water Lily

Nymphaea is the white-flowered Water Lily, called *Castalia* in the seventh edition of Gray's Manual and in Britton & Brown's Illustrated Flora; the genus called *Nymphaea* in those works is now known as *Nuphar*. Much of our material from Wisconsin has been identified by Professor H. S. Conard.

a. Flowers mostly 12 cm. or less broad, fragrant, with petals more or less pointed; sepals and lower leaf-surfaces often purple; petiole not streaked with purple .... 1. *N. odorata.*

a. Flowers larger, not fragrant, with petals pointed; sepals and leaf-surfaces without purple; petioles with several purple streaks .... 2. *N. tuberosa.*

1. N. ODORATA Ait. Throughout the state in quiet water of lakes and streams. Map 3.

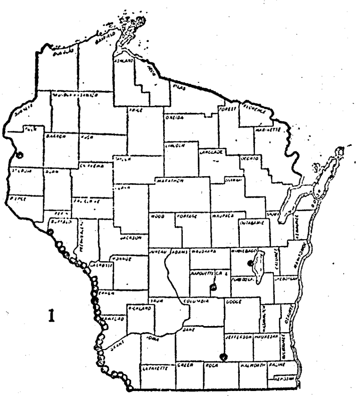
2. N. TUBEROSA Paine. Apparently throughout the state and as common as the other species. Map 4.

2514. NUPHAR. Spatterdock

This is the yellow Water Lily or Cow Lily, called *Nymphaea* in Gray's Manual and the Illustrated Flora; it also appears in the literature as *Nymphozanthus*.

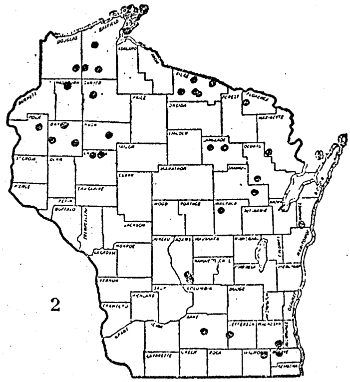
a. Anthers shorter than the filaments; blades of leaves mostly less than 20 cm. long

b. Flower 2 cm. or less wide; stigma with less than 10 rays; young fruit without a ring of decaying stamens; depth of sinus about 2/3 the length of the midrib .... 1. *N. microphyllum.*



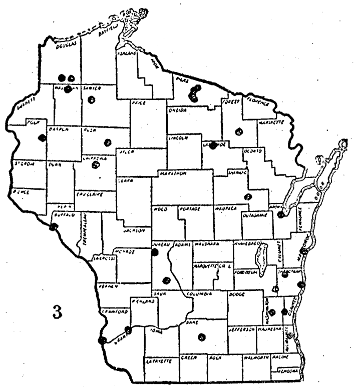
1

Nelumbo lutea



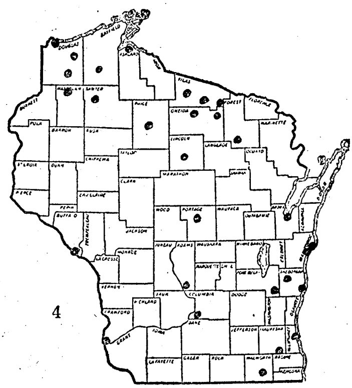
2

Brasenia Schreberi



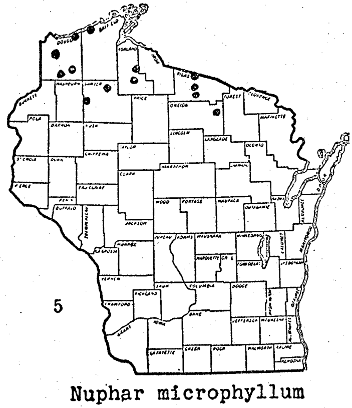
3

Nymphaea odorata



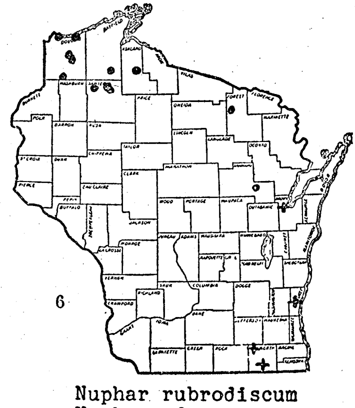
4

Nymphaea tuberosa



5

Nuphar microphyllum



6

Nuphar rubrodiscum
Nuphar advena

b. Flowers 3 cm. or more wide; stigma with more than 10 rays; young fruit with a ring of decaying stamens; depth of sinus about 1/2 the length of the midrib .... 2. *N. rubrodiscum.*

a. Anthers as long as the filaments or longer; blades of leaves mostly 20 cm. or more long

c. Leaves usually erect, the petiole oval in cross-section, blade with a widely open sinus; flowers usually not marked with red .... 3. *N. advena.*

c. Leaves usually floating, the petiole flattened on the upper surface and with 2 narrow wings, blade with a narrow sinus or overlapping lobes; base of sepals and fruit often marked with red .... 4. *N. variegatum.*

1. N. MICROPHYLLUM (Pers.) Fernald. In small lakes with muck or Sphagnum margins, northern Wisconsin. Map 5.

2. N. RUBRODISCUM Morong. Northern Wisconsin. Map 6, dots.

3. N. ADVENA AIT. This species appears to be rare in southeastern Wisconsin and to grade into the next. Two collections from Whitewater, Walworth County, have rounded petioles; in one the sinus is open and in the other the basal lobes overlap, while in both the sepals are marked with red. Some of the leaves were erect, others were floating. Likewise, a collection from Cedarburg, Ozaukee County, has rounded petioles and wide open sinuses, but the sepals are marked with red. The species is reported (as *Nymphaea advena*) from Delavan, Walworth County, and Green Bay, Brown County, by Miller & Standley, Contrib. U. S. Nat. Herb. 16, pt. 3: 86. 1912. Map 6, crosses.

4. N. VARIEGATUM Engelm. Common except in the Driftless Area, where it is abundant only along the Mississippi River. Map 7.

CERATOPHYLLACEAE. Hornwort Family

2516. CERATOPHYLLUM. Coontail

a. Divisions of leaves ribbon-like, from very fine to almost 1 mm. wide, toothed .... 1. *C. demersum*

a. Divisions of leaves thread-like and tapering to a hair-like tip, scarcely or not at all toothed .... 2. *C. echinatum*

1. C. DEMERSUM L. Usually in hard water, throughout the state except perhaps in some parts of the Driftless Area. Map 8.

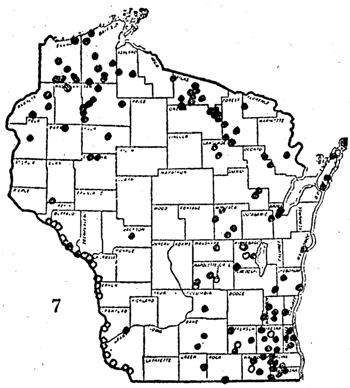
2. C. ECHINATUM Gray. *C. demersum* var. *echinatum* of Gray's Manual; see Muenscher, Am. Journ. Bot. 27: 231–233. 1940, and Fernald, Rhodora 43: 551–552. 1941. Uncommon but widespread in the state. Map 9.

RANUNCULACEAE. Buttercup Family

The species of this family were mapped in 1930 by Lois Almon, Preliminary Reports XI., Trans. Wis. Acad. 25: 205–214. The maps are not repeated here, but changes in nomenclature and additions to our knowledge of their occurrence in the state are noted.

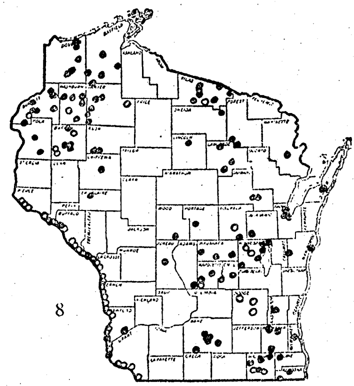
a. Plants aquatic or in wet places
- *b.* Petals present, yellow or white; sepals green.... 2546. *Ranunculus.*
- *b.* Petals absent; sepals yellow or whitish .... 2524. *Caltha.*

a. Plants of uplands
- *c.* Leaves simple or once compound
  - *d.* Herbs, not climbing
    - *e.* Flowers yellow
      - *f.* Leaves simple, or compound with leaflets longer than broad .... 2546. *Ranunculus.*
      - *f.* Leaves with 3 leaflets, each as broad as long .... 2534. *Coptis.*
    - *e.* Flowers white, green or blue
      - *g.* Flowers radially symmetrical
        - *h.* Flowers borne on naked scapes
          - *i.* Leaves as broad as long, 3-lobed . 2541B. *Hepatica.*
          - *i.* Leaves grass-like or tongue-like . 2543. *Myosurus.*
        - *h.* Flowering stems with leaves or a whorl of leaf-like bracts
          - *j.* Leaves or their divisions pointed at tip
            - *k.* One leaf sessile and close to the flower, the other petioled and at some distance below. 2522. *Hydrastis.*
            - *k.* Leaves or bracts whorled, or sessile and solitary .... 2541. *Anemone*
          - *j.* Leaves rounded at tip .... 2541A. *Anemonella.*
      - *g.* Flowers bilaterally symmetrical
        - *l.* Flowers with a spur .... 2539. *Delphinium.*
        - *l.* Flowers with a hood .... 2540. *Aconitum.*
  - *d.* Stems climbing or trailing .... 2542. *Clematis.*



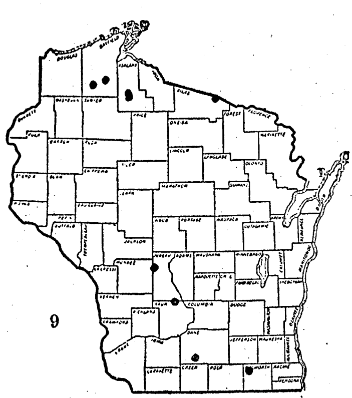
7

Nuphar variegatum



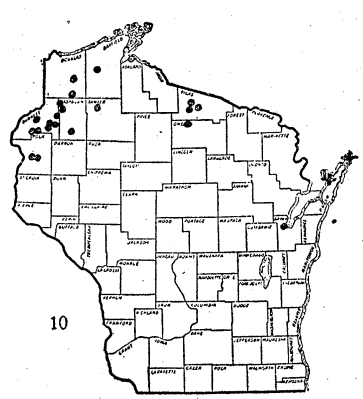
8

Ceratophyllum demersum



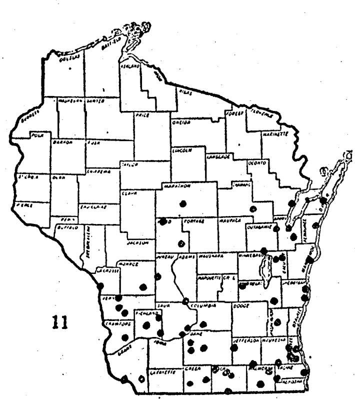
9

Ceratophyllum echinatum



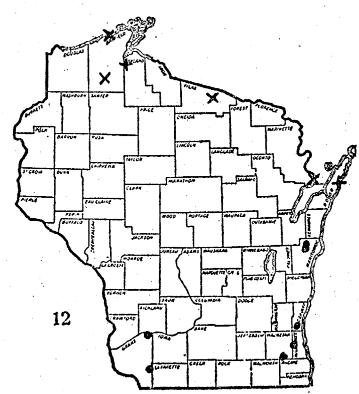
10

Ranunculus reptans
R. reptans v. ovalis



11

Podophyllum peltatum



12

Ranunculus Gmelini
✕ var. terrestris
+ f. Purshii
Jeffersonia diphylla

c. Leaves twice or more compound
  m. Petals with long spurs .... 2538. *Aquilegia.*
  m. Petals without spurs, often absent
    n. Flowers many in a raceme or panicle
      o. Leaflets with many sharp teeth .... 2537. *Actaea.*
      o. Leaflets entire or with a few teeth or lobes .... 2548. *Thalictrum.*
    n. Flowers solitary or a few together
      p. Divisions of leaves ribbon-like .... 2541. *Anemone.*
      p. Divisions of leaves not ribbon-like
        q. Stem with a whorl of leaves ..... 2541A. *Anemonella.*
        q. Stems with scattered leaves .... 2532. *Isopyrum.*

2522. HYDRASTIS. Goldenseal

H. CANADENSIS L. Probably once more abundant, but now rather rare in rich woods in the southern half of the state.

2524. CALTHA. Marsh Marigold

a. Plants tufted with nearly erect stems and bright yellow flowers .... 1. *C. palustris.*
a. Plants with floating stems and white or pinkish flowers .... 2. *C. natans.*

1. C. PALUSTRIS. Throughout the state in swamps and marshes.
2. C. NATANS Pall. Foxboro, Douglas County.

2532. ISOPYRUM. False Rue Anemone

I. BITERNATUM (Raf.) T. & G. Rather local in rich woods in the southern half of the state. This species ordinarily has the lobes of the leaflets rounded; f. ACUTILOBUM Fassett,[1] with pointed lobes, has been collected in Dodge County.

2534. COPTIS. Goldthread

C. TRIFOLIA (L.) Salisb., var. GROENLANDICA (Oeder) Fassett.[2] In bogs and moist woods, of general occurrence except southeast of a line drawn from Polk to Walworth Counties.

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[1] I. BITERNATUM (Raf.) T. & G., f. **acutilobum**, n.f., lobis foliolarum acutis.—Limestone ledge, Horicon, Dodge County, Wisconsin, June 8, 1929, *Fassett* no. 8393 (TYPE in Herb. Univ. of Wis.).

[2] In 1929 Professor Fernald pointed out that the typical *C. trifolia* is a plant of northeastern Asia and Alaska while the plant of northeastern America and Greenland differs in what Dr. Hultén later characterized as "several although not very striking respects." The chiefly American plant was accordingly called *C. groenlandica* (Oeder) Fernald, but Fernald commented: "Completely isolated as they are, they constitute two very strong geographic varieties or, presumably, two distinct species. Until more transitional material than we yet know comes to hand it seems more reasonable to treat them as two species, which, however, may eventually be merged." In 1937 Dr. Hultén fulfilled this prediction by calling attention to transitional material in southeastern Alaska and reducing *C. groenlandica* to a subspecies. In the varietal category it becomes:
C. TRIFOLIA (L.) Salisb., var. **groenlandica** (Oeder) n.comb. *Anemone groenlandica* Oeder, Fl. Dan. iv. fasc. x. 5, t. dlxvi. 1770. *Coptis groenlandica* Fernald, Rhodora 31: 142. 1929. *C. trifolia* subsp. *groenlandica* Hultén, Fl. Aleutian Is. 178. 1937.

2537. ACTAEA. Baneberry

a. Fruiting pedicels slender; summit of ovary, in flower, narrowed to about one half the diameter of the stigma
- *b.* Mature berries red .... 1. *A. rubra.*
- *b.* Mature berries white .... *f. neglecta.*

a. Fruiting pedicels thickened; summit of ovary, in flower, narrowed only to 3/4 or more the diameter of the stigma
- *c.* Berries white .... 2. *A. pachypoda.*
- *c.* Berries red or pink
  - *d.* Berries and pedicels dark red .... f. *rubrocarpa.*
  - *d.* Berries and pedicels pink .... f. *microcarpa.*

1. A. RUBRA (Ait.) Willd. Common in woods throughout the state. F. NEGLECTA (Gillman) Robinson often occurs with the red-berried form. *A. rubra* var. *gigantea* Gates was reported from Eau Claire County by Miss Almon; *A. rubra* shows a gradation in size of leaflets from those only 3 cm. long to those more than 10 cm. long, but there seems to be no "break" in the series. The larger ones tend to be truncate to cordate at base and the smaller ones are usually cuneate, but there is no very good correlation.

2. A. PACHYPODA Ell. *A. alba* of Preliminary Report and of many authors; see Mackenzie, Torreya 28: 53. 1928, and Fernald, Rhodora 42: 260–265. 1940. Widely distributed in the state but somewhat local. F. MICROCARPA (DC.) Fassett[3] has been collected in Iowa County. F. RUBROCARPA (Killip) Fernald is presumably the identity of a specimen from Grant County with thickened pedicels but labelled "Red Baneberry" by the collector.

2538. AQUILEGIA. Columbine

A. CANADENSIS L. Throughout the state in woods, on cliffs and shores, etc. F. FLAVIFLORA (Tenney) Britton, with yellow flowers, has been collected in woods on a hillside bordering the Wisconsin River in Dane County.

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[3] A. PACHYPODA **f. microcarpa** (DC.) n. comb. *A. brachypetala* DC., 8 *microcarpa* DC., Syst. 1: 385. 1817; Fernald, Rhodora 42: 261. 1940. This seems to be the plant reported by the writer, in Rhodora 34: 96. 1932, as *A. alba* f. *rubrocarpa*, with the following comment: "The berries, rhachis and pedicels are pink, and the thickness of the pedicels is intermediate between that of *A. alba* and that of *A. rubra*. The characters of the plant strongly suggest that it is a hybrid between the two species."

2539. DELPHINIUM. Larkspur

a. Introduced annuals of vacant lots, etc.; pistil one
b. Pedicel shorter than bract; fruit glabrous .... 1. *D. Consolida.*
b. Pedicel longer than bract; fruit pubescent .... 2. *D. Ajacis.*
a. Native perennial on northwestern prairies; pistils three .... 3. *D. virescens.*

1. D. CONSOLIDA L. Milwaukee and Racine and doubtless elsewhere, escaping from cultivation.

2. D. AJACIS L. Milwaukee and Janesville and doubtless elsewhere, escaping from cultivation.

3. D. VIRESCENS Nutt. *D. Penardi* of Preliminary Report; see Perry, Rhodora 39: 20–22. 1937. Sand prairies and prairie hillsides, Douglas to La Crosse and Monroe Counties. While this species is very variable where its range overlaps that of *D. caroliniana* (see Steyermark, Spring Flora of Missouri, p. 203), it is quite constant in its characters in Wisconsin, the stem being always glandular-pubescent above and crisp-pubescent toward the base.

2540. ACONITUM. Monkshood

A. NOVEBORACENSE Gray, var. QUASICILIATUM Fassett, Rhodora 31: 49. 1929. In addition to the two localities in Wisconsin cited in the original description this has now been collected at Parfrey's Glen in Sauk County a few miles within the glaciated part of the Baraboo Hills, and at Coon Valley in Vernon County near the center of the Driftless Area. *A. uncinatum* is reported from Wisconsin in the seventh edition of Gray's Manual and in Britton & Brown's Illustrated Flora; there are no specimens from this state and there is in the Gray Herbarium a note from Lapham stating that his report of *A. uncinatum* from Wisconsin was an error.

2541. ANEMONE. Anemone

a. Segments of the involucre ribbon-like, not toothed
b. Involucre and stem densely covered with long silky hairs .... 1. *A. patens* var. *Wolfgangiana.*
b. Involucre and stem with a few scattered hairs... .... 2. *A. multifida* var. *hudsoniana.*
a. Segments of the involucre toothed
c. Sepals 10–20 .... 3. *A. caroliniana.*

c. Sepals 4–7
  d. Sepals hairy on the back
    e. Involucral leaves petioled
      f. Divisions of involucral leaves narrow, toothed only above the middle; fruiting head several times as long as thick; pistils densely woolly in flower so that only the tips of the stigma are visible; peduncles usually naked above the involucre .... 4. *A. cylindrica.*
      f. Divisions of involucral leaves ovate, toothed to below the middle; fruiting heads not more than twice as long as thick; pistils silky in flower with the whole style plainly visible; all but the earliest peduncle with secondary involucral leaves near the middle
        g. Anthers 0.7–1.1 mm. long; fruiting head 7–11 mm. thick with styles ascending at about 45 degrees
          h. Sepals white and petaloid .... 5. *A. riparia.*
          h. Sepals greenish and leathery ..... f. *inconspicua.*
        g. Anthers 1.2–1.6 mm. long; fruiting head 12–15 mm. thick with styles spreading at about 90 degrees
          i. Sepals greenish or yellowish and leathery .... 6. *A. virginiana.*
          i. Sepals white and petaloid .... f. *leucosepala.*
    e. Involucral leaves not petioled .... 7. *A. canadensis.*
  d. Sepals not hairy .... 8. *A. quinquefolia* var. *interior.*

1. A. PATENS L., var. WOLFGANGIANA (Bess.) Koch. Pasque Flower. Locally abundant on original prairie southwest of a line drawn from St. Croix County to Milwaukee County, and rarely northwestward to southern Douglas County.

2. A. MULTIFIDA Poir., var. HUDSONIANA DC.; Fernald, Rhodora 19: 141. 1917. Collected at Elkhart Lake, Sheboygan County, in 1909.

3. A. CAROLINIANA Walt. Rare on sand terraces in Eau Claire, Pierce and La Crosse Counties.

4. A. CYLINDRICA Gray. Candleweed. Open woods or prairies and sand plains in the southern half of the state, rarely northward to Washburn and Vilas Counties.

5. A. RIPARIA Fernald. Most commonly in the north but sometimes occurring in southern Wisconsin. F. INCONSPICUA Fernald, Rhodora 19: 140. 1917, is rarely found.

6. A. VIRGINIANA L. Thimbleweed. Throughout the state, perhaps a little more abundant southward. F. LEUCOSEPALA Fernald, l.c., is rarely found.

7. A. CANADENSIS L. Roadside turf and moist open ground throughout the state.

8. A. QUINQUEFOLIA L., var. INTERIOR Fernald, Rhodora 37: 260. 1935. Wood Anemone. In woods throughout Wisconsin.

2541A. ANEMONELLA. Rue Anemone

A. THALICTROIDES (L.) Spach. In woods southwestward, northeast to Pierce, Dunn, Eau Claire, Monroe, Columbia, Dodge and Milwaukee Counties.

A. THALICTROIDES f. FAVILLIANA Bergseng[4], with the stamens and pistils all replaced by sepals, is rare. The specimen from Lake Mills has pink flowers, while it has been reported with white flowers near Pewaukee, Waukesha County.

2541B. HEPATICA. Hepatica

One species is usually abundant locally to the exclusion of the other; for example, in Dane County only *H. acutiloba* is found in the vicinity of Madison, while *H. americana* occurs in the northwest corner of the county. An occasional individual appears to be intermediate.

1. H. ACUTILOBA DC. Sharplobe Hepatica. Common in woods north to Barron, Marathon, Shawano, Marinette and Door Counties.

2. H. AMERICANA (DC.) Ker. Roundlobe Hepatica. *H. triloba* of American authors; see Fernald, Rhodora 19: 45. 1917. Locally abundant throughout the state.

2542. CLEMATIS. Clematis

a. Flowers in a compound inflorescence, less than 1 cm. long, whitish .... 1. *C. virginiana.*
a. Flowers solitary, 4–5 cm. long, purple .... 2. *C. verticillaris.*

1. C. VIRGINIANA L. Virgin's Bower. Thickets and open ground, often climbing over shrubs.

[4] In May, 1946, Mr. Stoughton Faville of Lake Mills sent to Mrs. M. S. Bergseng, Herbarium Assistant at the University of Wisconsin, a double-flowered *Anemonella* for which she supplies the following description: *Anemonella thalictroides* f. Favilliana, n.f., floribus plenis.—Fence corner in field, Lake Mills, Wisconsin, May 1, 1946, *Stoughton Faville* (TYPE in Herb. Univ. of Wis.).

2. C. VERTICILLARIS DC. Purple Clematis. Woods and rocky places, not very common, in the northwest part of the state southward to St. Croix, Clark, Marathon, Lincoln and Oneida Counties, and locally southward to the Dalles of the Wisconsin River and Parfrey's Glen in Sauk County, and Blue Mounds in Dane County.

2543. MYOSURUS. Mousetail

M. MINIMUS L. Probably adventive, Pharmacy Garden of University of Wisconsin, Madison.

2546. RANUNCULUS. Buttercup

a. Plants floating in the water, or prostrate on the mud and rooting at the nodes, or connected by horizontal rootstocks
- *b.* Stem-leaves compound or deeply cleft
  - *c.* Flowers white; leaves with thread-like divisions
    - *d.* Leaves very limp and collapsing when taken from the water, with a petiole between the stipule and the division into 3 parts .... 1. *R. trichophyllus.*
    - *d.* Leaves stiff and keeping their shape when taken from the water, without petioles and dividing into 3 parts at the stipule . . . 2. *R. longirostris.*
  - *c.* Flowers yellow; divisions of leaves flat (but sometimes ribbon-like and very narrow)
    - *e.* Divisions of leaves narrowly ribbonlike, or, if broader, with the base of each division of the same texture as the rest
      - *f.* Petals 6–17 mm. long; fruits (including the beak) 2.5–3.5 mm. long, with a wing-margin; blades of leaves 1.5–10 cm. long
        - *g.* Leaves dissected into many narrow segments 2 mm. or less wide; plants not hairy; submersed forms .... 4. *R. flabellaris.*
        - *g.* Leaves with broader divisions; plants often hairy; forms stranded on the mud .... f. *riparius.*
      - *f.* Petals 3.5–5 mm. long; fruits (including the beak) 1.5–3 mm. long, not wing-margined; blades of leaves 1–2 cm. long
        - *h.* Leaves with divisions several mm. wide; plants often hairy; forms growing on the mud ...... 5. *R. Gmelini* var. *terrestris.*

h. Leaves with divisions 1 mm. or less wide; plants not hairy; submersed forms .... f. *Purshii.*

e. Leaves divided into 3 leaflets each of which has a distinct stalk of different texture from the flat part of the blade

i. Stems hairy

j. Hairs appressed .... 13. *R. repens.*

j. Hairs spreading .... var. *villosus.*

i. Stems glabrous or nearly so .... var. *glabratus.*

b. Leaves simple, flat or thread-like

k. Blades of leaves truncate or slightly heart-shaped at base, with toothed margins

l. Stems without hairs .... 3. *R. Cymbalaria.*

l. Stems closely hairy .... f. *hebecaulis.*

k. Blades of leaves thread-like, or if flat tapered at base, with entire margins

m. Leaves thread-like .... 6. *R. reptans.*

m. Leaves with flat blades 2 mm. or more wide .... var. *ovalis.*

a. Plants not connected by runners, with basal leaves, and stems which are usually erect (prostrate but not rooting in one species)

n. Petals inconspicuous, shorter than or barely exceeding the sepals

o. Styles hooked

p. Stems with spreading hairs .... 10. *R. recurvatus.*

p. Stems glabrous .... f. *laevicaulis.*

o. Styles not hooked

q. Basal leaves simple (occasionally one of them 3-parted); head of fruits globular

r. Stems and peduncles glabrous............ 9. *R. abortivus.*

r. Stems and peduncles closely pubescent .... var. *acrolasius.*

q. Basal leaves compound or deeply lobed; head of fruits much longer than thick

r. Stems bristly-hairy; achenes with a beak-like style .... 14. *R. pensylvanicus.*

r. Stems smooth or with inconspicuous hairs; achene beakless

s. Face of mature achene with faint transverse ridges; the 3 lobes of the stem-leaves usually toothed or shallowly lobed .... 8. *R. sceleratus.*

s. Face of achene without transverse ridges; the 3 lobes of the stem-leaves deeply lobed or divided ..... var. *multifidus.*

n. Petals conspicuous, several times as long as the sepals
  t. Basal leaves oval, not lobed or divided .... 7. *R. rhomboideus.*
  t. Basal leaves deeply cleft or divided
    u. Style 1 mm. or more long, erect or ascending, beak-like
      v. Roots thickened and fleshy; lateral leaflets rarely stalked; plants without long prostrate branches .... 11. *R. fascicularis.*
      v. Roots not thickened and fleshy; lateral leaflets with stalks 5 mm. or more long; plants soon developing long prostrate branches .... 12. *R. septentrionalis.*
    u. Style very short, recurved, not beak-like ...... 15. *R. acris.*

1. R. TRICHOPHYLLUS Chaix. Water Crowfoot. *R. aquatilis* var. *capillaceus* of Preliminary Report; see Drew, Rhodora 38: 17. 1936. In lakes and streams throughout the state.

2. R. LONGIROSTRIS Godron. Stiff Water Crowfoot. *R. circinatus* of Preliminary Report; see Drew, Rhodora 38: 42. 1936. Southeastern Wisconsin, rarely northwestward to Crawford, Waushara and Brown Counties; Lake Superior region in Ashland County.

3. R. CYMBALARIA Pursh. Seaside Crowfoot. Very rare along Lake Michigan shore in Manitowoc, Racine and Kenosha Counties, inland only at Lake Geneva in Walworth County where collected in 1885. Also adventive in Central Park in Superior, Douglas County. Much of the material from Lake Michigan shore is f. HEBECAULIS Fernald, Rhodora 16: 162. 1914, and the plants from Superior approach this form. Some sheets have both glabrous and pubescent plants.

4. R. FLABELLARIS Raf. Yellow Water Crowfoot. *R. delphinifolius* of Preliminary Reports; see Fernald, Rhodora 38: 171. 1936, and Benson, Bull. Torrey Club 69: 315. 1942. In quiet water throughout the state, perhaps most common southeastward. F. RIPARIUS Fernald, l.c., (*R. delphinifolius* var. *terrestris* of Gray's Manual) is occasionally found on muddy shores.

5. R. GMELINI DC., var. TERRESTRIS (Ledeb.) Benson. *R. Purshii* of Gray's Manual; see Hara, Rhodora 41: 386. 1939, and Benson, Bull. Torrey Club 69: 313. 1942. Apparently rare in northern Wisconsin (Map 12, x's). F. PURSHII (Richards.)

Fassett[5] has been collected in a cold spring-fed brook near Jacksonport in Door County and near Ashland in Ashland County (Map 12, crosses).

6. R. REPTANS L. Creeping Spearwort. *R. Flammula* var. *filiformis* of Gray's Manual; see Rhodora 19: 135-137. 1917; *R. Flammula* var. *filiformis* (Michx.) Hook.; Benson, Bull. Torrey Club 69: 306. 1942. Very common on sandy lake shores of northwestern Wisconsin and at Green Bay in Brown County (Map 10, dots). The leaves vary from threadlike to flat and about 1.5 mm. wide, in the latter case approaching var. *ovalis*. Var. OVALIS (Bigel.) T. & G. (*R. Flammula* var. *reptans* of Gray's Manual; *R. Flamula* var. *ovalis* (Bigel.) Benson, l.c., p. 305), with blades of leaves from 2–7 mm. wide, has been collected in Door County (Map 10, crosses).

7. R. RHOMBOIDEUS Goldie. Dwarf Buttercup. Prairies and sand, from Pierce, Dunn, Eau Claire, Portage and Shawano Counties southward; not collected but probably to be expected in the southwest corner of the state in Vernon, Crawford, Richland, Iowa and Lafayette Counties.

8. R. SCELERATUS L. Cursed Crowfoot. On muddy shores and in shallow water from Dane, Columbia, Brown and Door Counties southward and eastward. Var. MULTIFIDUS Nutt. is approached by plants with achenes not wrinkled and leaves slightly more divided than usual, from Fox Lake in Dodge County and Dousman in Waukesha County, and less strongly approached by a collection from Fish Creek in Door County, which has smooth achenes but leaves like the ordinary *R. sceleratus*.

9. R. ABORTIVUS L. Small-flowered Buttercup. In woods, pastures, etc., throughout the state. The generally more northern var. ACROLASIUS Fernald, Rhodora 40: 418. 1938, has been collected in 13 counties from the northern to the southern borders of Wisconsin, but its validity as a geographic variety is shown by the fact that while in northern Wisconsin it may exist as the major element in many populations its occurrence southward is only as an occasional pubescent individual among a great majority of glabrous ones; moreover, north

[5] R. GMELINI DC., var. TERRESTRIS (Ledeb) Benson, f. **Purshii** (Richards.) n. comb. *R. Purshii* Richards., Bot. App. Frankl. 1st. Jour. ed. I, 741. 1823. *R. Gmelini* var. *Purshii* (Richards.) Hara, Rhodora 41. 386. 1939. Hara recognizes the submersed state as var. *Purshii* and the emersed one as var. *limosus*, while Benson treats the whole range of ecological forms as one geographic variety to which the earliest name *terrestris* must unfortunately be applied.

of Wisconsin var. *acrolasius* becomes the only representative of the species, while southward it disappears. See Fassett, Amer. Midl. Nat. 27: 512–522. 1942.

A peculiar individual from Pine Hollow near Poynette in Columbia County appears to be closely related to *R. abortivus.* It has hooked styles a little longer than in that species, while some of the basal leaves have the shape and pubescence characteristic of *R. rhomboideus.* Dr. Lyman Benson, monographer of North American *Ranunculus,* has examined the specimen and commented: "Petals 4.5 mm. long, otherwise a mixture of characters of *R. abortivus and R. micranthus.*" It was collected by the late Dr. A. L. Frolick on May 24, 1935, and all attempts to find more plants have failed. *R. micranthus* is not known from Wisconsin. Pine Hollow is only a few miles east of the Driftless Area, where many endemics and isolated species are known.

10. R. RECURVATUS Poir. Hooked Buttercup. Rather common in rich woods throughout the state. F. LAEVICAULIS Weatherby, Rhodora 31: 164. 1929, was collected in company with the common pubescent type, at Pine Hollow during one of the unsuccessful searches for the peculiar plant described in the preceding paragraph.

11. R. FASCICULARIS Muhl. Early Buttercup. Open ground, north to Pierce, Dunn, Juneau, Waupaca and Brown Counties.

12. R. SEPTENTRIONALIS Poir. Marsh Buttercup. Throughout the state in marshes and wet woods. The stems may be glabrous, or may have appressed, spreading or reflexed hairs.

13. R. REPENS L. Creeping Buttercup. Rarely adventive in the eastern part of the state. Several varieties have been recognized (Fernald, Rhodora 21: 169. 1919). The typical form and var. GLABRATUS DC. have been collected at Sturgeon Bay in Door County; var. VILLOSUS Lamotte has been collected in a park at Madison in Dane County, in a tamarack swamp at Addison in Washington County, and on a lawn in Wauwatosa, Milwaukee County; var. GLABRATUS DC. has been collected at Milwaukee, Milwaukee County, and Shawano, Shawano County.

Young individuals of this species sometimes lack the creeping stems and may be difficult to distinguish from young plants of *R. septentrionalis* lacking prostrate stems. There are characters in the young carpels and fruits as follows: *R. repens* has the carpels abruptly narrowed to a curved beak 0.5 mm. long in flower and about 1 mm. long in fruit, and the mature nutlet is plump, scarcely keeled, 2–2.5 mm. long, while *R. septentrionalis* has the carpel gradually tapered to a stout straight or slightly curved beak which is 1 mm. long in flower and 2 mm. or more long in fruit, and the mature nutlet is flattened on the sides and broadly keeled, 3–3.5 mm. long.

14. R. PENSYLVANICUS L. f. Bristly Crowfoot. Common throughout the state in open wet places, bogs, etc.

15. R. ACRIS L. Tall Buttercup. This introduced species is found across northern Wisconsin, south to Washburn, Taylor, Marathon, Brown and Kewaunee Counties, and in the southeastern part of the state from Monroe County southeastward. The first collection in Wisconsin was in 1858 in the Apostle Islands in Ashland County, a seat of early settlement. It was found by Lapham in Milwaukee, and collected at Racine in 1879. The first collection in Dane County was in 1886, but here it is not yet very abundant.

2548. THALICTRUM. Meadowrue

a. Stem-leaves with a petiole between the sheath and the division into 3 parts
 b. Plants with a short stout rootstock; leaflets thin, smooth, the edges not revolute; flowering in May; achenes bluntly pointed equally at both ends ...... 1. *T. dioicum.*
 b. Plants with long rootstocks; leaflets thick, rugose, the margins revolute; flowering in June and July; achenes rounded to a stipitate base and long-tapered to the tip
  c. Stigmas 1.0–2.0 (rarely 2.5) mm. long; mature achenes with body 3.0–4.0 mm. long and 2.4 mm. or less thick; anthers 2.0–3.5 mm. long with an apiculate tip about 0.1 mm. long ... 2. *T. venulosum.*
  c. Stigmas 2.0–4.0 mm. (rarely more) long; mature achenes with body 4.0–6.0 mm. long and 2.5 mm. or more thick; anthers 3.0–4.0 mm. long with an apiculate tip about 0.4 mm. long .. 3. *T. confine.*
a. Stem-leaves sessile, dividing into 3 parts directly above the sheath
 d. Leaflets not glabrous beneath
  e. Lower surfaces of leaflets covered with minute stalked glands .... 4. *T. revolutum.*
  e. Lower surfaces of leaflets with jointed hairs . 5. *T. dasycarpum.*
 d. Leaflets perfectly glabrous beneath .... 6. ?

1. T. DIOICUM L. Early Meadowrue. Rich woods throughout the state, perhaps less common northward.

2. T. VENULOSUM Trel. A collection is cited from R. R. right-of-way north of Hayward, Sawyer County, by Boivin, Rhodora 46: 439. 1944.

3. T. CONFINE Fernald. On sandy soil, Wisconsin Point, Superior, Douglas County.

4. T. REVOLUTUM DC. Rather rare in the southeastern corner of the state from Washington and Rock counties southeastward.

5. T. DASYCARPUM Fisch. & Lall. Purple Meadowrue. Mostly in meadows, throughout the state.

6. From southeastern Wisconsin there are six collections of a plant resembling the two preceding species but with the firm rugose revolute-margined leaves absolutely glabrous beneath. The leaflets of all of our *T. revolutum* have the same texture, as do some of those of *T. dasycarpum.* There are similar plants collected in Iowa and northern Illinois, while from Missouri Dr. Steyermark has labelled several collections *T. revolutum* f. *glabrum* Pennell. The anthers range from 1–2 mm. long in the Wisconsin plant, and Dr. Boivin, Rhodora 46: 471. 1944, describes the anthers of *T. revolutum* as being 1.7–2.8 mm. long. Boivin recognizes a glabrous variety of *T. dasycarpum* but describes it as having membranous leaves and anthers 2.2–3.2 mm. long.

BERBERIDACEAE. Barberry Family

a. Plants herbaceous; leaves 5 cm. or more long, compound or deeply lobed
- *b.* Leaves palmately deeply lobed .... 2558. *Podophyllum.*
- *b.* Leaves compound
  - *c.* Leaves cut into 2 leaflets .... 2559. *Jeffersonia.*
  - *c.* Leaves cut into many leaflets .... 2565. *Caulophyllum.*

a. Plants shrubby; leaves less than 5 cm. long, appearing simple .... 2566. *Berberis.*

2558. PODOPHYLLUM. Mayapple

P. PELTATUM L. Common in woods in the southern half of Wisconsin. Map 11. A plant answering the description of f. APHYLLUM Plitt, Rhodora 33: 229. 1931, was reported by

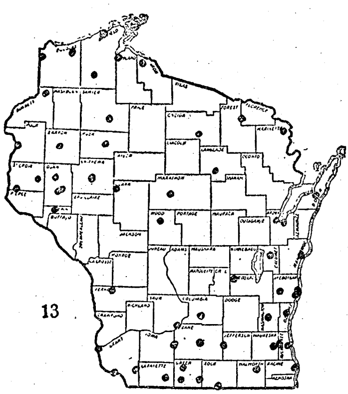
Wadmond, Fl. Racine & Kenosha Counties, Trans. Wis. Acad. 16: 838. 1909.

2559. JEFFERSONIA. Twinleaf

J. DIPHYLLA (L.) Pers. Rare and local in rich woods of southern Wisconsin. Map 12, dots.

2565. CAULOPHYLLUM. Blue Cohosh

C. THALICTROIDES (L.) Michx. Not uncommon, and characteristic of rich woods throughout the state. Map 13.



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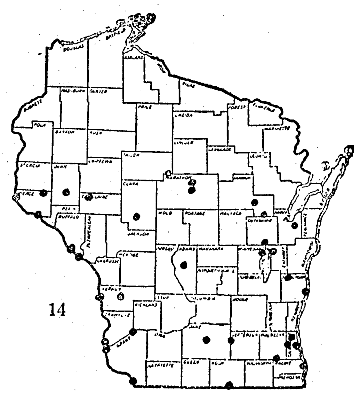
Caulophyllum thalictroides



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Menispermum canadense

2566. BERBERIS. Barberry

The 3 species most apt to be found in Wisconsin are keyed as follows by Deam in the Flora of Indiana:

a. Leaves entire; spines generally simple; flowers in fascicles of 2–6; petals notched .... *B. Thunbergii.*

a. Leaves not entire, the margins more or less serrate; spines generally 3-pronged

- *b.* Margins of leaves regularly bristly-serrate; racemes many-flowered; petals entire; two year old branches grayish .... *B. vulgaris.*
- *b.* Margins of leaves irregularly serrate, the teeth not bristly-pointed; racemes few-flowered; petals notched; two year old branches reddish brown ... *B. canadensis.*

B. THUNBERGII DC., the Japanese Barberry, is commonly planted but rarely escapes; B. VULGARIS L., the European Barberry, was formerly planted and widely escaped, and is still found occasionally in woods and pastures despite the campaign for its eradication; B. CANADENSIS Mill., the Allegheny Barberry, is rarely planted.

MENISPERMACEAE. Moonseed Family

2567. MENISPERMUM. Moonseed

M. CANADENSE L. Rather local, mostly in wooded alluvial soils northward to Pierce, Dunn, Eau Claire, Clark, Taylor, Marathon, Shawano and Manitowoc Counties. Map 14.

LAURACEAE. Laurel Family

2795. SASSAFRAS. Sassafras

The writer has never seen a specimen of Sassafras from Wisconsin. Dr. R. P. Hoy, History of Walworth County, Wisconsin, p. 133. 1882, wrote: "Sassafras officinale is a small tree of fine appearance with fragrant leaves and bark. Grows in Kenosha county. Should be cultivated." Mr. S. C. Wadmond did not list it in his Flora of Racine and Kenosha Counties, but he recently wrote me as follows: "My memory is that Dr. Hoy used to find Sassafras in an early day along Pike Creek (Kenosha County) near its outlet into Lake Michigan, but I cannot recall definitely whether Dr. Davis [Dr. J. J. Davis, well known in the field of mycology] had ever encountered it. I am sure that if a station for it had existed when I was compiling my Flora, Dr. Davis would have directed me to it, as was his general custom."

Since Deam's Flora of Indiana records both *S. albidum* (Nutt.) Nees and *S. albidum* var. *molle* (Raf.) Fernald (see Rhodora 15: 14–18. 1913, and 38: 178–179. 1936) from the counties in Indiana bordering Lake Michigan, it is not unreasonable to expect Sassafras in Kenosha County, Wisconsin. Less expected, however, are reports from two adjacent counties, Marquette and Green Lake, in central Wisconsin. On October 25, 1857, William P. Huntington, U. S. Deputy Surveyor, making the original land survey, laid out the line between Sections 22 and 23 in Township 16 North, Range 9 East, in what is now Marquette County, and described the ground cover, in part, as follows: "Undergrowth red & black willow, alder, green-briar, prickly ash, barberry, gooseberry, blackberry, Poison Sumach, sassafras." Of course, he might have been mistaken about the sassafras. The writer has done considerable collecting in the region, and has never encountered it.

Just 15 miles southeast of the point where Surveyor Huntington reported Sassafras is the town of Marquette, in Green Lake County on the south shore of Lake Puckaway. In early 1929 Mr. F. M. Uhler wrote me about some plants noted by Mr. W. L. McAtee at Marquette, as follows: "All three of these plants were recorded by Mr. McAtee at Marquette, Wisconsin, during the period between October 21 and November 6, 1908. He collected a specimen of *Tanacetum huronense* at that point on November 4, 1908, and a specimen of *Opuntia Rafinesquii* 'on granite among red cedars' on November 5, 1908. *Sassafras variifolium* was merely recorded in his list for that period and no specimen preserved." *Tanacetum huronense,* it may be remarked, is known in Wisconsin only as a rare plant of the Lake Michigan shore in Door County. In September, 1929, Mr. Uhler and I spent a day collecting in the region of Marquette; we found *Opuntia Rafinesquii* on granite among red cedars, but no *Tanacetum huronense,* and no Sassafras.

A CYTOLOGICAL STUDY OF THE DEVELOPMENT OF THE OOSPORE OF SCLEROSPORA MACROSPORA (SACC.)

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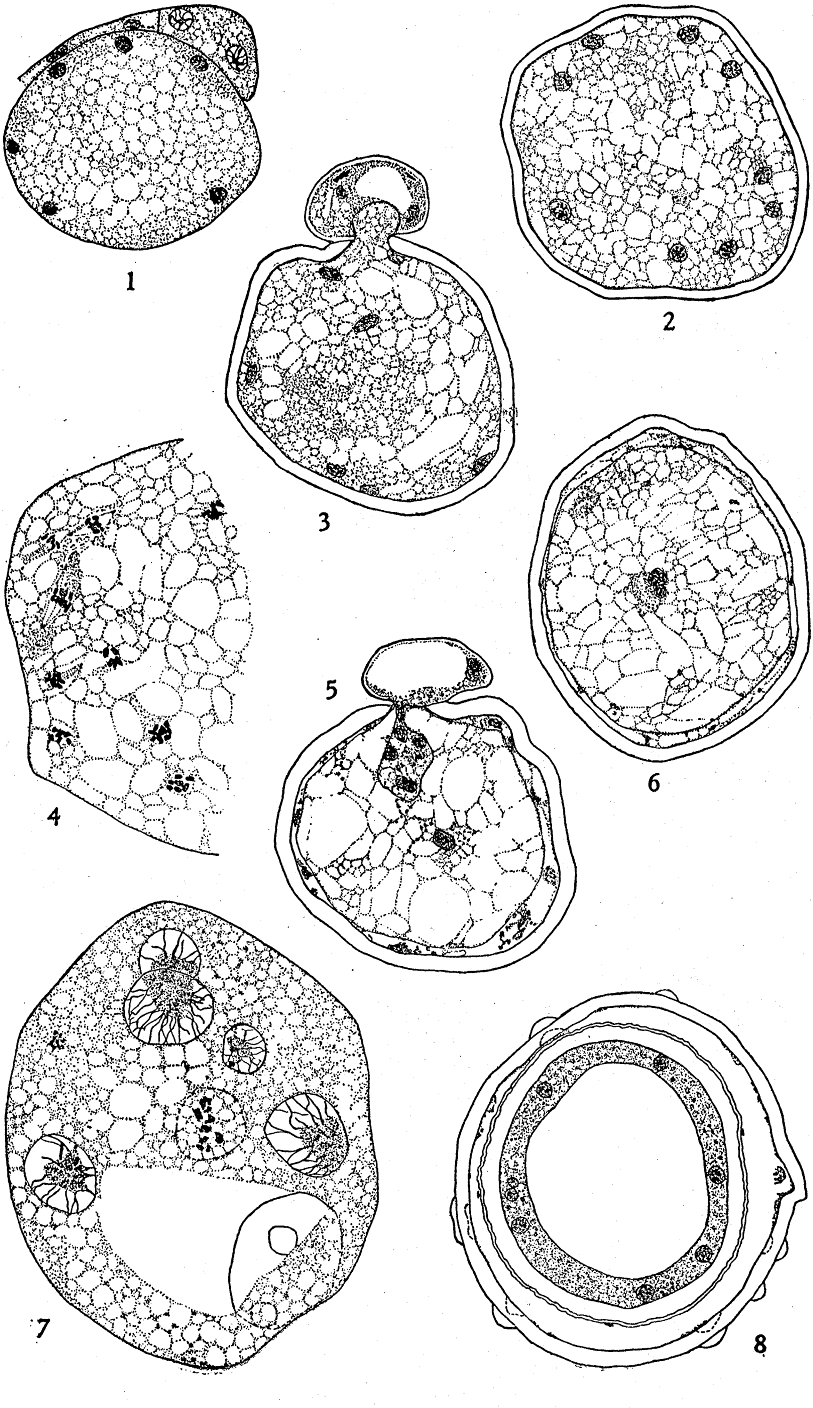
The author became acquainted with the fungus known as *Sclerospora macrospora* (Sacc.) in the summer of 1941 while at the Biological Laboratories of Harvard University. Dr. William H. Weston kindly made available his own exsiccate and gave detailed descriptions of the territory in Tennessee and Kentucky where he had previously collected (17), which made possible the securing of fresh material for study. This was especially fortunate because, so far as the author is aware, investigations of the cytology of members of the genus *Sclerospora* have been limited to the single species, *S. graminicola* (Sacc.) Schroet (2,3,7,8,13).

It is the purpose of the writer to set forth in this paper the main features of the development of the sex organs and oospore of *Sclerospora macrospora* (Sacc.), [*Phytophthora macrospora* (Sacc.) S. Ito and I. Tanaka] and to show in a preliminary way how these cytological characteristics may influence the classification of the fungus. The writer hopes that later Weston, who has been intermittently working on this oomycete for a long time, will publish further on its identity and taxonomic affiliations as well as on its geographic distribution and range of parasitism.

* This investigation was carried out with the aid of a grant from the A.A.A.S. received through the Wisconsin Academy of Science, Arts and Letters.
It is a pleasure to acknowledge the inspiration and counsel supplied by Dr. William H. Weston in the inception and during the course of the investigation.
Many thanks go to Miss Frances Bielinski who helped make the slides.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Description of Figures 1–8

All drawings were made of sectioned material with the aid of a camera lucida. Magnifications are given for each drawing as reproduced.

1. A young antheridium attached to a young oogonium. The early peripheral distribution of the oogonial nuclei is indicated. ×653.
2. An oogonium showing the thick wall. ×653.
3. A female gametangium projecting into the antheridium. ×653.
4. The first mitosis of nuclei in the oogonium. ×1460.
5. The two sex organs showing the fertilization tube with several nuclei. "Zonation" and migration or dissolution of all oogonial nuclei but one has taken place. ×653.
6. An oospore in which karyogamy is about to take place. ×653.
7. An oospore showing nuclei in different phases of mitosis. ×1460.
8. A resting spore showing the thick-walled oospore surrounded by the oogonial wall. The coenocytic condition is apparent. ×653.

Materials and Methods

Collections of infected wheat containing oogonia were made June 13, 1942 near Fulton, Kentucky. This location was in the general vicinity where Weston reported the presence of *Sclerospora macrospora* on wheat in 1921 (17). The diseased leaf tissue was fixed in F A A, Craf I (10), Flemming medium, and Carnoy's solution without chloroform (75 ml. anhydrous ethyl alcohol and 25 ml. glacial acetic acid). The tissue fixed in Craf I and Flemming was most useful. The material was run up into paraffin and sectioned at 10 microns. It was stained with Flemming's triple stain, iron-alum hematoxylin, and crystal violet-iodine.

Observations

The sexual organs were observed to have arisen intercellularly and usually intimately associated with the vascular bundles of the wheat plant. It was possible to distinguish the antheridial and oogonial primordia only after the oogonial element had attained a relatively large size (Fig. 1) and the hyphae were in contact. The cytoplasm, in both structures, was at first uniformly and minutely vacuolate. Counts made in 17 of the male elements showed from six to nine nuclei to be present in the antheridium after segmentation of the antheridial hypha. A simultaneous division of the antheridial nuclei was observed (Fig. 1) previous to a mitosis of the nuclei in the female organ. Mitoses of nuclei in male organs attached to oogonia which had differentiated further were found. This seemed to point to the conclusion that there were two successive, simultaneous divisions of nuclei in the antheridium. Further evidence in support of the theory that two divisions took place was found when counts were made of the nuclei in fully developed male gametangia, and compared with the counts from the young organs, a range of from 16 to 28 nuclei being observed in nine mature antheridia. However, a great variation existed in antheridial size and the counts of nuclei observed did not absolutely prove that two successive mitoses always took place.

The wall of the young oogone thickened soon after the maximum size of the gametangium had been attained (Fig. 2). The average thickness of the oogonial wall was found to be two microns. A range of from 30 to 45 nuclei which tended to be peripheral in location was observed to be present in the oogonia. These nuclei soon increased in size (Figs. 1,2,3) and a simultaneous nuclear division took place (Fig. 4) previous to a definite "zonation" of the cytoplasm. After these mitoses, differentiation of the cytoplasm into ooplasm and periplasm and at the same time a degeneration of the nuclei in the periplasm were found to occur (Fig. 5). No second simultaneous mitosis of nuclei was observed, but it was not uncommon to find some of the nuclei in the oogonium, subsequent to the early divisions, in the metabolic condition and at the same time different phases of mitosis. Because of this degeneration of nuclei and the great variation in size of the oogonia, comparison of nuclear counts in young and old oogonia were not very reliable in determining the number of divisions. However, a range of from 52 to 120 nuclei was obtained when an attempt was made to get maximum numbers. Almost from the start few nuclei were found in the central region of the oogone (Figs. 1,2,3), and before fertilization all but one of the nuclei originally present, or those produced later by division, migrated to the periplasm or degenerated until eventually a single female pronucleus existed in the center of the oosphere (Fig. 5).

A characteristic coenocentrum was not found. Some tendency for a small amount of dense cytoplasm to be present in the center of the oosphere was observed (Figs. 5,6), but this was never abundant and may have been caused by the failure of the central part of the cytoplasm to have its vacuoles increase in size, a characteristic typical for most of the cytoplasm (Figs. 1 to 5).

The wall of the oogone was observed to have remained thin at the region of contact with the antheridium and the two walls were so closely associated that a separation was not apparent. This intimate association of the sex organs was further accentuated by a protrusion of the oogonial material into the antheridium, the "receptive papilla" of Wager (16) and Stevens (11) (Fig. 5). Typical also of this association was the eccentric position of the oosphere wherein the egg was placed near the side of the oogonium to which the antheridium was attached. The fertilization tube was very conspicuous (Fig. 5) and was observed to contain six or more nuclei, all evidence indicating that at least most of these entered the oosphere. However, it was clearly indicated that but one nuclear union took place, a small male pronucleus uniting with a slightly larger female pronucleus, the remaining nuclei from the antheridium degenerating (Fig. 6).

Due to the scarcity of oospores showing divisions of the union nucleus and its daughter nuclei, it was assumed that once the union was completed the nuclear divisions followed rapidly. However, it was evident that nuclear divisions follow soon after fertilization (Fig. 7) and that the resting spores contained numerous nuclei (Fig. 8). From 33 to 44 nuclei were found in each oospore located in the peripheral cytoplasm, the center being occupied by a more or less homogeneous central body (Figs. 7,8) of reserve material.

During the maturation of the oospore the wall reached an average thickness of three microns. There were clearly visible at least two layers, an outer thin one and a comparatively thick inner wall. A large percent of the oospores observed in sectioned material had the thin outer coat minutely wrinkled. This condition did not seem to be an artifact, since the inner wall was definitely, in many instances, minutely roughened. However, not all oospores were observed to be so roughened and this condition was not clearly distinguished in unsectioned material. In a different manner the oogone wall became roughened. Due apparently to a folding of this wall, protrusions were formed (Fig. 8). Such foldings were caused apparently by a shrinking of the wall of the oogone and conformation of the wall to the surrounding cells.

Discussion

The phycomycete considered here was first described by Saccardo (9), who included it in the genus *Sclerospora* largely on the basis of the thickened wall of the oogone, the imperfect stage being unknown. The description of the voluminous, papillate, lemon-shaped sporangia as being born singly and externally on short peduncles by Peglion (5) and Peyronel (6) brought into question the taxonomic position of *Sclerospora macrospora* (Sacc.), since this condition was so unlike the members of the genus. Tanaka (15) in 1940 described this fungus as *Phytophthora macrospora* (Sacc.) S. Ito and I. Tanaka and considered *Sclerospora macrospora* as a synonym.

A comparison of the cytological features of the fungus herein referred to as *Sclerospora macrospora* with the published reports of both amphigynous and paragynous *Phytophthoras* casts doubt on the advisability of including the parasite in the genus *Phytophthora.* The thick oogonial wall alone would seem to exclude the fungus from the above genus, since the published reports of Murphy in 1918 (4) for the amphigynous *Phytophthora erythroseptica* and of Blackwell for the essentially paragynous *P. cactorum* (1) clearly indicate the thin nature of this wall. To this discrepancy may be added other cytological differences. It has long been considered that the number of nuclei present in the mature oospore is a good criterion of the taxonomic position of a member of the Peronosporales, since all members of the Albuginaceae studied cytologically have coenocytic resting spores while *Sclerospora* (as exemplified by *S. graminicola*), *Plasmopara, Peronospora,* and *Phytophthora* have a delayed union of the pronuclei, the mature oospore being monocaryon.

The development of the oospore of *Sclerospora macrospora* seems to be more like that of *Albugo tragopogonis* as described by Stevens (12) than any other member of the Peronosporales so far studied. In *A. tragopogonis* several nuclei enter the oosphere from the antheridium and but one unites with the single functional female nucleus. *A. ipomoeae-panduranae,* a fungus similar to *A. tragopogonis* in many respects (14), has been reported by Stevens as having a slight but very perceptible thickening of the oogonial wall. However, there would seem to be little justification for placing *Sclerospora macrospora* in the genus *Albugo* on the basis of the asexual phase.

Summary

From six to nine nuclei were observed in the young antheridium and from 30 to 45 nuclei in the oogonial initial. Simultaneous mitoses were found in both sex organs, and at least some of the nuclei so produced underwent a second division. Several nuclei were found to enter the oosphere, one single male nucleus uniting with the solitary female pronucleus, the rest disintegrating. The mature oospore contained from 33 to 44 nuclei. The oogonial wall averaged two microns in thickness, and the wall of the oospore consisted of a thin outer layer and

thick inner layer, the combined thickness of the two averaging three microns.

A preliminary consideration of the taxonomic position of the fungus led to the conclusion that this species could not easily be placed in any known genus. Further work now contemplated may well lead to the erection of a new genus.

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NOTES ON WISCONSIN PARASITIC FUNGI. VIII.

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In the University of Wisconsin Herbarium there is a specimen of ALBUGO CANDIDA (Pers.) O. Ktze. on *Thelypodium wrightii* from Zion Park, Utah, collected June 25, 1926 by E. J. Kraus. Although this is not Wisconsin material it is mentioned here for the sake of a record, since so far as I can determine *T. wrightii* has not been listed elsewhere as a host for this fungus.

Davis in his "Parasitic Fungi of Wisconsin" states that UNCINULA NECATOR (Schw.) Burr. is common on *Vitis vulpina* in Wisconsin. Over a ten-year period I have seen many thousand plants of *V. vulpina,* but have observed U. NECATOR in a single case only. This may have been more abundant in past years, but it is perhaps significant that there is but a single earlier specimen on this host, collected 40 years ago, in the Wisconsin Herbarium, and one in the Davis Herbarium, collected 56 years ago.

Plants of the showy garden subject, *Cleome spinosa,* in a University of Wisconsin greenhouse were lethally blighted by a powdery mildew, but perithecia failed to develop.

The oidial stage of presumed ERYSIPHE CICHORACEARUM DC. has been found in abundance on *Hieracium longipilum* at Madison. *Hieracium canadense* is regularly thus infected, but mature perithecia seem not to have been collected on Hieracium in Wisconsin.

Thompson (Phytopath. *31*: 241, 1941) finds a Mycosphaerella to be the perfect stage connected with SEPTORIA MUSIVA Peck, cause of the common leaf-spot disease of poplar. This he names MYCOSPHAERELLA POPULORUM. (Davis followed Petrak in considering S. MUSIVA Peck to be a synonym of S. POPULI Desm., and the numerous specimens in the Wisconsin Herbarium are thus filed.)

Demaree and Wilcox (Phytopath. *33*: 986, 1943) present evidence to show that the organism causing the common leaf-spot of raspberry, usually supposed to be SEPTORIA RUBI West., is identical with CYLINDROSPORIUM RUBI Ell. & Morg., and that the latter name must be supplanted by that of the ascigerous stage, SPHAERULINA RUBI Demaree & Wilcox. They question the connection of MYCOSPHAERELLA RUBI Roark (Roark worked in Wisconsin) with the leaf-spot of Rubus. In their artificial inoculations the raspberry leaf-spot fungus could not be carried over to dewberry and blackberry. They suggest the temporary retention of the binomial SEPTORIA RUBI for designating the fungus causing the leaf-spot in the Eubatus section of Rubus.

The ascigerous stage of ACANTHOSTIGMA OCCIDENTALE (Ell. & Ev.) Sacc. occurs associated with the conidial stage in a collection on *Artemisia ludoviciana*, made at Madison, June 21, 1944. Previous Wisconsin specimens on this host have had conidia only.

Mature PLEOSPORA sp. has been found closely associated and presumably connected with Alternaria on small, definitely delimited arid spots on living leaves of squash. The asci are about $65 \times 30\mu$, the ascospores about 25×13–15μ. It is questionable, however, that the fungus is parasitic since the spots are of a type that might be caused by insects.

COLEOSPORIUM SOLIDAGINIS (Schw.) Thüm. I occurred in great profusion on needles of young trees of *Pinus resinosa* planted in a nursery in the University of Wisconsin Arboretum at Madison, May 26, 1944. A single small earlier collection on this host was made by Davis from planted specimens in Peninsula State Park, Door Co.

In Davis' "Parasitic Fungi of Wisconsin," p. 43, it is indicated that telia only of UROMYCES ALOPECURI Seym. have been found in Wisconsin, but uredia have been collected also as shown by Davis' own specimens on *Alopecurus geniculatus* var. *aristulatus* from Haugen, Barron Co., and Big Bend, Waukesha Co.

In the summer and fall of 1943 PUCCINIA VIRGATA Ell. & Ev., previously unreported from Wisconsin, occurred in vast abundance on *Sorghastrum nutans* in the University of Wisconsin Arboretum at Madison. In 1944, on the same plants, not a trace of the rust could be found.

A Phyllosticta on leaves of *Syringa vulgaris* from Madison does not meet the specifications of hitherto described Phyllostictae on this host. The conidia are like those of PHYLLOSTICTA

SYRINGAE West., but the leaf spotting is quite different. In the Madison material very large marginal areas are involved, up to one fourth to half the leaf surface. The type of necrosis is that frequently associated with Ascochyta, but microscopic examination of many leaves shows no evidence whatever of septation in any of the conidia. It is possible that the fungus is secondary.

A Phyllosticta which may be of the type of PHYLLOSTICTA DECIDUA Ell. & Kell. has been found on leaves of *Silphium integrifolium* collected near Eagle, Waukesha Co. The leaves are heavily rusted by PUCCINIA SILPHII and the epiphyllous pycnidia are restricted to arid, whitish regions above the telial cushions. The hyaline, short-cylindrical conidia are $3–3.5 \times 6–8\mu$.

Another in the series of indeterminate and dubiously parasitic small-spored Phyllostictae on astericolous and solidaginicolous hosts has been observed on large gray spots on leaves of *Aster lucidulus*. The pycnidia are large and very dark, with numerous hyaline, biguttulate conidia about $7 \times 2\mu$. The spots appear to have been caused, at least partially, by the infestation of insects.

A problem of great importance to those interested in the identification of fungi parasitic on plants has recently been brought rather forcibly to my attention although, as all must who work with these parasites, I have always been aware of its existence. The problem is the old one of how much emphasis should be placed on hosts as bases for establishment of species of plant parasitic fungi.

In the fall of 1944 I collected a species of Ascochyta on the leaves of what I identified as a large rayless species of Senecio. This is firmly established as an escape on the grounds of a long-abandoned farmhouse near Madison. Examination of the literature showed that Petrak (Ann. Mycol. *22*: 167, 1924) described ASCOCHYTA SENECIONICOLA on *Senecio sarracenicus* from central Europe, a species which the Madison specimen matches almost exactly in microscopic characters, both from the printed description and from Petrak's own specimens in the University Herbarium. Although in the Wisconsin material the spots are somewhat smaller and better defined, it was nevertheless placed in the herbarium as ASCOCHYTA SENECIONICOLA Petr. Later in the year, following a more careful check of the host, I discovered that my supposed rayless Senecio is the common mint geranium, *Chrysanthemum balsamita* L. var. *tanacetoides* Boiss. In the Gray's

Manual treatment Chrysanthemum and Senecio are in different tribes, the Anthemideae and Senecioneae respectively, although these tribes are placed next one another.

The question, then, is: should ASCOCHYTA SENECIONICOLA, described on Senecio, be reported as occurring on the not too closely related Chrysanthemum, or should my specimen be described as new, since no similar Ascochyta appears to have been described on Chrysanthemum? The problem thus posed is perhaps insoluble without cross inoculations between hosts, a thing which is unfortunately often not feasible unless the hosts are of considerable economic importance. In the present case it is probably best to see whether the fungus can be collected again at the same station and, if so, attempt to obtain cultures with which to try infection of Senecio. In my experience, so sporadic is the occurrence of most parasites that the chances are at least even that this will not be found again.

An interesting Ascochyta on *Solanum dulcamara* was collected in small quantity at Madison, July, 1943. The fungus occurs on numerous transparent spots on the leaf, and parasitism is perhaps doubtful. When gathered, the impression was that it was probably PHYLLOSTICTA DECIDUA Ell. & Kell., although it was noted that the pycnidia did not show the translucency so often characteristic of PH. DECIDUA. However, microscopic examination revealed an Ascochyta with small, black, indistinctly ostiolate pycnidia, 60–90μ diam. The hyaline, uniseptate conidia are $6–10 \times 3.5–4.5\mu$. This fungus does not seem to correspond to ASCOCHYTA DULCAMARAE Bubak, PHYLLOSTICTA DULCAMARAE Sacc., or PHYLLOSTICTA PERFORANS Ell. & Ev.

Certain of the Wisconsin specimens of Septoria on Alnus that have been variously placed under SEPTORIA ALNI Sacc. and SEPTORIA ALNIFOLIA Ell. & Ev. have the pycnidial walls so imperfectly developed it would seem they might better be referred to Cylindrosporium. In particular is this true of a specimen collected at Madison in 1943 on *Alnus incana.* On the basis of microscopic morphological characters alone this is a good Cylindrosporium, but the type of host lesion, and one's knowledge of bridging forms, suggest its inclusion with the alnicolous Septorias.

As in the case of similar material placed in the herbarium by Davis, a specimen of SEPTORIA GEI Rob. & Desm. on radicle leaves of *Geum canadense* from Madison has imperfect pycnidia verging on acervuli, and the conidia are up to 50μ long. This species seems very close to Cylindrosporium.

SEPTORIA DEARNESSII Ell. & Ev. has been found on *Angelica atropurpurea* in 1943 in the University Arboretum at Madison. The only other Wisconsin station for this species is Eagleville, Waukesha Co.

PHLEOSPORA ANEMONES Ell. & Kell. on *Anemone virginiana* from Madison was at first determined as SEPTORIA CYLINDRICA Ell. & Ev. The latter species was described in 1900 on *Anemone cylindrica* from Montana, and so similar is the description to that of PHLEOSPORA ANEMONES that it appeared that these might be conspecific. No specimen of SEPTORIA CYLINDRICA is in the Wisconsin Herbarium, but material of the Phleospora was sent to Dr. Linder of the Farlow Herbarium who finds that the two are in no way different and that both correspond to the type of P. ANEMONES. The latter name must stand unless this is considered to be a Septoria, in which case S. CYLINDRICA Ell. & Ev. would be the designation. (J. J. Davis, in his "Parasitic Fungi of Wisconsin," p. 79, gives this the new name of SEPTORIA PUNICEA which is untenable, since S. CYLINDRICA is the earlier name. Dr. Linder points out that O. Kuntze in 1898 transferred PHLEOSPORA ANEMONES to SEPTORIA ANEMONES (E. &. K.) O. Ktze. This appears to be a later homonym, since Desmazieres applied the same name to another and well-known fungus forty odd years previously.)

An excipulaceous fungus, which perhaps should be assigned to PATELLINA Speg., has been found at Madison on *Penthorum sedoides*. The amphigenous, flesh-colored, cup-like fruiting structures are sessile and firmly seated in the host tissue, but project noticeably above the surface. The brown spots are very definite, almost circular, about 5 mm. diam. The cups are 125μ or more in diam., and the long, slender phores, some of which are branched, are about $30–40 \times 1.5\mu$. They are crowded in the cup and tend to curve toward the center. The acrogenous, hyaline conidia are ellipsoid to allantoid, about $5–8 \times 2\mu$, and are produced in great profusion.

An unusual dematiaceous fungus occurs on an undetermined narrow-leaved species of Carex, collected at Eagleville, Waukesha Co., August 8, 1943. So far as I have been able to determine this does not correspond in its characters to any previously described genus. The specimen is ample and in excellent condition, but it seems inadvisable to erect a new genus of parasitic fungi where the host concerned is unknown as to species. However, the following descriptive notes are given as a possible aid to others who may find the same thing and wish data and material for comparison. The specimen will be preserved and available for examination. The fungus is hypophyllous on narrow, more or less elongate, medium brown spots on the living leaves. The gregarious, seriate tufts of conidiophores are produced through the stomata in fascicles which are compact at the base, but in which the individual conidiophores spread widely upwards. The phores are pale brown below, rather deep brown in mass, fading into hyaline toward the tips, usually obscurely once or twice septate, more or less geniculate and tortuous, sometimes once branched near the base, or sometimes with pseudo-branching which is the result of anastomosis between adjacent conidiophores. There are from about 10-20 phores (approx.) in a tuft. The more strongly geniculate phores may have a number of spore scars, and the tips are frequently denticulate with several scars in close proximity. The phores are from $30\text{–}80 \times 3\text{–}3.5\mu$, mostly about $45 \times 3\mu$. The conidia, by direct lighting of the dried material as collected, with appropriate magnification, are seen to be several-catenulate, and when the conidiophores are denticulate several chains of conidia may be produced simultaneuosly from near the tip of a single conidiophore. The conidia are continuous, hyaline, globose or broadly ellipsoid or ovoid, from $5\text{–}13 \times 4\text{–}6\mu$. Those which are globose are of course not more than 6μ diam.

A very interesting species of Cladosporium has been found on living leaves of *Acer negundo* at Madison, August 1944. This species is characterized by the presence, free among the conidiophores, of large numbers of germinated conidia which at first, because of their uniformity, were taken to be spores of a Cercospora type. (A specimen from the same tree taken a month later corresponds exactly to that collected in August). These germinated spores form structures which measure from about $50\text{–}115\mu$ long and are 2– or 3–septate. They are strongly constricted at the septa and the primary, original cell which is itself only rarely septate (as is so frequently the case in Cladosporium) runs from about $15\text{–}21 \times 9\text{–}11\mu$. Examination of these cells as they are borne on the conidiophores before dispersal shows them to be of the same length, but considerably narrower, as one would expect of ungerminated spores. There is often the appearance of catenulation, although this may be due, in some cases at least, to germination in situ on the conidiophore. The very dark conidiophores are composed of short-cylindric, almost isodiametric cells and are markedly several times geniculate and crooked. They are frequently two to three times branched, at wide angles, and are of stiff and awkward aspect. I do not find a previous report of Cladosporium on box elder, and this may be a new species. I shall be pleased to furnish material to any mycologist who will undertake the specific determination of this fungus.

In my opinion CLADOSPORIUM AROMATICUM Ell. & Ev. and CLADOSPORIUM NERVALE Ell. & Dearn. on Rhus are the same thing, and since the former name is the earlier it should be used. One principal supposed difference between the two forms is that in C. AROMATICUM the fungus is supposed to be epiphyllous, while in C. NERVALE it is, by implication at least, hypophyllous. Recent collections made near Madison on *Rhus glabra* show the fungus to be amphigenous, somewhat diffuse on the upper surface and with a fairly prominent development along the midrib on the lower surface. Differences in conidiophore length do not seem to be of diagnostic importance. Fungi Columbiani 2010, supposedly type material of C. NERVALE, has no conidiophores over 80μ long, but in the description on the label they are given as 150 $\times$ 6μ. Also, the supposed differences in the shape of the conidia appear not to be significant.

CERCOSPORA DULCAMARAE (Peck) Ell. & Ev. on *Solanum dulcamara* (Jour. Myc. *1* : 55, 1885) as described has the fruiting forming indefinite, subviolaceous, or greenish-lead-colored patches on the lower surface of the leaf, and also more sparingly so above but without any distinct spots. In an earlier paper (Trans. Wis. Acad. Sci. *32*: 79, 1940) I mentioned a collection made at Mazomanie, Wis. in which "the conidiophores are borne on definitely delimited, arid white spots with a wide, blackish-brown border." Two later collections made in successive years at Madison show similar sharply defined spots, but a specimen taken at Madison in 1944 has the effuse type of fruiting, as do two earlier collections made by Davis. On the basis of macroscopic appearance one would immediately conclude that two different fungi are involved, but microscopically the differences are not so apparent. The conidiophores are perhaps somewhat longer and more closely fascicled in the form producing the definite spots; but the conidia are much the same, and Professor

Chupp stated that the Mazomanie specimem was probably best referred to C. DULCAMARAE. If the two forms should be constantly found over a long period of years, however, it would seem that at least a varietal distinction might be justified.

In 1944 at Madison, on *Senecio balsamitae,* there was found a Cercospora which is borne on very definite small spots, and in which the fruiting, though amphigenous, is chiefly epiphyllous. A specimen was sent to Professor Chupp for determination and it is his opinion that this should be referred to CERCOSPORA SENECIONICOLA J. J. Davis (Trans. Wis. Acad. Sci. *30*: 10, 1937) on the basis of similar microscopic characters, and indeed they do correspond closely. In C. SENECIONICOLA, as described on *Senecio aureus,* the spots are indeterminate and the fungus hypophyllous and effused. It is interesting that Davis found this in the effused condition on *Senecio balsamitae,* as well as on *S. aureus.*

In "Notes on Wisconsin Parasitic Fungi. III" (Trans. Wis. Acad. Sci. *35:* 120, 1943) mention is made of an Alternaria possibly parasitic on leaves of *Petalostemum candidum.* A similar fungus has recently been observed, this time on definite lesions on green stems of the same host.

In the lists of additional hosts and species not hitherto reported for Wisconsin which follow, all collections, unless otherwise specified, were made at Madison, Dane Co.

ADDITIONAL HOSTS

The fungi listed have not before been reported as occurring on these hosts in Wisconsin.

PERONOSPORA PARASITICA (Pers.) Fr. on *Draba nemorosa.* Marinette Co., Marinette, June 23, 1916. On a phanerogamic specimen collected by the late Charles Goessl. This is presumably the form of P. PARASITICA which Gäumann sets apart as PERONOSPORA DRABAE.

SPHAEROTHECA HUMULI var. FULIGINEA (Schl.) Salm. on *Erigeron canadensis.* October 17, 1944.

MICROSPHAERA ALNI (Wallr.) Wint. on *Lathyrus palustris* var. *myrtifolius.* October 22, 1910. Coll. J. R. Heddle. I do not find any other specimens in the herbarium on this variety of Lathyrus, which some authors set aside as a distinct species.

MICROSPHAERA DIFFUSA C. & P. on *Desmodium acuminatum.* (*D. grandiflorum* of Gray's Manual, 7th ed.) October 22, 1910. Coll. J. R. Heddle. Not only new to Wisconsin, but seemingly not reported elsewhere as a host for this fungus.

ERYSIPHE POLYGONI DC. on *Pisum sativum.* Grant Co., Platteville, September 1, 1888. Coll. and det. by S. M. Tracy. This specimen was distributed as one of the Reliquiae Seymourianae. E. POLYGONI is not mentioned in Davis' notes as occurring on cultivated pea in Wisconsin.

If the development of spores on the living host is one of the criteria distinguishing ERYSIPHE CICHORACEARUM DC. from E. GALEOPSIDIS DC., then a recent (1944) collection on *Scutellaria lateriflora* must be assigned to E. CICHORACEARUM. Davis at one time listed his specimens on this host as E. CICHORACEARUM, but later filed them all as E. GALEOPSIDIS. Examination of these specimens shows that they too have asci with spores, and they are plainly not overwintered material. For this reason, therefore, the record of E. GALEOPSIDIS on *Scutellaria lateriflora* in Wisconsin seems to be incorrect.

PUCCINIA CORONATA Cda. II, III on *Agropyron repens.* August 10, 1944. Arthur's Manual lists only Vermont as a host locality for P. CORONATA on quack grass.

PUCCINIA EXTENSICOLA Plowr. II, III on *Carex stellulata* var. *cephalantha.* July 20, 1943.

PUCCINIA CARICIS (Schum.) Schroet. II, III on *Carex stricta.* September 15, 1944.

PHYLLOSTICTA NEBULOSA Sacc. on *Arenaria lateriflora.* Sauk Co., Town of Sumpter, Baxter's Hollow, July 8, 1944. The spores of the specimen on Arenaria are somewhat wider than the 2μ of the description, averaging about 2.5μ, as do those of other Wisconsin specimens on Silene. As in most of the specimens on Silene, the pycnidia are on dead portions of the leaves.

PHYLLOSTICTA DECIDUA Ell. & Kell. on *Geum strictum.* July 30. On *Monarda fistulosa,* July 19. On *Solanum dulcamara.* July 22. All collected in 1943. Although this is doubtfully parasitic, it is included because of previous mention on other hosts in Wisconsin lists.

PHYLLOSTICTA PHASEOLINA Sacc. on *Soja max.* Rock Co. Janesville, July 14, 1944. Coll. E. E. Honey & J. G. Dickson.

ASCOCHYTA GRAMINICOLA Sacc. on *Muhlenbergia foliosa.* October 8, 1944. Seymour does not list *M. foliosa* as a host of this fungus.

SEPTORIA ATROPURPUREA Peck on *Solidago altissima.* September 28, 1944. In this specimen the flexuous sporules are from 60–90 $\times$ 2–2.5μ. *Solidago latifolia* is the only other species of Solidago reported as bearing S. ATROPURPUREA in Wisconsin. The spots on *S. altissima,* paler in the center, are similar to those on *S. latifolia.*

HENDERSONIA TYPHAE Oud. on *Typha angustifolia.* September 8, 1944. Doubtfully parasitic. Davis made an earlier collection on this host species, but did not refer to it as such. A Wisconsin specimen placed in the herbarium as STAGONOSPORA TYPHOIDEARUM (Desm.) Sacc. has deeply olivaceous spores and seems to be H. TYPHAE Oud.

RAMULARIA AEQUIVOCA (Ces.) Sacc. on *Ranunculus pennsylvanicus.* July 12, 1944. Not listed by Seymour on this host.

LEPTOTHYRIUM SIMILISPORUM (Ell. & Davis) Davis on *Solidago altissima.* September 1, 1943. Apparently a new host for this fungus, with no reports from Wisconsin or elsewhere.

HELMINTHOSPORIUM SATIVUM Pamm., King & Bakke on *Muhlenbergia foliosa.* October 8, 1944. Numerous single spore cultures were obtained and submitted to Professor J. L. Allison, Associate Pathologist, U. S. D. A., stationed at Madison, who states that these show the cultural growth characteristics of H. SATIVUM. Not listed in Seymour on this host.

CERCOSPORA CARICINA Ell. & Dearn on *Carex interior.* July 1, 1944. This is a slender and somewhat depauperate development of what is usually a decidedly more robust species.

CERCOSPORA VARIICOLOR Wint. on *Paeonia officinalis.* September 30, 1944.

CERCOSPORA CORDATAE Chupp & Greene on *Zizia aurea.* Walworth Co., Pickerel Lake, September 19, 1941; Waukesha Co., Eagleville, October 6, 1941, September 3, 1942; Dane Co., Madison, July 2, 1943, June 11, 1944. This species was described on *Zizia cordata* from material collected by J. J. Davis at Racine, Wis. in 1890, and an additional specimen on the same host was collected on the Scuppernong Prairie near Eagle, Waukesha Co. in 1941. On *Zizia aurea,* in some cases, the conidiophores are longer than the 35μ maximum of the description, running to 50μ or slightly more.

CERCOSPORA BLEPHILIAE Chupp & Greene on *Lycopus uniflorus*. September 1, 1944. Determined by Professor Chupp.

ADDITIONAL SPECIES

The fungi listed have not before been reported as occurring in Wisconsin.

BIFUSELLA FAULLII Darker on *Abies balsamea*. Vilas Co., July 27, 1902. Coll. J. J. Davis. Det. Dr. G. D. Darker. The effused or labyrinthine pycnidia of this species occur together with PHACIDIUM BALSAMEAE J. J. Davis. Dr. Darker states that B. FAULLII is the primary pathogenic agent, and that the Phacidium is secondary.

PUCCINIA MILLEFOLII Fckl. on *Artemisia frigida*. Pepin Co., Stockholm, August 25, 1935. Coll. N. C. Fassett and R. I. Evans. Arthur's Manual lists no station east of North Dakota for this lepto- form.

PHYLLOSTICTA SALICICOLA Thum. on *Salix*. sp. July 13, 1944.

SEPTORIA CARICIS Pass. on *Carex stricta*. July 15, 1944. This appears to be truly parasitic and shows close microscopic correspondence with Sydow's Mycotheca germanica No. 2199.

SEPTORIA CARAGANAE P. Henn. on *Caragana arborescens* (cult.). Washburn Co., Spooner, August 14, 1944. Coll. E. E. Honey. On the grounds of the University of Wisconsin Experimental Farm. Apparently not before reported from the United States.

SEPTORIA MENTHAE (Thüm.) Oud. on *Monarda fistulosa*. September 1, 1944. Referred here with some doubt. The pycnidia are most inconspicuous, and detectable only in sections. The sporules are mostly from 40–55 $\times$ 1.5–2μ. That S. MENTHICOLA Sacc. & Let. is distinct from S. MENTHAE seems questionable. S. MENTHAE is the earlier name. European material in the Wisconsin Herbarium labeled S. MENTHAE has spores of the dimensions specified for S. MENTHICOLA and there do not seem to be any well-marked differences in the host lesions. (An interesting member of the Staurosporae occurs together with the Septoria on some of the spots. The small, hyaline, 3-radiate conidia are borne on almost obsolete conidiophores which are aggregated in rudimentary acervuli. This is probably not a parasite.)

HYALOTHYRIDIUM CALAMAGROSTIDIS sp. nov.

Maculis amphigenis, ellipsoideis vel fusiformibus, aliquoties confluentibus, supra pallidioribus cum marginibus angustis, fusco-purpureis, .25–1.5 cm. longis; pycnidiis elementariis, subepidermidibus, dispersis, profunde immersis, amphigenis, globosis, erumpentibus, ostiolatis, 110–135μ diam., muris cum cellis pallido-brunneis, planis, compressis, fere concoloribus cum proximis cellis hospitibus; conidiophoris non distinctis, sed cellis fertilibus infra in pycnidiis; conidiis hyalinis, cellis multis, variatis, anguste vel late ellipsoideus, ovatis, vel obovatis, 30–45 $\times$ 16–23μ, plerumque apiculate, apicibus hyalinis, 3–13 (plerumque 4–6) $\times$ 1.5–2μ.

Spots amphigenous, ellipsoid or fusiform, sometimes confluent, paler above with a narrow, dark purple border; .25–1.5 cm. long; pycnidia rudimentary, subepidermal, scattered, deeply sunken in the host tissue, amphigenous, globose, erumpent, ostiolate, 110–135μ diam., wall of pale brown, flattened, compressed cells, almost concolorous with surrounding host cells; conidiophores not differentiated, but sporiferous tissue occupying the lower half of the inner surface of the pycnidium; conidia hyaline, many-celled, variable, narrowly to broadly ellipsoid, ovate, or obovate, 30–45 $\times$ 16–23μ, usually with a pointed hyaline apiculum 3–13 (mostly 4–6) $\times$ 1.5–2μ.

On living leaves of *Calamagrostis canadensis*. Madison, Dane Co., Wis., U. S. A., August 18, 1944. Coll. H. C. Greene. The type specimen is deposited in the University of Wisconsin Cryptogamic Herbarium.

The divisions in the conidia have occurred in many planes so that the cells are not generally in even tiers, but are opposite to one another after the fashion of roughly hewn stones cemented in a wall. The individual cells are variable in size and shape, but are often oblong, or rhomboidal, or otherwise angled. Frequently as many as twenty are in view simultaneously on one side of a conidium. So striking, large, and unusual are the conidia that it was at first doubted that the organism was a fungus, but a germination test showed the development of large numbers of rapidly elongating germ tubes, one per cell, so there seems no question of the true fungal nature of H. CALAMAGROSTIDIS. This is the hyaline counterpart of Camarosporium.

MARSONIA GLOEODES sp. nov.

Acervulis hypophyllis, dispersis, subepidermidibus, immersis, sed cum conidiis in massis erumpentibus, 100–150μ diam. ca.; conidiophoris curtissimis, prope obsoletis; conidiis hyalinis, cylindraceis, cum septis mediis distinctis, leviter constrictis septis, cum exoperidiis statim fractis, sed constanter affixis, 19–23 $\times$ 6–7μ.

Acervuli hypophyllous, scattered, subepidermal in origin, sunken in host mesophyll, but producing erumpent masses of conidia, 100–150μ diam. ca.; conidiophores very short, almost obsolete, not plainly differentiated from non-sporiferous tissue; conidia hyaline, cylindrical, with distinct median septum, slightly constricted at septum, with a soon ruptured, but persistently adherent outer wall or envelope, 19–23 $\times$ 6–7μ.

On living leaves of *Fraxinus americana*. Madison, Dane Co., Wis., U.S.A. August 4, 1944. Coll. H. C. Greene. The type specimen is deposited in the University of Wisconsin Cryptogamic Herbarium.

The conidia of M. GLOEDES are most distinctive, and when first examined seemed to have thickened hyaline caps at their ends, with appendages radiating from the caps. However, more careful and extended observation shows that the supposed appendages are merely ragged, free-hanging portions of the outer envelope which remains more or less firmly attached at both ends of the conidium, producing the appearance of caps on the apices.

When examined under a hand lens this fungus, in its gross appearance, is extremely suggestive of one of the MARSONIA FRAXINI-SEPTORIA BESSEYI intergrading series (see Davis, Trans. Wis. Acad. Sci. *21:* 289, 1924) and at the time of collection was thought to be such. The conidia are, however, utterly different.

CYLINDROSPORIUM CELTIDIS Earle on *Celtis occidentalis*. August 4, 1944. The specimen on which the description is based occurred on leaves of *Celtis mississippiensis* from Alabama. The spore characters are given as "cylindric or clavate, guttate, at length obscurely several septate, 20–25 $\times$ 3μ." The further statement is made that this somewhat closely resembles CYLINDROSPORIUM ULMICOLUM Ell. & Ev. which, however, has spores 45–65 $\times$ 4μ. In the Madison specimen most of the spores are from 30–35 $\times$ 3μ, with extremes of 22–42μ being noted. Many of the spores show considerable curvature. They are frequently clavate and in other particulars the Wisconsin material shows rather close correspondence to the description. (Heald and Wolf described CYLINDROSPORIUM DEFOLIATUM on southern hackberry, but this involved large portions of leaves, or entire leaves. The spores are given as 30–42 × 3μ, cylindrical, which is, to be sure, more in the range of my specimen on *C. occidentalis*. Possibly the two are conspecific. If so, C. CELTIDIS is the earlier name.)

CLADOSPORIUM LYSIMACHIAE sp. nov.

Amphigenis, effusis, indeterminatis, fuligineis, in foliis caulibusque; conidiophoris plerumque solitariis, sed aliquoties in fasciis (minus quam decem), fusca infra, apicibus pallido-brunneis, erectis, vel aliquoties angulosis et laxis, nonnihil sinuosis, dense denticulatis, continuis vel 1–3–septatis, plerumque, 50–105 × 5μ; conidiis pallido-fuscis, fusoideis-cylindraceis, apiculatis, constanter 1–septatis, leviter angustatis septis, 17–23 × 5–7μ.

Amphigenous in diffuse, indeterminate, blackish-brown patches on leaves and stems; conidiophores usually single, but occasionally in small tufts (less than ten), dark brown below, tip pale brown, erect or sometimes angled and spreading, somewhat sinuate, closely geniculate in the upper half, tip often denticulate, continuous or 1–3–septate, mostly 50–105 × 5μ; conidia pale fuscous, fusoid-cylindrical, definitely apiculate, usually pronouncedly so at one end, regularly 1–septate, slightly constricted at septum, 17–23 × 5–7μ.

On living leaves and stems of Lysimachia terrestris. Madison, Dane Co., Wis., U.S.A., August 24, 1943. Coll. H. C. Greene. Similar material on the same host was collected in August 1944 at the same station. Both the type specimen and the later collection have been deposited in the University of Wisconsin Cryptogamic Herbarium.

In thin, appropriately stained sections the scanty internal mycelium appears to be exclusively intraepidermal. The place of origin of the conidiophores seems to bear no relation to the stomatal openings.

It should be pointed out that while many species of Cladosporium have been described, most of the earlier descriptions are inadequate, and it is difficult and often impossible to tell whether a species which comes under observation has been previously described. However, it is felt that less confusion is created by providing an adequate description and a new name, than by placing a newly found form arbitrarily under an old and dubious name to disconcert future investigators. So far as I have been able to determine, only one other species of Cladosporium has been described on Primulaceae and that on a genus which does not occur in the New World. It is, furthermore, obviously quite different from the species on *Lysimachia terrestris*.

A specimen of the saprophytic and ineptly named MACROSPORIUM PARASTICUM Thüm. has been presented to the Wisconsin Herbarium by Dr. E. E. Honey. In this connection it should perhaps be noted that the allegedly parasitic MACROSPORIUM PORRI Ell., likewise on *Allium cepa,* was reported many years ago as occurring in Wisconsin, but was not recorded in Davis' notes.

NOTES ON WISCONSIN PARASITIC FUNGI. IX.

H. C. GREENE

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These notes, unless it is otherwise specified, are concerned with collections of fungi made during the season of 1945. The type specimens of the new species described are deposited in the University of Wisconsin Cryptogamic Herbarium.

Desmodium acuminatum (*D. grandiflorum* of Gray's Manual, 7th ed.) in the vicinity of Madison in the summer of 1945 was heavily parasitized by a powdery mildew, presumably MICROSPHAERA DIFFUSA Cke. & Pk., but perithecia were not formed since the mildew was in turn parasitized by Cicinnobolus.

Mature perithecia of SPHAEROTHECA HUMULI var. FULIGINEA (Schl.) Salm. occur on the lower portions of plants of *Veronica serpyllifolia* collected at Madison, May 12. This is very good specimen material accompanied by conidia, indubitably the current season's, so it seems reasonable to assume that the perithecia also developed in 1945. A rather long, abnormal warm spell in April may account for this, for Wisconsin, phenomenally early development of perithecia. On the same plants is found RAMULARIA VERONICAE Fckl., represented in the herbarium on this host by a single previous specimen taken at Madison thirty years ago.

Apothecia of SCLEROTINIA SEAVERI Rehm were collected April 8 at Madison on overwintered fruits of *Prunus serotina*. Specimens of the Monilia stage from Wisconsin are numerous, but none of the perfect stage were in the herbarium. A week later apothecia of SCLEROTINIA FRUCTICOLA (Wint.) Rehm were found on mummified fruits of wild plum, *Prunus americana*. This also was not represented in the herbarium.

The ascigerous stage of CLAVICEPS PURPUREA (Fr.) Tul. occurred in some quantity on fallen grains of *Bromus inermis* at the University Farms in late June. Of the many previous collections of this fungus in the herbarium there are none of the perfect stage from Wisconsin or elsewhere in America, but there are several specimens of European origin.

The growth known as OPHIODOTHIS HAYDENI (B. & C.) Sacc. is common on certain species of Aster in marshes in Wisconsin. Fungi Columbiani 3042 is a good representation of this. Whether it is a single organism or a group of organisms is questionable for the developments so far as observed, have been uniformly sterile. The original description of O. HAYDENI is utterly inadequate.

Previous collections of ENTYLOMA ASTER-SERICEANUM Zund. have all been made from mature host plants late in the season. A specimen taken near Madison on April 12, however, shows the fungus in good maturity on the basal leaves of developing shoots of *Aster sericeus*. Evidently the fungus overwinters in the crown of the host plant and develops concurrently with the earliest leaves which dry up and fall away later in the season. All previous specimens have been on the small upper stem leaves.

PUCCINIA EXTENSICOLA Plowr. I on *Hieracium longipilum* occurred in considerable abundance at Madison in May and June. A poor specimen from Blue River, Grant Co., collected in 1935 by Davis and me provides the only previous Wisconsin record on this host, nor does Dr. Cummins know of collections from elsewhere.

The uredinoid aecia of PUCCINIA HIERACII (Schum.) Mart. were found on *Hieracium canadense* at Madison, May 29. There do not appear to be any other Wisconsin specimens of this stage of the rust.

PUCCINIA ASTERIS Duby occurred in great abundance on *Aster oblongifolius* var. *angustatus* Shinners on a hillside "prairie" in Dane Co., near Sauk City, August 1. A 1940 collection, reported as being on *Aster oblongifolius,* appears likewise to be on var. *angustatus.*

Plants of *Aristida tuberculosa,* heavily infected with telia of UROMYCES PECKIANUS Farl., were gathered at Arena, Iowa Co., October 1, 1944. This material was overwintered out of doors, and in the spring of 1945 an attempt was made to infect plants of *Plantago rugelii* growing in the open. The plants were heavily mulched with the infected grass in the latter part of April. No infection had occurred by the first week in June, despite weather conditions which were seemingly very favorable for such development. Apparently no cultures have been made with teliospores from *A. tuberculosa.* According to Arthur, evidence has been obtained of strongly marked racial characters, partly geographic and partly dependent on host. Perhaps this has some bearing on the present case.

A fungus which may be identical with PHOMA SEPINICOLA (Kickx) Sacc. has been found on living stems of *Rosa* sp. The pycnidia are gregarious, the conidia greenish-hyaline, mostly about 6 × 8μ. The Phoma is on dark purplish areas, but on the same stems there are conspicuous ellipsoid arid lesions with many small pycnidia which contain microconidia, 4–5 × 2μ. It seems doubtful that the latter are connected with the Phoma. Perhaps they are the precursors of Diaporthe or some similar form.

PHYLLOSTICTA DISCINCTA J. J. Davis was described on *Uvularia grandiflora* (Trans. Wis. Acad. Sci. *16:* 747, 1910). In Davis' "Parasitic Fungi of Wisconsin," p. 63, it is erroneously stated that *Oakesia sessilifolia* was the host. The original packet contains indubitable leaves of Uvularia. Davis later expressed doubt as to the validity of PH. DISCINCTA, but I have recently made a collection of identical material on the same host. The spores are small and do not resemble those of the PH. CRUENTA complex, so it seems quite probable that this is a good species.

What is taken to be MACROPHOMA TILIACEA Peck is prevalent on dead branches and twigs of specimens of *Tilia americana* on the University of Wisconsin campus. This may be a weak parasite. Many of the large, widely ostiolate pycnidia are without contents, but when found, the spores are uniformly hyaline and without any suggestion of gradation into Sphaeropsis.

DIPLODIA TAXI (Sow.) DeNot. occurred on languishing foliage of *Taxus* sp. in a nursery at Madison, March 22. Probably, but not certainly, saprophytic. (On leaves of the same plants, but so far as observed not associated with the Diplodia, there occurred an Ascomycete which is doubtfully referred to Phacidium. The fructifications are almost, if not quite aparaphysate, the large asci about 105–110 × 20–25μ, and the hyaline, oblong-ellipsoidal ascospores 30–33 × 12–14μ. Even if this properly belongs in Phacidium, on the basis of dimensions it cannot be PHACIDIUM TAXI Fr. or P. TAXICOLA Dearn. & House. Davis has reported the former from Wisconsin.)

In an earlier paper (Farlowia *1:* 575, 1944) mention was made of Stagonospora on *Andropogon furcatus* and other grasses in Wisconsin. It was stated that the spores were about of the order of 30–35 × 10–12μ, several septate and markedly guttulate. In an additional collection, made August 4, 1945, on *Andropogon furcatus* of what is plainly the same thing, the mature conidia are from about 40–55 × 8–13μ. The pycnidia are subcuticular and can be easily lifted from the leaf with a needle. This fungus evidently occurs consistently on *A furcatus* and perhaps is distinct from similar forms on Sorghastrum and Panicum.

A Septoria of the S. SOLIDAGINICOLA-FUMOSA-DAVISII complex on *Aster tradescanti* from Madison has the characters which are usually assigned to S. FUMOSA Peck. However, this species has seemingly not been reported on Aster before.

A specimen of SEPTORIA ATROPURPUREA Peck on *Aster macrophyllus* from Devil's Lake, Sauk Co., has exceedingly large multiseptate sporules, up to 120 × 3μ. They are extruded in cirrhi.

In a collection of MARSONIA DELASTREI (Delacr.) Saac. on *Silene stellata,* made near Mazomanie, Dane Co., many of the conidia are biseptate and 30μ or more long.

A doubtfully parasitic fungus which has been determined as PESTALOTIA FUNEREA Desm. is abundant on blighted needles of cuttings of *Pinus strobus* from a nursery at Wisconsin Rapids. Coll. A. J. Riker, June 6, 1944. Det. M. P. Backus.

Limber and Cash (Mycologia *37:* 129, 1945) state that the fungus which has been known as LEPTOTHYRIUM DRYINUM Sacc., and which occurs on oaks in Wisconsin, is not properly a member of the Leptostromataceae. Following Gilman and Archer they consider that the proper name of the organism is ACTINOPLETE DRYINA (Sacc.) Hoehn.

In my experience Hyphomycetes sometimes, probably commonly, overwinter by means of the formation of sclerotia which frequently resemble immature perithecia, but which, instead of forming asci, merely give rise to large numbers of conidia, following spring rains. In the spring of 1945 at Madison leaves of *Pentstemon digitalis* bearing these "pseudoperithecia" on old spots of CERCOSPORA PENTSTEMONIS Ell. & Kell., and leaves of *Zizia aurea* bearing similar structures on old spots of CERCOSPORA CORDATAE Chupp & Greene, were found to bear numerous tufts of conidia produced on short conidiophores from the surface of the sclerotial elements. A similar condition was noted the year previously for CERCOSEPTORIA LEPTOSPERMA (Pk.) Petr.

CERCOSPORELLA SAXIFRAGAE Rostr. on *Saxifraga pennsylvanica* was found in abundant development in the Wisconsin River bottoms near Sauk City, May 30, and also at Madison, August 9. The only earlier collection was made by Davis at Portage, Columbia Co., in 1927.

ADDITIONAL HOSTS

Not previously recorded as bearing the fungi mentioned in Wisconsin.

PERONOSPORA PARASITICA (Pers.) Fr. on *Cardamine parviflora var. arenicola.* Iowa Co., Arena, May 23. Apparently the first report of the fungus on this host.

SPHAEROTHECA HUMULI (DC.) Burr. on *Humulus americanus.* Dane Co., Madison, July 9. Perithecia apparently not hitherto recorded from Wisconsin on this host, although conidia are often developed.

CLAVICEPS PURPUREA (Fr.) Tul. on *Calamagrostis neglecta.* Sclerotia were observed on a specimen of *C. neglecta* in the phanerogamic section of the University of Wisconsin Herbarium. The specimen was collected by J. R. Heddle at Madison, July 1909.

COLEOSPORIUM SOLIDAGINIS (Schw.) Thüm. II, III on *Solidago rigida.* Dane Co., Madison, July 9.

PUCCINIA EXTENSICOLA Plowr. 0 on *Aster azureus.* Sauk Co., Cactus Bluff, Town of Prairie du Sac, July 7. The lesions had apparently reached the limits of development and a number of leaves from different plants over a wide area showed no mature aecia, although the amphigenous pycnia were well formed. On *Aster laevis.* Columbia Co., Black Hawk's Lookout, near Prairie du Sac, June 17. The North American Flora lists this on *A. laevis* from Colorado, Nebraska and New Mexico, so the present collection represents a decided eastward extension of range insofar as the particular host is concerned. On *Aster lucidulus.* Dane Co., Madison, June 19. This listing is made since *A. lucidulus* is now set out from *A. puniceus,* although Davis reports the rust on *A. puniceus.* (Mature aecia are present on *A. laevis* and *A. lucidulus*).

PUCCINIA ELEOCHARIDIS Arth. I on *Eupatorium maculatum*. Dane Co., Madison, June. The host is the common species which occurs in marshes in Wisconsin and was not formerly differentiated from the woodland species, *E. purpureum*. Other parasites which, in my personal experience, occur on *E. maculatum* in Wisconsin are ERYSIPHE CICHORACEARUM DC. and CERCOSPORA PERFOLIATA Ell. & Ev.

PUCCINIA RUBIGO-VERA (DC.) Wint. II, III on *Elymus glaucus*. Waushara Co., Hancock, August 1944. Coll. Etlar Nielsen; II on *Agropyron intermedium*. Dane Co., Madison, July 1944. Coll. Etlar Nielsen. Both these hosts were cultivated.

PHYLLOSTICTA DECIDUA Ell. & Kell. on *Verbena stricta*. Columbia Co., Black Hawk's Lookout near Prairie du Sac, June 17; On *Epilobium* sp. Dane Co., Madison, July 26. Not previously reported on any species of Epilobium in Wisconsin. As Davis noted for a collection of this fungus on *Agrimonia striata* (Trans. Wis. Acad. Sci. *19*(2): 678, 1919), the conidia are decidedly brownish, and it is a question whether the fungus is properly placed under Phyllosticta.

PHYLLOSTICTA LIATRIDIS J. J. Davis on *Liatris spheroidea*. Dane Co., Madison, August 4. As in an earlier collection on *Liatris spheroidea* f. *benkei* (the white-flowered form of *L. spheroidea*), the conidia are somewhat smaller than those of the original collection on *Liatris spicata*. In type of lesion and in other respects there is great similarity however.

For the sake of a record a microconidial fungus, so-called PHYLLOSTICTA ANGELICAE Sacc., which occurs commonly in the fall on *Angelica atropurpurea* in the vicinity of Madison, is listed here. This is connected with FUSICLADIUM DEPRESSUM (B. & Br.) Sacc., and both are supposedly stages of PHYLLACHORA ANGELICAE (Fr.) Fckl. The latter, however, is included in Saccardo's enumeration of dubious Phyllachorae whose perfect stages are not known, and so far as I am aware the existence of such a stage has never been verified for PH. ANGELICAE. In an earlier note (Trans. Wis. Acad. Sci. *34:* 85, 1942) I reported the lack of further development, following overwintering, on several occasions, of such material. At that time I had overlooked the existence of the name PHYLLOSTICTA ANGELICAE, so failed to mention it.

STAGONOSPORA BROMI Smith & Ramsb. on *Bromus kalmii*. Sauk Co., Cactus Bluff, Town of Prairie du Sac, July 7. A scanty collection, but entirely characteristic. On *Bromus ciliatus*. Dane Co., Madison, July 19. Collected in quantity in the Lake Wingra marsh. On *Bromus purgans*. Sauk Co., Devil's Lake, July 27. Although typical leaf lesions are numerous, the pycnidia are very sparingly produced in this specimen.

SEPTORIA COMMONSII Ell. & Ev. on *Cirsium altissimum*. Sauk Co., Cactus Bluff, Town of Prairie du Sac, July 7. This is the host from which Ellis and Everhart described S. COMMONSII. That this species is really distinct from SEPTORIA CIRSII Niessl is questionable.

SEPTORIA ANGULARIS Dearn. & Barth. on *Solidago latifolia*. Columbia Co., Gibraltar Rock near Okee, July 1. The sporules are 26–36 $\times$ 1.5μ. As the authors indicated, this is probably very close to, if not identical with, SEPTORIA FUMOSA Peck. The spots are distinctly larger and squarer than those which I have been accustomed to associate with S. FUMOSA.

SEPTORIA CACALIAE Ell. & Ev. on *Cacalia tuberosa*. Dane Co., Madison, August 9. Of the species of Cacalia on which this has been collected in Wisconsin (*C. atriplicifolia, C. reniformis, C. suaveolens, C. tuberosa*) only *C. atriplicifolia* shows well-marked lesions with a distinct, narrow purple border and arid center. While on the other hosts the fungus usually occurs on definite lesions, they are uniformly dark and lack differentiation between center and margin. However, a specimen in the herbarium from Kansas on *C. tuberosa* shows lesions of a type intermediate between the extremes described.

SEPTORIA LACTUCICOLA Ell. & Mart. on *Lactuca spicata*. Dane Co., Madison, June 24. Davis reports SEPTORIA UNICOLOR Wint. on this host, but in the present material I am unable to see that the organism is other than S. LACTUCICOLA. It appears probable that these species are one and the same, and since the Ellis and Martin name is the earlier, it seems best to use it.

MARSONIA POTENTILLAE (Desm.) Fisch, var. TORMENTILLAE Trail on *Fragaria vesca* var. *americana*. Dane Co., Pine Bluff, June 29. Listed as the variety because of the relatively small conidia which do not exceed 16μ. Also from Madison and from Gibraltar Rock, Columbia Co.

SEPTOGLOEUM CONVOLVULI Ell. & Ev. on *Convolvulus arvensis*. Dane Co., Madison, June 21. Placed here with some doubt. It is probable that SEPTOGLOEUM CONVOLVULI and STAGONOSPORA CONVOLVULI Dearn. & House intergrade. Some of the conidia in the present specimen are up to 35 $\times$ 5μ and the walls of the fruiting body are rather well formed.

RAMULARIA VIRGAUREAE Thüm. on *Aster laevis*. Columbia Co., Black Hawk's Lookout near Prairie du Sac, July 18. In general Davis' remarks (Trans. Wis. Acad. Sci. *24:* 274, 1929) concerning a collection of this variable organism on *Aster sagittifolius* apply to the specimen on *A. laevis*. The conidia here are markedly catenulate with a considerable range in length. On *Solidago juncea,* Dane Co., Madison, July 30. Definitely a Ramularia with no suggestion of Cercosporella.

CERCOSPORA PARVIMACULANS J. J. Davis on *Solidago juncea*. Dane Co., Madison, July 30.

TUBERCULINA PERSICINA (Ditm.) Sacc. on PUCCINIA PANICI Diet. I on *Euphorbia corollata*. Dane Co., Madison, July 31. On UROMYCES ACUMINATUS Arth. I on *Phlox pilosa*. Dane Co., near Sauk City, May 30. The host is U. ACUMINATUS POLEMONII (Pk.) J. J. Davis of Arthur's Manual. Davis collected this on U. ACUMINATUS STEIRONEMATIS (Arth.) J. J. Davis where the phanerogamic host was *Steironema ciliatum*.

ADDITIONAL SPECIES

The following species have not before been listed in these or in Davis' notes as occurring in Wisconsin.

SPORODINIA GRANDIS Link on *Boletus castaneus*. Dane Co., Madison, July 25. Coll. E. J. Backus. Det. M. P. Backus. On *Strobilomyces strobilaceus*. Dane Co., 6 mi. west of Black Earth, August 12. Coll. & det. M. P. Backus.

Chamberlain and Allison (Phytopath. *35:* 241, 1945) report studies of PYRENOPHORA BROMI (Died.) Drechsler, the perfect stage of HELMINTHOSPORIUM BROMI Died., on the basis of material on *Bromus inermis* from the grass nurseries at the Wisconsin Agricultural Experiment station in Madison.

PHOMOPSIS EXCELSIOR Tapy on twigs of *Quercus velutina*. Sauk Co., T12N, R5E S9 NW/SE, Highway 33, June 5. Coll. & det. E. E. Honey.

CONIOTHYRIUM CONCENTRICUM (Desm.) Sacc. on *Yucca filamentosa*. Dane Co., Madison, June 19. Although this occurred on the still green leaves it is perhaps but doubtfully parasitic. The host plant is growing on a roadside bank in the University of Wisconsin Arboretum and is one of the southern species which are hardy in this region.

PHYLLOSTICTA UMBRINO-FUMOSA sp. nov.

Maculis plerumque orbicularibus, 3–8 mm. diam., fuligineis, immarginatis; pycnidiis flavido-brunneis tinctis fumosis, 100–125μ diam., applanatis, immersis, gregatim, ostiolatis; conidiis hyalinis, oblongatis vel ellipsoideis, plerumque 2–guttulatis, 4–7 $\times$ 2.5–3μ.

Spots mostly orbicular, 3–8 mm. diam., fuliginous, immarginate; pycnidia sooty yellowish brown, 100–125 diam., flattened, immersed, closely clustered, ostiolate; conidia hyaline, oblong or ellipsoidal, mostly 2–guttulate, 4–7 $\times$ 2.5–3μ.

On leaves of *Eupatorium urticaefolium*. Madison, Dane Co., Wisconsin, U. S. A., August 7, 1945.

The inconspicuous pycnidia are apparent only by transmitted light, when they appear as translucent areas in the smoky spots.

Three other species of Phyllosticta which have been described on Eupatorium, and some of the principal characters in which they differ from PH. UMBRINO-FUMOSA are as follows:

PH. EUPATORIICOLA Kab. & Bub. Spots sordid, obscure brown, immarginate; conidia 3–4 $\times$ 1–1.5μ.

PH. EUPATORINA Thüm. Spots grayish with wide, dark purple margin; conidia 6 $\times$ 2.5–3μ. The conidia here are similar.

PH. EUPATORII Allesch. Spots dark gray, with obscure purple margin; conidia 10–15 $\times$ 3–4μ.

PHOMOPSIS DIACHENII Sacc. on *Pastinaca sativa*. Dane Co., Madison, July and August. On fruit and living leaves. In general, on the fruit the fusoid conidia run 6–12 $\times$ 3μ, instead of the 8–10 $\times$ 3μ of the description. The scolecospores are narrowly tapered at one end, frequently strongly curved at the same end, and are from about 14–20 $\times$ 1.5–2μ. On leaves, both pycnidia and their contents run somewhat larger than on the dry papery carpels, but otherwise the microscopic characters are practically identical. Although the description indicates that the fungus occurs on fruit only, in lack of evidence to the contrary I assume that but one organism is involved since (1) the host is the same (2) the microscopic aspect is the same (3) the affected plants were identical or in close proximity and (4) the infection occurred at the same time in late July and early August. No spots occur on the fruits, which bear many pycnidia evenly dispersed and which differ from non-infected fruits principally in being somewhat paler. On leaves, however, the spots are striking, variable, mostly somewhat ellipsoidal, usually about 2–5 mm. long diam., although sometimes irregular and considerably larger by confluence. The margins are deep purple, of varying width, and contrast strongly with the pale to reddish-brown centers. There are from one to several spots per leaflet, and they are most conspicuous. Pycnidia are produced sparingly on the leaves, in contrast to their abundant development on the fruit. P. DIACHENII has also been found on fruits of the closely related (to Pastinaca) *Heracleum lanatum* in a collection made by Davis at Mineral Point, Iowa Co., August 10, 1927. This was labeled GLOEOSPORIUM ACHENIICOLUM Rostr., but there can be no doubt that it is a characteristic Phomopsis. Therefore, the record of GLOEOSPORIUM ACHENIICOLUM for Wisconsin must be deleted.

STAGONOSPORA BRACHYELYTRI sp. nov.

Maculis pallido-brunneis, marginibus angustis fuscis, plerumque elongatis, 5–15 × 1.5 mm., venis sequentibus; pycnidiis brunneis, subglobosis, 100–150μ diam., plerumque 100–110μ, obscure ostiolatis; conidiis hyalinis, granulosis, subclavatis vel cylindraceis, saepe curvatis leniter, distincte 1–3–septatis, 13–33 × 5–7μ.

Spots pale brown with narrow dark brown margins, mostly elongate, 5–15 × 1.5 mm., following venation; pycnidia brown, subglobose, 100–150μ diam., mostly 100–110μ, indistinctly ostiolate; conidia hyaline, granular, subclavate or cylindrical, often slightly curved, distinctly 1–3–septate, 13–33 × 5–7μ.

On leaves of *Brachyelytrum erectum*. Devil's Lake, Sauk Co., Wisconsin, U. S. A., July 27, 1945.

Many conidia were measured and, while the extremes are as given, those conidia which have less than 3 septa and are shorter than 22–23μ are exceptional.

STAGONOSPORA CRYPTOTAENIAE sp. nov.

Maculis conspicuis, orbicularibus, centris fuscis, marginibus flavidis, latis, ca. .5–1 cm. diam.; pycnidiis hypophyllis, fumosis, muris exilibus, magnis, frequenter 250μ diam. distincte ostiolatis; conidiophoris fere obsoletis vel obsoletis; conidiis 0–3–septatis, plerumque 1–2–septatis, hyalinis granulosis, oblongatis vel irregularibus, 25–55 $\times$ 14–16μ.

Spots conspicuous, orbicular, with dark brown center and wide yellowish border, about .5–1 cm. diam., pycnidia hypophyllous, sooty, thin-walled, large, frequently 250μ diam., or somewhat larger, ostiole well-defined; conidiophores almost or quite obsolete; conidia 0–3–septate, mostly 1– and 2–septate, hyaline, granular, oblong or somewhat irregularly shaped, 25–55 $\times$ 14–16μ.

On leaves of *Cryptotaenia canadensis*. Madison, Dane Co., Wisconsin, U.S.A., June 24, 1945.

When fresh, the large pycnidia are noticeably erumpent. They tend to collapse, however, on drying and pressing, as would be expected where the walls are so thin and the host substrate of such delicate texture. There is seemingly a complete absence of reports of Stagonospora on Umbelliferae in America, and in Europe, but there is no doubt that this is a representative species of the genus.

In 1929 Davis (Trans. Wis. Acad. Sci. *24:* 290, 1929) mentioned, with descriptive notes, a species of Septoria which he had found at Portage on *Lithospermum canescens*. What is plainly the same fungus, on the same host, has recently been found in some quantity at Madison, so a formal description seems justified. Davis filed his specimen as SEPTORIA LITHOSPERMI nom. herb. It seems proper to employ this name for the new species which is described as SEPTORIA LITHOSPERMI Davis & Greene.

SEPTORIA LITHOSPERMI Davis & Greene sp. nov.

Maculis parvis, irregularibus, orbicularibus vel angularibus, fuscis; pycnidiis epiphyllis, subepidermidibus, supra imperfectis, globosis, brunneis, 60–70μ diam.; conidiis hyalinis, obscure septatis, plerumque curvatis, 35–65 $\times$ 2–3μ.

Spots small, irregular, orbicular or angled, dark brown; pycnidia epiphyllous, subepidermal, imperfect above, globose, brown, 60–70μ diam.; conidia hyaline, obscurely septate, usually curved, 35–65 $\times$ 2–3μ.

On leaves of *Lithospermum canescens*. Madison, Dane Co., Wisconsin, U. S. A., July 25, 1945.

The pycnidia are most inconspicuous and can be detected only in sections. As Davis stated, Lithospermum in Wisconsin is usually notable for lack of parasites.

GLOEOSPORIUM HEPATICAE Peck on *Hepatica acutiloba*. Dane Co., Madison, May 12. Dearness & House (Report of State Botanist of New York, 1919, p. 35) described GLOEOSPORIUM ACUTILOBA which is said to differ from G. HEPATICAE in having larger, chiefly hypophyllous acervuli and much smaller spores, mostly 7 × 2μ, as opposed to 15–25 × 6.5–7.5μ for G. HEPATICAE.

In my Notes III (Trans. Wis. Acad. Sci. *35:* 118, 1943) I mentioned, with descriptive comments, what appeared to be a species of Colletotrichum with curved, appendaged conidia, occurring on *Andropogon furcatus* and *Sorghastrum nutans*. Dr. D. A. Preston has pointed out that this is probably ELLISIELLA CAUDATA Sacc., and so it seems to be, although whether Ellisiella can really be generically distinct from Colletotrichum seems doubtful to me.

RAMULARIA OVULARIOIDES sp. nov.

Maculis irregularibus, plerumque elongatis, supra fusco-brunneis, infra pallidioribus, frequenter totis segmentis foliis coopertis; conidiophoris hyalinis, floccis 8–12, divergentibus, 20–30 × 3–3.5μ, nascentibus ab basibus gibbosis parvis, brunneis, substomatibus; conidiis hyalinis, ellipsoideis vel cylindraceis, 10–25 (plerumque 10–15) × 3.5–4.5μ, 0–1–septatis.

Spots irregular, mostly elongate, dark brown above, paler below, frequently involving entire segments of leaf; conidiophores hyaline, in tufts of 8–12, widely spreading, 20–30 × 3–3.5μ, produced from small, brown, substomatal, tuberculate bases; conidia hyaline, ellipsoid or cylindrical, 10–25 (mostly 10–15) × 3.5–4.5μ, 0–1–septate.

On leaves of *Anemone cylindrica*. Madison, Dane Co., Wisconsin, U. S. A., July 31, 1945.

This species is very destructive to the host plant. All plants in a group of 25 or 30 were seriously blighted. There is little evidence of catenulation. Most of the conidia are short and nonseptate, reminiscent of Ovularia. A small collection of this species was made in 1942 and discussed in an earlier note (Trans. Wis. Acad. Sci. *35:* 119, 1943).

MYCOGONE ROSEOLA Pound & Clements on *Helvella elastica.* Columbia Co., Gibraltar Rock near Okee, July 1. This has the appearance of a vigorous parasite.

HELMINTHOSPORIUM AVENAE Eidam on *Avena sativa.* Dane Co., Madison, July 5. This common species seems not to have been previously mentioned in Davis' notes or in my current series, so is therefore included for the sake of a complete record. Professor J. G. Dickson has presented the herbarium with a specimen of the perfect stage of this fungus, PYRENOPHORA AVENAE Ito, on oat straw, Monticello, Green Co., June 12. (Although the propriety and legality of continued usage of the name of an imperfect stage after demonstration of the connected perfect stage may be questioned, I feel that in many cases such a name is more useful than that of the little known and rarely encountered perfect stage, especially where parasites are concerned).

A species of Cercospora which was found on leaves of *Triosteum perfoliatum* was sent to Professor Chupp for inspection and determination. He regards it as a new species so it is described jointly with him as CERCOSPORA TRIOSTEI Chupp & Greene sp. nov.

CERCOSPORA TRIOSTEI Chupp & Greene sp. nov.

Maculis subcirculis vel irregularibus, 2–4 mm. diam., constanter umbrinis vel cum cingulis fuscis; fructificationibus amphigenis; floccis minutis, nigris; stromatibus parvis, 20μ diam. vel minus, cellis fuscis compositis; fasciis cum 2–12 cauliculis divergentibus; conidiophoris olivaceo-brunneis pallidis vel mediis, interdum angustatis apicibus, parce septatis non ramosis, 0–4–geniculatis, rectis vel curvatis vel tortuosis, apicibus obtuso-rotundatis vel subtruncatis, 3–5 $\times$ 30–120μ; conidiis olivaceis pallidis vel mediis, obclavato-cylindraceis, rectis vel leniter curvis, 1–7–septatis, basibus obconico-truncatis, apicibus brevibus, conicis, 3–5.5 $\times$ 30–70μ.

Spots subcircular or irregular, 2–4 mm. diam., uniformly dull brown or with a narrow dark margin; fruiting amphigenous; pustules minute, black; stromata small, up to 20μ diam., made up of dark brown cells; fascicles 2–12 divergent stalks; conidiophores pale to medium olivaceous brown, fairly uniform in color, sometimes more narrow near the tip, sparingly septate, not branched, 0–4–geniculate, straight to curved or tortuous, bluntly rounded to subtruncate tip, 3–5 $\times$ 30–120μ;

conidia pale to medium olivaceous, obclavate-cylindric, straight to mildly curved, 1–7–septate, base obconically truncate, tip short, conic, 3–5.5 × 30–70μ.

On leaves of *Triosteum perfoliatum.* Pine Bluff, Dane Co., Wisconsin, U.S.A., June 29, 1945.

CERCOSPORA LYCII Ell. & Halst. on *Lycium halimifolium.* Dane Co., Madison, August 12.

Plakidas (Phytopath. *35:* 185, 1945), following Chupp, concludes that the fungus on *Juniperus communis* var. *depressa* (and also on *Juniperus virginiana*) which has been called CERCOSPORA SEQUOIAE var. JUNIPERI Ell. & Ev., common in Wisconsin and originally described from Wisconsin material, is not properly a Cercospora because the conidia are echinulate and because they are produced from a thick, more or less convex sclerotial stroma, considered to be a sporodochium. It appears that this is probably EXOSPORIUM DEFLECTENS Karst., although the conidia show a much greater range in length than the 14–20μ of Karsten's description. The specimens in the herbarium have been relabeled as EXOSPORIUM DEFLECTENS, and the name CERCOSPORA SEQUOIAE var. JUNIPERI must be deleted.

THE WISCONSIN SPECIES OF PELTIGERA

Papers on Wisconsin Lichens, No. 2.

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In the recent revival of interest in lichens in the United States, need has been felt for bringing up to date the taxonomic treatments of the North American lichens. Among those groups in need of revision is the genus *Peltigera*. A series of papers by V. Gyelnik of Budapest, in preparation toward a monograph of the Peltigeras of the world, necessitates a critical re-examination of our own species.

In the determination of *Peltigera* specimens, the usual spore and apothecial characters by which other groups of lichens are identified are in most cases of less importance than the thallus characters. The character of the upper surface, the type of venation of the under surface, and the nature of the rhizinae are of prime importance. The rhizinae as classified by Gyelnik **(16)** are: 1. simple, e.g. *P. canina* or *P. polydactyla* var. *dolichorrhiza;* 2. pappose, simple but with a tuft of hyphae at the tip, e.g. *P. canina* var. *spuria* f. *sorediata;* 3. fasciculate, with a number of more or less parallel strong rhizinae bound in a bundle, e.g. *P. polydactyla;* 4. fibrillose, with a number of lesser hyphae extending at right angles to the main rhizoid and sometimes repeatedly branched and forming a spongy mat, e.g. *P. canina* var. *spongiosa.* The presence or absence of soredia and isidia also provide characters of some value. The Peltigeras are a plastic group, much modified by the environment, and variance of these characters sometimes makes it difficult to place certain specimens. It would seem that transplantation experiments would go far toward helping understand the species limits in this genus. Field studies of this type are much needed.

Almost no mention of Wisconsin *Peltigeras* has been made in the literature. I. A. Lapham (19) lists *P. rufescens* (*P. canina* var. *rufescens*) from Milwaukee. This specimen is now in the Tuckerman Collection at the Farlow Herbarium, Harvard University. Bruce Fink (4) lists *Peltigera pulverulenta* from a collection made by L. H. Pammel at La Crosse. This specimen, in the Herbarium of the University of Michigan, however, is not this species but *P. polydactyla* var. *crassoides.*

The principal collectors of *Peltigera* material in Wisconsin are L. S. Cheney, R. H. Denniston, and the writer. Dr. Denniston's private herbarium has now been given to the University of Wisconsin and is being incorporated in the University Herbarium. I am indebted for additional collections to Dr. G. S. Bryan, Dr. R. I. Evans, Dr. L. H. Shinners, Robert Ellarson, and Mrs. F. E. Lund, Jr. Unless otherwise stated, the collections cited are by the writer. The full set of specimens is in the Herbarium of the University of Wisconsin. Duplicates of many are in the private herbarium of the writer and have also been used in exchanges. In as many cases as possible the nomenclature has been checked back to the original publications. Spore measurements were made in water mounts.

Grateful acknowledgment is made to Dr. David H. Linder of the Farlow Herbarium, Harvard University, for making fully available the facilities of that herbarium during the progress of this study.

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Key to the Wisconsin Peltigeras

1. Algae of thallus Chlorophyceae; warty cephalodia containing *Nostoc* on the upper or under surface of the thallus. Sect. Phlebia Wallr.
    2. Upper surface of the thallus with warty cephalodia; under surface with scattered, fasciculate rhizinae; thallus and lobes large, up to 6 cm. across; apothecia vertical.
        3. Underside lacking veins, covered with an even tomentum, bluish or brownish black at the center, pale white or brownish at the margin. la. *P. aphthosa* var. *typica.*
        3. Underside with brown veins, interspaces pale, center blackish, margins paler.
            4. Margins not crisped. . . . lb. *P. aphthosa* var. *variolosa*
            4. Margins crisped. . . . lc. *P. aphthosa* var. *variolosa* f. *crispa*

2. Lower surface of the thallus with small black cephalodia on the veins; under surface attached centrally or at one side by a group of rhizinae; thallus small, up to 2 cm. across, apothecia horizontal. . . . 2. *P. venosa*

1. Algae of thallus Myxophyceae; thallus lacking cephalodia. Sect. Emprostea (Ach.) Vainio.

5. Thallus upperside smooth or verruculose-scabrid, lacking tomentum.

6. Upper surface smooth, shining, lacking scattered cylindrical isidia but sometimes with flat, squamulose, isidia; underside dark, veinless or with broad flat veins which are not strongly raised as in *P. canina.*

7. Underside with broad, flat veins.

8. Apothecia horizontal.

9. Lacking isidia. . . . 3. *P. horizontalis*

9. With squamulose, flat isidia . . . 3a. *P. horizontalis* f. *zopfi.*

8. Apothecia vertical.

10. Rhizinae short, mostly fasciculate. . . . 4a. *P. polydactyla* var. *typica*

11. Apothecia over 2 mm. long, lobes more than a cm. across.

12. Lacking isidia.

13. Thallus lobes with margins raised, more or less undulate but not crisped. . . . 4a. *P. polydactyla* var. *typica*

13. Thallus lobes with dilacerate or dilacerate-crisped margins. . . . 4d. *P. polydactyla* f. *lophyra*

12. With flat isidia, especially along the margins and cracks in the thallus . . . 4c. *P. polydactyla* f. *microphylla*

11. Apothecia about 2 mm. long, plant small, lobes less than 1 cm. across. . . . 4b. *P. polydactyla* f. *microcarpa*

10. Rhizinae long, over 5 mm., simple. 4e. *P. polydactyla* var. *dolichorrhiza*

7. Underside lacking veins; plants small, thick, pusilloid; apothecia vertical; rhizinae short, fasciculate . . . 4f. *P. polydactyla* var. *crassoides*

6. Upper surface verruculose-scabrid, with scattered cylindrical isidia; underside pale, veins narrow, strongly raised . . . 5. *P. evansiana*

5. Thallus with a layer of tomentum on the upper surface, at least toward the margins.

14. Thallus large, lobes usually longer than 3 cm., prostrate, with only the margins ascending; rhizinae simple or fibrillose.
    15. Rhizinae fibrillose-confluent . . . 6g. *P. canina* var. *spongiosa*
    15. Rhizinae simple or fibrillose but not confluent or forming a spongy mat below.
        16. Veins white, rhizinae white; plant usually of shady places and bogs, pliable; grayish or brownish green in color . . . 6a. *P. canina* var. *albescens*
        16. Veins brown, often white at the margins, rhizinae brown.
            17. With small, squamulose isidia along the edge of the thallus or on the upper surface, especially along cracks. . . . 6d. *P. canina* var. *rufescens* f. *innovans*
            17. Lacking isidia
                18. Lobes long and broad, over 1.5 cm. across, veins brown to margin, plant pliable, growing in shady places, tomentum of upperside usually arachnoid. . . . 6b. *P. canina* var. *ulorrhiza*
                18. Lobes short and narrow, usually less than 1.5 cm. across, veins usually white near the margin, brown to the center, plant brittle, often splitting when pressed, growing in sunny places, tomentum of upperside usually fairly dense. . . . 6c. *P. canina* var. *rufescens*

14. Thallus small, lobes up to 3 cm. long, ascending, often cochleate; veins raised, narrow, white at the margins, brown to the center; rhizinae simple or pappose (sometimes fibrillose in f. *sorediata*)
    19. Thallus lacking soredia . . . 6e. *P. canina* var. *spuria*
    19. Thallus with coarse gray soredia in rounded spots on the upper surface . . . 6f. *P. canina* var. *spuria* f. *sorediata*

(1) PELTIGERA APHTHOSA (L.) Willd., Flora Berolinensis. 347, 1787

Lichen aphthosus L., Sp. Pl. 1148, 1753.

Lichen caninus var. *aphthosus* Weis., Plant. Cryptog. Flora Goettingens. 80, 1770.

Lichen verrucifer Gmelin., Syst. Natur. II, Pars. II, 1373, 1770.

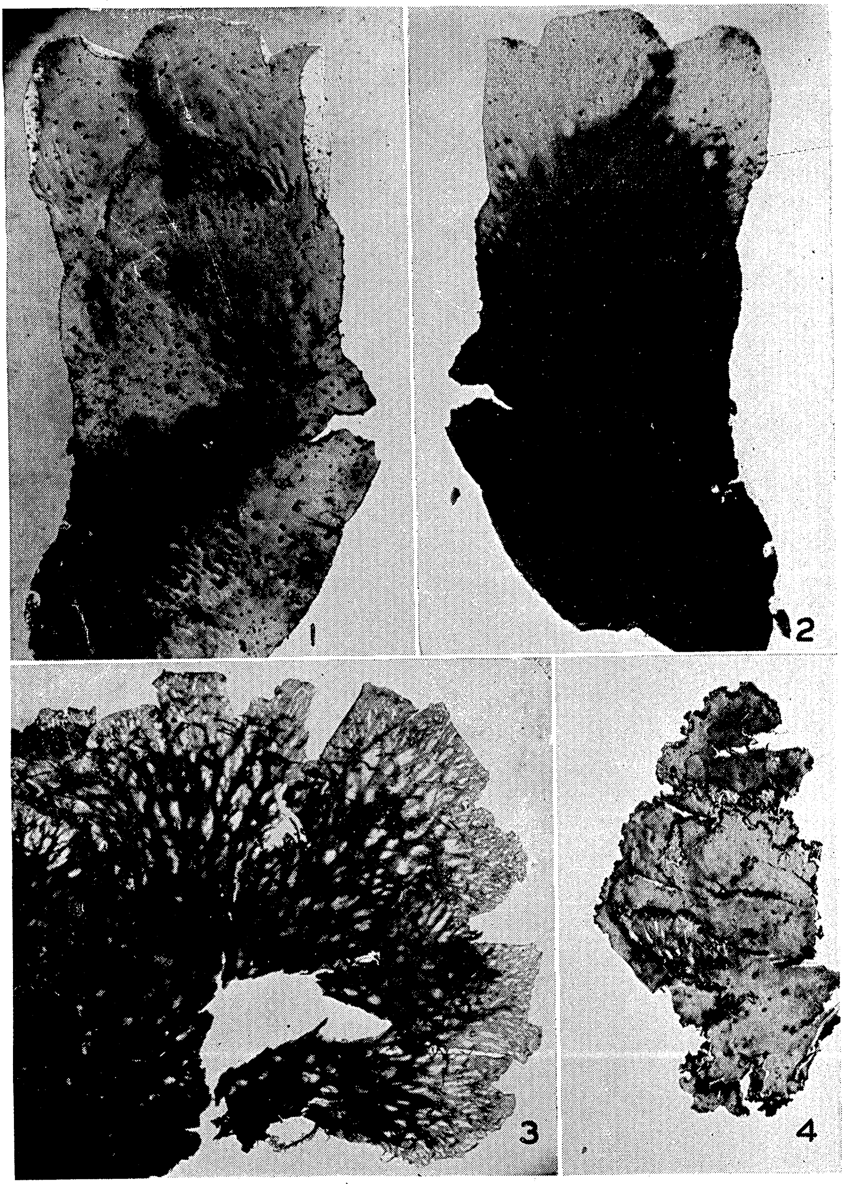

PLATE I.—1. *P. aphthosa*, upperside; 2. *P. aphthosa*, underside; 3. *P. aphthosa* var. *variolosa*, underside; 4. *P. aphthosa* var. *variolosa* f. *crispa*. All Figures same scale as Plate 3.

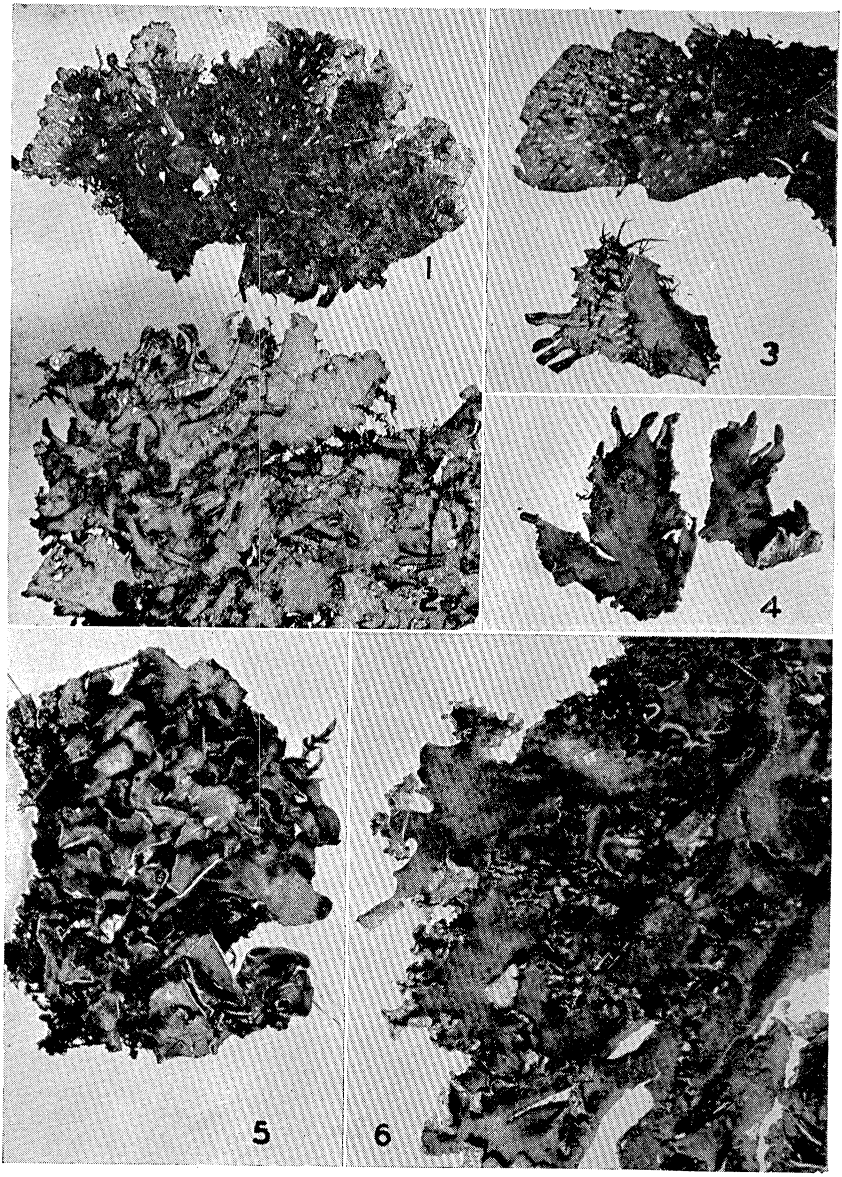

PLATE II.—1. *P. polydactyla*, underside; 2. *P. polydactyla*, upperside; 3. *P. polydactyla* var. *dolichorrhiza* (from a specimen from Maine det. by Gyelnik); 4. *P. polydactyla* f. *microcarpa*; 5. *P. polydactyla* f. *lophyra*; 6. *P. polydactyla* f. *microphylla*. Figs. 5 and 6 enlarged to scale on Plate 5, other Figures on same scale as Plate 3.

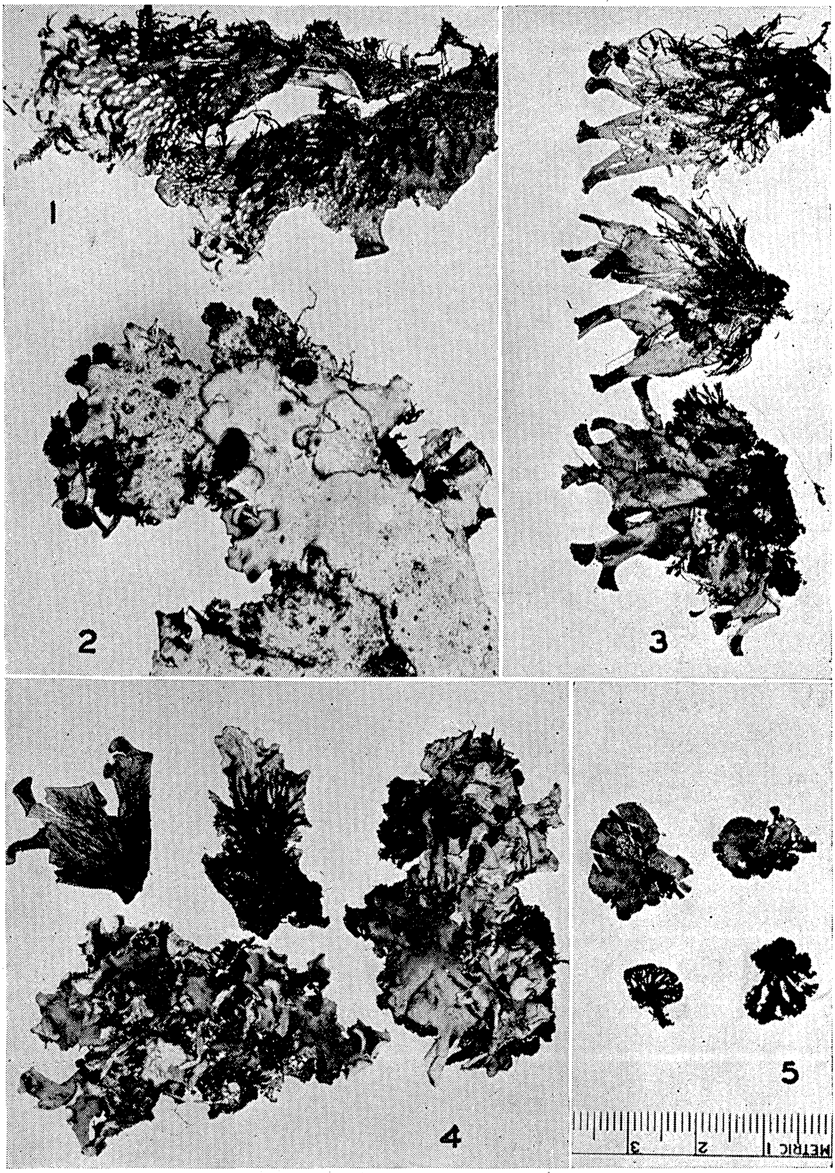

PLATE III.—1. *P. horizontalis*, underside; 2. *P. horizontalis*, upperside; 3. Three thalli of *P. canina* var. *spuria;* 4. Four pieces of the same thallus of *P. canina* var. *rufescens;* 5. *P. venosa*, 4 thalli, uppersides, above; lowersides below.

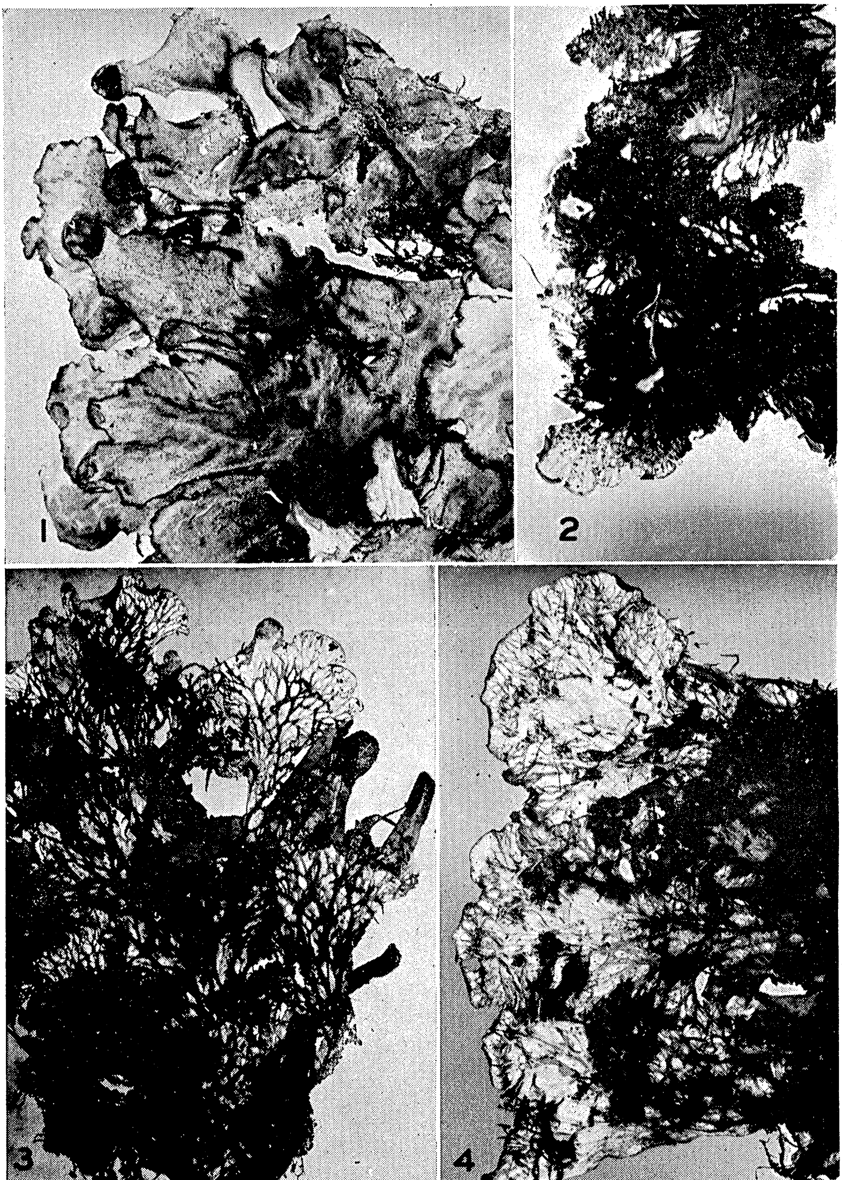

PLATE IV.—1. *P. canina*, upperside; 2. *P. canina* var. *spongiosa*, underside; 3. *P. canina* var. *ulorrhiza*, underside; 4. *P. canina* var. *albescens*, underside. All to same scale as Plate 3.

Lichen verrucosus Weber, Spicil. Flor. Goettingens. 273, 1778.

Peltigera amplissima Hoffm., Deutschl. Flora. 106, 1796.

Peltidea aphthosa Ach., Method. Lich. 287, 1803.

Peltidea aphthosa var. *verrucosa* Ach., Lich. Univ. 515, 1810.

Peltidea verrucosa Röhling, Deutschl. Flora III, 117, 1813.

Peltigera aphthosa var. *phymatodes* Wallr., Flora Cryptog. German., III, 560, 1831.

Peltigera aphthosa f. *verrucosa* Dietrich, Lichenogr. German., 27, 1832–1837.

Thallus large, lobes broad, up to 10 cm. long and 6 cm. broad, edges ascending; upper surface smooth erect tomentose toward tips of lobes, with warty cephalodia scattered upon it, pale to apple green when moist, leaden green when dry; underside pale at the margins, blackening toward the center, veinless or with white or dark veins, the veinless variety with an even, close, nap of tomentum; rhizinae scattered, fasciculate; apothecia large, up to 16 mm. across, on extended lobules, the sides reflexed, the margins becoming crenate, the disk reddish-brown to blackish-brown; the hypothecium brown; the hymenium hyaline; paraphyses simple, thickened and brown at the tips; asci cylindrico-clavate; spores acicular, 3-5 sepate, 49-53 $\times$ 4–5μ in Wisconsin material.

On earth, rotting logs, humus, rocks.

1a. PELTIGERA APHTHOSA var. TYPICA.

ADAMS: Cold Water Canyon, 1894, *L. S. Cheney;* DOUGLAS: Amnicon Falls, 1942, *Mrs. F. E. Lund, Jr.;* upper Brule Bog near highway P, 1943; west side of ravine of Black River, Pattison State Park, 1942; MARATHON: Wausau, 1894, *L. S. Cheney;* MARINETTE: Pike River Falls, Amberg, 1939; OCONTO: Mountain, 1915, *J. J. Davis;* POLK: St. Croix Falls, 1927, *W. F.*

Typical *Peltigera aphthosa* is confined in Wisconsin to white cedar bogs and cold ravines and is not as widespread nor as abundant as var. *variolosa.* The typical variety is covered with a soft, even brown or bluish-black tomentum below. It may reach a larger size than the veined variety.

1b. PELTIGERA APHTHOSA var. VARIOLOSA (Mass.) Thomson, Comb. Nov.

Peltigera aphthosa f. *variolosa* Mass., Schedul. Critic. III, 64, 1856.

Peltigera aphthosa f. *minor* Tuck., Synops. N. A. Lich. I, 106, 1882.

Peltigera leucophlebia f. *variolosa* Gyel., Magy. Bot. Lapok 23: 79, 1925.

(non *Peltigera aphthosa* var. *leucophlebia Nyl.* (24) vide Nilsson (23)).

Peltigera leucophlebia Gyel., Magy. Bot. Lapok 23: 79, 1925.

Peltigera aphthosa f. *angustiloba* Fokin et Nikolsk, Trudy Vjästkago gosudarst Musej., 1926.

Peltigera variolosa Gyel., Magy. Bot. Lapok 25: 252, 1927.

Peltigera variolosa f. *dactylodes* Gyel., Nyt. Magazin for Naturvid. 68: 269, 1930.

ADAMS: Cold Water Canyon, 1894, *L. S. Cheney;* ASHLAND: Bad River Gorge, Mellen, 1927, *L. R. Wilson;* BURNETT: no locality, 1927, *L. R. Wilson;* DOOR: Washington Island, 1931, *J. J. Davis;* DOUGLAS: Falls of Copper Creek, Superior, 1942; ravine of Black River, Pattison State Park, 1942; IRON: west of mouth of Montreal River, 1896; *L. S. Cheney;* JUNEAU: Wisconsin Dells, 1936; SAUK: Rocky Arbor State Park, Wisconsin Dells, 1945; VILAS: Conover, 1897, *L. S. Cheney.*

Variety *variolosa* is characterized by the brown to black venation of the underside of the thallus; otherwise the characters are as in the typical plant. This variety is more southern and widespread in the United States than the typical plant and is usually in warmer and drier habitats.

1c. PELTIGERA APHTHOSA var. VARIOLOSA f. CRISPA (Vainio) A Zahlbr.

Peltidea aphthosa f. *crispa* Vainio, Meddel. Soc. Fauna et Flora Fennica 3: 99, 1878.

Peltigera aphthosa f. *crispa* A. Zahlbr., Cat. Lich. Univ. III, 451, 1925.

Peltigera variolosa f. *crispa* Gyel. apud Erichs., Verhandl. des Bot. Verein der Prov. Brandenb. 60: 223, 1928.

MARINETTE: Thunder River, Thunder Mt., 1937.

This form differs from the variety only in that the thallus and margins are crisped.

2. *Peltigera venosa* (L.) Baumg., Flora Lipsiens. 581, 1790.
   Lichen venosus L., Sp. Pl. 1148, 1753.
   Peltidea venosa Ach., Method. Lich. 282, 1803.

Thallus small, up to 2 cm. across, rounded, single, fan-shaped lobes, sometimes somewhat divided; upper surface smooth, shining, apple-green when wet, grayish- or brownish-green when dry; underside with strong, dark brown or black veins and white interspaces; attached by a single group of rhizoids at one side; cephalodia on the veins, dark green to black; apothecia marginal, round, horizontal, up to about 5 mm. in diameter, the margin crenate, the disk reddish to blackish brown; hypothecium brown; hymenium hyaline; spores hyaline to brownish, (1–) 3 septate, 24–37 × 6–8 μ in Wisconsin material.

Among mosses on wet cliff faces.

Rare and thus far collected only on the cliffs on the west side of the ravine of the Black River at Pattison State Park, Douglas Co., 1942 and by J. W. Thomson, Jr. and R. I. Evans, 1944.

3. PELTIGERA HORIZONTALIS (Huds.) Baumg., Flora Lipsiens. 562, 1790.
   Lichen horizontalis Huds., Flora Anglica. 543, 1762.
   Lichen horizontalis var. *nebulosus* Vill., Hist. Plant. Dauphin III, 960, 1789.
   Peltidea horizontalis Ach., Method. Lich. 288, 1803.
   Peltigera canina var. *horizontalis* March apud Hall, Vrolik et Mulder, Bijdrag t. d. Natuurk. Wetensch 5: 198, 1830.
   Peltigera rufescens var. *horizontalis* Sprengl., Flora Halens., ed. 2: 543, 1832.
   Peltigera horizontalis f. *lobatoides* Gyel., Magy. Bot. Lapok 28: 61, 1929.

Thallus large, the rounded lobes up to about 3 cm. broad and several cm. long; upperside smooth, shining, bluish-gray or greenish gray when moist, lead gray or brownish gray or brown when dry, lacking tomentum or cylindrical isidia but sometimes producing tiny flat squamules or "isidia" when regenerating following injury; underside reticulate with broad flat veins forming an almost confluent tomentum, the veins brown to black, the interspaces white; rhizinae black, sparse, fasciculate; apothecia brown to chestnut-brown, round, horizontal, the margins crenate; hypothecium brown; hymenium hyaline; spores hyaline, fusiform, 3 septate, 25–45 × 3.5–6 μ in Wisconsin material.

On soil, fallen logs, and mossy rocks in moist woods.

ASHLAND: Mellen, 1927, *L. R. Wilson;* COLUMBIA: 5 miles southwest of Portage, 1945; DOUGLAS: upper Brule River, 1942; Pattison State Park; 1942; Winneboujou, 1942; Falls of Copper Creek, Superior, 1942; road to Wisconsin Point, Superior, 1942; FOREST: east of Wapigon Lake, 1945; IRON: shore of Lake Superior west of Montreal River, 1896, *L. S. Cheney;* MARINETTE: Pike River Falls, Amberg, 1939; ONEIDA: Rhinelander, 1893, *L. S. Cheney;* SAUK: Rocky Arbor State Park, 1945.

When the apothecia are not present, *P. horizontalis* is indistinguishable from *P. polydactyla.* Many herbarium specimens thus cannot be satisfactorily placed in either species. Specimens showing regeneration in the form of small flat "isidia" or squamules have been named *Peltigera Zopfi* by Gyelnik but I am doubtful that these should be segregated as a distinct species. Following the practice in the Cladoniae (e. g. *Cladonia rangiferina* f. *prolifera, C. pyxidata* var. *neglecta* f. *peritheta., C. caroliniana* f. *prolifera*) the species of Gyelnik becomes:

3a. PELTIGERA HORIZONTALIS f. ZOPFI (Gyel.) Thomson Comb. Nov.

Peltigera Zopfi Gyel., Bot. Közlem. 24: 134, 1927.

Wisconsin specimens which may fall into this category or into the analogous form, *Peltigera polydactyla* f. *microphylla* Anders, were collected at Pattison State Park, Douglas Co., 1942. The specimens lack apothecia and cannot be placed in either species with certainty.

4. PELTIGERA POLYDACTYLA (Neck.) Hoffm., Descript. et Adumbr. Plant. Lich I, 19, 1790.

Lichen polydactilon Neck., Method. Muscor. 85, 1771.

Lichen caninus var. *polydactylon* Lightf., Flora Scotica II, 846, 1777.

Lichen caninus var. *pellucidus* Weber, Spicil. Flora Goettingens. 270, 1778.

Peltigera polydactylon Hoffm., Descript. et Adumbr. Plant. Lich I, 19, 1790.

Peltidea polydactyla Ach., Method. Lich. 286, 1803.

Peltidea polydactyla var. *pellucida* Ach., Method. Lich. 287, 1803.

Peltidea hymenina Ach., Method. Lich. 284, 1803.

Peltidea glauca Pers. apud Ach., Lich. Univ. 518, 1810.

Peltidea pellucida S. Gray. A Natur. Arrang. Brit. Plants I, 429, 1821.

Peltidea horizontalis var. *hymenina* Ach., Synops. Lich. 238, 1814.

Peltigera canina var. *attenuata* March apud Hall, Vrolik et Mulder, Bijdrag t. d. Natuurk. Wetensch. 5: 198, 1830.

Peltigera hymenina Del. apud Duby, Botanic. Gallic. II. 597, 1830.

Peltigera polydactyla f. *pellucida* Dietrich, Lichenogr. German. 27, 1832–37.

Peltigera rufescens var. *polydactyla* Torss., Enumer. Lich. et Byssac. Scand. 8, 1843.

Peltigera polydactyla var. vulgaris Körb., Syst. Lich. German. 61, 1855.

Peltigera canina var. *coriacea* f. *polydactyla* Krmphbr., Denkschrift Kgl. bayer. Bot. Ges. 4; 2 abth: 124, 1861.

Peltigera canina var. *polydactyla* Branth. et Rostr., Bot. Tidsskrift 3: 175, 1869.

Peltigera magyarica Gyel., Magy. Bot. Lapok 28: 61, 1929.

Thallus variable, pusilloid (single erect lobes) to large and imbricate, the lobes up to 4 cm. broad and several cm. long; upperside dark greenish-blue when moist, slaty or bluish or greenish gray or brownish when dry, the margins ascending, some forms crisped or proliferate; upperside smooth, shining; underside with broad, flat, white to more usually brown or black, reticulated veins with very small white interspaces; rhizoids sparse, short and fasciculate or over 5 mm. long and simple, dark brown to black; apothecia 2 to 5 mm. across on erect narrow lobules at the ascendent tips of the lobes, the sides usually reflexed, the disk reddish- or chestnut-brown to black, the margin crenate; hypothecium brown; hymenium hyaline; spores hyaline, 3–9 septate, acicular, slightly curved 48–71 $\times$ 3–4.5 μ in Wisconsin material.

On soil, moss, logs, rocks and bases of trees in moist woods.

4a. PELTIGERA POLYDACTYLA var. TYPICA.

ASHLAND: Mellen, 1927, *L. R. Wilson;* DOUGLAS: Pattison State Park, 1942; at mouth of Dutchman's Creek, Superior, 1942; Blueberry, 1907, coll. probably *J. J. Davis;* Ranger Station, Brule River, 1943; Stone's Bridge, Brule River, 1942; Upper Brule River, 1942; GRANT: Glen Haven, 1921, *Chas. E. Allen;* IOWA: Hollandale, 1925, *R. H. Denniston;* Tower Hill State Park, 1945; IRON: Lake Superior Shore near Montreal River, 1896, *L. S. Cheney;* JUNEAU: Upham Woods, Wisconsin Dells, 1944; LINCOLN: Grandfather Bull Falls, 1893, *L. S. Cheney;* MARATHON: Granite Heights, 1894, *L. S. Cheney;* MARINETTE: Dunbar, 1945; VILAS: Sayner, 1941.

The species is very variable in character and a number of varieties and forms have been split from it. Those which have been distinguished from Wisconsin are:

4b. PELTIGERA POLYDACTYLA f. MICROCARPA (Ach.) Mérat, Nouv. Flor. Lich. ed. 2, I: 199, 1821.

Peltidea polydactyla var. *microcarpa* Ach., Lich. Univ. 520, 1810.

Peltigera polydactyla var. *hymenina* f. *microcarpa* Flotow, 28 Jahresber. Schlesisch. vaterländ. Kultur. 125, 1850.

Peltigera polydactyla var. *microcarpa* f. *cephalodigera* Müll. Arg., Flora 72: 144, 1889.

Peltigera polydactyla var. *nervosa* Gyel., Osterr. Bot. Zeit. 77: 225, 1928.

Peltigera polydactyla var. *subnervosa* Gyel., Magy. Bot. Lapok 28: 61, 1929.

Thallus and apothecia small, the former about one cm. or less across the lobes; the apothecia about two mm. across.

BAYFIELD: on a boulder in woods, Pigeon Lake, Drummond, 1945.

4c. PELTIGERA POLYDACTYLA f. MICROPHYLLA Anders. Lotos 76: 320, 1928.

Peltigera perfida Gyel. apud Anders., Die Strauch-und Laubflecht. Mitteleurop. 49, 1928.

Peltigera microphylla Gyel., Bryologist 34: 18 & 19, 1931.

Similar to *P. polydactyla,* but with tiny proliferations or "isidia" on the margins and upper surface, especially where obviously injured.

DOUGLAS: north of Brule, 1943.

4d. PELTIGERA POLYDACTYLA f. LOPHYRA (Ach.) Nyl., Lich. Scand. 90, 1861.

Peltidea horizontalis var. *lophyra* Ach., Lich. Univ. 516, 1810.

Peltidea canina var. *glabra* Ach., Synops. Lich. 239, 1814.

Peltidea rufescens var. *collina* Ach. Meth. 285, 1803.

Peltigera polydactyla f. *collina* Nyl., Synop. Lich I. 327, 1860.

As redefined by Gyelnik (17) the description becomes: similar to the typical plant but with the margins dilacerate to dilacerate-crisped.

IOWA: hill near Tower Hill Park, 1939.

4e. PELTIGERA POLYDACTYLA var. DOLICHORRHIZA Nyl., Synops. Lich. I., 327, 1860.

Peltigera dolichorrhiza Nyl., Lich. Nov. Zeland. 43, 1888.

Similar to the species but the thallus tends to be thinner. The rhizinae are more than 5 mm. long, dark brown or black and simple. The underside is light brownish white to brown.

DOUGLAS: upper Brule River bog, 1943; RUSK: no locality, 1921, *R. H. Denniston.*

4f. PELTIGERA POLYDACTYLA var. CRASSOIDES Gyel. Magy. Bot. Lapok 29: 51, 1930.

Peltigera polydactyla var. *hymenina* Auct. (Vide Gyelnik l.c.)

Thallus small, dark colored, thick, rigid instead of flexible, underside with the veins confluent and almost no interspaces, rhizinae short, fasciculate. Otherwise as in the species.

This variety resembles P. malacea very much but is smooth and shining above, lacking the erect tomentum of that species.

DANE: West of Middleton, 1936, R. H. Denniston; La Crosse, no date, *L. H. Pammel* (specimen in Herb. Univ. Mich.); VERNON: Coon Valley, 1945.

5. PELTIGERA EVANSIANA Gyel., Bryologist 34: 16, 1931.

Thallus small, lobes usually a cm. or less across; upper side pale gray, brownish-gray or brown, lacking tomentum but scabrid, not smooth or shining, with cylindrical, dark brown, sometimes branched, club-shaped isidia scattered over the surface, the isidia not associated with cracks or breaks in the thallus; underside pale brownish white to brown, with a network of light brown to brown, raised, narrow veins and large interspaces; the rhizinae simple, up to 4 mm. long. Sterile in Wisconsin material as well as in the type.

ADAMS: Coldwater Canyon, north of Wisconsin Dells, 1945; BAYFIELD: Pigeon Lake, Drummond, 1945; DOUGLAS: Upper Brule River above Stone's Bridge, 1942; Winneboujou, 1942; Brule River Ranger Station, 1943; Pattison State Park, 1944; Mouth of Nebagamon Creek, 1943; FOREST: East of Wapigon Lake, 1945; east of Crandon, 1945; GRANT: Glen Haven, 1921, *Chas. E. Allen;* IOWA: Hollandale, 1925, *R. H. Denniston;* Tower Hill State Park, 1945; JUNEAU: Upham Woods, Wisconsin Dells, 1944; LAFAYETTE: Darlington, 1946, *P. Nelson;* MARINETTE: Wausaukee, 1945; Dunbar, 1945; SAUK: Rocky Arbor State Park, 1945; Devil's Lake, 1924, *R. H. Denniston;* WAUKESHA: Martin's Woods, Big Bend, 1945.

6. PELTIGERA CANINA (L.) Willd., Flora Berolinens., Prodrom. 347, 1787.

Lichen caninus L., Sp. Pl. 1149, 1753.

Lichen caninus var. *cinereus* Weis., Flor. Goetting. 78, 1770.

Lichen terrestris Lam., Flore. Franç., I. 84, 1788.

Lichen venosus Gilib., Exercit. Phytol. 601, 1792 (non Linn.)

Peltidea canina Ach., Method. Lich. 283, 1803.

Dermatodea canina St. Hil., Expos. Famil. Natur. 20, 1805.

Peltigera canina var. *palmata* Del. apud Duby. Bot. Gallic II. 598, 1830.

Peltigera canina var. *vulgaris* Duby, Bot. Gallic II. 598, 1830.

Peltigera canina f. *digitata* Hazsl., Birod. Zuzmo-Flor. 56, 1884.

Peltigera canina var. *membranacea* f. *palmata* Oliv., Expos. Lich. Ouest. France I. 156, 1897.

Peltigera canina var. *canina* Boist., Nouv. Flore. Lich. 2. 80, 1903.

Peltigera Plittii var. *macrolobata* Gyel., Fedde Repert. 29: 9, 1931.

Peltigera Plittii var. *sandwicensis* Gyel., Fedde Repert. 29: 9, 1931.

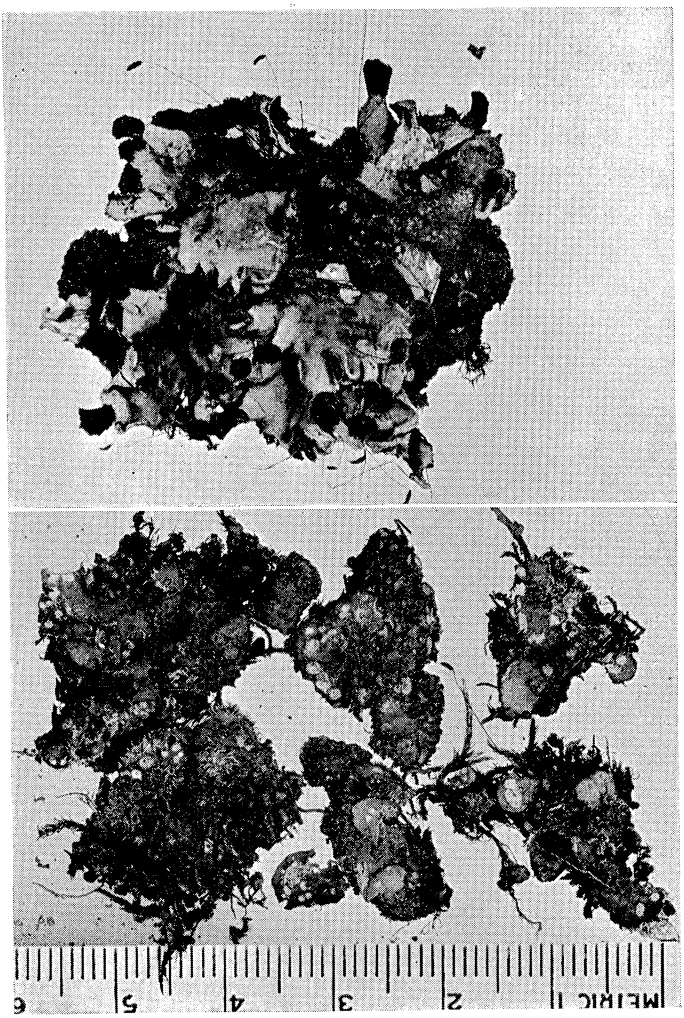

PLATE V.—*P. canina* var. *spuria* f. *sorediata*, upper with the '*spuria*' type thallus, lower with 'hazslinszkyi' type thallus.

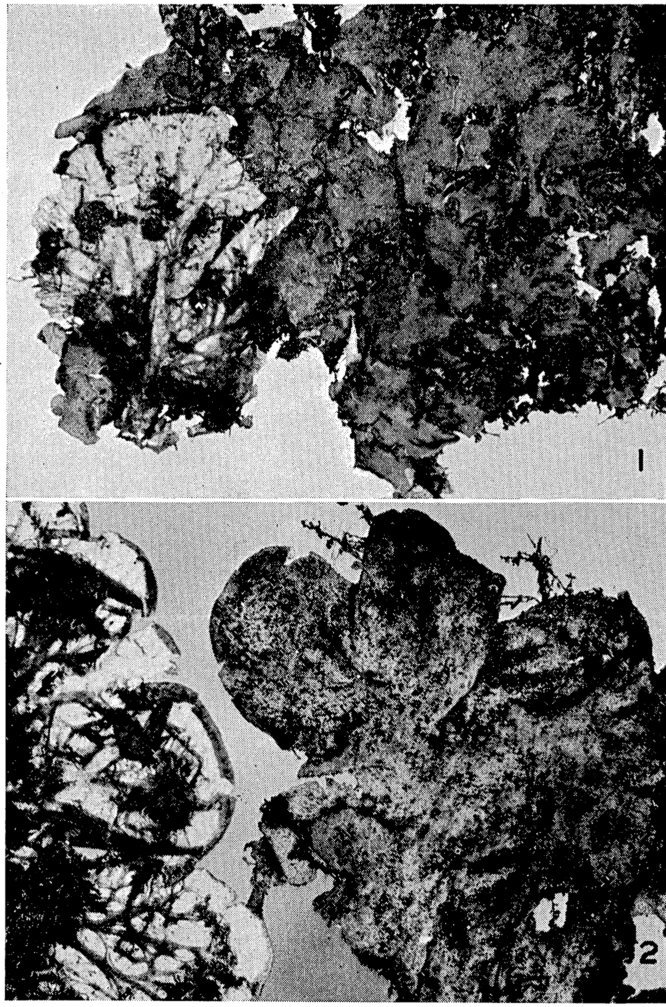

PLATE VI.—1. P. *canina* var. *rufescens* f. *innovans;* 2. *P. evansiana.* Scale same as Plate 5.

Peltigera Plittii f. *suffusa* Gyel., Lilloa 3: 64, 1938.

Peltigera canina f. *palmata* A. Zahlbr., Cat. Lich. Univ. III. 464, 1925.

Thallus very variable; size up to 30 cm. or more across, lobes up to 30 mm. across, slate gray, greenish brown or brown above with an arachnoid or dense tomentum toward the margins, dull or shining above toward the older thallus parts; in one form with coarse gray soredia in rounded spots on the upper surface of the thallus; below with strong network of raised white to brown veins, with the white or brown rhizinae, simple, fasciculate, or fibrillose, sometimes forming a spongy nap below; apothecia vertical, the sides reflexed, the disk light brown to reddish or chestnut-brown or black, the margin crenate; hypothecium brown, hymenium hyaline, spores 3–9 septate, acicular, hyaline to yellowish, 23–67 × 3–6.5 μ in Wisconsin material.

A number of species have been separated from *Peltigera canina* by various authors, but I find myself unable to accord most such specimens anything more than the rank of variety. *P. canina* is exceedingly variable and in the field the segregated 'species' do not seem to hold good. For example, thalli observed on rock outcrops in Northern Wisconsin have been indubitable *P. rufescens* in the center and *P. canina* var. *ulorrhiza* or var. *albescens* at the border. Regeneration of the thallus following injury by snails, insects, or larger animals brings about the formation of tiny platelets or "isidia" along the borders of the injury and along cracks in the thallus, thus producing the 'species' *P. praetextata* and similar segregates. Scholander has already shown (26) that *P. leptoderma* is but an etomentose variant of *P. erumpens.* It does not seem to me that the presence or absence of soredia in the case of *P. erumpens* is a valid character for species differentiation. As C. F. E. Ericksen points out (3) *P. leptoderma, P. Hazslinskyi,* and *P. erumpens* are doubtfully separable from *P. spuria.* As far as I am able to make out in field studies, *P. Hazslinskyi* is but the juvenile stage of growth of *P. spuria.* The young pusilloid condition grades imperceptably into the larger canina-like, or really spuria-like, thalli of '*P. erumpens*' in the same colony. I also can not see that these are more than sorediate forms of the spuria type of thallus as gradations with all the appearance of *P. spuria* and esorediate or with from one fleck of soredia to a heavy flecking with the spots of soredia exist in the same colony. On rock outcrops in the cutover areas of Northern Wisconsin it is common to find the *P. rufescens* type of thallus breaking up into the *P. spuria* type toward the margins where the lichen intermixes with mosses. It is this type of observation which leads me to reduce *P. rufescens* and *P. spuria* to the rank of varieties rather than retaining them as species. It is obvious that a plastic species such as *P. canina* would be excellent material for a study of transplants and development of individual thalli. Upon such a study depends the final placing of the nomenclatorial units.

6a. PELTIGERA CANINA var. ALBESCENS (Wahlbg.) Thomson, Comb. Nov.

Peltidea leucorrhiza Flk. Deutsch. Lich. No. 153, 8 Lief. 10, 1821.

Peltidea canina var. *albescens* Wahlb. Flora Suec. II. 842, 1826.

Peltigera canina var. *leucorrhiza* Flotow. 28 Jahresber, Schlesisch Gesellsch für vaterland Kultur. 124, 1850.

Peltigera canina var. *membranacea* f. *genuina* Krmphbr., Denkschrift. Kgl. Bayer. Bot. Gesell. 4, 2 abth. 124, 1861.

Peltigera canina f. *leucorrhiza* Arn. Flora 67: 233, 1884.

Peltigera canina var. *membranacea* f. *leucorrhiza* Oliv., Expos. Lich. Ouest. France I. 156, 1897.

This variety is the typical material of *Peltigera canina* with white or brown veins and interspaces and light rhizoids below. According to international rules, Wahlenberg's earliest usage of varietal rank must be taken up.

DOUGLAS: Pattison State Park, 1942; 1935, *R. H. Denniston;* Brule, 1944; N. P. Johnson Bridge North of Brule, 1944; Lyman Lake, 1942, *Olive S. Thomson;* east of Superior, 1942; falls of Copper Creek, south of Superior, 1942; FOREST: east of Wapigon Lake, 1945; GRANT: Close Creek, Glen Haven, 1921, *C. E. Allen;* Glen Haven, 1921, *C. E. Allen;* IOWA: Hollandale, 1925, *R. H. Denniston;* ONEIDA: Monico, 1945; PORTAGE: nine miles north of Stevens Point, 1938; SAUK: Rocky Arbor State Park, Wisconsin Dells, 1945; VILAS: Sayner, 1941; Allequash Lake near Trout Lake, 1938; Lac Vieux Desert, 1893, *L. S. Cheney.*

6b. PELTIGERA CANINA var. ULORRHIZA (Flk.) Schaer. Enumer. Critic. Lich. Europ. 20, 1850.

Peltidea ulorrhiza Flk. Deutsch. Lich. no. 154, 11, 1821.

Peltigera canina var. *coriacea* f. *campestris* Krmphbr., Denkschrift. Kgl. Bayer. Bot. Gesellsch. 4, 2 abth. 125, 1861.

Peltigera canina f. *ulorrhiza* Oliv., Memoir. Soc. Nation. Scienc. Natur. Cherbourg. 36: 218, 1907.

The underside of this variety has the veins and rhizoids dark brown; the interspaces creamy or yellowish to pale brown. It seems to represent a transition between typical *canina* and var. *rufescens*.

DANE: Lake *Wingra*, 1893, *Heald and Buell;* DOOR: Peninsula State Park, 1928, *R. H. Denniston;* DOUGLAS: White cedar swamp at head of Brule River, 1944, *J. W. Thomson, Jr. and R. I. Evans;* falls of Copper Creek, south of Superior, 1942; east of Superior, 1942; FOND DU LAC: Wolf Lake, Marshfield, 1938, *L. H. Shinners;* LINCOLN: Gleason, 1945; MARATHON: Wausau, 1938; SAUK: Rocky Arbor State Park, Wisconsin Dells, 1945; Devil's Lake, 1935; 1945; ST. CROIX: Hudson, 1945.

6c. PELTIGERA CANINA var. RUFESCENS (Weis.) Mudd., Manual Brit. Lich. 82, 1861.

Lichen caninus var. *rufescens* Weis., Plant. Cryptog. Flor. Goettingens. 79, 1770.

Lichen rufescens Neck., Method. Muscor. 79, 1771.

Lichen rufus Gmelin., System. Natur. II, Pars. II. 1373, 1791.

Peltigera rufescens Humb., Flor. Friburg. Specim. 2, 1793.

Peltidea rufescens Ach., Method. Lich. 285, 1803.

Peltidea canina var. *crispa* Ach., Lich. Univ. 519, 1810.

Peltidea canina var. *inflexa* Ach., Lich. Univ. 518, 1810.

Peltidea malacea f. *inflexa* Ach., Synops. Lich. 240, 1814.

Peltidea canina var. *rufescens* Hook., Flora Scotica II. 60, 1821.

Peltigera canina var. *crispa* Merat., Nouv. Flor. Envir. Paris ed. 2, I. 199, 1821.

Peltigera canina var. *inflexa* Duby. Bot. Gallic. II. 598, 1830.

Peltigera canina var. *crispata* Kickx., Flora Cryptog. Louvain. 91, 1835.

Peltigera rufescens var. *pachyphylla* f. *crispa* Flotow, 28 Jahresberich. Schlesisch. Gesellsch. Vaterländ Kultur. 124, 1850.
Peltigera rufescens f. *incusa* Körb., Syst. Lich. Germ. 59, 1855.
Peltigera canina var. *coriacea* f. *genuina* Krmphbr., Denkschrift. Kgl. Bayer. Bot. Gesellsch. 4, 2 abth. 124, 1861.
Peltigera canina var. *coriacea* f. *incusa* Krmphbr., Denkschrift. Kgl. Bayer. Bot. Gesellsch. 4, 2 abth. 125, 1861.
Peltigera canina var. *membranacea* f. *rufa* Krmphbr., Denkschrift. Kgl. Bayer. Bot. Gesellsch. 4, 2 abth. 124, 1861.
Peltigera malacea var. *crispa* Th. Fr., Nova Acta Reg. Soc. Scient. Upsal. Ser. 3. 3: 144, 1861.
Peltigera rufescens var. *inflexa* Kicks., Flore Cryptog. Flandres I. 215, 1867.
Peltigera canina var. *ulorrhiza* f. *crispa* Hepp, Flecht. Europ. No. 850, 1867.
Peltigera canina f. *rufa*. Rabh., Cryptog. Flora von Sachsen, 2 abth. 309, 1870.
Peltigera canina f. *crispata* Koltz, Recueil Memoir, et Trav. Soc. Botan. Luxemburg, 13: 172, 1897.
Peltigera canina f. *rufa* Koltz, Recueil Memoir et Trav. Soc. Bot. Luxemburg 13: 172, 1897.
Peltigera canina subsp. *rufescens* var. *inflexa* Boist., Nouv. Flore. Lich. part 2: 81, 1903.
Peltigera rufescens f. *inflexa* Zahlbr., Cat. Lich. Univ. III, 487, 1925.
Peltigera aloïsii Gyel., Oestr. Bot. Zeitschr. 77: 222, 1928.
Peltigera suomensis Gyel., Magy. Bot. Lapok, 28: 60, 1929.
Peltigera rufescens f. *albidula* Gyel., Magy. Bot. Lapok 28: 61, 1929.
Peltigera canina var. *suomensis* Räs., Annal. Mo. Bot. Gard. 20: 16, 1933.
Peltigera plittii f. *ornata* Gyel., Lilloa 3: 64, 1938.
Peltigera plittii f. *suffusa* Gyel., Lilloa 3: 64, 1938.
Peltigera plittii f. *subsuffusa* Gyel., Lilloa 3: 64, 1938.

As Gyelnik points out in Bot. Koz. 24, 1927 the differences between typical *P. canina* and var. *rufescens* are slight. The latter is smaller, more brittle, generally reddish, with cell walls of the upper layer slightly thicker (2–3 instead of 1–2 μ thick) and grows in drier, more sunny habitats than the typical species, vars. *albescens* and *ulorrhiza.* The difference in the habitats suggests that var. *rufescens* is but an ecological variant of *P. canina.* Not only in the identification of specimens but also in the literature there has been considerable confusion of the two "species." In any large number of collections, all intergrades between the two may be found and it does not seem to me that they should be maintained as separate species. On very dry, sunny, rock outcrops the plant is typically crisped and narrow lobed with the lobes inrolled at the margins; but as the same thallus may have broader, flatter lobes toward the circumference where more moisture may be available trickling down the rock, I have not recognized f. or var. *inflexa.* Such crisped, narrow-lobed plants with a very thick, instead of an arachnoid, tomentum on the upper surface are called *P. plittii* f. *ornata* by Gyelnik. The var. *rufescens* is the most abundant variety of *P. canina* in this state as well as in North America.

BAYFIELD: Brule Barrens, T46N, R.9W., Sec. 30, 1943; COLUMBIA: 5 miles southwest of Portage, 1945; DANE: Beeches' Prairie near Sauk City, 1945, *M. B. Berseng and Joan Wright;* DOOR: Washington Island, 1931, *J. J. Davis;* DOUGLAS: Amnicon Falls, 1942; Brule, 1943; South of Superior, 1942; 1944; Dewey, 1942, Sugar Camp Hill, north of Brule, 1943; FOND DU LAC: Oakfield, 1936; FOREST: Crandon, 1945; IOWA: Blue Mounds, 1921, *R. H. Denniston;* Hollandale, 1925, *R. H. Denniston;* JUNEAU: Germantown, 1894, *L. S. Cheney;* MARATHON: Rib Hill, 1945; MARINETTE: Dunbar, 1945; Wausaukee, 1945; ONEIDA: Monico, 1945; 2 miles west of Monico, 1945; PORTAGE: Stevens Point, 1894, *L. S. Cheney;* east of Stevens Point, 1938; RACINE: Wind Lake, 1945; ST. CROIX: By Lake St. Croix, Hudson, 1945 (Specimen is a transition between this and var. *spuria*); SAUK: Spring Green, 1939; Parfrey's Glen, 1924, *R. H. Denniston;* Devil's Lake, 1907, 1916, *J. R. Heddle;* Devil's Lake, 1922, *R. H. Denniston;* Baxter's Hollow, Baraboo Range, 1939; VILAS: Conover, 1893, *L. S. Cheney;* VERNON: Coon Valley, 1945.

6d. PELTIGERA CANINA var. RUFESCENS f. INNOVANS (Körb) Thomson, Comb. Nov.

Peltidea ulorrhiza var. *praetextata* Flk. apud Sommerf. Suppl. Flor. Lappon. 123, 1826.

Peltigera canina var. *membranacea* f. *sorediata* Schaer., Enumer. Critic. Lich. Europ. 20, 1850. (non *Peltigera canina* var. *spuria* f. *sorediata* l. c.)

Peltigera rufescens f. *innovans* Körb., Syst. Lich. Germ. 60, 1855.

Peltigera rufescens var. *praetextata* Nyl., Synops. Lich. I. 324, 1860.

Peltigera canina var. *coriacea* f. *sorediata* Krmphbr., Denkschrift. Kgl. Bayer. Bot. Gesellsch. 4, 2 abth. 125, 1861.

Peltigera rufescens var. *innovans* Kickx, Flore. Crypt. Flandres II. 215, 1867.

Peltigera canina var. *crispa* Flagey, Memoir. Soc. d'Emulat. Doubs. 420, 1882. (Non Ach.)

Peltigera canina var. *limbata* Mudd, Manual Brit. Lich. 83, 1861.

Peltigera canina f. *undulata* Arn., Flora 67: 234, 1884.

Peltigera canina f. *vivipara* Hazsl., Magy. Birod. Zuzmö-Flor. 56, 1884.

Peltigera polydactyla var. *undulata* Hue, Bull. Soc. Bot. France 41: 177, 1894.

Peltigera praetextata Wainio, Termeszetr. Füzetek, 22: 306, 1899.

Peltigera canina var. *praetextata* Hue. Nouv. Archiv. du Muséum, Ser. 4, II. 95, 1900.

Peltigera canina subsp. *rufescens* var. *praetextata* Boist., Nouv. Flore. Lich. part 2. 81, 1903.

Peltigera praetextata var. *subglabra* Gyel. apud Erichs. in. Verhandl. Bot. Verein Prov. Brand. 70: 221, 1928.

Peltigera praetextata f. *lapponica* Gyel., Magy. Bot. Lapok 28: 61, 1929.

Peltigera praetextata var. *ilseana* K. S. K., Fedde Repert. 28: 203, 1930.

Peltigera praetextata f. *subglabra* Gyel., Lilloa 3: 64, 1938.

Peltigera praetextata f. *vivipara* Gyel., Lilloa 3: 64, 1938.

This form resembles *P. canina* var. *rufescens* but has small flat platelets or "isidia" growing from the edges and upperside especially along cracks and injured spots. It represents a regeneration phenomenon rather than a distinct species. Specimens have been described with cylindrical, probably true isidia, but I have not seen these. In accordance with the international rules, the earliest acceptable name in the formal rank is taken up.

COLUMBIA: Black Hawk Lookout opposite Prairie Du Sac, 1941, *Olive Thomson;* 5 miles southwest of Portage, 1945; JUNEAU: Upham Woods, Wisconsin Dells, 1944; SAUK: Devil's Lake, 1922, *R. H. Denniston;* VERNON: southeast of Coon Valley, 1946; WALWORTH: Whitewater, 1940; WAUKESHA: Martin's Woods, Big Bend, 1945.

6e. PELTIGERA CANINA var. SPURIA (Ach.) Schaer., Lich. Helvet. Spicil. Sect. 6. 265, 1833.

Lichen spurius Ach., Lichenogr. Suec. Prodrom. 159, 1798.

Peltidea spuria Ach., Method. Lich. 283, 1803.

Peltigera spuria Lam. et D. C., Flore Franç, ed. 3, II. 406, 1805.

Peltidea canina var. *spuria* Ach., Lich. Univers. 518, 1810.

Peltidea polydactyla var. *spuria* Schlecht., Flora Berolinens, II. 84, 1824.

Peltigera polydactyla var. *spuria* Mann, Lich. in Bohemia Observ. Dispos. 71, 1825.

Peltigera venosa var. *digitata* March apud. Hall, Vrolik et Mulder, Bijdrag. t.d. Natuurk. Wetensch. 5: 198, 1830.

Peltigera canina var. *pusilla* E. Fries., Lich. Europ. Ref. 45, 1831.

Peltigera rufescens var. *pachyphylla* f. *spuria* Flotow, 28 Jahresber. Schlesisch. Gesellsch. Vaterländ Kultur. 124, 1850.

Peltigera rufescens f. *spuria* Körb., Syst. Lich. Germ. 59, 1855.

Peltigera pusilla Körb., Syst. Lich. Germ. 59, 1855.

Peltigera rufescens Hook., Handbook New Zealand Flora. 566, 1867. (non alior)

Peltigera spuriella Wainio, Acta Societatis pro Fauna et Flora Fennica 7: 180, 1890.

Peltigera behringiana Gyel., Oester. Bot. Zeitschr. 77: 222, 1928.

The thallus of this variety is quite similar to that of var. *rufescens* with which it intergrades but the lobes are short, more or less erect, separated from each other and usually are gray or bluish-green rather than brownish in color. The apothecia are smaller, darker, and more strongly reflexed on the sides than in var. *rufescens.*

ADAMS: Plainfield, 1935; DANE: Northwest of Evansville, 1944, *Geo. S. Bryan;* DOUGLAS: Pattison State Park, 1942; Winneboujou, Brule River, 1942; LANGLADE: Parrish, 1945; ONEIDA: 3 miles west of Monico, 1945; Doherty Lake, 1893, *L. S. Cheney;* VILAS: Sayner, 1941; south of Sayner, 1941; Lost Creek, Sayner, 1938; Star Lake, 1946.

6f. PELTIGERA CANINA var. SPURIA f. SOREDIATA Schaer. Enumer. Critic. Lich. Europ. 20, 1850.

Peltidea erumpens Tayl. In Hook. London Jour. of Bot., 6: 184, 1847.

Peltigera canina var. *sorediifera* Schaer. Lich. Helvet. Spicil. Sect. 6, 265, 1833.

Peltigera canina f. *sorediifera* Zahlbr. Cat. Lich. Univ. III. 464, 1925.

Peltigera canina var. *soreumatica* Flotow, 28 Jahresber. Schlesisch. Gesellsch. für. Vaterländ Kultur. 124, 1850.

Peltigera leptoderma Nyl. Synops. Lich. I. 325, 1860.

Peltigera canina var. *notata* Th. Fr., Kgl. Svensk. Vetensk. Akad. Handl. 7: 15, 1867.

Peltigera canina var. *extenuata* Nyl. apud. Wainio, Meddel. Soc. Fauna et Flora Fennic. 5: 49, 1873.

Peltigera ulcerata Müll. Arg., Flora 63: 261, 1880.

Peltigera extenuata Wainio, Meddel. Soc. Fauna et Flora Fennic. 6: 129, 1881.

Peltigera rufescens f. *sorediata* Oliv., Flore Lich. Orne, I. 92, 1882.

Peltigera rufescens var. *vulnerata* Müll. Arg., Flora 65: 305, 1882.

Peltigera pusilla var. *vulnerata* Müll. Arg., Flora 69: 133, 1888.

Peltigera erumpens Wainio, Etud. Lich. Bresil. 182, 1890.

Peltigera spuria var. *erumpens* Harm., Bull. Soc. Scienc. Nancy, Ser. 2, 31: 248, 1897.

Peltigera canina var. *erumpens* Hue, Nouv. Archiv. du Muséum, Ser. 4, 2: 96, 1900.

Peltigera canina f. *cyatheum* Norm. apud. Lynge, Bergens Museums Aarborg 9, 109, 1910.

Peltigera sorediata Fink apud. Corringt., Ohio State U. Bull. 25: 356, 1921.

Peltigera Hazslinszkyi Gyel. apud. Anders. Die Strauch und Laub Flecht. Mitteleurop. 44, 1928.

Peltigera erumpens f. *glabrescens* Gyel. apud. Erichs., Verhandl. Bot. Verein. Prov. Brandenbourg 70: 219, 1928.

Peltigera leptoderma var. *brasiliensis* Gyel., Oester. Bot. Zeitschs. 77: 224, 1928.

Peltigera erumpens f. *densa* Gyel., Magy. Bot. Lapok, 28: 61, 1929.

Peltigera erumpens f. *scabrida* Gyel., Magy. Bot. Lapok, 28: 61, 1929.

Peltigera vainioi Gyel., Magy. Bot. Lapok, 28: 61, 1929.

Peltigera erumpens f. *leptoderma* Scholander, Nyt. Magazin for. Naturvid. 73: 52, 1933.

This form is distinguished by the rounded spots bearing coarse gray soredia on the upper surface of the thallus. The amount of tomentum on the upper surface of the thallus varies from lacking or almost lacking to a rather dense layer at the margins. The upper surface may be smooth to whitish pruinose scabrid in spots. The thalli vary from very tiny, cochleate, separate lobes to larger spuria-like lobes. The rhizinae on the underside vary from simple or pappose to a fairly dense mat of fibrillose rhizinae. Numerous forms, varieties, and species have been made of these variations but the intergradation observed in the field is such as to lead one to believe that they are but normal variation of a very plastic plant and not entitled to nomenclatorial recognition. The smaller forms are more common on newly invaded soil such as ditchbanks and abandoned sandy fields; the larger plants tending toward the *spuria* and *rufescens* types are on less disturbed habitats.

ADAMS: 10 miles east of Friendship, 1935; BAYFIELD: Pigeon Lake, Drummond, 1945; COLUMBIA: Black Hawk Lookout opposite Prairie du Sac, 1935; DANE: Black Earth, 1921, *E. J. Kraus;* Picture Rock, 1938, *L. H. Shinners;* DOUGLAS: Upper Brule River Valley, 1943, 1946; east of Superior, 1942; Dewey, 1942; Pattison State Park, 1944; *J. W. Thomson, Jr.* and *R. I. Evans;* Superior, 1942; south of Superior, 1942; DUNN: Eau Galle, 1927, *R. H. Denniston;* JACKSON: 8 miles south of Black River Falls, 1945; MARINETTE: Dunbar, 1945 (with parasites);

Wausaukee, 1945; MONROE: 9 miles west of Tomah, 1935; ONEIDA: 2 miles west of Monico, 1945; SAUK: Ableman, 1940; WASHBURN: Sarona, 1944, *R. I. Evans;* VILAS: Conover, 1893, *L. S. Cheney;* Star Lake, 1946.

6g. PELTIGERA CANINA var. SPONGIOSA Tuck., Genera. Lich. 38, 1872.

Peltigera canina f. *spongiosa* Tuck., Synops. North. Amer. Lich. I, 109, 1882.

Peltigera canina subvar. *spongiosa* Boist., Nouv. Flore Lich., part 2, 80, 1903.

Peltigera canina subsp. *spongiosa* Fink., Contrib. U. S. Nat'l. Herb. 14: 163, 1910.

Similar to var. albescens with light colored veins and underside, but the rhizinae on the underside are strongly fibrillose and form a dense mat.

DOUGLAS: Falls of Copper Creek, south of Superior, 1942; Little Joe Falls, Brule River, 1943; VERNON: Coon Valley, 1945, *Bob Ellarson,* this specimen approaches this variety but the mat of rhizinae is not very heavy; VILAS: Found Lake near Sayner, 1941.

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HOST-PARASITE RELATIONSHIPS AND GEOGRAPHICAL DISTRIBUTION OF THE PHYSALOPTERINAE (NEMATODA)

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INTRODUCTION

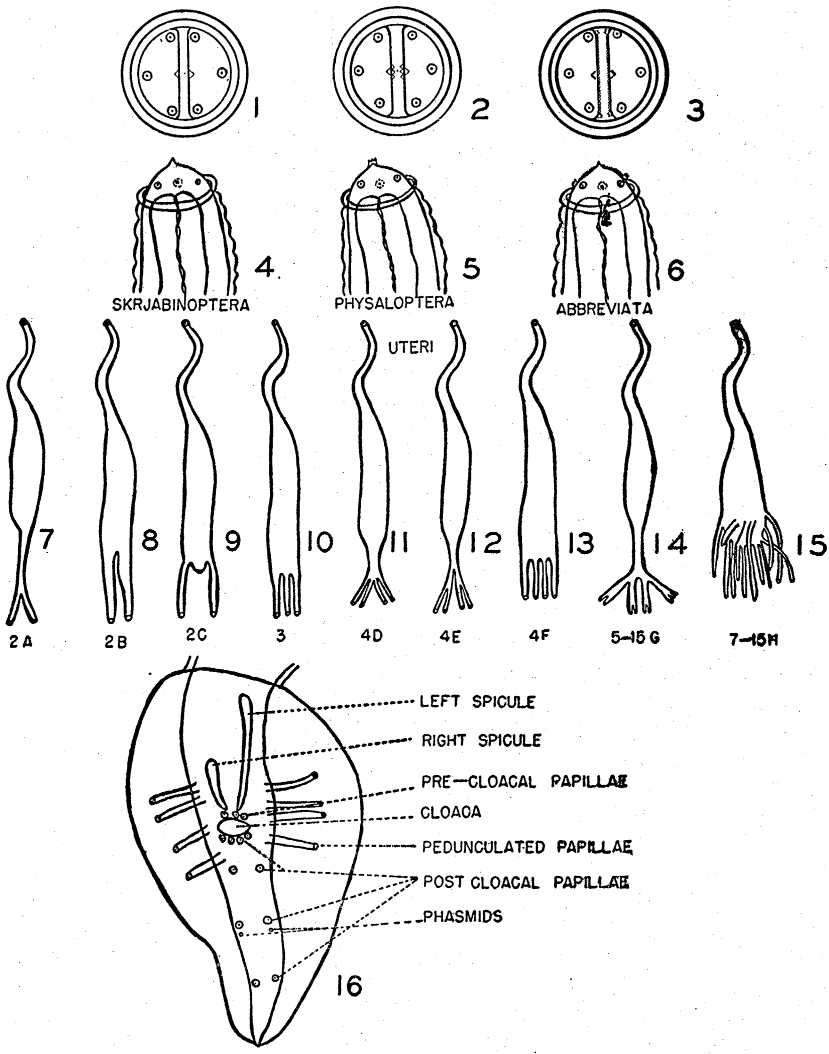
The host-parasite relationships of the subfamily Physalopterinae, a group of nematode worms varying in size from ¼ to 4 inches in length which lives in the stomach of many animals, are not very well known. This is due in part because the Physalopteridae present more taxonomic difficulty than other spirurids since they tend toward polydelphy.

Positive identification of species can be made only on characters possessed by both male and female specimens. The characters of value for species determination in the Physalopterinae are as follows, in the order of their importance: (1) dentition (generic value), (2) number of uteri, (3) mode of origin of uteri, (4) number of male ventral papillae, (5) arrangement of male ventral papillae, (6) shape of spicules , (7) length of spicules, and (8) position of vulva. (figs. 1–16)

Certain characters cannot be used for specific determination because of the wide variation within species: (1) posterior sheath, (2) size and height of teeth, (3) length of esophagus, (4) position of excretory pore and cervical papillae, (5) size of eggs, (6) shape of bursa, (7) bursal markings, and (8) shape of seminal receptacle.

Ortlepp (1922, 1937) divided the genus *Physaloptera* into four groups on the basis of uterine numbers: Didelphys (2), Tridelphys (3), Tetradelphys (4) and Polydelphys (more than 4). Also the mode of origin of the uteri were taken into consideration. At the present time the origin of the uteri has been divided into various groups: 2A (2 uteri with common

CHARACTERS USED FOR PHYSALOPTERINAE CLASSIFICATION



MALE BURSA—VENTRAL VIEW

Explanation of Plate

All figures diagrammatic

Fig. 1. Anterior end, *enface* view of *Skrjabinoptera*.
Fig. 2. Anterior end, *enface* view of *Physaloptera*.
Fig. 3. Anterior end, *enface* view of *Abbreviata*.
Fig. 4. Anterior end, lateral view of *Skrjabinoptera*.
Fig. 5. Anterior end, lateral view of *Physaloptera*.
Fig. 6. Anterior end, lateral view of *Abbreviata*.
Fig. 7. 2A type uteri.
Fig. 8. 2B type uteri.
Fig. 9. 2C type uteri.
Fig. 10. 3 type uteri.
Fig. 11. 4D type uteri.
Fig. 12. 4E type uteri.
Fig. 13. 4F type uteri.
Fig. 14. 5–15G type uteri.
Fig. 15. 7–15H type uteri.
Fig. 16. Male bursa, ventral view of typical Physalopterinae.

trunk), 2B (2 uteri without common trunk), 2C (2 uteri without common trunk, branches from the lateral sides), 3 (3 uteri without common trunk), 4D (4 uteri with common trunk), 4E (4 uteri with bifurcation of common trunk), 4F (4 uteri without common trunk), 5–15G (5–15 uteri with common trunk), and 7–15H (7–15 uteri without common trunk). (Figs. 7–15)

When Schulz (1927) divided the genus *Physaloptera* into several genera according to pseudolabial dentition the family Physalopteridae was broken into two subfamilies, namely, Physalopterinae and Proleptinae. The latter contains five genera: *Proleptus, Thubunaea, Heliconema, Ortleppina,* and *Physalopteroides.* Morgan (1943) placed the genus *Physalopteriodes* Wu and Liu (1940) in the subfamily Physalopterinae, but further evidence showed closer relationship of *Physalopteroides* to *Thubunaea,* and consequently has been placed in the subfamily Proleptinae. The subfamily Physalopterinae has since been grouped into four genera by Schulz (1927) and Baylis (1934). The genera include *Physaloptera* Rudolphi, 1819; *Abbreviata* (Travassos, 1920) Schulz, 1927; *Skrjabinoptera* Schulz, 1927; and *Pseudophysaloptera* Baylis, 1934.

LIFE CYCLE

The life cycles of the Physalopterinae are still unknown. On the basis of findings in allied genera of the spirurids, this group of nematodes will probably require certain arthropods as intermediate hosts. Alicata (1937) found that the embryonated eggs of *Physaloptera turgida* after ingestion by the cockroach (*Blatella germanica*) developed to the 3rd stage larvae. Hobmaier (1941) reported similar findings for *P. maxillaris.* Cram (1931) and Boughton (1937) reported the finding of immature *Physaloptera* encysted in the breast muscles of bobwhite quail (*Colinus v. virginiania*) and the ruffed grouse (*Bonasa umbellus*). As soon as some of the life cycles of the more common species of *Physaloptera* have been determined the host-parasite relationships of the group will become more easily understood. This would enable one to conduct animal experiments on host-specificity.

The knowledge of host specificity and speciation is yet too meager for final analysis and no doubt many synonyms exist. Considerable more experimental evidence is needed to justify the naming of new species created entirely on host occurrence.

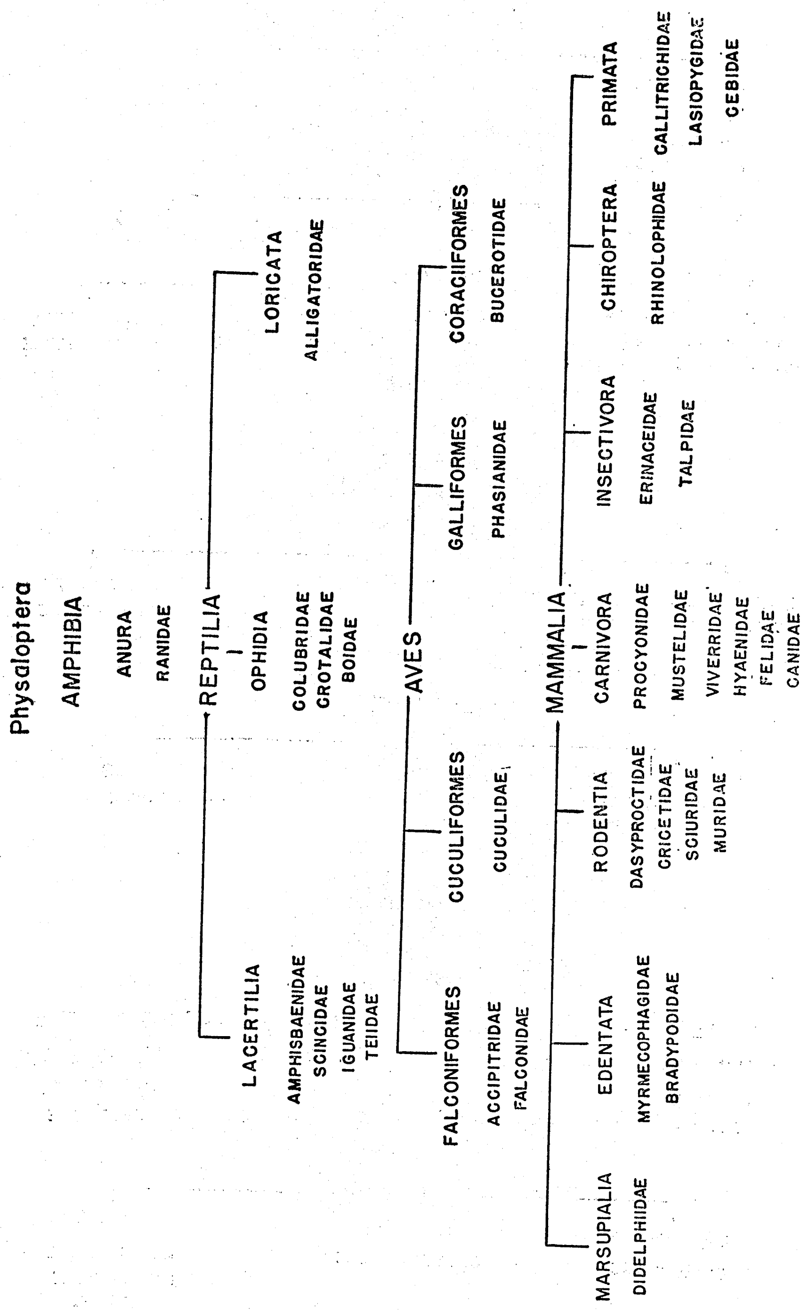


CHART 1.—Host spread of the *Physaloptera* arranged by Classes, Orders, and Families.

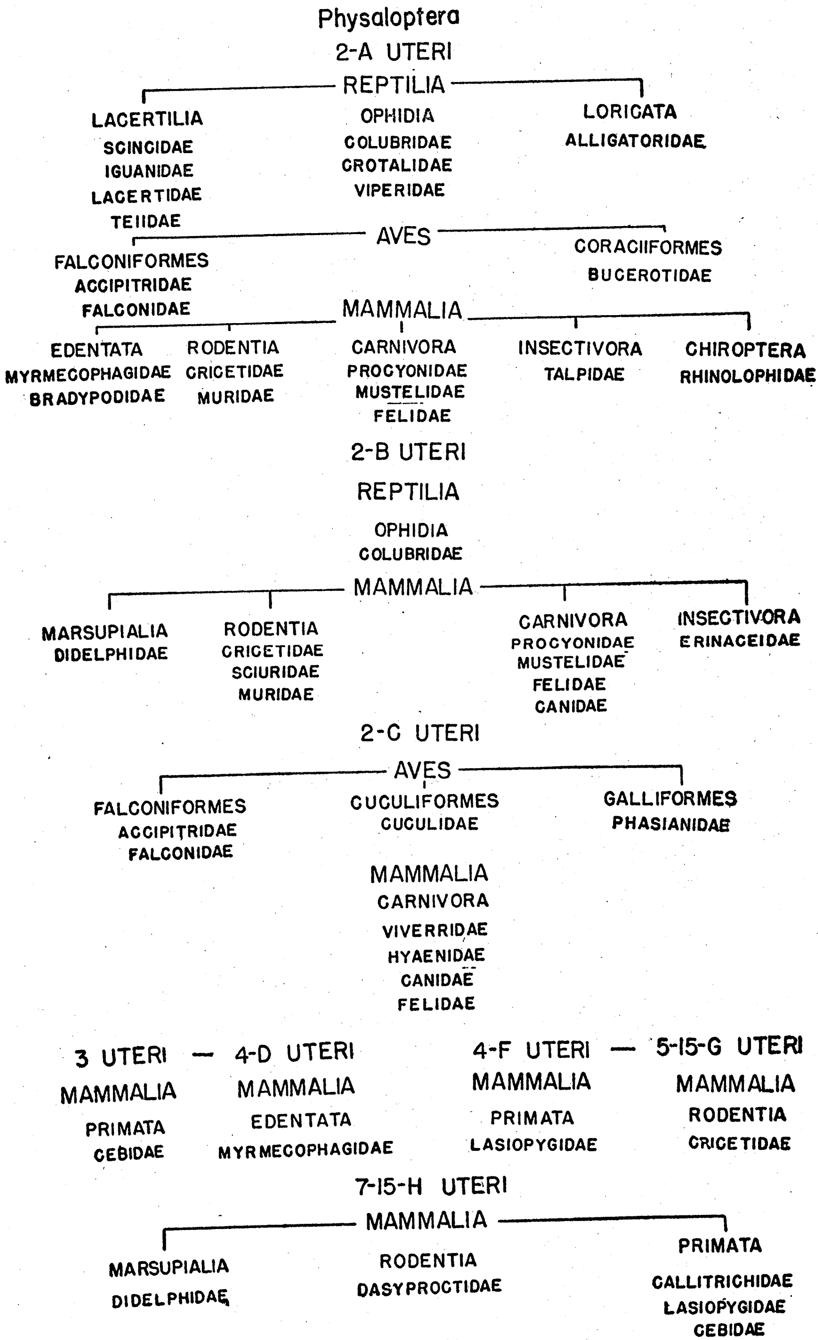


CHART 2.—Different types of uterine origin in the *Physaloptera* arranged by Classes, Orders, and Families of the hosts.

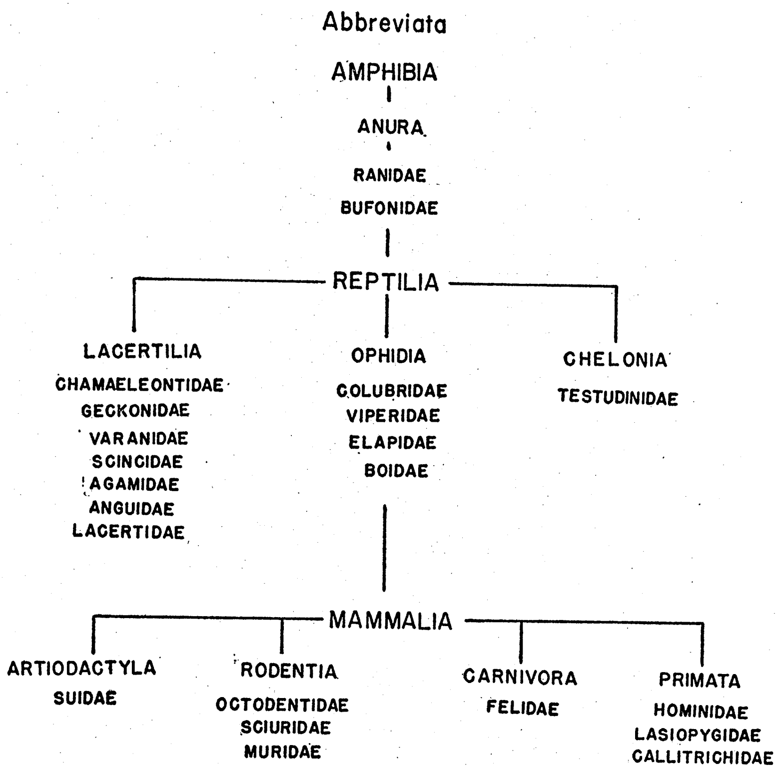


CHART 3.—Host spread of the *Abbreviata* arranged by Classes, Orders, and Families.

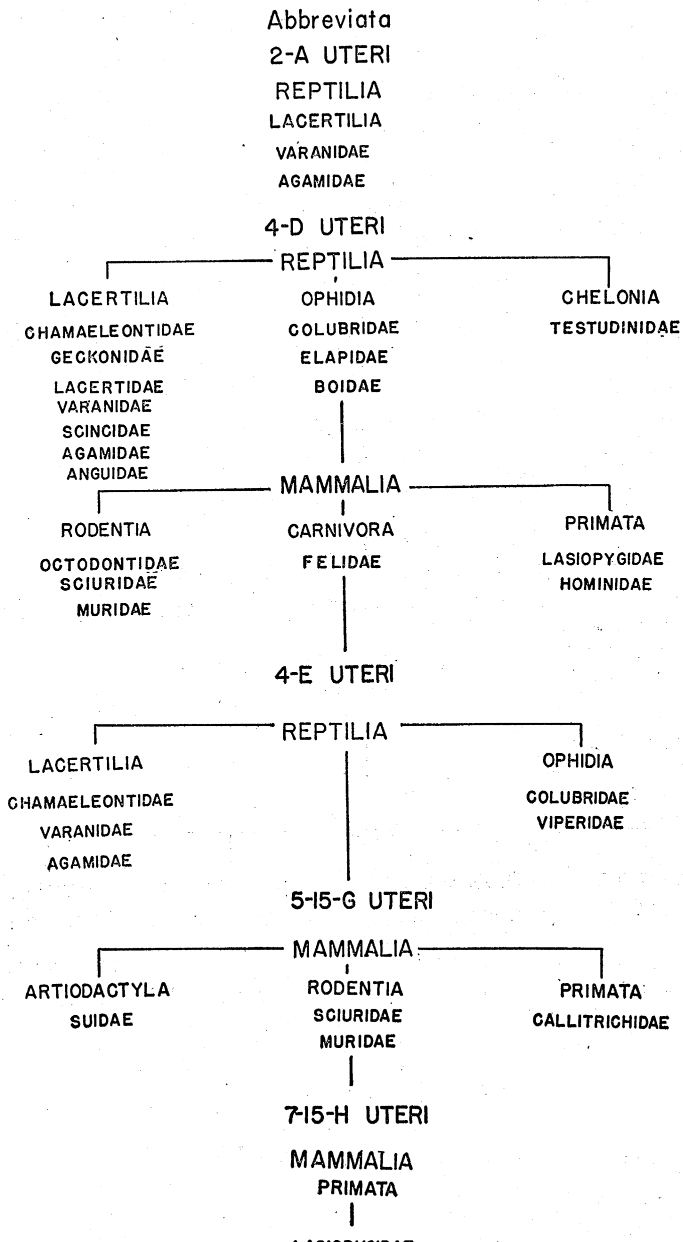


CHART 4.—Different types of uterine origin in the *Abbreviata* arranged by Classes, Orders, and Families of the hosts.

RELATIONSHIPS OF THE *PHYSALOPTERA*

Physaloptera is now characterized by 1 externolateral tooth and 1 internal group of 3 teeth, and usually no denticles on the margins of the pseudolabia. The genus contains approximately 42 species. They are represented in the following hosts: *Amphibia;* ANURA (Ranidae) [1 species]; Reptilia; LACERTILIA (Scincidae, Teiidae, Amphisbaenidae, Iguanidae), OPHIDIA (Colubridae, Crotalidae, Boidae), LORICATA (Alligatoridae) [4 species]; *Aves*: FALCONIFORMES (Accipitridae, Falconidae), CUCULIFORMES (Cuculidae), GALLIFORMES (Phasianidae, Tetraonidae), STRIGIFORMES (Strigidae), CORACIIFORMES (Bucerotidae), CICONIIFORMES (Threskiornithoidae), SPHENISCIFORMES (Spheniscidae) [12 species]; *Mammalia*: CARNIVORA (Canidae, Felidae, Mustelidae, Procyonidae, Hyaenidae, Viverridae) [9 species]; RODENTIA (Muridae, Sciuridae, Cricetidae, Dasyproctidae) [5 species]; CHIROPTERA (Rhinolophidae) [1 species]; EDENTATA (Myrmecophagidae, Bradypodidae) [2 species]; INSECTIVORA (Erinaceidae, Talpidae) [4 species]; MARSUPIALIA (Didelphiidae) [2 species]; PRIMATA (Cebidae, Lasiopygidae, Callitrichidae) [3 species].

The genus *Physaloptera* is widely distributed throughout the animal kingdom embracing 42 species among 4 classes, 15 orders representing 33 families. The number of hosts totals well over 250 different animals. Chart 1 shows in tabular form the spread of hosts as arranged by orders. The Amphibia is represented by 1 family, Reptilia by 8, Aves by 5, and the Mammalia by 19. The order Carnivora has the largest number of families, six being represented.

Of the 42 known valid species several are somewhat restricted in geographical distribution. This may be due to the range of the various susceptible hosts; *P. abjecta, P. torquata,* and *P. limbata* has been reported only from the United States; *P. amphibia* only from the Philippine Islands (Luzon); *P. brachycera* from Angola; *P. crosi, P. galinieri, P. losseni, P. rapacis, P. aduensis, P. canis, P. immerpani, P. bedfordi* from Africa; *P. hieracideae* from Australia; *P. mexicana* from Mexico; *P. reevisi* from China; *P. mirandai, P. magnipapilla, P. papillotruncata, P. torresi, P. anomala* and *P. bonnei,* from South America; *P. masoodi* and *P. tumefaciens* from India. The most cosmopolitan species would include *P. praeputialis, P.*

maxillaris, P. turgida, P. getula, P. rara, P. alata and *P. acuticauda.*

From the examination of host-parasite lists, several species of *Physaloptera* may occur in a similar host. For example, *P. praeputialis* may occur in the cat, mountain lion, bobcat, dog, or gray fox. Two different species of *Physaloptera* have never been reported occurring in the same animal at the same time; for example, *P. praeputialis* and *P. rara* from the same dog. Super parasitism is not known to occur in the Physalopterinae.

The genus *Physaloptera* is the only member of the subfamily *Physalopterinae* reported from birds. So far as is known, species occurring in birds have not been found in any other class of vertebrates. It is probably safe to say that species of *Physaloptera* found in birds are host specific for Aves. This is, of course, discounting aberrant or pseudoparasites.

This group of nematode worms are found mainly in the pharynx, crop, esophagus, proventriculus, ventriculus and occasionally in the intestine of various bird hosts. Rarely, immature forms are found encysted in breast muscles of birds. There are two cases on record of *Physaloptera* found in the orbital cavity of birds; *P. acuticauda* from a South American black hawk and *Physaloptera* sp. from a sacred ibis.

All of the species of *Physaloptera* found in birds have been recorded from the order Falconiformes; *P. acuticauda* has the widest host range, having been found in Falconiformes, Galliformes, and Cuculiformes; *P. galinieri* next with a host range of two orders, Falconiformes and Coraciiformes. The remaining species from birds are restricted entirely to Falconiformes. Many immature *Physaloptera* have been reported from birds not in the order Falconiformes, thus suggesting accidental hosts.

The *Physaloptera* from the Reptilia have a spear-shaped left spicule, a characteristic not found in the *Physaloptera* from the Amphibia, Aves, or Mammalia.

The following parasite-host list of the *Physaloptera* has been arranged by classes, orders, and families to facilitate a comprehensive view of host parasite relationships. The geographical distribution is also given. Morgan reported in detail the *Physaloptera* from certain host groups (1941, 1942, 1943, 1944).

Physaloptera papuensis Johnson and Mawson, 1940, probably from a bandicoot from Papua; *P. peramelis* Johnson and Mawson, 1939, *P. parvicollaris* Johnson and Mawson, 1940, from

Parameles nasuta (long-nosed bandicoot); *P. peragale* Johnson and Mawson, 1940, *P. thalacomys* Johnson and Mawson, 1940, from *Peragale minor* (rabbit bandicoot or bilby) and *P. sarcophili* Johnson and Mawson, 1940, from *Sarcophilus harrisi* (Tasmanian devil), all from various Australian marsupials, cannot be evaluated because of inadequate descriptions. The species position of these *Physaloptera* must remain doubtful until the types are re-examined and the number and mode of origin of the uteri determined. Also, the male spicules and papillae should be accurately pictured. *Physaloptera troughtoni* Johnson and Mawson, 1941, from *Rattus assimilis* may be a synonym of *P. getula* while the position of *P. banfieldi* Johnson and Mawson, 1941, from *Melomys banfieldi* (Muridae) is not clear. The description of *P. hieracideae* Johnson and Mawson, 1941, from *Hieracidea orientalis* (brown hawk) is not complete for species identification.

LIST OF SPECIES OF *PHYSALOPTERA* AND HOSTS ACCORDING TO CLASSES, ORDERS, FAMILIES AND GEOGRAPHICAL DISTRIBUTION

AMPHIBIA

1. *P. amphibia* Linstow, 1899. ANURA (Ranidae) Philippine Islands, Luzon.

REPTILIA

2. *P. abjecta* Leidy, 1856. Syn. *P. variegata* Reiber, Byrd, and Parker, 1940. OPHIDIA (Colubridae) U. S. A. (Pennsylvania, Georgia, Florida, Mississippi, Wisconsin)
3. *P. obtusissima* Molin, 1860. Syn. *P. monodens* Molin, 1860; *P. squamatae* Harwood, 1932. OPHIDIA (Colubridae, Crotalidae, Boidae). LACERTILIA (Scincidae). Brazil, New Britain, U. S. A. (California, Pennsylvania, Ohio, Wisconsin, Mississippi, Texas).
4. *P. retusa* Rudolphi, 1819. Syn. *Spiroptera retusa* Dujardin, 1845, *P. largarda* Sprehn, 1932; *P. mucronata* of Leidy, 1856. LACERTILIA (Teiidae, Amphisbaenidae, Iguanidae) LORICATA (Alligatoridae). Brazil, U. S. A. (New York, Utah).

AVES

5. *P. acuticauda* Molin, 1860. Syn. *P. truncata* Schneider, 1866; *P. quadridentata* Walton, 1927. FALCONIFORMES (Accipitridae). CUCULIFORMES (Cuculidae). GALLIFORMES (Phasianidae) Brazil, Africa, Mexico, French Guiana, U. S. A. (Florida, Wisconsin, Arizona).
6. *P. alata* Rudolphi, 1819. Syn. *Spiroptera physalura* Dujardin, 1845; *P. megalostoma* Creplin, 1839; *P. alata chevreuxi* Seurat, 1914; *P. alata nouveli* Seurat, 1915. FALCONIFORMES (Accipitridae). Italy, Austria, Africa, China, Germany, Brazil, Japan, France, Australia, Canada, U. S. A. (Colorado, Wisconsin).
7. *P. brachycerca* Kreis, 1938. FALCONIFORMES (Accipitridae). Angola.
8. *P. crosi* Seurat, 1914. FALCONIFORMES (Accipitridae). Africa.
9. *P. galinieri* Seurat, 1914. FALCONIFORMES (Accipitridae). CORACIIFORMES (Bucerotidae). Africa.
10. *P. hieracideae* Johnson and Mawson, 1941. FALCONIFORMES (Accipitridae). Australia.
11. *P. losseni* Ortlepp, 1937. FALCONIFORMES (Accipitridae). Africa.
12. *P. mexicana* Caballero, 1937. FALCONIFORMES (Accipitridae). Mexico.
13. *P. rapacis* Monnig, 1926. FALCONIFORMES (Accipitridae). Africa.
14. *P. reevisi* Chu, 1931. FALCONIFORMES (Accipitridae). China.
15. *P. subalata* Schneider, 1866. FALCONIFORMES (Falconidae, Accipitridae). Brazil, Europe.

MAMMALIA

16. *P. mirandai* Lent and Freitas, 1937. MARSUPIALIA (Didelphiidae). Brazil.
17. *P. turgida* Rudolphi, 1819. Syn. *P. ackerti* Hill, 1939. MARSUPIALIA (Didelphiidae). Brazil, U. S. A., Panama.
18. *P. magnipapilla* Molin, 1860. EDENTATA (Myrmecophagidae). Brazil.

19. *P. papillotruncata* Molin, 1860. Syn. *P. pyramidalis* Linstow, 1879. EDENTATA (Myrmecophagidae, Bradypodidae). Brazil.
20. *P. aduensis* Baylis, 1928. RODENTIA (Muridae). Africa (Nigeria).
21. *P. getula* Seurat, 1917. Syn. *P. bispiculata* Vaz and Pereira, 1935. RODENTIA (Muridae, Cricetidae, Sciuridae). Africa, Brazil. U. S. A. (Florida, Georgia, Texas, Louisiana, Colorado, Montana).
22. *P. massino* Schulz, 1926. Syn. *P. spinicauda* McLeod, 1933. RODENTIA (Muridae, Sciuridae). Russia, Canada, U. S. A. (Minnesota, Wisconsin).
23. *P. muris-brasiliensis* Diesing, 1861. Syn. *Spiroptera bilabiata* Molin, 1860; *P. circularis* Linstow, 1897; *P. sciuri* Parona, 1898; *P. ruwenzorii* Parona, 1907; *P. inermis*? Linstow, 1906. RODENTIA (Muridae, Cricetidae). Brazil, Hawaiian Islands, U. S. A. (Iowa, Georgia).
24. *P. torresi* (Travassos, 1920). RODENTIA (Dasyproctidae). Brazil.
25. *P. maxillaris* Molin, 1860. Syn. *P. semilanceolata* Molin, 1860; *P. mephites* Solanet, 1909; *P. mydai* Baylis, 1926. CARNIVORA (Mustelidae, Procyonidae). Brazil, Europe, Argentina, Trinidad, British West Indies, Canada, Mexico, Borneo. U. S. A. (New York, Iowa, Illinois, Wisconsin, Louisiana, California, Nebraska, Montana).
26. *P. rara* Hall and Wigdor, 1918. Syn. *P. cerdocyona* Sprehn, 1932; *P. felidis* Ackert, 1936; *P. clausa* of Caballero and Peregrina 1938; *P. turgida* of Leigh, 1940. CARNIVORA (Canidae, Felidae). Mexico, Germany, U. S. A. (Wisconsin, Michigan, Tennessee, Minnesota, Iowa, Mississippi, Nebraska, Kansas, North Dakota, South Dakota, California, Virginia, Arizona, Illinois, Kansas).
27. *P. praeputialis* Linstow 1889. Syn. *Chlamydonema felineum Hegt,* 1910; *C. praeputialis* Travassos, 1917; *C. praeputiale* Yorke and Maplestone, 1926. CARNIVORA (Felidae, Canidae, Viverridae). Brazil, Batavia, Belgium, British Guiana, Federated Malay States, China, Ceylon, Dutch Guiana, India, Eastern Russia, Southwest Russia, Puerto Rico, Panama, Africa (Nigeria, Tanganyika, Zanzibar) Union of South Africa, Mexico. U. S. A.

(Wisconsin, Iowa, Indiana, West Virginia, California, Oregon, Arizona, Virginia, New Hampshire, Nevada).

28. *P. torquata* Leidy, 1886. Syn. *P. papillotruncata* of Canavan, 1931. CARNIVORA (Mustelidae, Procyonidae). U. S. A. (Pennsylvania, Wisconsin, Illinois, Montana, Arizona, Iowa).
29. *P. anomala* Molin, 1860. CARNIVORA (Felidae). Brazil, Dutch Guiana.
30. *P. brevispiculum* Linstow, 1906. Syn. *P. malayensis* Ortlepp, 1922; *Chlamydonema fuelleborni* Mirza and Narain, 1934. CARNIVORA (Felidae Hyaenidae). Ceylon, Federated Malay States, Nigeria, India.
31. *P. canis Monnig,* 1929. CARNIVORA (Canidae, Felidae). South Africa.
32. *P. masoodi* (Mirza, 1934). Syn. *Chlamydonema masoodi* Mirza, 1934. CARNIVORA (Felidae). India.
33. *P. terdentata* Molin, 1860. Syn. *P. digitata* Schneider 1866. CARNIVORA (Felidae). Brazil, Sudan.
34. *P. clausa* Rudolphi, 1819. Syn. *Spiroptera clausa* Dujardin, 1845; *P. dispar* Linstow, 1904. INSECTIVORA (Erinaceidae). Russia, China, Europe, Africa (Nigeria, Tunis, Tanganyika).
35. *P. immerpani* Ortlepp, 1937. INSECTIVORA (Erinaceidae). South Africa.
36. *P. seurati* Issaistchikoff 1926. INSECTIVORA (Erinaceidae). Russia, Europe.
37. *P. limbata* Leidy, 1856. INSECTIVORA (Talpidae). U. S. A. (Wisconsin, Iowa, Illinois, Maryland, Kansas, Vermont).
38. *P. bedfordi* Ortlepp, 1932. CHIROPTERA (Rhinolophidae). South Africa.
39. *P. cebi* Ortlepp, 1923. PRIMATA (Cebidae). South America.
40. *P. dilatata* Rudolphi, 1819. Syn. *P. multiuteri* Canavan, 1929. PRIMATA. (Lasiopygidae, Cebidae, Callitrichidae). Brazil, Panama, Peru.
41. *P. tumefaciens* Henry and Blanc, 1912. PRIMATA (Lasiopygidae). India.
42. *P. bonnei* Ortlepp, 1922. Host unknown. Probably Reptilia. Dutch Guiana.

UTERINE TYPE RELATIONSHIPS

The genus *Physaloptera* has the widest uterine range in the subfamily Physalopterinae. Eight different uterine origins and numbers are represented. The 2-A type has the largest host spread in the group including the Reptilia (8 families), Aves (3 families), and Mammalia (5 orders and 9 families). The 2B type includes the Reptilia (1 family) and Mammalia (4 orders and 9 families). The 2C group is represented by Aves (3 orders, 4 families) Mammalia (1 order, 4 families). The remaining uterine types of 3, 4–D, 4–F, 5–15G and 7–15H are found only in mammals as shown by Chart 2.

RELATIONSHIPS OF THE *ABBREVIATA*

Abbreviata is characterized by 1 externolateral tooth, 1 internolateral tooth and 2 double submedian teeth on each pseudolabium; usually the entire margin of the pseudolabia is dentated (Fig. 1-16). This genus has been recorded from many hosts, namely, Amphibia, chiefly Reptilia, and Mammalia. Schulz (1927) placed 23 species in this genus although approximately 27 species are now listed. Of the 27 species, 17 are parasites of the Reptilia: LACERTILIA (Varanidae, Agamidae, Lacertidae, Anguidae, Scincidae, Geckonidae, Chamaeleontidae), OPHIDIA (Colubridae, Elapidae, Boidae, Viperidae), CHELONIA (Testudinidae). One species is from the Amphibia: ANURA (Ranidae, Bufonidae). The remaining 9 species are recorded from the *Mammalia:* CARNIVORA (Felidae) [1 species]; ARTIODACTYLA (Suidae) [1 species]; PRIMATA (Hominidae, Lasiopygidae, Callitrichidae) [3 species]; RODENTIA (Muridae, Sciuridae, Octodontidae) [4 species]. Many of the *Abbreviata* are found in Africa, the remainder in Europe, Asia, Australia, and North America.

The genus *Abbreviata* is not as widely distributed among hosts as the *Physaloptera*. However, the majority of species are found in Reptiles. Three classes, 5 orders and 22 families are represented among the hosts. Chart 3 shows the distribution of the genus arranged by host family relationships. The Amphibia is represented by 2 families, Reptilia by 12 and the Mammalia by 8. The lizards are by far the most prominent host.

Geographically, 15 species are found in Africa, 3 in the United States, and 2 in Australia. The locality of the hosts of three species is not known. No species is very widely distributed; *A. abbreviata, A. varani,* and *A. caucasica* have the widest geographical range.

The parasite host list of the *Abbreviata* has been arranged similar to that of the *Physaloptera* for convenience in study.

This genus does not occur in birds, although there have been two cases on record of accidental or pseudoparasites of *Abbreviata* from Aves. *Abbreviata* originally described from Reptilia was reported by Linstow (1883) from *Aconia alba* (white stork) and *A. gemina* (Linstow, 1899) originally described from a cat was reported by Railliet (1915) from a domestic chicken. Morgan (1945) reported in some detail on the genus *Abbreviata.*

UTERINE TYPE RELATIONSHIPS

Only 5 uterine types are found in the *Abbreviata* in comparison with 8 for the *Physaloptera.* The 2-A type uteri is restricted to the Reptilia (2 families), type 4-D to Reptilia (12 families) and Mammalia (3 orders, 6 families), 4-E to Reptilia (5 families); type 5–15–G and 7–15–H are found only in the Mammalia as shown in Chart 4.

LIST OF SPECIES OF *ABBREVIATA* AND HOSTS ACCORDING TO CLASSES, ORDERS, FAMILIES, AND GEOGRAPHICAL DISTRIBUTION

AMPHIBIA

1. *A. ranae* (Wallon, 1931). ANURA (Ranidae Bufonidae). U. S. A. (Indiana, Louisiana, Wisconsin, Illinois, Oklahoma). [Larval form.]

REPTILIA

2. *A. gracilis* (Ortlepp, 1922). LACERTILIA. Uganda.
3. *A. leptosoma* (Gervais, 1848). LACERTILIA (Varanidae, Agamidae). Algeria.
4. *A. abbreviata* (Rudolphi, 1819). LACERTILIA (Lacertidae, Agamidae, Anguidae). OPHIDIA (Colubridae). Spain, Algeria, Turkestan, British East Africa.

5. *A. amaniensis* (Sandground, 1928). LACERTILIA (Agamidae). Africa.
6. *A. antarctica* (Linstow, 1899). Syn. *Physaloptera alba* Stossich, 1902. OPHIDIA (Elapidae, Boidae). LACERTILIA (Scincidae, Varanidae). Australia.
7. *A. bancrofti* (Irwin-Smith, 1922). Syn. *Physaloptera natricus* Kreis, 1940; *P. physignathi* Baylis, 1924. LACERTILIA (Geckonidae, Agamidae). OPHIDIA (Colubridae). Australia, New Zealand.
8. *A. heterocephala* (Kreis, 1940). LACERTILIA (Agamidae). Location not given.
9. *A. leidyi* (Walton, 1927). LACERTILIA (Varanidae). Location not given.
10. *A. oligopapillata* (Kreis, 1940). LACERTILIA (Scincidae). Location not given.
11. *A. ortleppi* (Sandground, 1928). LACERTILIA (Chamaeleontidae). Africa.
12. *A. pallaryi* (Seurat, 1917). LACERTILIA (Agamidae). Morocco.
13. *A. polydentata* (Walton, 1932). LACERTILIA (Geckonidae). British East Africa.
14. *A. varani* (Parona, 1889). Syn. *Physaloptera quadrovaria* Leiper, 1908. LACERTILIA (Varanidae Iguaindae). OPHIDIA (Colubridae). Ceylon, India, China, U. S. A. (Maryland, Wisconsin, Illinois).
15. *A. achari* (Mirza, 1935). LACERTILIA (Agamidae). India.
16. *A. paradoxa* (Linstow, 1908). Syn. *Physaloptera affinis* Gedoelst, 1916. LACERTILIA (Varanidae). OPHIDIA (Viperidae, Colubridae). South Africa, Algeria, Belgian Congo, Sudan, Nigeria.
17. *A. tasmania* (Ortlepp, 1937). LACERTILIA (Chamaeleontidae). Rhodesia.
18. *A. terrapenis* (Hill, 1941). CHELONIA (Testudinidae). U. S. A. (Oklahoma).

MAMMALIA

19. *A. joyeuxia* (Gendre, 1928). ARTIODACTYLA (Suidae). Africa.
20. *A. africana* (Monnig, 1923). RODENTIA (Muridae, Octodontidae, Sciuridae). South Africa.

21. *A. leiperi* (Skrjabin, 1924). RODENTIA (Sciuridae). Russia.
22. *A. capensis* (Ortlepp, 1922). RODENTIA (Sciuridae). South Africa.
23. *A. musculi* (Thwaite, 1927). RODENTIA (Muridae). Ceylon.
24. *A. vandenbrandeni* (Gedoelst, 1924). CARNIVORA (Felidae). Belgian Congo.
25. *A. caucasica* (Linstow, 1902). Syn. *Physaloptera mordens* Leiper, 1908. PRIMATA (Hominidae, Lasiopygidae). Caucasus, Uganda, Africa, Arabia, North East Africa.
26. *A. poicilometra* Sandground, 1936. PRIMATA (Callitrichidae). East Africa.
27. *A. multipapillata* (Kreis, 1940). PRIMATA (Lasiopygidae). Location not given.

RELATIONSHIPS OF THE *SKRJABINOPTERA* AND *PSEUDOPHYSALOPTERA*

Skrjabinoptera is characterized by a single internolateral tooth on each pseudolabium and is restricted entirely to the Reptilia. At the present time 4 species are included in this genus and are found in the OPHIDIA (Colubridae), LACERTILIA (Chamaeleontidae, Iguanidae).

Skrjabinoptera colubri and *S. simplicidens* have been reported only from Australia; *S. chamaeleontis* only from Africa (Belgian Congo; *S. phrynosoma* is the only well-known representative of the genus. The geographical distribution is limited to Southern United States and Mexico, the range of the horned toad, American chamaeleon, and tree lizards. This species is restricted entirely to the family Iguanidae. The 2A and 4D types of uteri are represented in this genus, 2 species in each group. Morgan (1943) reported on the occurrence of this genus in North America.

LIST OF SPECIES OF *SKRJABINOPTERA* AND HOSTS ACCORDING TO CLASSES, ORDERS, FAMILIES, AND GEOGRAPHICAL DISTRIBUTION

REPTILIA

1. *S. colubri* (Rudolphi, 1819) OPHIDIA (Colubridae) Australia.
2. *S. chamaeleontis* (Gedoelst, 1916) LACERTILIA (Chamaeleondidae) Belgian Congo, Africa.
3. *S. simplicidens* (Ortlepp, 1922) LACERTILIA Australia.

4. *S. phrynosoma* (Ortlepp, 1922) LACERTILIA (Iguanidae) Mexico, U. S. A. (Texas, New Mexico, Oklahoma, California, Arizona, Utah, Idaho, South Carolina, Louisiana, and Florida).

The genus *Pseudophysaloptera* has pseudolabia similar to *Physaloptera,* however, the male is without caudal pedunculated papillae and spicules. Only one species is known at the present time; *P. soricina* from *Crocidura* sp. (shrew) from Tanganyika. Chen (1927) reported this parasite from *Suncus coerulus* (shrew) from China. Morgan (1941) also recovered this species from *Sorex p. personatus* (masked shrew). The genus so far as known is restricted to the Insectivora (Soricidae). The female possesses the 2-A type uteri. The species, reported by Yokagawa (1922) from *Sorex* sp. (*P. formosana*) cannot be grouped conveniently because of inadequate descriptions.

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HIGHEST ABANDONED BEACH RIDGES IN NORTHERN DOOR COUNTY, WISCONSIN

O. L. KOWALKE

I. INTRODUCTION

The abandoned beach ridges in Wisconsin along Lake Michigan and Green Bay have been studied by several investigators and all of them reported the existence of ridges much above the present level of the water. James W. Goldthwait in 1907, in Bulletin XVII of the "Wisconsin Geological and Natural History Survey," described his own studies of the beach ridges in eastern Wisconsin, together with a compilation of the observations of others. It is generally agreed that the highest of these ridges were formed during the existence of the post-glacial "Lake Algonquin."

A topographic survey by the writer and E. F. Kowalke in 1935 at Ellison Bay, Wisconsin, disclosed abandoned beach ridges, respectively at 588 feet, 604 feet, and 650 feet above sea level, whereas the level of water in Green Bay stood at 578 feet. Consideration of the locations of those beach ridges at the 650 foot level, or Algonquin stage, together with other topographical features, indicated that at one time there were "islands" where now there is consolidated land.

What shapes did these "islands" have and where were they located? Were there islands farther to the south of Ellison Bay? The purpose of this study was to answer these questions.

II. SURVEYING PROCEDURES

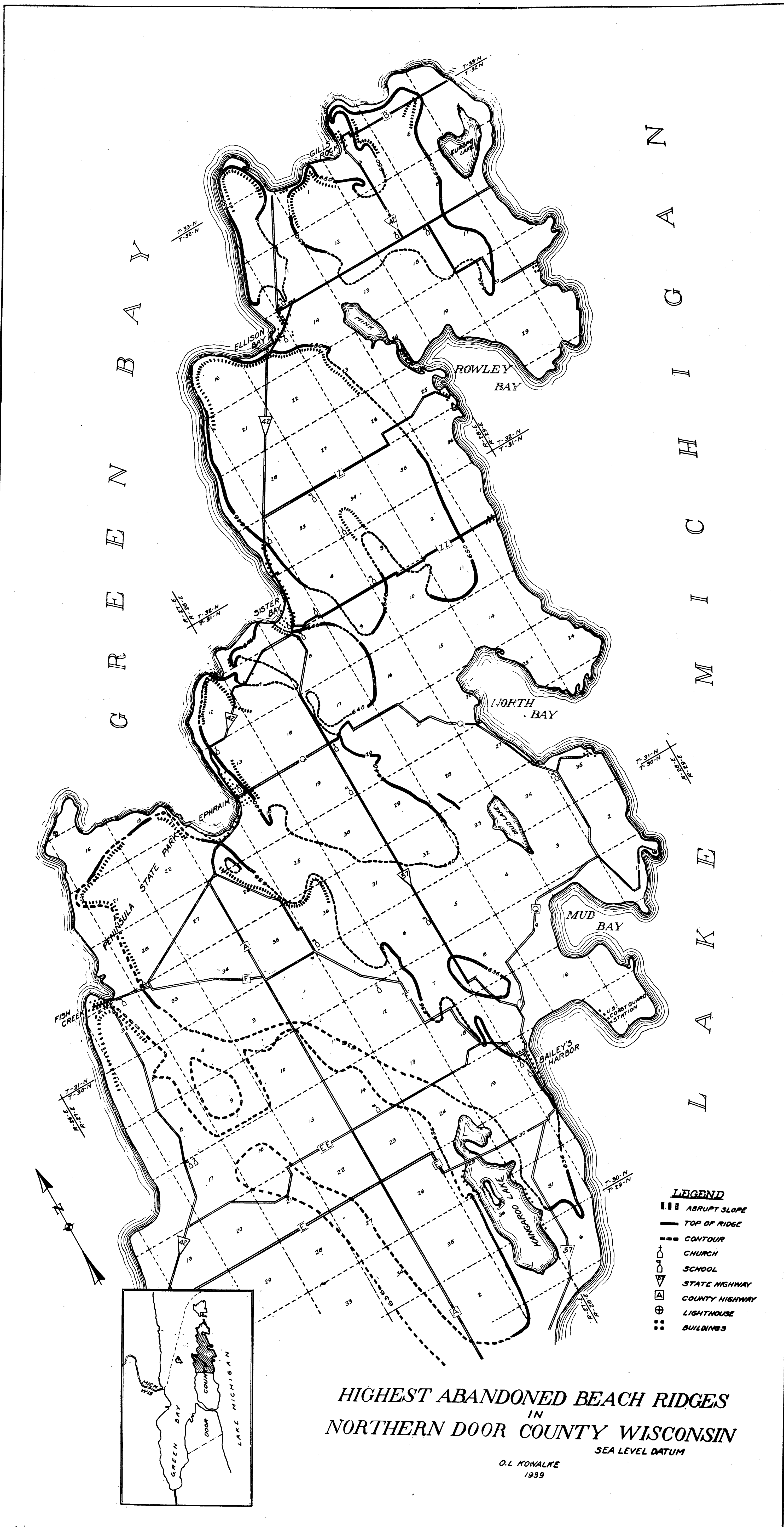
Except for swampy and very stony areas, the northern end of Door County is for the most part under cultivation and is provided liberally with roads. It was thus convenient to walk from the water's edge inland either north to south or east to west until a ridge was encountered. That spot was then marked on a map of land ownership printed on the scale of 1.5 inches to the mile.

The elevations of such discovered ridges were then determined by leveling with a transit and a stadia rod, the bases for the elevations being the bench marks set at intervals along Wisconsin State Highway 42 by the U. S. Coast and Geodetic Survey. From these bench marks the water level in Green Bay or Lake Michigan was ascertained when the elevation of a beach ridge was being measured. The water level did not change significantly from day to day in July and August of a given year, but it did vary from year to year; and this study extended over four summers during July and August. After the elevations of the highest ridges in a given area had been ascertained, and after their locations were noted on the land ownership map, leveling was continued to ascertain where the elevations of the crests of the ridges would lie in such areas where no ridges were found or could be discerned.

Reference is now made to Plate I. The highest beach ridges found are represented there by broad solid lines and the elevations in feet above sea level indicated by the numbers in the lines. The locations of the levels of the crests of beach ridges in areas where no ridges were found are represented by lines made of dashes. In other words, the lines made with dashes represent where the elevation of the crest of the ridge would lie if it were continued. The combination of a solid line and a dashed line showing a given elevation is called a contour and it must close on itself and make a complete loop.

III. The Ancient "Islands" and "Water Ways"

Inspection of the map in Plate I reveals that the contours of the beach ridges at the 650 to 636 foot levels form six "islands." The size of the "islands" seems to increase the farther south it is located. The elevation of the ridges at the northern end of the map is 650 feet above sea level, whereas 18 miles to the south in the latitude of Kangaroo Lake the elevation is 636 feet. This difference in elevations has been ascribed to a lifting of the land due to the disappearance of the ice farther north. George M. Stanley, in *Bul. of the Geological Society of America,* 47; 1933, and 48; 1665, tells of his studies of abandoned beach ridges on Georgian Bay in Lake Huron and of finding, for example, that the highest Algonquin ridges



HIGHEST ABANDONED BEACH RIDGES IN NORTHERN DOOR COUNTY WISCONSIN

lay at 794 to 875 feet above sea level. Robert R. Schrock, in *Trans. Wisconsin Acad. of Science, Arts and Letters,* 32; 203, on "Geology of Washington Island," points out that "Lake Algonquin" stood at levels of 650 feet and 630 feet above sea level.

On the "islands" the slope of the land towards Green Bay is rather steep and often quite abrupt; the slope toward Lake Michigan is in general gentle and uniform. On the Green Bay ends of the "islands" from Ellison Bay south to Egg Harbor the elevation of the high land stands between 700 and 770 feet above sea level. Each of the "islands" has a core of Niagara limestone which is covered with earth varying in depth from a few inches to several feet; in some places the rock cover is a glacial deposit of sand and gravel in the form of mounds or small drumlins.

Because of the steep and abrupt slopes of the land towards Green Bay, the beach ridges are often absent; there was no support for the material rolled along by the waves. For example, there are no beach ridges at the 650 foot level on the cliff in Section 16, Town 32 North, Range 28 East near Ellison Bay, nor in the Peninsula State Park near Ephraim in Sections 15 and 23 and in Sections 21 and 28, all in Town 31 North, Range 27 East, nor along the cliffs at Fish Creek in Section 32, Town 31 North, Range 27 East. On the other hand, on the more gradual slopes of land towards Lake Michigan, the highest ridges are found in nearly all cases where it was possible for wave motion to form them. Where such ridges lie on cultivated areas, they are often obliterated by the successive plowings and draggings.

Some aspects of the smaller "islands" are worthy of comment. Beginning at the north end, consider the "island" lying north of Ellison Bay in Sections 2, 10, and 11, of Town 32 North and in Section 35, Town 33 North, in Range 28 East. The waterway between it and the "island" lying just east was narrow and the slopes of the ground on both "islands" is steep at the entrance from Garret Bay in Section 2. The creek now empyting into the Mink River rises in the southeast corner of Section 2.

Consider next the northeast portion of the "island" between Sister Bay and Ephraim, lying just south of the village of Sister Bay in Sections 5, 6, 7, 8, 16 and 17 of Town 31 North.

It may originally have been a separate island for it has a core of limestone and the high point of present ground is around 680 feet above sea level. Note how close the lobe of the contour extending southeasterly through Section 7 approaches the lobe which extends northward along the west side of Section 17; the ends of the lobes are only a few hundred feet apart. The crest of the divide between these lobes had an elevation of about 660 feet which is only around 20 feet above the crest of the beach ridge contour. The soil of that divide on the north side of Highway 57, at the southwest corner of Section 8, is loam on top of gravel and sand, whereas immediately to the south of the highway at that point, the soil is red clay.

Another small but interesting "island" is the one located just north of Baileys Harbor in Sections 7, 8, and 17 of Town 30 North, Range 28 East. This "island" also has a core of solid limestone and the beach ridge on it is intersected twice by Highway 57. One such intersection is on the section line between Sections 7 and 8, Town 30 North, Range 28 East and is shown in Plate II. The crest of the section of the beach ridge at this place is about 10 to 12 feet above the adjacent land. The ridge may be discerned in the upper left of the picture winding its way toward the southeast.

A third small "island" is located south of Fish Creek in Sections 4 and 9 of Town 30 North, Range 27 East. It has a core of limestone and its upper surface is dome-shaped rising to an elevation of around 660 feet. There are no evidences of beach ridges at the 636 foot level.

Although it is not now an "island," the area just west and northwest of Kangaroo Lake, lying in Sections 10, 14, 15, 22, 23, 26, 27, 34 and 35 of Town 30 North and in Section 2 of Town 29 North, all in Range 27 East, could have been an "island" if the barrier across the northern half of Section 16, Town 30 North had not been there. The elevation of the crest of this barrier is around 660 feet above sea level and the top loam soil is thin and is underlain with a gravel deposit. Because the barrier was under cultivation, no shore lines were discernible and no digging was done.

In the absence of the barrier across the northern half of Section 16, there could have been two arms of Lake Michigan extending northwesterly to meet the arm extending southeasterly

PLATE II.—East face of cut through beach ridge by Highway 57 on section line between Sections 7 and 8, T30N, R28E.

PLATE III.—Ancient beach plane showing rounded field stones. Section 16, T31N, R28E.

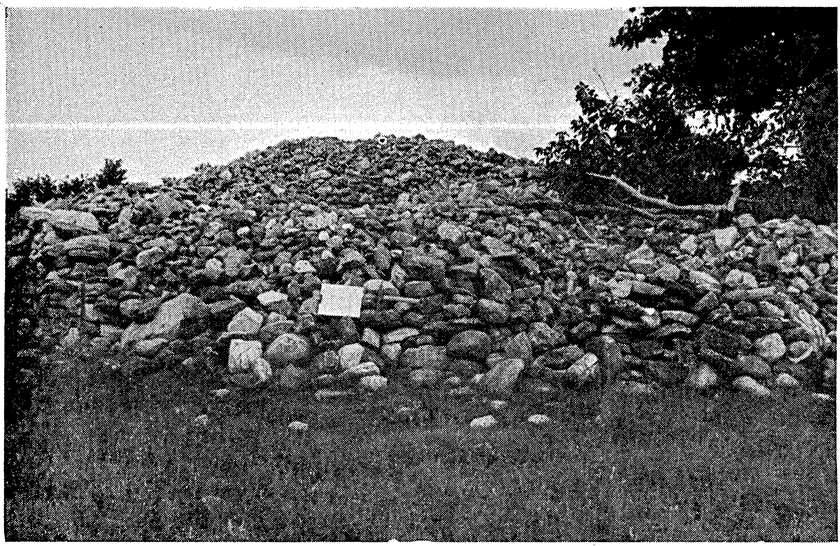


PLATE IV.—Mound of rounded beach stones. SE.¼ of SE.¼ of Section 9, T31N, R28E.

PLATE V.—Sharp-edged stones in fence.

PLATE VI.—Rock fence along Highway 57 in Section 20, T31N, R28E.

PLATE VII.—Rock fence showing shell fossils protruding from faces. SW.¼ of SW.¼ of Section 6, T30N, R28E.

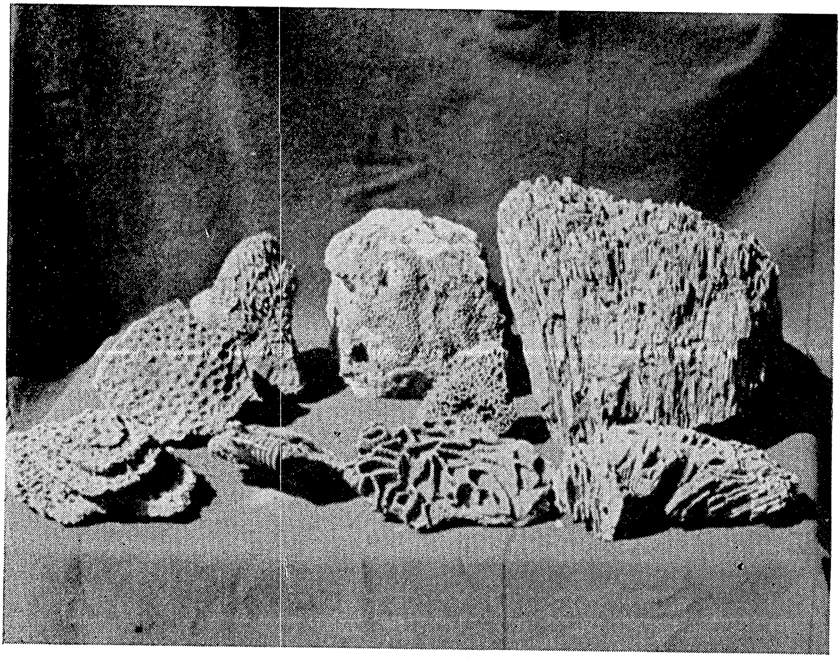


PLATE VIII.—Silicified corals—fossils.

from Green Bay at Fish Creek. At present there are, in fact, two creeks flowing into Lake Michigan where once arms of water from Lake Michigan could have existed.

Cursory examination of the region lying between Egg Harbor on Green Bay and Clarke's Lake south of Jacksonport on Lake Michigan suggests the existence of additional "islands" and water ways. Circumstances have, for the present, prevented additional surveys in this area.

IV. The Stones of the Fields

The stones now lying on the ground tell something about whether they had been subjected to attrition or to other agencies which reduced their size.

Wherever the waters of ancient "Lake Algonquin" had covered gently sloping beaches, the rocks now found are well rounded. An example of such beach is the one extending northwesterly from North Bay on Lake Michigan to Sections 9 and 16 in Town 31 North, Range 28 East. Sections 9 and 16 are almost entirely under cultivation and the rocks dislodged when plowing have been gathered into piles either in the fields or along the fence lines bordering the highway. In Plate III is shown the ancient beach with its piles of stones in the SE ¼ of NE. ¼ of Section 16 and in Plate IV a pile of rounded stones in the SE. ¼ of the SE¼ of Section 9.

On the other hand, where the water had not covered the land, the stones removed from the surface by plowing generally had corners which were quite sharp.

The field stones along Highway 57 south of the village of Sister Bay are flat pieces which originated from a chip limestone formation. Two illustrations will be shown: the first, Plate V, is a stone fence near the center of Section 18, Town 31 North, and the second, Plate VI, is another fence along Highway 57 in Section 20.

The field stones northwest from Baileys Harbor along County Trunk Highway F are also sharp-edged but somewhat larger than those shown in Plate V above. A stone fence a little east of C.T. Highway F in the SW. ¼ of SW. ¼ of Section 6, Town 30 North, Range 28 East is shown in Plate VII. Attention is called to the faces of the rocks shown in the picture. These faces have portions of shell fossils protruding and sometimes bits of coral. The shells and bits of coral are high in silica content and have resisted dissolution by carbonated waters more than the limestone matrix.

Searches in fields and also among stones in fences whose elevations are higher than 650 feet above sea level reveal some interesting and beautiful coral fossils. Some of these are shown in Plate VIII. At first it was puzzling to account for the fact that such delicate forms escaped destruction or dissolution. Chemical analysis of several varieties of the corals and of some shells showed that the content of silica ranged from around 78 percent to around 97 percent. The silica being insoluble in water charged with carbon dioxide was not etched while lying in leaf mold, whereas the limestone was dissolved. Hence the presence of delicately constructed corals and the presence of shell remains protruding from some limestones.

The author is grateful to his wife, Winifred Titus Kowalke, for her assistance in the field and for her constructive suggestions; and also to his brother E. F. Kowalke for drawing the map in Plate I.

ARTIFICIAL HYBRIDS BETWEEN MUSKELLUNGE AND NORTHERN PIKE

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INTRODUCTION

The study on which this report is based was made as a part of the research program of the biology division of the Wisconsin Conservation Department in order to determine the degree of fertility between the muskellunge, *Esox masquinongy masquinongy* (Mitchill) and the northern pike, *Esox lucius* (Linnaeus), the characteristics of such hybrids, and the desirability of this hybrid as a game fish. One of the principal long-time objectives of the study is to determine the value of this hybrid as a large, voracious predator for introduction into overpopulated waters.

The present report concerns itself with the characteristics of the two parent forms and of the hybrid, with preliminary observations on the fertility of the hybrids, and with observations concerning the status of the "tiger" muskellunge.

The study was initiated by the junior author and was interrupted by his call into the armed forces. It has been continued and somewhat expanded by the senior author for the present report.

History

Since the early studies of Francis Day, notably those reporting the development of the zebra trout and other trout hybrids by artificial fertilization (1884–1885), there has been considerable interest in the study of the characteristics of fish hybrids. This interest has lately been intensified by a comprehensive series of studies and reports by Dr. Carl L. Hubbs and his associates. A very good bibliography and summary of the general field may be found in Hubbs, Hubbs & Johnson (1943), Embody (1918) appears to be the first American to concern himself with interspecific hybrids in the genus *Esox*. He reported the artificial hybridization of the northern pike, *Esox lucius*, with the chain pickerel, *Esox niger*.[1]

The characteristics of the parent species and the hybrid are discussed and well illustrated by Embody. He found the hybrids to be intermediate in the matter of scale development on the operculum, but found that the juvenile hybrids were like the young of the northern pike rather than being intermediate or with a distinct color pattern of their own. The adult color pattern of the hybrids was not discussed.

Underhill (1939) reported on a repeat of the experimental crossing by Embody and found that the hybrids were essentially intermediate but that "the longest, however, shows the typical spotted color of the adult pike" (*E. lucius*). The fish reported upon were in their second winter.

Greeley and Bishop (1933) reported, without comment, on the discovery of specimens in the Upper Hudson River watershed which they classified as hybrids between *Esox americanus* and *Esox niger*.

Eddy (1941) and Eddy and Surber (1943) reported upon the first hybrids between the northern pike and the muskellunge, and Eddy (1941) has published some excellent figures of the typical adult muskellunge, northern pike and of the artificially produced hybrids.

One other hybrid combination is known in the genus *Esox*, that of *Esox niger* × *Esox vermiculatus* based on two specimens from Missouri in the University of Michigan collection (Hubbs, unpublished).

The problem of hybridization between these two species and the relationship of the so-called "tiger" muskellunge to the hybrids in Wisconsin, arose in 1937 when Dr. Edw. Schneberger (unpublished data) observed a small male northern pike taking part in the spawning act of a pair of muskellunge in Island Lake, Rusk County, Wisconsin. Early in June of that year he obtained a specimen about 20 inches (509mm.) long from Island Lake that displayed both muskellunge and northern pike characteristics and had some of the vertical bars of the "tiger" muskellunge. Dr. Schneberger identified the fish as a

1 Embody used the name *Esox reticulatus* for the chain pickerel. Terminology in the present paper follows that of Hubbs and Lagler (1941).

northern pike × muskellunge hybrid. This identification was confirmed by Dr. Carl L. Hubbs, then Curator of Fishes at the Museum of Zoology, University of Michigan. This specimen is now in the University of Michigan Museum of Zoology, and was re-examined during the present study.

In the spring of 1939 a group of muskellunge eggs were fertilized with milt from a northern pike. The eggs were incubated in glass hatching jars at the Woodruff Hatchery, and the fry were placed in rearing ponds where they reached a length of 14 inches during the first growing season. This growth was somewhat better than that attained by young of either of the parent species during the same period. A similar rapid early growth was reported by Eddy (1941). In 1940 six lots of eggs were obtained and reciprocal muskellunge × northern pike crosses were made with fish of various color patterns. Each lot of eggs was kept separate and the young reared in separate rearing ponds. At the end of the first growing season morphological and color characteristics were compared. There were no noticeable variations in either morphology or color in the six lots, nor did they differ from the 1939 specimens. No special records were kept of the percent of hatch of these eggs, but the hatch was good, probably in excess of 80%. When the difficulties of handling small lots of eggs in the hatchery are taken into account this figure is very satisfactory. A satisfactory hatch was likewise obtained from a lot of eggs hatched during the 1945 season, also at the Woodruff Hatchery, and the young hybrids again exhibited a more rapid growth than the young of either of the parent species reared under identical conditions.

The 1939 hybrids were planted out in six small, landlocked lakes that were overpopulated with pan fishes. Other than a small planting of 258 fish in 200-acre (81 hectares) Lake Wingra, Dane County, Wisconsin, the largest lake planted was Trilby in Vilas county. This lake has an area of 150 acres (61 hectares) and was stocked on July 2, 1940 with 200 fingerling hybrids. On September 13, 1940, 176 of these hybrids averaging 12 inches in length, were recovered by the use of fyke nets.

The large adult hybrid material used in the present study represents material collected from the 1939 plantings or fish that were retained in the Woodruff Hatchery ponds. Several were recovered in the Minocqua Thorofare, a body of water immediately below the hatchery which was planted with fish from the 1939 and 1940 year classes.

MATERIALS AND METHODS

With the exception of one young hybrid borrowed from the University of Michigan Museum of Zoology and originating in the experimental laboratory of the University of Minnesota, all of the material for the present study came from Wisconsin. All of the hybrids were produced in the Woodruff Hatchery, near Woodruff, Oneida County, except the one from Minnesota and the wild specimen from Island Lake. A total of 46 hybrids were critically studied. Fourteen of these were between 86 and 100 mm. (3.4–3.9 inches) in total length, 9 between 101 and 200 mm. (4–7.9 inches), and the remaining 23 were over 200 mm. long, most of them being in excess of 20 inches. The largest hybrid examined was an adult female 997 mm. (39.2 inches) long from Lake Wingra, Dane county. Most of these were examined dead, either as fresh or preserved specimens. Five adults were etherized, examined and returned alive to the Woodruff ponds. Eight "tiger" muskellunge were examined by the junior author while in the hands of fishermen, but critical counts and measurements were not recorded from these.

Complete counts and measurements were made on 36 muskellunge, 26 being between 100 and 200 mm. (3.9–7.9 inches) in total length and 10 being adults, the largest 920 mm. long (36.2 inches). All but two of these were examined dead. Other examinations, notably pore counts, and development of cheek scales were made on other adults, but these were live, unanesthetized fish from spawning nets and certain measurements and counts were not practical. The total number of muskellunge examined was 83.

Fifty northern pike were studied, three of which were under 100 mm. (3.9 inches) in total length, 22 were between 100 and 200 mm. (3.9–7.9 inches) and the remaining 25 were adults, ranging up to 820 mm. (32.2 inches) in length.

Counts were made of the number of pores of the lateral line system opening into the ventral surface of the mandible. These are referred to as "mandibular pores." Counts were made for the separate half-jaws and were totalled for both jaws. These are presented as Tables 1 and 2.

Counts were also made of the branchiostegal rays on both sides. The analysis of this count apparently was more significant when totalled rather than when given for one side only, and is presented in that manner in Table 3.

Measurements were made of various aspects of the head and three are here presented as being of the most value. These are the measurement of the snout into the length of the head; the length of the maxillary into the length of the head; and the width of the snout into its length. Measurements were made by means of a divider and fractions, to the nearest tenth, were estimated by visual projection in the customary manner. These measurements are reported in Tables 4, 5, and 6.

The development of the scales on the cheek, long a standard taxonomic criterion of the genus *Esox,* was evaluated by estimating the degree of squamation to the nearest tenth. These estimates are presented in Table 7.

Color notes and observations on the size of the mandibular pores were made from living or freshly killed specimens, as were the photographs for the figures.

Characteristics of Hybrids and Parent Forms

Mandibular Pores

Of the several characteristics now in use to distinguish the muskellunge from the northern pike, that of the number of mandibular pores is one of the simplest and probably the most reliable single character. As may be seen from the counts in Table 1, the northern pike almost always has five large pores on each mandible, for a total count of 10, as indicated in Table 2. Individuals do show up where one pore has been doubled and two pores are found to be occupying the site normally occupied by one. One northern pike fingerling from Lake Nebagamon, Douglas County, has only four pores on each mandible, an abnormality apparently caused by the loss of the third pore on each side.

Of 83 muskellunge on which the mandibular pores were counted only two fish had as few as 11 pores. There were several 6–6 counts. The data are tabulated in Tables 1 and 2. In

TABLE 1

MANDIBULAR PORES IN SINGLE JAW

Species	Number of Pores							Average
	4	5	6	7	8	9	10	
Northern	5	93	2	......	......	......	......	4.97
Hybrid	......	13	48	23	4	3	1	6.34
Muskellunge	......	2	50	75	34	3	2	6.95

TABLE 2

TOTAL NUMBER OF MANDIBULAR PORES

Species	Number of Pores in Both Mandibles										Average
	8	9	10	11	12	13	14	15	16	17	
Northern	1	3	44	2	....	....	....	....	....	....	9.94
Hybrid	....	....	2	7	19	7	3	4	3	1	12.67
Muskellunge	....	....	....	2	14	19	23	12	10	3	13.86

addition to the number of pores present, the size of the pores is a very reliable characteristic to distinguish northern pike and muskellunge from one another. This character is one which is not readily measurable nor reducible to tabular form. The mandibular pores correspond in size to the head pores on each species. The differences in size of head pores is well shown in Figures 5 and 7, where the top of the head is pictured.

The hybrids closely approach the muskellunge in the size and number of the head and mandibular pores. This is shown in Tables 1 and 2 and in Figure 6. The average number of pores in the paired mandibles of the hybrid is 12.67 contrasted to a value of 13.86 for the muskellunge and the single pore counts run consistently lower, but the figures are so close that the identification of any single individual on this one character alone is not possible. The mandibular and head pores do appear to be very slightly larger on the hybrids than on muskellunge of comparable size, but the difference is not decided and certainly the pores are not intermediate in size as might be expected.

Branchiostegal Rays

The number of branchiostegal rays, like the mandibular pores, is a character of great value in distinguishing northern pike from muskellunge. The values given by Hubbs and Lagler (1941) hold very well for Wisconsin specimens. The figures for the total number of rays per fish are presented in Table 3. It will be noted that there is no overlap in number between

TABLE 3

TOTAL NUMBER OF BRANCHIOSTEGAL RAYS

Species	Number of Rays													Average
	26	27	28	29	30	31	32	33	34	35	36	37	38	
Northern.	1	1	3	16	18	11	....	....	....	....	....	....	....	29.64
Hybrid...	....	....	....	....	....	....	1	4	4	12	16	5	4	35.50
Muskellunge..	....	....	....	....	....	....	....	1	7	16	8	3	2	35.30

the northern pike and the muskellunge. It was felt that this should be a valuable character for the identification of hybrids, but the counts revealed an almost identical count with that of the muskellunge. The counts for the hybrids, in fact, averaged slightly higher than for the muskellunge, the average total number being 35.50 in the hybrid and 35.30 in the muskellunge. It was noticed there was a considerable tendency among the hybrids to develop some unusually small weak rays at the anterior end of the series. This seems to indicate some disturbance in the ray formation and although the number would indicate complete dominance of this character, the splint-like nature of certain of these rays, especially in the specimens with the higher counts, is indicative of some hereditary tendency to reduce the rays in strength if not in number.

Measurements

Observation indicated that there was a decided difference in the development of the snout and the caudal peduncle on the northern pike as contrasted to the muskellunge, and it appeared that the hybrid specimens were intermediate in these characteristics. Preliminary studies indicated, however, that the differences in the caudal peduncle were more apparent than real, and this measurement was dropped. The values for the width of the snout measured into its length and the length of the

TABLE 4

Length of Snout Measured into Head Length

Species	Total Length in mm.	Times Snout Enters into Head Length								Average
		2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	
Northern	74–200	....	....	2	20	8	1	1	....	2.33
Hybrid	96–200	....	1	13	9	....	....	....	....	2.23
Muskellunge	82–200	1	19	4	1	....	....	....	....	2.12
Northern	over 200	....	....	....	7	3	6	2	....	2.42
Hybrid	over 200	....	....	3	3	10	4	2	1	2.41
Muskellunge	over 200	....	1	1	17	3	2	1	....	2.33

TABLE 5

Width of Snout Measured into its Length

Species	Total Length in mm.	Times Width of Snout Enters its Length													Average
		1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	
Northern	74–200	...	...	...	...	2	5	17	7	...	...	...	...	...	1.70
Hybrid	96–200	...	1	3	1	8	11	4	...	...	...	...	...	...	1.53
Muskellunge	82–200	...	...	...	...	...	1	1	7	5	4	5	1	1	2.04
Northern	over 200	...	2	1	6	2	2	5	...	...	...	...	...	...	1.49
Hybrid	over 200	1	1	7	3	1	1	1	1	...	...	...	...	...	1.39
Muskellunge	over 200	...	...	1	5	2	1	1	...	...	...	...	...	...	1.46

TABLE 6

Length of the Maxillary Measured into the Head

Species	Total Length in mm.	Times Maxillary Enters into Head							Average
		1.9	2.0	2.1	2.2	2.3	2.4	2.5	
Northern	74–200	.....	.....	3	16	12	.....	.....	2.23
Hybrid	96–200	.....	.....	.....	2	12	7	2	2.34
Muskellunge	82–200	.....	.....	.....	1	18	4	2	2.33
Northern	over 200	.....	3	6	7	3	.....	.....	2.15
Hybrid	over 200	4	5	8	4	1	1	.....	2.08
Muskellunge	over 200	1	8	21	9	1	.....	.....	2.10

maxillary measured into the length of the head were continued through as many specimens as were available. The differences did not prove to be as significant as it was thought they might, and there is a decided change in proportions dependent on the size of the fish, but there remains a consistent difference in the three forms and the hybrids do appear to be intermediate. The break in development apparently occurs around the 200 mm. total length stage and consequently the tabulation of these measurements has been made for fish above and below that value. Comparisons should be made between fish of the same size group. The tabulation of these measurements is presented in Tables 4, 5, and 6. Figure 1 also shows to good advantage the longer snout of the young muskellunge when contrasted with that of the younger northern pike. The differences are most pronounced in the young and become obliterated with increasing size.

Cheek Scales

Fishermen have long relied on the presence or absence of cheek scales to distinguish muskellunge from northern pike. The character has, however, been more or less relegated to a secondary place in scientific determinations within recent years. Data were collected on this character from 46 northern pike, 46 hybrids and 42 muskellunge, and tabulated on the degree of development of cheek scales by tenths. The results are summarized on Table 7. Only three northern pike were not fully scaled on the cheeks and the development of scales on these individuals was marked.

TABLE 7

DEVELOPMENT OF CHEEK SCALES

Species	Total Length in mm.	Degree of Squamation of Cheek Expressed in Tenths											Average
		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	
Northern	74–200	...	...	...	...	...	...	...	...	...	...	28	1.00
Hybrid	82–200	12	...	1	2	1	1	...	3	2	...	...	0.14
Muskellunge	96–200	16	1	4	3	...	...	...	...	...	...	...	0.04
Northern	over 200	...	...	...	...	...	...	...	...	8	...	15	0.93
Hybrid	over 200	...	...	...	1	1	2	...	2	4	3	10	0.83
Muskellunge	over 200	...	11	12	12	1	4	...	1	1	...	...	0.25

Only two muskellunge showed cheek squamation in excess of 0.5. The adult hybrids appeared to be intermediate.

In the hybrids and the muskellunge the development of cheek scales occurs rather late in the development of the fish. The differences in average values of specimens over and under 200 mm. shows this very well. The scales appear first as minute embedded particles, quite difficult to distinguish. Only four of 16 hybrids under 100 mm. in length showed any development of cheek scales, and all individuals above 200 mm. had at least a part of the cheek covered with scales.

Coloration and Color Pattern

The color differences between the young of the three forms under consideration is well brought out by the photographs (Figures 1 to 4). In the first few weeks the muskellunge and hybrid fingerlings have similar color patterns. There is, however, a tendency for the markings on the hybrids to be more sharply defined. This can be seen in Figure 1 by comparing muskellunge and hybrid fingerlings of the same age. As the fingerlings become larger, however, (about 70 mm.) the similarity is lost and the hybrids take on a very distinct pattern and are readily distinguishable from true muskellunge. The characteristic "tiger" markings are now developed in the form of vertical bars, separated by white stripes. Figure 2 shows this characteristic pattern in comparison to the muskellunge and northern pike fingerling. In this photograph it is seen that from the side view the dorsal region of the muskellunge is a solid color, while the white stripes of the hybrid continue into the dorsal area. These stripes manifest themselves into a reticulation when the hybrid is viewed from the top (Figure 3). One strong and persistent character of smaller muskellunge fingerlings is the presence of a white stripe down the dorsal mid-line (Figure 4). This character gradually fades away and by the end of the first growing season it has either completely disappeared or is very faint. This stripe also tends to develop on the hybrid, but does not normally continue beyond the nape, as shown in Figure 3.

The adult muskellunge is famous for its color variations but in most cases it can readily be distinguished from the hybrid by the fact that the reticulations of the young hybrid

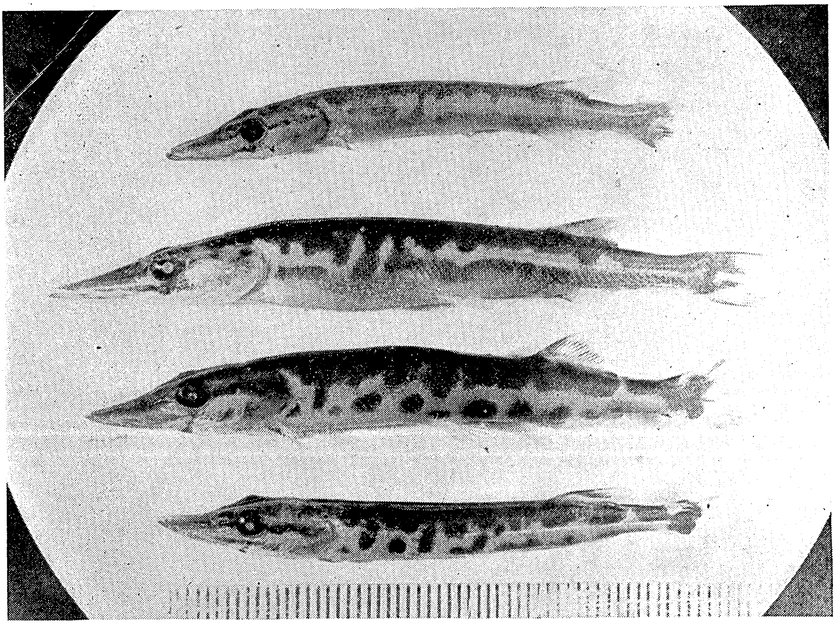

FIG. 1.—Upper: Two muskellunge fingerlings three weeks old; five weeks old. Lower: Two muskellunge x northern pike five weeks, and three weeks old.

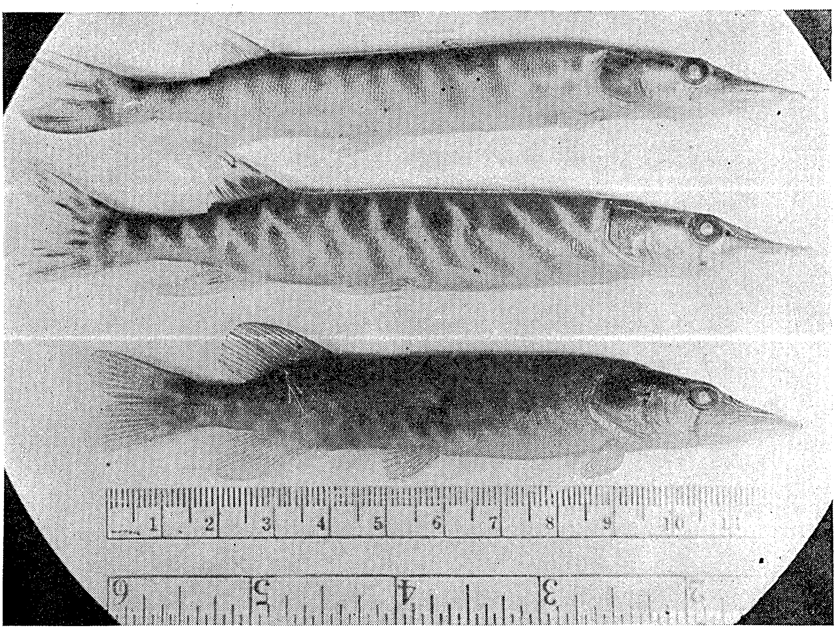

FIG. 2.—Muskellunge fingerling. Center: Muskellunge x northern pike. Lower: Northern pike. All four-months-old fish.

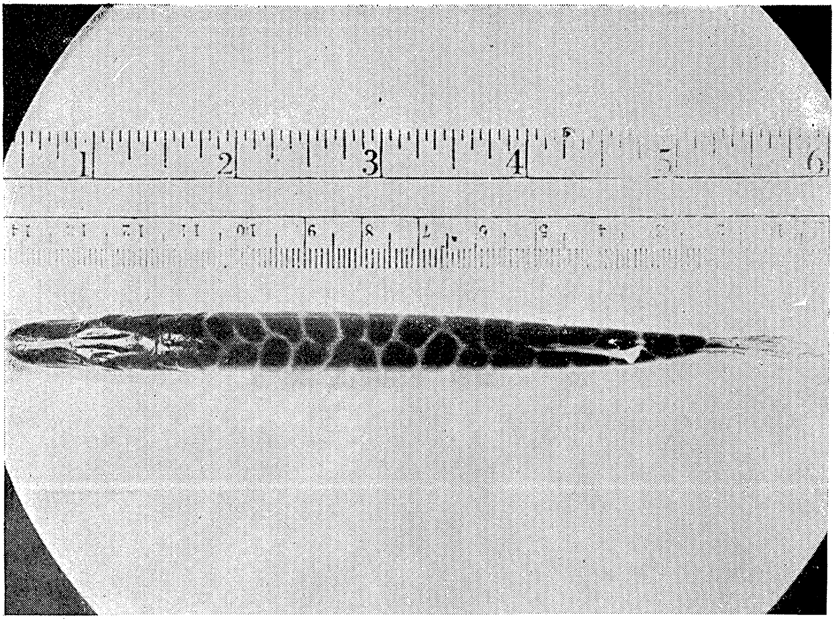

FIG. 3.—Dorsal view of muskellunge x northern pike.

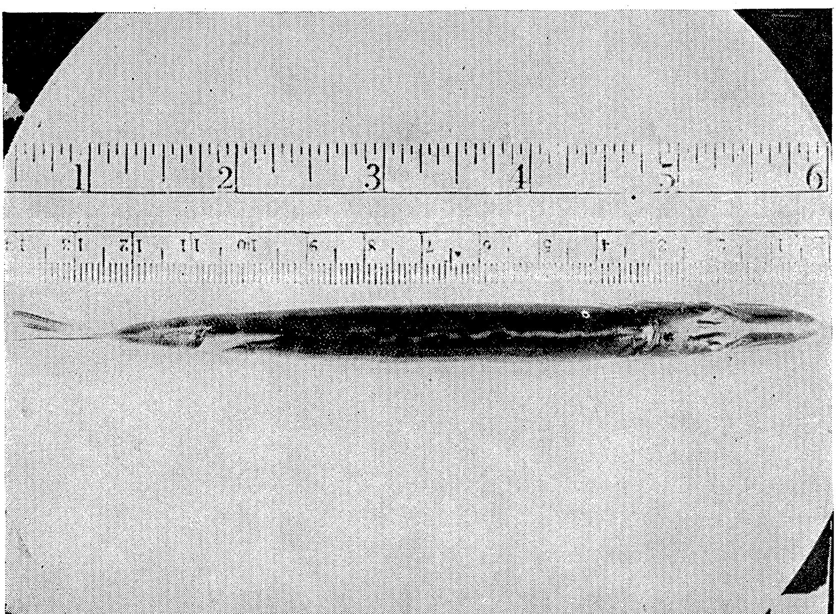

FIG. 4.—Dorsal view of muskellunge fingerling.

FIG. 5.—Head of northern pike, length 52 cm., showing size of head pores.

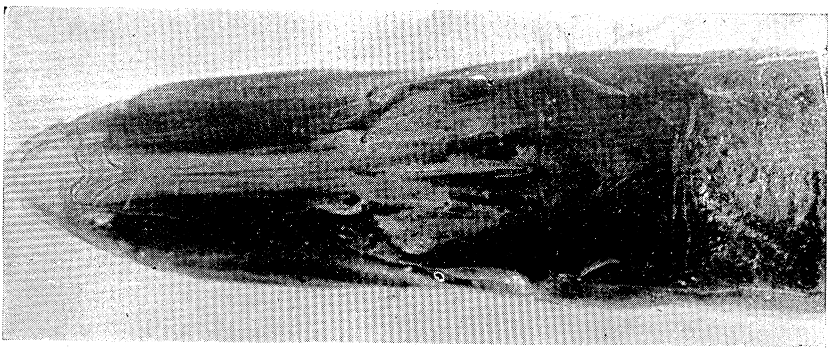

FIG. 6.—Head of muskellunge x northern pike, length 41 cm., showing size of head pores.

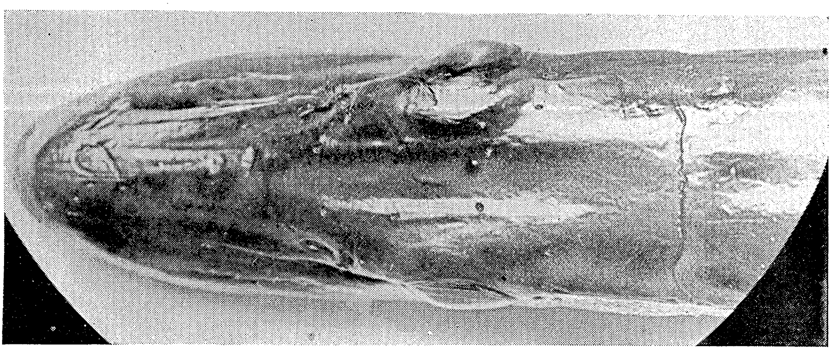

FIG. 7.—Head of muskellunge, length 98 cm., showing size of head pores.

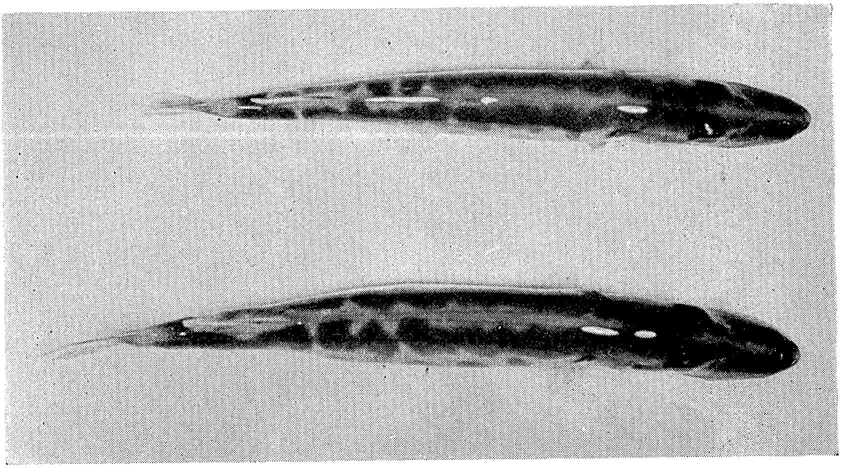

FIG. 8.—Dorsal view of hybrid x northern pike backcross. Five weeks old, length 70 cm.

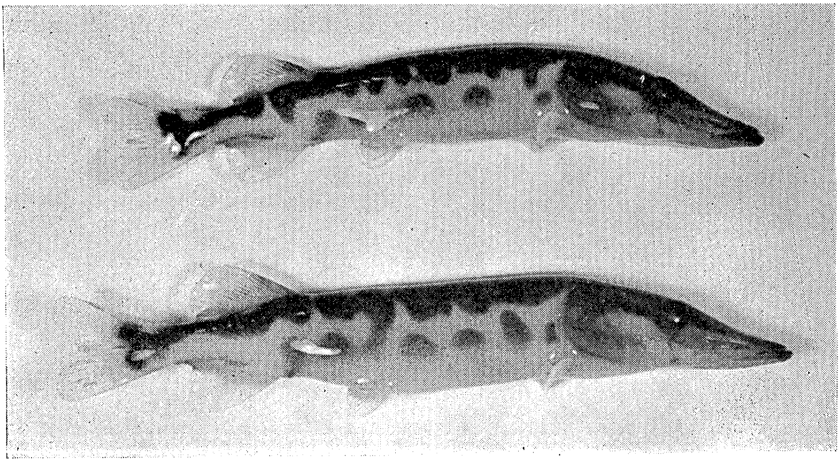

FIG. 9.—Lateral view of hybrid x northern pike backcross. Five weeks old, length 70 cm.

persist throughout life and the adult fish when viewed from above continues to show the light lines cutting through the dark pattern of the back. This is but rarely the case in true muskellunge. The adult pattern of the hybrid is well illustrated by Eddy (1941). Certain individuals from Muskellunge Lake, Vilas County, Wisconsin, very closely approach this hybrid color pattern, but most true muskellunge can be readily identified by the color pattern. The Muskellunge Lake fish are apparently pure muskellunge since there is no record of northern pike from the lake, nor have there been any pike or hybrid plantings there.

Comparison with Supposed Natural Hybrids

During the course of this investigation nine supposed natural hybrids, generally described as "tiger" muskellunge, have been examined. The characteristics of these fish compare favorably with the hybrids produced by artificial crosses. They agree as to color pattern, size and number of head pores and cheek squamation with the artificially produced hybrids. Experienced muskellunge fishermen who have examined the large adult hybrids, especially those from Lake Wingra (the largest), declare them to be the same as the highly prized "tiger" of the northern waters.

Additional evidence that the "tiger" muskellunge is in reality a hybrid is found from the fact that so far no truly authentic "tigers" have been reported from waters in which northern pike were absent, but always from lakes and flowages where both muskellunge and northern pike occur. It is apparent from the account given by Eddy (1941) and Eddy and Surber (1943) that the term "tiger" muskellunge is not applied to the same fish in Wisconsin that it is in Minnesota, where the typical muskellunge is considered a "tiger." The striping of the artificial hybrid, and of the wild so-called "tiger" in northern Wisconsin is a great deal more distinct than that shown by Eddy and Surber in their color plate. This plate is a very good reproduction of the normal or typical muskellunge of this region.

Fertility and Sex Ratio of Hybrids

It has been found that most of the hybrid fish produced or discovered in North American freshwaters are sterile. It was originally hoped that this would be the case with the hybrid muskellunge because it was planned to use the fish extensively in the reduction of pan-fish overpopulations where the permanent introduction of a large predator might upset the balance of the lake and do more harm than the original overpopulation. Results within the past few months indicate that the hybrid muskellunge is not altogether sterile, although it undoubtedly has a greatly reduced fertility.

The largest hybrid muskellunge examined was a ripe female seined from Lake Wingra on April 4, 1945. The ovaries were in a hemorrhagic condition and were partially filled with normal-appearing eggs. Microscopic examination of sections from the fresh ovary made and studied by Professor R. K. Meyer of the University of Wisconsin Department of Zoology, revealed that ovulation had occurred. A second large female from Lake Wingra appeared to have likewise spawned at least part of her eggs.

A large female of the 1939 hatch was examined at the Woodruff Hatchery in the spring of 1945, along with five males of the 1940 hatch. Although northern pike had completed their spawning run at the time and muskellunge were spawning, these fish were all in the "hard" condition. The female and one of the males were injected with a suspension of whole, acetone-dried pituitary of carp, 100 milligrams of the dried carp pituitary being injected into the female and 50 milligrams into the male. (Hasler, Meyer and Field (1940) induced muskellunge to spawn with this dose.) Within five days the female yielded eggs. These were back-crossed with both muskellunge and northern pike. Only a very small quantity of eggs ("several ounces") was secured from the injected female. The eggs were divided into equal lots and one fertilized with milt from a northern pike, the other with milt from a muskellunge.

Only a very few of the backcross combination of hybrid × muskellunge hatched and all of these fry died in the first few hours after hatching.

Both the hatch and the survival of the other backcross, i.e., hybrid × northern pike, were much better. In spite of food-supply difficulties caused by the abnormal spring of 1945, it was possible to bring eight fish through to the five-weeks stage. Three were killed and preserved at this size. The remaining five will be kept alive, if possible, until they become mature.

In hatchery practice two or three quarts of eggs are hatched in each jar. It is extremely difficult to handle and hatch a small lot of eggs properly. For this reason no definite conclusion can be reached regarding the fertility of the hybrid eggs. A rather low yield of eggs and a low fertility is indicated but further study is needed on this point.

The injected male did not yield milt and no attempt to force ripening of the male by repeated injections of the hormone was made. Sectional studies of testes from the largest male, obtained from tissues collected at the peak of the spawning season, tend to confirm our opinion, based on gross anatomical examination, that the males are incapable of producing sperm. The testes appear to be in an arrested state of development in all of the males examined.

Of the 27 hybrid specimens large enough for an accurate determination of sex, 18 were females and nine were males. There appears to be only a relatively slight disturbance in the normal sex ratio.

The three hybrid × northern pike backcross specimens available for study are remarkably uniform in appearance. They are about five weeks old. Dorsal and lateral views of one of these specimens are shown in Figures 8 and 9.

At five weeks of age the color pattern in the genus *Esox* is remarkably uniform for all the species in the genus and there is little distinctive about the backcross individuals.

The light mid-dorsal streak is strong and continues from the tip of the snout to the anterior base of the dorsal fin, being interrupted on the back half of the head. In this character the backcross fish more closely resemble the muskellunge than either the hybrid or the northern pike.

The three specimens at hand are peculiar in that the light mid-dorsal stripe, the tip of the snout, side of the head and tip of the chin are pinkish due to the transparency of the outer skin and the showing through of the blood in these unpigmented areas.

The branchiostegal ray counts on the three specimens at hand are: 18–19, 19–19, and 18–18.

The mandibular pore counts are: 6–5, 6–6, and 5–6.

The scales of the cheek are not yet developed. The snout-head measures are not distinguishable from hybrid specimens of the same size.

SUMMARY

Artificial hybrids between the northern pike, *Esox lucius* (Linnaeus) and the muskellunge, *Esox masquinongy masquinongy* (Mitchill) have been produced in the Woodruff Hatchery of the Wisconsin Conservation Department. These have been studied at various stages in their growth and comparisons made between the hybrids and both of the parent forms.

Fertility in the cross is high, equal to that of either of the parent species.

Analyses of the mandibular pore number, size of the head pores, number of branchiostegal rays, various measurements of the snout, and estimates of the development of the cheek scales were made.

The development of the head pores is to some degree intermediate, but definitely tends more toward the muskellunge than to the northern pike, averaging 4.95 in the northern pike (for one jaw), 6.34 in the hybrid and 6.95 in the muskellunge (Table 1).

The branchiostegal ray count of the hybrid is as high as that of the muskellunge, and is probably due to the development of small rays in the anterior end of the series indicating only a partial suppression of the full development found in the muskellunge. The average total number of rays in the northern pike was 29.64; in the hybrid 35.50; and in the muskellunge 35.30.

The snout measurements indicate a definite difference in snout length of the muskellunge, which has the longer snout, and the northern pike, and indicates that the hybrid is intermediate in this respect. The relative differences in snout length tend to become obliterated with age and are not significant in the adults.

Examination has revealed that the differences in the development of the cheek scales is still a useful character in the distinction of northern pike and muskellunge. The hybrids are intermediate in this character.

The color pattern of the young hybrid musky is quite distinctive, the reticulated marking on the back being diagnostic when contrasted with the dark area in the young muskellunge, which is not broken by cross stripes but which is marked with a sharp, distinct, white mid-dorsal streak. This mid-dorsal

streak of the muskellunge disappears with increasing size, and the normal muskellunge presents an unbroken dark area. The reticulations and light lines across the back of the hybrid persist throughout life and together with the greater development of the cheek scales in the hybrid offer one of the best key characters to its identification.

The characteristics of the adult hatchery-produced hybrids appear to be identical with those of the so-called "tiger" muskellunge, and there is increasing evidence that the "tiger" muskellunge in reality is a natural hybrid between the muskellunge and the northern pike.

Although the fertility appears to be low, recent evidence indicates that the female hybrids, at least, are capable of natural reproduction, that their eggs are fertile and that the resultant young survive at least in the backcross with northern pike. Hybrid × northern pike backcross fish have been studied at the five-weeks-old stage and five others will be reared through to adults if possible. None of the very few hybrid × muskellunge backcross fry which hatched out survived more than a few hours. At five weeks of age, the hybrid northern pike backcross fish more clearly resemble muskellunge than northern pike in color. The pore count averages 5.7 and the branchiostegal ray count averages 18.5 in the three fingerlings examined. Further studies are being made on this aspect of the problem.

Present data indicate that the male hybrids are probably sterile.

ACKNOWLEDGMENTS

Dr. Edw. Schneberger and Mr. D. John O'Donnell, Superintendent of Fisheries and Chief Biologist respectively of the Wisconsin Conservation Department, have jointly supervised the present project and made it possible for us to carry on this study. Valuable suggestions were made concerning the methods of study by Prof. Carl L. Hubbs of the Scripps Institute of Oceanography, University of California. Mr. Arthur Oehmcke, Area Supervisor of the Northeast Fisheries Area, Wisconsin Conservation Department, has provided all the facilities for the spawning and care of the hybrids, the collection of the parent species material and aided the study in every way possible. Mr. Warren Churchill, Northeastern Area Biologist, Wisconsin Conservation Department, injected the adult hybrids, has cared for many of the other details of the project, and is continuing with the care of the young backcross material. Dr. Reeve M. Bailey, Associate Curator, Fish Division, Museum of Zoology, University of Michigan, loaned us the hybrid material in his charge. We are indebted to all of these men for their valuable assistance.

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FOX HYBRIDS[1]

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There are many kinds of foxes, classified in different species and genera, but the present report is chiefly concerned with two of these which have recently been brought under domestication. These are the common red fox (Figure 1), including the various color-phases derived from it, such as standard silver (Figure 2), platinum, pearl platinum, and others, and the Arctic fox, which has two principal color-phases, white (Figure 3) and blue (Figure 4). Under the designation red fox we are including all the geographical "species" and subspecies of the red fox group, as they are apparently capable of interbreeding freely; and for convenience we are referring to them all as *Vulpes vulpes* (the North American equivalent being *Vulpes fulva*). For the same reason we shall not differentiate between the described "species" of the Arctic fox, which is circumpolar in its distribution. The typical form, *Alopex lagopus lagopus*, is "restricted to Arctic regions of Europe and Asia, but said to reach Bering Island in Bering Sea" (Anthony, 1928). In Alaska and Arctic North America to Labrador and Greenland are other related forms, some of which have been dignified by specific names, but practical experience shows that they all interbreed readily and may therefore be lumped together as the "*lagopus* group" without further quarrel as to terminology. Unless specifically indicated otherwise, therefore, references to "Vulpes" will indicate members of the red fox group and "Alopex" those of the *lagopus* group.

Black, or silver, and cross foxes, both of which are color-phases of the red, occur in the wild with considerable frequency

[1] Joint contribution from the Department of Genetics (Paper No 365) and Veterinary Science. Supported in part by Wisconsin Agricultural Experiment Station, Project 614, Fur Farm Research.

[2] At present Lieutenant (j.g.), U.S.N.R. [Since returned]

and their pelts have long been articles of trade. Other color variants also occasionally appear among wild foxes, but most of the newer color-phases have arisen and been established in captivity. Domestication of the silver fox, and the present large industry in this country and Europe, grew slowly from a small and inauspicious beginning on Prince Edward Island in 1887 or 1888 (Ashbrook, 1923; Raynes and Jones, 1912). It was not until 1910 that its "secrets" became generally known and breeding stock available. Early breeding concentrated on the black (dark silver) fox, though later lighter silvers became popular. Other color-phases cropped up as mutations from time to time, but these were looked upon as indications of "impurity" in the stock and were disposed of quickly and quietly. In 1940 a shipment of "platina" pelts, a color-phase started in Norway a few years before, was sent to New York. These skins brought phenomenal prices and stirred up great interest in the "color-phase fox" in this country (Cole and Shackelford, 1943). As a consequence all new types that have appeared have since been eagerly sought and not only cross breeding but hybridization between species has been resorted to in the attempt to produce new colors or color combinations.

The Arctic fox is typically white in winter and sooty brown in the summer. The blue color-phase is everywhere bluish drab and does not change to white in winter. In much of its range the white phase predominates, but in others, notably the Aleutian Islands and the Pribilofs, the blue phase is in the majority. Some management of the Arctic fox population was attempted in Alaska by the Russians, beginning early in the nineteenth century, when they are said to have introduced blue foxes to Kiska Island and to have encouraged the killing off of the whites while protecting the blues. Efforts to raise blue foxes on islands farther to the east and south began about 1885 (Ashbrook, 1925). The foxes run wild on the islands, the natural food obtainable being supplemented by products, mostly fish, from the surrounding waters. In the winter the animals are trapped for their furs, there being some selection of those to be retained as breeders. While this may be referred to as fur farming, it can scarcely be considered domestication. Within the last decade or so, however, fur breeding and management of the Arctic fox, after the manner of the red fox color-phases, has become quite widespread. The blue fox has proven to be very amenable to such conditions.

VULPES–ALOPEX HYBRIDS

There appear to be few, if any, records of Vulpes–Alopex hybrids prior to what may be called their period of domestication. This cannot be due entirely to isolation since the northern range of Vulpes overlaps that of Alopex to a considerable extent. More likely it is due to a natural antipathy of the two species. Also the breeding season of the blue fox is normally considerably later than that of the red.

Case 1. The earliest record of a hybrid between these species which we have been able to locate appeared in the American Fur Breeder in 1929 (Anon., 1929). There it is stated:

> "In December [1928?] a fox breeder from the northwest sent a novel fox pelt into the New York market that created quite a sensation. The breeder claimed that the pelt was the result of a mating between a silver fox and a blue fox.
>
> "The skin was described as a dark, smoky brown, with silvery guard hairs, and lacking the reddish cast observed in many blue foxes.
>
> "The breeder stated that the possibilities of breeding out a hybrid strain of uniform animals from mating blue foxes with silvers is uncertain, as other pups in the same litter were irregularly marked, one having the body pelt of a silver fox with a blue fox's tail."

Although not so stated, it is to be presumed that this mating was made with foxes in confinement and that the silver was the male parent. The description of the pelt agrees well with that of other known hybrids, although the variation said to occur in other members of the litter is rather surprising. The statement that one pup had a "blue fox's tail" presumably implies that it did not have a white tip.

Case 2. The following year (Anon., 1930) the same journal had another note of a hybrid litter, as follows:

> "Mr. P. J. Haggard, owner of the Big Bend Fur Farms at Coleharbor, North Dakota, reports that he has a litter of puppies from a native red female, which was accidentally mated to a blue fox male."

We have no further information of this alleged mating.

Case 3. The next report, in point of time, was made by a Russian worker (Starkov, 1940) and is of especial interest as artificial insemination was employed to produce the cross. The hope was not only to produce in this way a new color characteristic in the silver fox but to combine with it the high prolificacy of the blue fox. Two silver foxes were each inseminated on the first and second day of heat with sperm of the Arctic fox, procured by masturbation. One of the females produced a single hybrid pup. Its juvenile coat was gray and the post-juvenile coloring like that of the Arctic fox. Later it darkened somewhat and assumed more the color of young silver foxes. Growth rate was greater and the eyes opened earlier than in either parental form; also, the body was longer than in silver fox pups of corresponding age. In external appearance the hybrid had resemblances to both parents. It had rounded ears and not only made little jumps like the Arctic fox but growled like one when held up. The legs were long, however, as in the silver. The underfur was light slate color and dense as in the Arctic, but the tail was white at the tip. It is not stated whether the guard hairs were banded, nor is the sex of the pup mentioned. This is mistakenly claimed to be the first demonstration that it is possible to cross these two species.

Case 4. The American Fur Breeder of August, 1941, has the following note (Anon., 1941):

> "Art Doyle of the All Star Ranch at Winnipeg reports a successful mating between a pearl platinum male fox and a Greenland blue female fox. A litter of nine pups resulted consisting of six males and three females. Mr. Doyle says the pups have white-tipped brushes and the ears of a standard fox."

Mr. Doyle has kindly furnished additional information which differs slightly from the note above. It appears that of the nine pups seven, three males and four females, survived, so the complete litter was presumably five males and four females. The surviving males were pelted and attempts made to breed the females. Three of these were paired respectively with pearl platinum silver, white-marked silver and standard silver males, and one with a Greenland blue male. However, no pups were produced by any of the matings and all the hybrid females were pelted the following season. A pronounced peculiarity of these females was their fear during the mating season of any male except a blue (Arctic).

The fur quality of the female hybrids was much better than that of the males and more silvery, the silver being scattered and spikey in appearance in the males. The guard hair was shorter than in silvers; underfur blue.

Case 5. In October, 1941, the authors had opportunity to examine on the ranch of Mr. Sanford Colpitts at Salisbury, N. B., a specimen reputed to be from a mating, made by another breeder, of a red or cross male to a female blue fox. Its general appearance, as well as certain specific genetic characters, indicated its hybrid origin. It was from a litter of eight pups, six of which were dark in appearance, similar to the one in the possession of Mr. Colpitts. The color of the other two pups was not stated; presumably they died very early.

In general appearance this hybrid, a female, was intermediate between the two parent species but resembled rather more the blue fox. Size and ear length were intermediate; fur with the general texture of that of Alopex but of a silver-black color which must have come from Vulpes. Further, she had a striking white tail-tip, which is entirely foreign to Alopex. Figure 6, a photograph taken at the time of our visit, shows the intermediate appearance of the head, the predominantly Alopex coat character and the white tail-tip, which last obviously came from the male parent.

This vixen was three years old at that time. Attempts had been made each year to mate her back to Vulpes males (silvers), but without success. She at no time showed evidence of being in heat.

Case 6. According to a note in the American Fur Breeder (Anon., 1941), John W. Green-Armytage, owner of the Crichton Blue Fox and Fur Ranch at Clarkleigh, Manitoba, reported that he had successfully crossed a white fox with a white-face silver (see Figure 10). Mrs. Green-Armytage has kindly furnished us with additional information. The white male was "Greenland type." There were six pups in the litter, four males and two females. Two of the pups had white faces, a black stripe down the middle of the back, fading into pale reddish on the sides, and a golden color on the belly. It was suggested from this color that they be called "golden platinums." The other four hybrids were much redder, but also had the black stripe down the back. The brush was well described as "golden platinum" and ended in a white tip on all six pups.

Attempts were made to breed male and female hybrids together and also to breed a male hybrid to white-face Vulpes, but were unsuccessful.

Case 7. Silver foxes (Vulpes) were introduced into Iceland at some time in the past and Kristin P. Briem writes in the Black Fox Magazine (Briem, 1941),

> "You might like to know if silver foxes have not got out of the pens and are living wild in the mountains. Several foxes have got away for a time, but they have all been caught, and, mostly shot. This country has no dense woods to give protection to the silver foxes as their countries of origin had. I have only heard of one silver fox vixen that has bred in the wild and had young ones. This spring a vixen was discovered and traced to her lair. She had mated to a white fox and had three pups. I am told two of the pups are as silver foxes, but one is more like the white fox."

This report would seem to indicate that crossing may occur between the two species in the wild when an individual of one species, within the range of the other, can find no representative of its own kind with which to mate.

Case 8. In 1942 and 1943, Mr. Eugene Finlay of Jefferson, Oregon, produced two litters from blue females bred to a silver fox male. The first year this male bred a blue female that had been running in the pen with him. The resulting litter consisted of 10 pups. The following year a strange female was put with the same male, but he had apparently overcome the inter-species antipathy and "she could not bluff him." This female raised a litter of 12 hybrid pups. In 1944 Mr. Finlay attempted to mate a male Cody platinum fox[3] to a blue female. They were placed in adjoining pens, with a six-inch space separating them, to enable them to become acquainted. When put together, they exhibited sexual interest but successful mating was not obtained. A female hybrid retained by Mr. Finlay came in season late and did not breed.

Four of the Finlay hybrids, two males and two females, were obtained by the Associated Fur Farms, Inc., of New Holstein, Wisconsin. One of the females died early in 1943, but in October of that year, the senior author, accompanied by Dr.

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[3] A light strain of platinum silver. See Cole and Shackelford (1943).

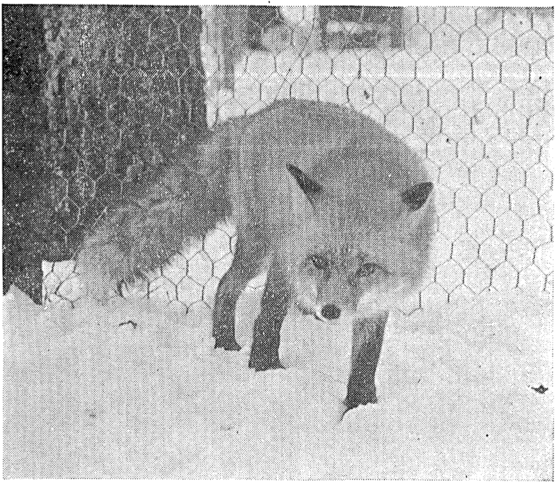

FIG. 1.—North American Red Fox (Vulpes). Photograph courtesy Wisconsin Conservation Department.

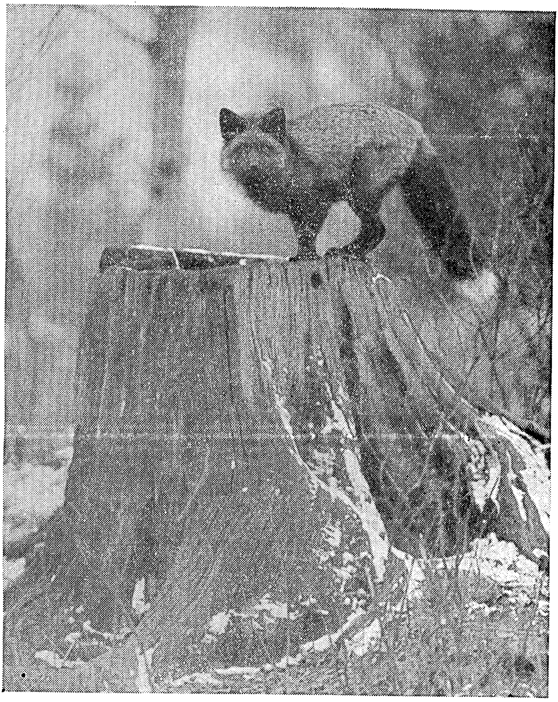

FIG. 2.—Standard Silver Fox (Vulpes). Courtesy American National Fur and Market Journal.

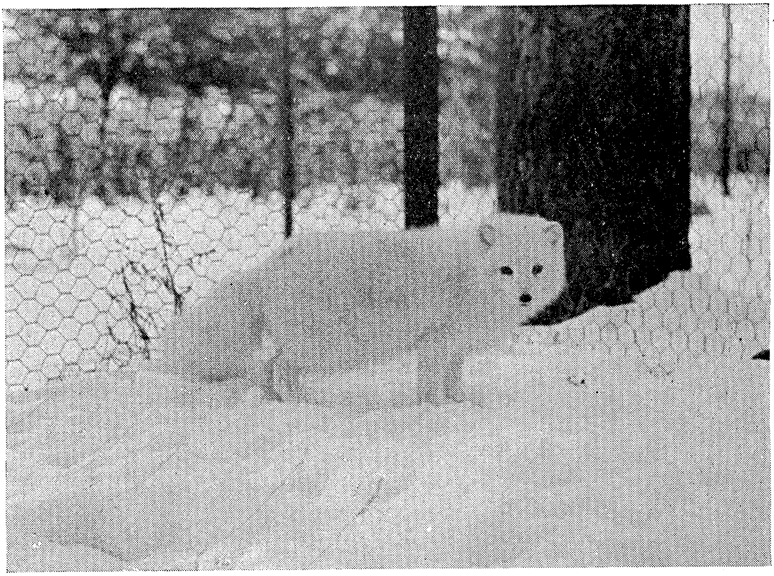

FIG. 3.—White phase Arctic Fox (Alopex) in winter pelage. Photograph from Wisconsin Conservation Department.

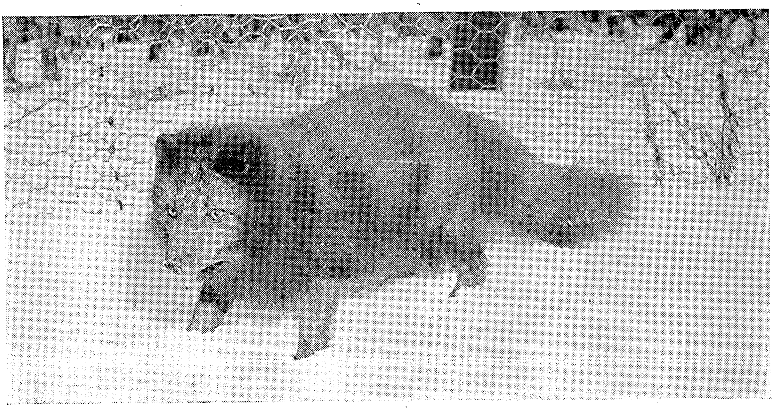

FIG. 4.—Blue phase Arctic Fox (Alopex) in winter pelage.

FIG. 5.—Blue phase Arctic Fox in summer pelage, Aleutian Islands. Photograph courtesy of U. S. Fish and Wildlife Service.

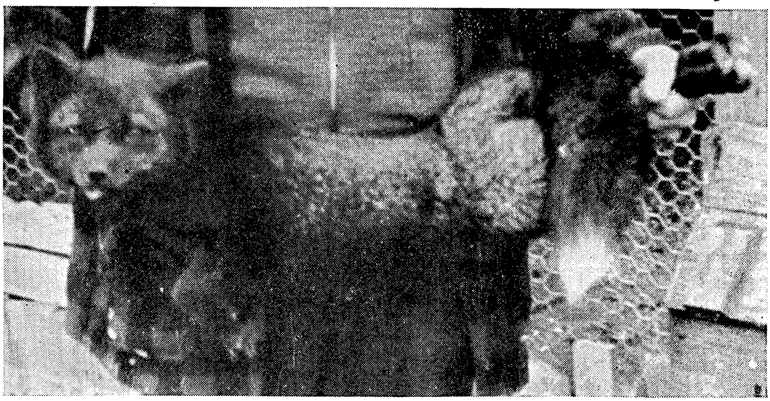

FIG. 6.—Vulpes–Alopex hybrid, female. From ranch of Mr. Sanford Colpitts, Salisbury, N. B. Photographed October, 1941.

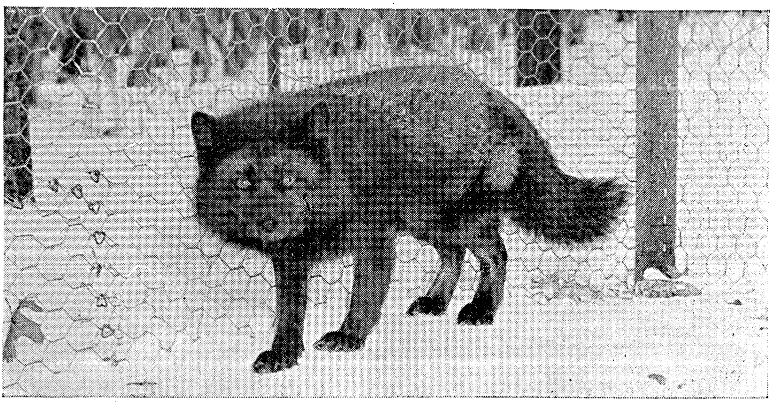

FIG. 7.—Vulpes–Alopex hybrid, male. From Silver male and Blue female parents. Photograph from Wisconsin Conservation Department.

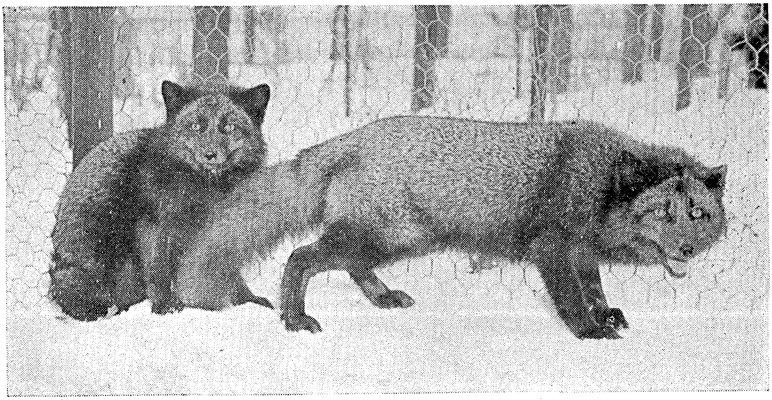

FIG. 8.—Vulpes–Alopex hybrids, female at left, male at right. Same parentage as male in Figure 7. Photograph from Wisconsin Conservation Department.

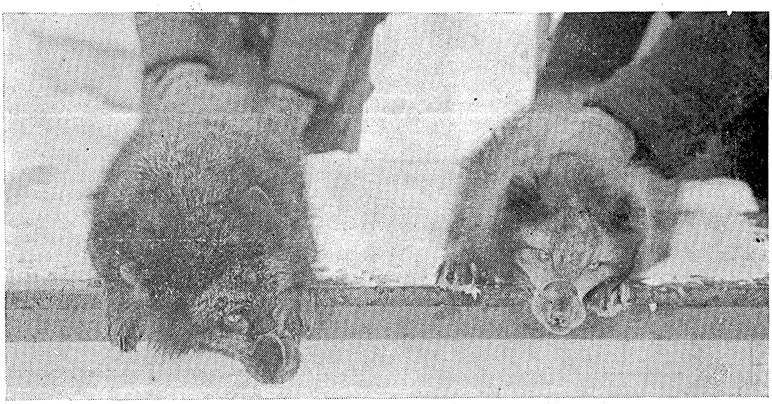

FIG. 9.—Hybrid shown in Figure 7 at left, Blue Fox at right. Photograph from Wisconsin Conservation Department.

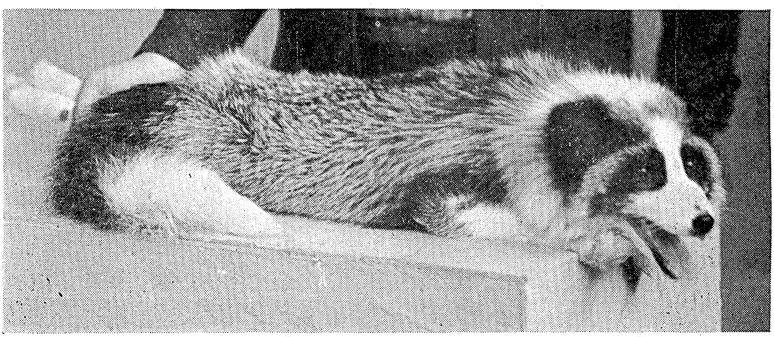

FIG. 10.—White-face color phase of Silver Fox (Vulpes). Photograph from Mr. Bruno Delsman, Hartland, Wisconsin.

C. K. Whitehair, had opportunity to observe the remaining three animals (Figures 7 & 8) at the Elcho, Wisconsin, ranch of the Associated Fur Farms. The female that died had acted as if in heat during the season but had not been seen to breed. Two or three weeks later it was thought she might be pregnant but examination when she died a short time later revealed no embryos. Efforts to breed the other hybrids proving futile, these three animals were generously donated to the Wisconsin State Conservation Department in September, 1944, and have since been available for study on the State Game Farm at Poynette.[4]

TABLE 1

APPROXIMATE MEASUREMENTS, IN INCHES, OF VULPES, ALOPEX, AND HYBRIDS

Taken on live animals at Wisconsin State Game Farm, July 24, 1945. These individuals of Vulpes and Alopex are, of course, not the actual parents of the hybrids.

	Height at Shoulder	Nose to Rump	Tail to End of Flesh	Tail to End of Hair	Ear Length
Native Red (male)....	15¾	25	13	15½	3½
Silver (male)..........	17	25	15	18	3½
Hybrid (male)........	15½	25½	14¼	17	3
Hybrid (female).......	15¼	24½	12½	14½	2¾
Blue (male)...........	13	20½	11¾	13½	2¾

In general features the hybrids are intermediate between the two parent species, but when particular characteristics are considered, some can be seen to be derived from one parent and others from the other. The size, as can be seen from the measurements given in Table 1, approaches more nearly to that of Vulpes. When all three forms are fully furred out, the resemblance to Alopex is heightened by the shorter guard hair, which, together with the heavy coat of underfur, gives Alopex its characteristic "wooly" appearance. In summer, when the winter coat is shed, Vulpes and Alopex do not appear so different in form (compare Figure 5).

[4] We are greatly indebted to Mr. Eugene Finlay, of Oregon, and to Mr. Edw. P. Langenfeld, of the Associated Fur Farms, for information concerning the history of these hybrids. We also wish to thank Mr. W. F. Grimmer, Superintendent of Game Management, who has been most kind in offering us every facility; Dr. G. R. Hartsough [now with Associated Fur Farms, Inc.] and Mr. Thalacher, who aided in handling these not-so-gentle animals; and Mr. Staber Reese, also of the Conservation Department, who took the photographs of them used in this article.

Ear-length is intermediate. The face (Figure 9) appears more to resemble Alopex, but this also is probably in part due to the fur.

The hybrids have the dense wooly under-fur of Alopex, but the guard hair is shorter and consequently the general appearance is smoother. It is also much more silvered than the blue fox. The blue is often silvered in the face, and to some extent over the body, but this is due to the interspersal of white hairs, and not to white bars on the dark hairs. Small samples of fur plucked in December from the side of one of the male hybrids and from a blue female are compared with silver in the following analyses:

Blue fox—
72 percent of the fibers fine, crinkly under-fur, 25 mm. to 35 mm. long; about half of these gray throughout their length, the others with an average of 7 mm. of black at tip;
19 percent medium length guard hairs, 50–60 mm. long, basal two-thirds wavy and white, apical third black;
9 percent long guard hairs (60–80 mm.), very little wavy, white basally, black apically.

Hybrid—
68 percent fine, crinkly, gray to light gray under-fur, 15–30 mm., the longer ones with dark tips;
20 percent about the same length but less crinkly and black, lighter towards the base;
12 percent guard hairs up to 40 mm. in length, black at base and distally but *with a narrow white bar,* averaging 4 or 5 mm., just below the middle.

Silver—
20 percent wavy under-fur, 35–40 mm. in length, gray basally and with black tip;
80 percent guard hairs, 55–70 mm. long; of these about one-fourth gray to white at base, but otherwise black throughout, the other three-quarters similar but with a white bar of 8 or 10 mm. some 10–15 mm. from the tip.

These descriptions and measurements would of course vary a good deal in samples from different animals and if taken at different seasons or from different parts of the body. They do, however, serve to emphasize at least two points. The fur of the hybrid resembles Alopex in being 70 to 80 percent under-fur, and is like the silver in having a white band on the guard hair, a condition that does not seem to be found at all in the blue fox. This silvering, due to the banding of the guard hairs, shows plainly in the photographs. Judged as silvers, they would be put in about the "half" or "three-quarters" class. One of the males—the one with the female (at the right in Figure 8) —is distinctly lighter than the other (Figure 7).

In disposition the hybrids are "all blue fox"; they bark like blue foxes and stand up to an intruder in the pen where a silver would sneak away unless cornered. They however seem stronger and are certainly more vicious to handle than either parent, and show no tendency to become tame, as blue foxes often do.

Discussion

Some interesting conclusions can be drawn from Table 2, which summarizes the principal facts relative to all the hybrids between Vulpes and Alopex known to us. It is significant that the cross can be made in either direction, that is, with either species as the male parent. Whether this can be done with equal facility is not known, but it would seem that in either case special manipulation is necessary to overcome natural antipathies and to insure simultaneous breeding seasons. Furthermore, it is noteworthy, although natural, that the litter size tends to correspond to that of the female parent. Normal litter size in Vulpes is about 4 to 8, while Alopex may have from 8 or 9 to 12 or more pups to a litter. It will be noticed in Cases 6 and 7, in which Vulpes is the mother, the litters are of 6 and 3, respectively. Case 3 was not a normal mating and the litter size of the others is not known. The four known litters of Alopex females (Cases 4, 5 and 8) range from 8 to 12 pups each.

The sex ratio among the pups would be of considerable interest, but unfortunately these data are very inadequate. The only litters for which the records are complete are Cases 4 and 6; these total nine males to six females. The statement on Case 8, that the sexes were "about equal," was an impression from memory. According to "Haldane's law" (Haldane, 1922), an excess of females would be expected in a cross as wide as this, and Craft's (1933) investigation of the mule and other mammalian hybrids seems to support this hypothesis.

TABLE 2

SUMMARY OF KNOWN VULPES–ALOPEX HYBRIDS

CASE	MALE PARENT		FEMALE PARENT		NUMBER OF PUPS	SEXES OF PUPS	COLOR	TAIL TIP
	Genus	Color phase	Genus	Color phase				
1........	Vulpes	Silver	Alopex	Blue	Several	....	Dark smoky brown; silvered	One without white tip
2........	Alopex	Blue	Vulpes	Red	"Litter"	....	....	....
3........	Alopex	White?	Vulpes	Silver	1	....	By artificial insemination. Dark silvered	White tips
4........	Vulpes	Pearl platinum	Alopex	Blue	9	5 ♂ ♂ :4 ♀ ♀	....	White tipped
5........	Vulpes	Red or cross	Alopex	Blue	8	1 ♀ :7?	Dark-silvered	White tipped
6........	Alopex	White	Vulpes	White-face silver	6	4 ♂ ♂ :2 ♀ ♀	Segregation; 2 with white faces	White tipped
7........	Alopex	White	Vulpes	Silver	3	....	2 like silver; one more like white	....
8........	Vulpes	Silver	Alopex	Blue	12 10	"About equal"	Dark-silvered	Colored

The present data for the fox are just the reverse, but they are too few to admit of any definite conclusion.

Except for those cases in which a white Arctic-fox was involved the hybrids are rather consistently dark and silvered, irrespective of the direction of the cross. This would seem to indicate clearly that the barring of the guard hair in Vulpes is dominant to the plain, non-barred hair of the blue fox. Where the white Alopex is used, the evidence is not so clear. In Case 6 there is a further complication in that the mother was a white-face silver. White-face is a dominant character which is lethal in the homozygous condition, hence white-face animals are always heterozygous and segregation is to be expected when they are mated to plain-faced individuals (Cole and Shackelford, 1943). Such segregation evidently occurred in this case as it is mentioned that two of the pups had white faces and it is to be assumed that the others were unmarked. How Case 7 is to be explained is not so clear. There seems to be some indication of "white" and "silver," but the descriptions are too meager to make speculation profitable.

The situation regarding the white tip at the end of the "brush," which is characteristic of Vulpes, is confusing. In general it would appear to be dominant in the cross, but in Case 1 it is stated that one of the litter had the "body pelt of a silver fox with a blue fox's tail." This would suggest it was much like the hybrids in Case 8 and also that there was segregation in the litter. The basis of this segregation is not apparent.

The incentive breeders have had in making the silver by blue-fox cross has been the hope that, by backcrossing, the size of the blues might be increased and the higher productivity of the blues might be introduced into the silvers. Also the range of color in the blues might be extended by bringing into that species the barring from the silver. There seems little prospect, however, that this goal can be attained. All attempts thus far reported to breed the hybrids, either together or back to one of the parental species, have been unsuccessful. As Starkov (1940) pointed out, there is a big discrepancy in the chromosome complements of the two species. In this laboratory Wipf and Shackelford (1942) have verified 34 as the diploid number for Vulpes. Preliminary study of Alopex by Wipf (unpublished) agrees with Andres (1938), who reported 52 chromosomes for Alopex. As might be anticipated, the hybrid complement is apparenty 43. With this situation, infertility of the hybrids is not surprising. Reasoning from analogy, if any fertility is to be obtained, it would probably come from breeding a female hybrid back to the species that was its female parent, that is, a female from a silver father and blue mother to a blue male or from a blue father and silver mother to a silver male.

OTHER HYBRIDS

Since breeders are interested in the possibility of introducing variations into the domestic fox by hybridization, it may be worth while to discuss briefly what is known about crosses with other more or less closely related species. We can make no pretense of having reviewed the literature on the subject thoroughly, but will mention certain instances, known or assumed, that have come to our attention.

Red fox × *Gray fox*. The pelt of the gray fox (*Urocyon cinereoargenteus*, Figure 11) is described as "coarse pepper-and-salt, with the warm buffy under-fur showing through" (Seton, 1937). It has little or nothing to recommend it as a fur that would warrant its introduction into the domestic fox, even were such possible. But in spite of the fact that their ranges overlap in a considerable part of the United States there are few if any authentic records of hybrids between them. Bezdek (1944) has recently described a pelt which showed characteristics of both species and it is assumed to be the result of such a cross-mating in the wild. It had typical red fox face and tail, including the white tip; back, sides and belly typical of normal gray fox. The white tail-tip is interesting since the tail of the gray is black at the tip. This was said to be the only pelt of its kind among many thousands examined. It was considered "almost worthless" by the fur trade.

Bezdek concludes that "the presence of only an occasional report of such a case, and then in widely separated areas, suggests that when (and if) hybridization occurs in these genera, the offspring do not reproduce."

Fox × *Dog*. Hybrids between red fox and domestic dog have been reported from time to time, with what authenticity is not altogether clear. Reuter (1924) has reviewed the situation at some length and concludes that while dogs and foxes

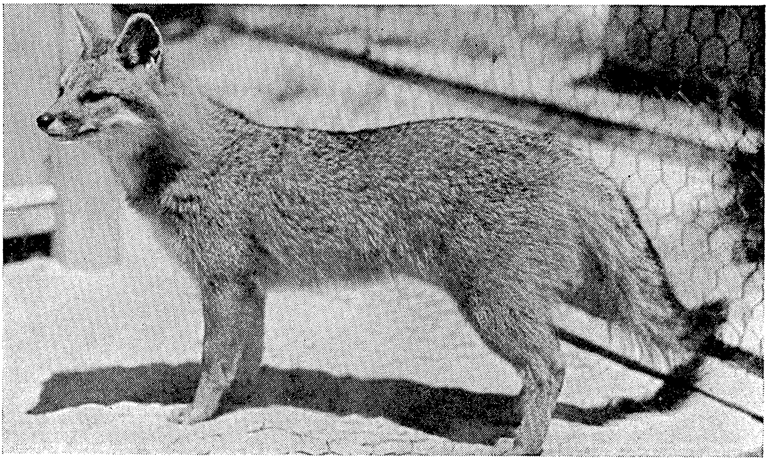

FIG. 11.—Gray Fox *(Urocyon cinereoargenteus)*. Photograph from Wisconsin Conservation Department.

of opposite sex may sometimes manifest sexual attraction during their periods of heat, they have never been known to produce young in the wild. Seton (1937, p. 510) states that he once saw a curious creature at the Cincinnati Zoo that was supposed to be a cross between a fox and a dog, but that its appearance rather suggested a coyote. He also states that Lord Cranley, in England, had for some time a cross between a black-and-tan bitch and a tame male fox and that it was intermediate between the two in color and other external characters, "but strange to say, the tail tip was black."

Heck (1932), Director of the Zoological Park at Hellabrunn–Munich, reports and pictures an apparently authentic hybrid between a male German fox (presumably *Vulpes vulpes*) and a small Spitz-like female dog, although it is not definitely stated that the mating was controlled. The hybrid was reddish in color, but not so deep red as the fox. It had the fine-boned appearance of the fox, a similar "gait" and the restlessness of the fox. The coat was more shaggy than that of the fox and the long, fine hair showed the influence of the Spitz mother. At the time of reporting the hybrid pup was not old enough for its fertility to be tested, but Heck seems to be convinced that occasional individuals of all species hybrids may be fertile in backcrosses and that specific differences may be transferred in this way. As further evidence of the ability of hybrids to breed he cites the mating of a supposed fox-dog hybrid with a female "small American wolf," which resulted in three pups. Unfortunately, too many of the reported cases of hybrids and of their fertility are based on inferences from incomplete information; only carefully controlled experiments can give decisive results. Even if hybrids between dog and fox may be produced, general experience of hybridization would make it appear extremely unlikely that the cross could be carried beyond the first backcross generation at most. Even if possible or desirable, the incorporation of characters of one species into the other would be a difficult task.

Coyote × Fox or Dog. There appears to be no record of the coyote (*Canis latrans*) hybridizing with the fox although they occur together over a considerable part of their range. This is perhaps just as well since the coyote seems to have no characters that would be of interest to the breeder of foxes. According to Seton (1937, p. 401) the coyote crosses readily with the dog and he cites a number of instances. He reports, furthermore, in connection with one case, that the hybrids "were intermediate in character and continued to be interfertile with either stock, at least for two or more generations." Further evidence should be forthcoming before this case is accepted at face value. Dice (1942) has recently given the detailed history of an authentic dog-coyote family. Unfortunately the pups did not live long enough for their fertility to be tested, which would be desirable under strict supervision.

Wolf × Dog or Fox. The North American Gray or Timber wolf (*Canis nubilus* and related species), and apparently also the European wolf (*Canis lupus*), cross so readily with the dog that the geneticist wonders whether they can rightfully be considered as separate species. But in spite of the fact that the wolf and dog are so closely related, there appear to be no records of the wolf crossing with either the fox or the coyote, although their ranges overlap extensively. That these crosses would occur in the wild seems extremely improbable, and so far as is known they have never been attempted with confined animals.

We may conclude, therefore, that while the red fox or its color-phases may under unusual circumstances cross with other related species as well as with the Arctic fox, it is unlikely that any of these crosses will be of practical use to the breeder, first because it is unlikely that such crosses can be carried beyond the first hybrid generation, and second, because anything that might be introduced in this way is in most cases of doubtful value.

Summary

This paper treats primarily of hybrids between the red fox group (*Vulpes vulpes* and related forms, including various color phases) and the white and blue phases of the Arctic fox (*Alopex lagopus*). Eight cases, culled from the literature, supplemented by reports directly from breeders, are summarized. It appears that this cross may be made in either direction with fair facility, but so far as they have been tested, the hybrids have been infertile. In one case the hybridization was accomplished by means of artificial insemination.

The hybrid is in general intermediate and to some extent a combination of the characters of the respective parent species. Rate of growth and size are more like the red fox but the general appearance of the coat resembles more the Arctic fox, especially in amount and fineness of under-fur. Silvering in the blue fox is caused by interspersal of wholly white guard hairs, while silvering in the red fox group is due primarily to a white band on the otherwise black guard hair. This character of banding on the guard hairs is carried by the hybrids and appears to be definitely a dominant. The white tail-tip of the red fox is usually expressed in the hybrid, but some have plain tails and there may be segregation even within a litter.

When the white phase of the Arctic fox is used in the cross, the hybrid pups show considerable reddish on the sides. In this they resemble the Arctic whites in summer pelage, but the red is even more distinct.

Crosses of white-face silver (heterozygous) with blues or whites result in apparently normal segregation of the white-face character in the pups.

The behavior, disposition and voice of the hybrids resemble the blue parent more closely.

The size of the hybrid litters, as might be expected, conforms to that of the species to which the female parent belongs.

Other hybrids, and reported hybrids, between species of the dog family (Canidae) are mentioned briefly. These include, besides the species discussed above, the gray fox (*Urocyon cinereoargenteus*), domestic dog, coyote (*Canis latrans*), and wolf (*Canis lupus,* and species). It is pointed out that these crosses hold little promise of producing anything of value for the practical breeder of fur animals.

Addendum

Just after the manuscript of the foregoing paper was completed there appeared in the *Canadian Silver Fox and Fur* of July, 1945, an article on "Arctic and Greenland Blue Foxes," by J. K. Aylwin, in which it was stated incidentally that experiments had been made on the "crossing of blues and whites with the silver fox and subsequently with the white-face." Upon inquiry, Mr. Aylwin replied that his detailed records were not at present available to him, but he kindly sent considerable general information which serves to corroborate and supplement that already in hand.

In 1931 a blue (Alopex) male was mated to a silver (Vulpes) female, with results similar to those reported above. The progeny were intermediate in size, with the short ear of the blue. Color a blend "but inferior, as far as the fur trade is concerned, to an average specimen of either a straight blue or silver." General appearance more like blues than silvers.

In 1932 and years following the cross of white fox with silver was made both ways. The general makeup and size of the pups were the same as in the previous case, but when the white Alopex is used a very definite red appears on the sides of all the pups (*cf.* Case 6 above).

In 1935 and subsequent years white foxes were crossed with white-face silvers, in both directions. General appearance of the pups was the same but, as reported by Green-Armytage, there was segregation of the white face, some of the pups having it and others not. The red color on the sides is even more pronounced in these white-face individuals, and is pale, giving the appearance of a platinum cross fox. Others are more or less red all over and may be likened to what is known in the fur trade as a "bastard red" (smoky red of Warwick and Hanson, as presented by Ashbrook in his chapter on "The breeding of fur animals" in the U. S. Department of Agriculture *Yearbook* for 1937). This reddish color always shows up when the white Arctic is used in the cross, on some more than on others, and in some cases is comparable to the red of a red fox. In most cases it is more definite than the reddish that appears on the sides of the Arctic fox in summer. These reddish hybrids go through some seasonal color change, but it is not nearly as marked as in the Arctic fox; the reddishness is always present and shows up strongest in the prime coat.

The white tail tip was inconstant among these pups, some of them having it, and others not.

The hybrids seemed to mate normally but, as in all other reports that have come to us, they failed to reproduce.

Addendum (August 1947)

One of the hybrid females mentioned in Case 8 was not observed in heat in 1945 or 1946, but came in heat the past breeding season. An Alopex male was placed with her, and she accepted service on the 24th, 25th and 26th of March; she did not appear to be pregnant at any time and no pups were born. The other female died in November 1945 and was never observed in heat. The male, having been completely castrated in March to obtain material for chromosome studies, was pelted in December 1946; castration appeared to have no affect on the notably vicious disposition of this individual.

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COPPER IN LAKE MUDS FROM LAKES OF THE MADISON AREA

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The use of copper sulfate for the control of algal growths started about 1904 with the work of Moore and Kellerman[1] who canvassed a large number of waterworks superintendents to ascertain the extent of algal growths in open reservoirs. The replies indicated the widespread nuisance created by the odors resulting from the growth of algae in impounded waters and caused them to work out dosages of copper sulfate necessary for the destruction or control of the offending type of algae. Later, after doing considerable field work in various parts of the United States, they published additional work in tabular form.[2] These results are widely used as dosage tables when algae control is contemplated. The city of Madison, Wisconsin was probably the first to apply copper sulfate to open lake water on a large scale for the control of air-borne odors due to algal growths. In 1918 bags of copper sulfate were dragged behind moving boats on Lake Monona. The purpose was to distribute the chemical in an attempt to alleviate the serious odor nuisance which began to appear rather regularly at times, notably during the summer months. About five tons were applied to Lake Monona in this manner during that first summer, but only with limited success in the control of the odors. In the Brittingham Bay area of that lake the treatment proved quite effective. During the following year and thereafter up to 1925 similar treatments were attempted but only in a rather irregular manner. In 1925 Dr. B. D. Domogalla[3] started systematic treatment of the entire lake and used 108,600 pounds of copper sulfate during May to September, inclusive. During the growing season he added about 30,000 pounds of copper sulfate per month. His calculation of distribution dosage was based on the upper fifteen feet of water and he states "In applying copper sulfate care was taken, especially in the bays and shallow waters, to keep the total concentration below six pounds per million gallons which Whipple states will kill fish." During the growing season of each of the next twenty years copper sulfate was applied to the waters of Lake Monona; the amounts and total quantity varied somewhat depending upon the need. Application control and better distribution technique have resulted in the saving of a considerable amount of chemical without reducing the effect of treatment.

The amount of copper sulfate crystals ($CuSO_4.5H_20$) applied annually to Lake Monona is shown in Table 1.

TABLE 1
COPPER SULFATE APPLIED TO LAKE MONONA BY YEARS*

Year	Total pounds	Year	Total pounds
1925	67,200	1935	89,750
1926	75,000	1936	75,800
1927	88,250	1937	81,600
1928	91,300	1938	68,750
1929	82,500	1939	58,393
1930	89,600	1940	67,500
1931	100,200	1941	58,500
1932	92,000	1942	59,100
1933	86,000	1943	68,600
1934	100,500	1944	69,800

* These data were furnished by The Madison Rivers and Lakes Commission through the courtesy of Dr. B. D. Domogalla.

The amounts of copper sulfate applied to Lakes Waubesa and Kegonsa, as furnished by courtesy of the Dane County Clerk, are given in Table 2.

TABLE 2
COPPER SULFATE APPLIED TO LAKES WAUBESA AND KEGONSA

Year	Total pounds	Year	Total pounds
1939	45,000	1942	36,000
1940	50,000	1943	80,000
1941	32,505	1944	100,000

The amounts of copper sulfate applied annually to these three lakes may vary somewhat from year to year; the data given, however, are for the total amounts purchased each year, and include a reasonable stock which is maintained for unexpected emergencies.

An outline map of the geographic relationship of the Madison Lakes is shown in Figure 1, and the physical data in Table 9.

The question of the final disposition of this copper prompted this report. If all the applied copper was deposited uniformly over the entire bottom surface of the lake, 1.2 grams of metallic copper in the form of compounds of copper would be found for each square foot of area. The calculation is for Lake Monona with an area of 5.44 square miles; it does not include the copper sulfate applied intermittently from 1918 to 1925.

In a series of experiments conducted by Woodbury, Palmer, and Walton[4] it was found that when copper sulfate was added to distilled water in a concentration of 1.5 parts per million, large mouth black bass were killed, and it appeared that this concentration in *distilled water* slightly exceeded the toxic limit for this species of fish. However, when a duplicate experiment was carried out with water from Lake Mendota, which has an alkalinity of about 170 parts per million, due principally to calcium and magnesium bicarbonates, the definite toxic limit was found to be about 200 parts of applied copper sulfate per million. The pH of Lake Mendota water, which was the water used in these experiments, has an average value of 8.0. When 200 parts per million of copper sulfate crystals are added to Lake Mendota water a bluish-white precipitate forms and the pH drops to 6.8. If, however, 200 parts of copper sulfate crystals per million are added to distilled water the pH drops to 5.6. The water of Lake Monona has an alkalinity approximately equal to that of Lake Mendota since the principal flowage into Lake Monona is water from Lake Mendota. From these and other qualitative data produced by our experiments we are of the opinion that much of the copper sulphate added to lake waters of notable alkalinity is precipitated as a basic copper compound of somewhat variable composition, depending upon the conditions prevailing at the time the copper was added.

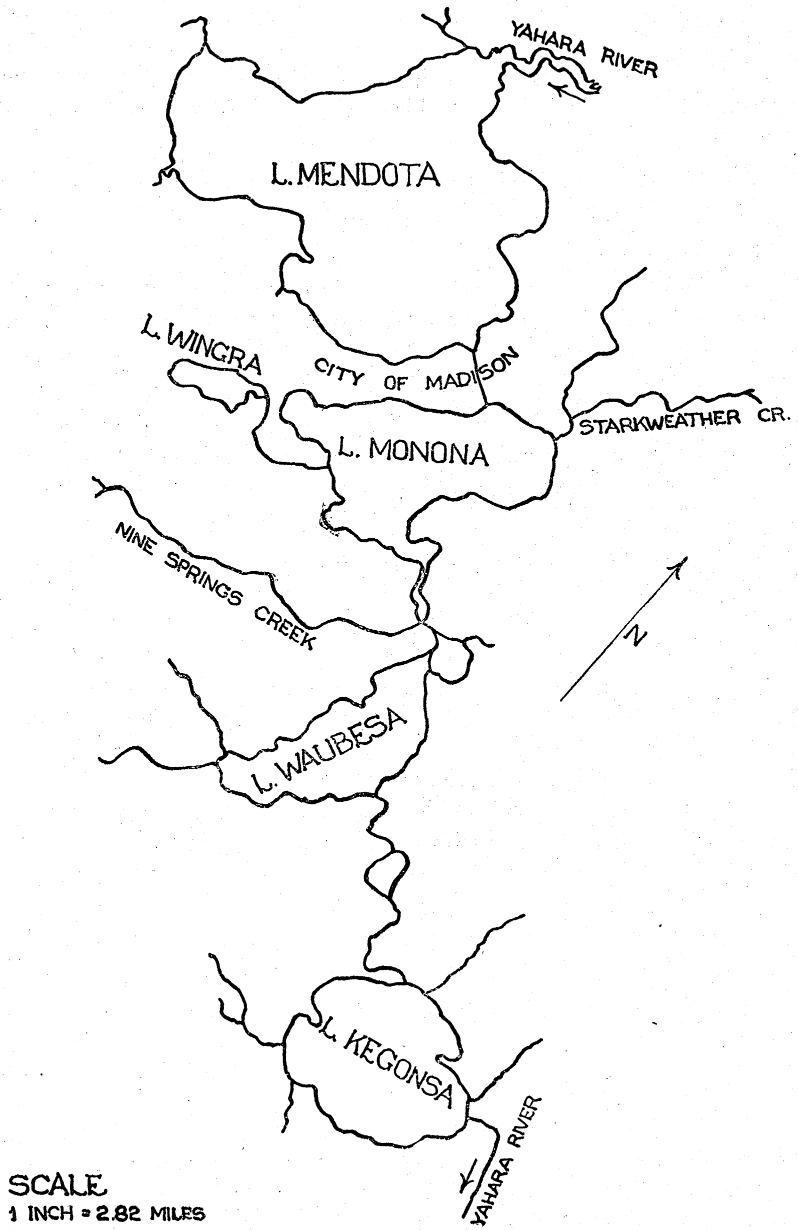

FIG. 1.—Showing geographical relationship of Madison lakes area.

DISTRIBUTION OF COPPER IN LAKE MUDS

Plagues of algae which have continually visited the Madison lakes area for the past seventy-five years and probably long before Madison existed, notably during the summer months, have become increasingly more frequent in occurrence and greater in intensity as the area has grown in population and in agricultural and industrial activity. Some of the reasons for this increase in frequency and intensity of blooming are described in reports by Dr. Clair N. Sawyer whose research on these lakes was performed from 1942 to 1944 under the sponsorship of the Governor's Committee. These reports, "Investigations of the Odor Nuisance Occurring in the Madison Lakes, Particularly Lakes Monona, Waubesa, and Kegonsa," are to be found in the library of the University of Wisconsin. It was during the second period, 1943-44, that Dr. Sawyer studied lake muds; and it was from his samples that most of the work on the copper content was done, notwithstanding that previous to this time Drs. Herman, Woodbury and Bartsch collected about 60 samples of muds from various locations in the Four Lakes chain. There was a total of over 200 samples of bottom muds collected from nearly that many locations. The locations may be ascertained by referring to the maps of the various bodies of water which are included in this report. All of the samples, except core samples, were collected from the bottom surface by means of a dredge constructed on the principle of a "clam shell" loading shovel. The core samples were obtained by use of a Jenkins sampler obtained through the courtesy of Professor W. H. Twenhofel of the University of Wisconsin. The samples collected varied in consistency and composition from black top slurry to rather stiff, compacted mud. A very few of the samples collected near the shore line were principally sand, while others were mixed with gravel. In all cases a representative sample consisting of about six ounces wet weight was transferred from the collection dredge to glass bottles with bakelite screw caps. Each sample was evaporated to dryness on a steam bath and afterwards dried in an oven at 105° C. to remove the last trace of moisture. The entire sample was ground in a mortar to homogeneity. Gravel and sandy samples were not reduced to a powder since naturally occurring copper was not sought.

COPPER DETERMINATION

Two sets of determinations were made. The first determination was for total copper and was intended to include all copper from the organic matter and that copper precipitated as a salt by virtue of the alkalinity of the lake waters. The second determination was made in such a manner that little of the organically combined copper would be recovered. One gram of the dried pulverized sample was taken for analysis in each case.

DETERMINATION OF TOTAL COPPER

One gram of the finely divided dried mud powder was transferred to a Kjeldahl flask, 20 ml. of concentrated sulfuric acid added, and the mixture digested until nearly colorless. The sample was cooled and 100 ml. of distilled water was added and the insoluble residue filtered off. The filtrate was then treated with 2 ml. of 30 percent hydrogen peroxide and again digested until entirely colorless. The digest was then cooled, about 50 ml. of distilled water added and then neutralized with concentrated ammonium hydroxide using a piece of litmus paper as an indicator. The neutralized sample was then filtered to remove the precipitated iron. The prepared filtrate containing the copper was transferred to a 125-ml. separatory funnel, 5 ml. of alkaline ammonium citrate solution and 5 ml. of sodium diethyldithiocarbamate solution were added and the whole mixed well. (The alkaline ammonium citrate solution consists of 80 ml. of concentrated ammonium hydroxide and 420 ml. of distilled water in which are dissolved 20 grams of ammonium citrate. The sodium diethyldithiocarbamate solution contains 0.5 percent of the reagent dissolved in distilled water.) After about 5 minutes had elapsed for the development of the copper carbamate color, 10 ml. of amyl acetate was added and the color extracted. Standards containing varying amounts of copper (0, 0.05, 0.1, 0.3 and 0.5 mg.) were prepared in exactly the same manner and a curve drawn from readings using a No. 430 filter and a Leitz-Maas photo-colorimeter. To make readings of the copper content of the samples, the amyl acetate solution of the color complex was placed in the photo-colorimeter and the reagent blank used to obtain 100 percent transmission, after which the colored sample containing copper complex was immediately read for percentage transmission. By reference to the standard curve the results in milligrams were then obtained. Since our results are given in milligrams per kilogram, the milligrams of copper per gram of sample were then multiplied by 1000.

Soluble Copper

A homogenous one-gram powdered sample of dried mud was transferred to a Kjeldahl flask, 100 ml. of 0.1 N hydrochloric acid was added and the contents boiled for one minute. The mixture was filtered while hot, 15 ml. of concentrated sulfuric acid added to the filtrate, evaporated to remove the water and digested until colorless. The sample was cooled, 50 ml. of distilled water added, cooled again and then neutralized with concentrated ammonium hydroxide. The solution was filtered to remove the iron hydroxide, treated with the copper reagents, extracted with amyl acetate and the copper was determined the same as for total copper.

Figure 2 shows the first forty-four samples as extracted with amyl acetate and gives an idea of the intensity of the colors obtained.

In Tables 3, 4, 5, 6, and 7 are given the data for both soluble and total copper calculated as metal. The accompanying maps Figures 3, 4, 5, and 6 show the locations of the sampling points from which the samples were obtained. The

TABLE 3

Lake Mendota. Total and Soluble Copper Found in Muds from Bottom of this Lake at Various Depths

(For location of sampling points consult the map of this lake)

Sample No.	Depth in Meters	Copper as Cu mg./kg. (dry mud)		Sample No.	Depth in Meters	Copper as Cu mg./kg. (dry mud)	
		Total	Soluble			Total	Soluble
1	0.91	32	2	7	8.5	48	12
2	12.1	60	2	8	1.4	30	2
3	23.4	68	6	9	1.4	45	6
4	13.6	55	11	200	24	145	100
5	1.5	....	....	201	24	25	4
6	17.0	50	31	206	18.7	135	44

TABLE 4

LAKE MONONA. TOTAL AND SOLUBLE COPPER FOUND IN MUDS FROM BOTTOM OF THIS LAKE FOR VARIOUS DEPTHS

(For location of sampling points consult the map of this lake)

SAMPLE No.	DEPTH IN METERS	COPPER as Cu mg./kg. (dry mud)		SAMPLE No.	DEPTH IN METERS	COPPER as Cu mg./kg. (dry mud)	
		Total	Soluble			Total	Soluble
10	0.91	440	280	147	6	155	122
11	17.2	500	352	148	17	690	400
12	13.0	400	331	149	15	680	400
13	1.1	70	26	150	13	640	343
14	2.7	73	23	151	20	690	317
15	2.7	45	13	152	18	690	308
16	1.8	110	100	153	16	690	343
17	0.5	28	4	154	14	640	336
18	3.3	335	210	155	12	790	360
45	0.9	27	25	156	10	360	185
46	1.2	18	12	157	8	200	18
48	0.6	23	11	158	20	590	380
49	6.0	320	200	159	18	600	337
50	2.7	50	1	160	18	680	355
51	7.3	80	18	161	16	690	360
52	3.3	150	62	162	14	993	360
53	0.97	390	308	163	12	1093	343
54	6.4	50	31	164	10	593	337
55	4.6	55	26	165	8	383	255
56	5.5	260	155	166	6	293	245
57	5.2	130	87	167	4	173	130
58	2.1	110	37	168	12	593	320
66	7.5	27	10	169	10	363	160
67	11	222	150	170	8	243	12
68	16	587	285	171	6	133	35
69	17.5	687	285	172	12	643	360
70	20	687	320	173	10	703	365
71	21.5	837	330	174	8	53	32
139	20	641	317	175	12	643	360
140	18	841	390	176	10	693	337
141	16	591	320	177	8	643	175
142	14	541	305	178	6	233	18
143	14	741	337	179	4	123	43
144	12	640	337	180	2.5	745	320
145	10	610	360	181	2	320	30
146	8	280	190	....	....	....	....

TABLE 5

LAKE WINGRA. TOTAL AND SOLUBLE COPPER FOUND IN MUDS FROM BOTTOM OF THIS LAKE AT VARIOUS DEPTHS

(For location of sampling points consult the map of this lake)

Sample No.	Depth in Meters	Copper as Cu mg./kg. (dry mud)		Sample No.	Depth in Meters	Copper as Cu mg./kg. (dry mud)	
		Total	Soluble			Total	Soluble
26	1.8	18	2	28	1.5	33	4
27	3.3	33	13	....	....	....	....

TABLE 6

LAKE WAUBESA. TOTAL AND SOLUBLE COPPER FOUND IN MUDS FROM THIS LAKE AT VARIOUS DEPTHS

(For location of sampling points consult the map of this lake)

Sample No.	Depth in Meters	Copper as Cu mg./kg. (dry mud)		Sample No.	Depth in Meters	Copper as Cu mg./kg. (dry mud)	
		Total	Soluble			Total	Soluble
19	1.5	175	80	88	9	221	62
20	0.91	135	50	89	8	104	6
21	4.3	245	101	90	10.5	258	230
22	10.6	400	251	91	10.5	314	230
23	8.8	415	260	92	10	278	240
24	2.1	145	62	93	9	329	235
25	0.6	22	6	94	8	353	200
29	0.91	138	50	95	7	268	200
72	3	18	15	96	6	318	50
73	6	52	25	97	5	261	62
74	7	117	20	98	4	196	90
75	9	307	110	99	3	96	6
76	10.5	277	140	100	2	146	6
77	bottom	252	16	101	1	206	27
78	2	118	2	102	10	296	165
79	3	115	2	103	9	313	155
80	4	148	37	104	8	356	270
81	5	159	13	105	7	214	37
82	6	135	6	106	6	176	62
83	7	117	51	107	5	145	80
84	8	305	250	108	4	275	130
85	9	179	130	109	3	250	165
86	10	305	200	110	2	150	12
87	10	349	240	111	1	28	12

TABLE 7

LAKE KEGONSA. TOTAL AND SOLUBLE COPPER FOUND IN MUDS FROM THIS LAKE AT VARIOUS DEPTHS

(For location of sampling points consult the map of this lake)

Sample No.	Depth in Meters	Copper as Cu mg./kg. (dry mud)		Sample No.	Depth in Meters	Copper as Cu mg./kg. (dry mud)	
		Total	Soluble			Total	Soluble
30	0.6	60	13	121	4	224	68
31	0.76	42	12	122	3	104	31
32	0.91	30	2	123	2	39	3
33	6.4	78	40	124	8	149	37
34	8.2	178	130	125	7	189	90
35	10	180	100	126	6	179	78
36	6.7	75	38	127	5	194	80
37	0.6	18	1	128	4	139	48
60	6	67	10	139	3	94	60
61	7	67	31	130	9.5	336	100
62	8.5	132	50	131	9	331	87
63	9.5	172	90	132	8	201	110
112	10	175	160	133	7	141	62
113	8	316	130	134	6	181	75
114	8	134	52	135	5	131	70
115	7	119	62	136	4	31	13
116	9.5	159	60	193	9	235	62
117	8	119	26	194	9	230	100
118	7	129	26	207	....	595	11
119	6	214	51	208	....	220	14
120	5	124	87	....	....	....	....

numbers on the lines correspond to the sample numbers given in the tables; the numbers in the circles show the total copper in milligrams per kilogram of dry mud for each sampling point. The tables also show the depth of the water at the place each sample was taken.

DISCUSSION OF RESULTS

It will be noted from Tables 1 and 2 that Lake Monona has received copper sulfate treatment for algal control for a much longer period than have Lakes Waubesa and Kegonsa. Furthermore, during the years of treatment of Lakes Waubesa and Kegonsa, these lakes were not "dosed" as heavily as Lake Monona. This is reflected in the amount of copper found in the layers of mud from these three lakes. In Table 3 for Lake Mendota we find a low result for copper in the mud except for two locations near which some slight copper sulfate treatment

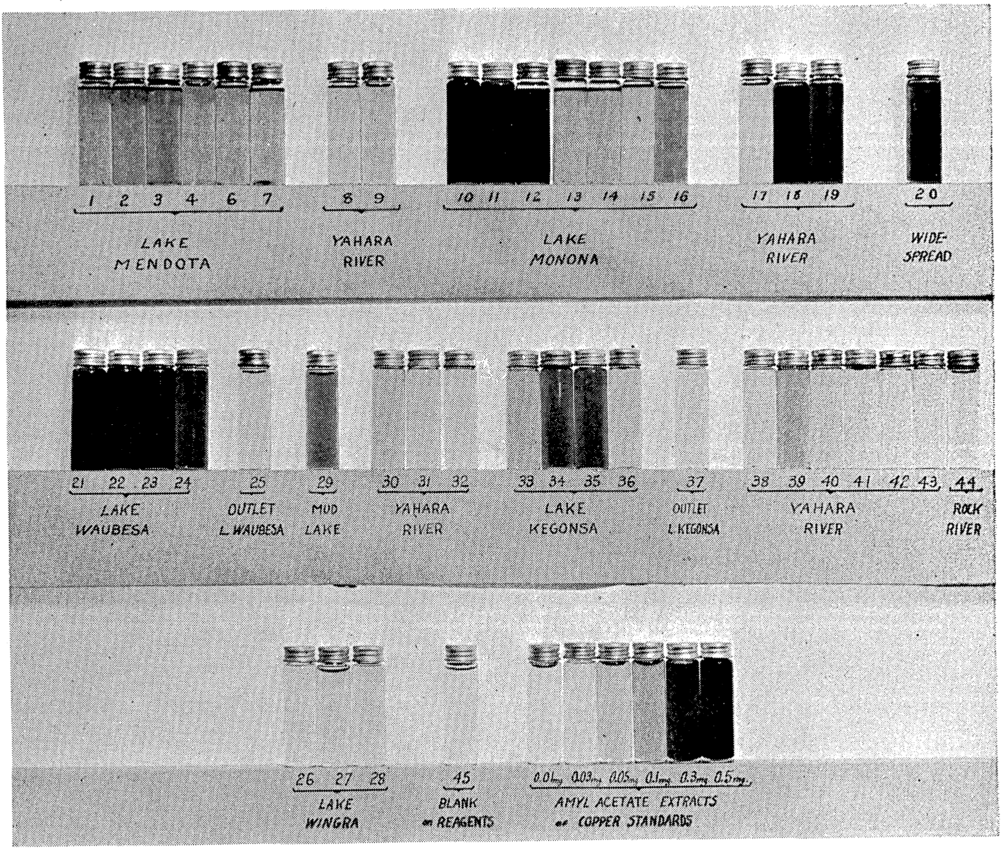

FIG. 2.—Showing the intensities of color produced by copper diethyldithiocarbamate in amyl acetate solution from some of the determinations of copper in lake muds.

had been applied. Lake Mendota results for copper in lake muds, except for the two locations mentioned, serve as a normal result for copper in muds from untreated waters. That these low results for Lake Mendota muds are in conformity with other untreated lakes is shown by results obtained from Lake Wingra which are shown in Table 5. Likewise, a sample furnished by Professor W. H. Twenhofel, of mud from Allequash Lake, located in the northern section of Wisconsin, showed a similar amount of copper, 25 milligrams per kilogram of dried mud. These two lakes (Wingra, Allequash) had received no copper treatment. Contrasting these findings for non-treated lakes with those receiving treatment, we find in all cases a substantial increase in the copper content of muds from treated lakes with the most marked increase in muds from Lake Monona. This is what would be expected since this lake has received more copper and for a longer time than have the others, Lakes Waubesa and Kegonsa.

The distribution of the precipitated copper in the treated lakes is of interest. A study of Figure 4 shows the greatest concentration of copper in the deeper parts of the lake. Sample No. 163 in Table 4 shows the highest copper content found —1093 mg. per kilogram. While the depth here is only 12 meters that sampling point is near a heavily sprayed area on the northeast shore. Other samples from deep sampling points in this area are also high in copper, while shallower parts in adjacent areas show less. It seems that the natural grading process tends to carry the precipitated copper compounds to lower levels. Somewhat the same results for distribution of copper are shown for both Lakes Waubesa and Kegonsa in Figures 5 and 6.

Results for the core samples are also worthy of note. From Table 8 it is seen that in Mendota muds there is no appreciable change in the copper content as the core penetrated to 8 feet, while in Monona a five-fold increase is shown down to a penetration of four feet into the bottom mud. In Lakes Waubesa and Kegonsa the penetration of copper had not extended below the one-foot level. Interpretation of the penetration of copper could be made upon the assumption that four feet of mud had deposited since the treatments were begun some 20 years ago, but such a rapid filling of the lake does not seem probable. Possibly there was considerable more filling at the point at which the core sample was taken. Action of burrowing fauna may have caused a mixing of the upper layers to this depth.

Any calculation of the total amount of copper deposited in a lake such as Lake Monona is fraught with many difficulties and assumptions. The area of Lake Monona is 5.44 square miles but in many places the muddy deposit does not extend entirely to the shore. Furthermore, the grading process in this lake, as in many lakes, has carried the fine material out to deeper water. Thus we find that the deposit containing excess copper

TABLE 8

CORE SAMPLES OF LAKE MUDS FROM THE VARIOUS LAKES

(For location of sampling points consult the map of these lakes)

DEPTH OF SAMPLE FT.	TOTAL COPPER as Cu in mg./kg. (dried mud)							
	Mendota		Monona		Waubesa		Kegonsa	
	Sample No.	Total Cu	Sample No.	Total Cu	Sample No.	Total Cu	Sample No.	Total Cu
0–1	......	......	195	595	187	215	182	105
1–2	202	25	196	225	188	30	183	95
2–3	203	20	197	245	189	38	184	47
3–4	204	7	198	230	190	60	185	20
4–8	205	26	199	8	191	18	186	7

TABLE 9

PHYSICAL DATA AND ALKALINITY OF WATER OF LAKES STUDIED

TYPE OF DATA	NAMES OF LAKES				
	Mendota	Monona	Waubesa	Kegonsa	Wingra
Common name of lake	Fourth	Third	Second	First	....
Length in miles	5.9	4.16	4.2	3.0	1.0
Width in miles	4.6	2.4	1.4	2.25	0.37
Area in square miles	15.2	5.44	3.18	4.91	0.37
Maximum depth meters	26.0	23.0	11.2	9.6	4.3
Average depth meters	12.2	8.5	4.9	4.6	2.7
Average drop between lakes in inches	36	3.4	18		
Volume water millions of gallons	126,385	31,409	10,634	15,603	1,479
Alkalinity as $CaCO_3$ in parts per million	168	176	195	200	170

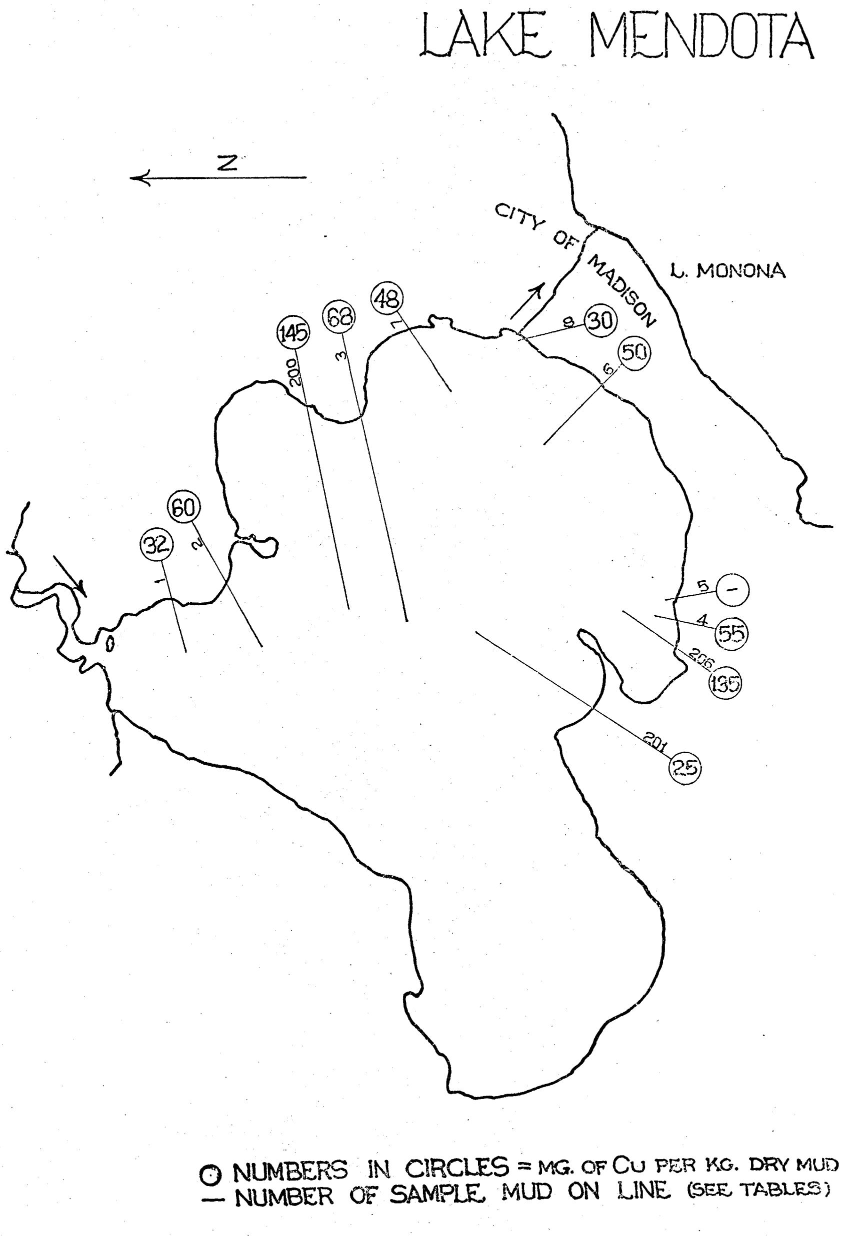

FIG. 3.—Outline map of Lake Mendota showing location of sampling points, sample numbers corresponding to data in tables at these points, and amount of copper found at the several sampling points. (c) refers to core samples.

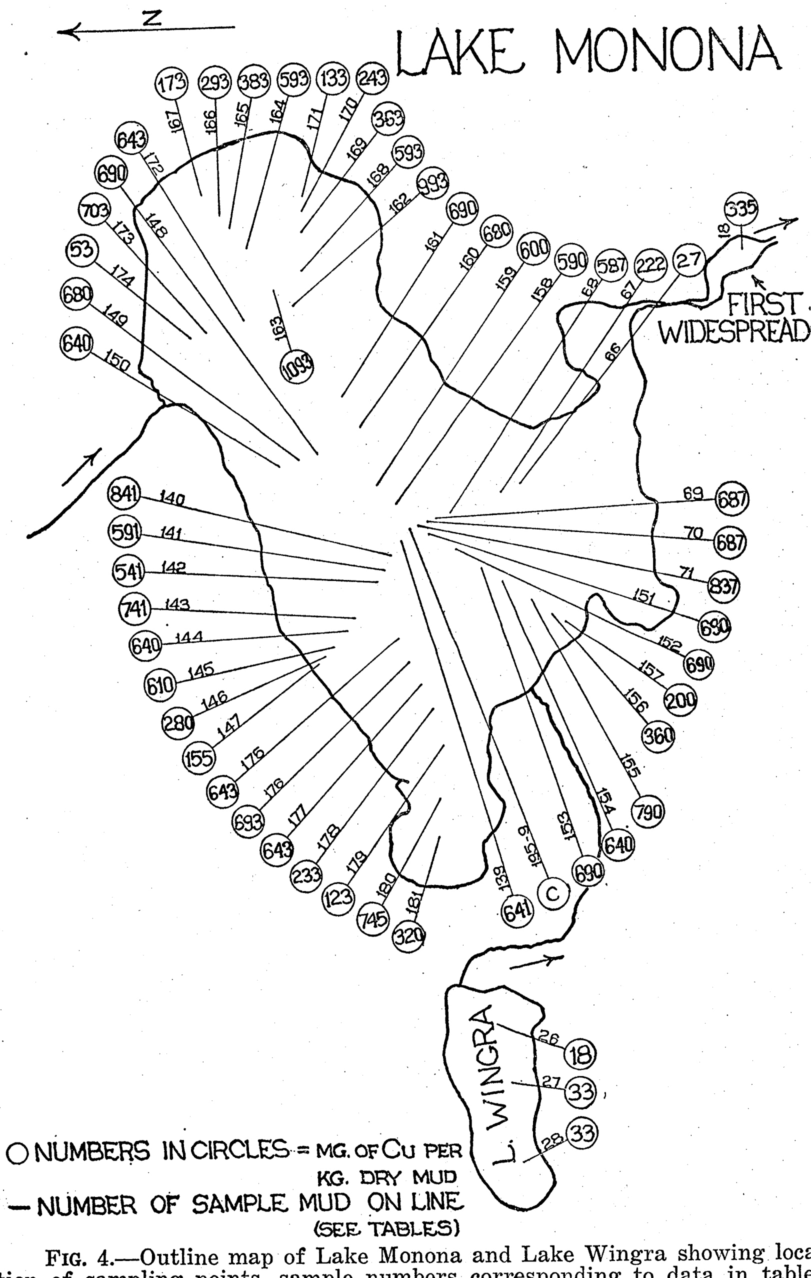

FIG. 4.—Outline map of Lake Monona and Lake Wingra showing location of sampling points, sample numbers corresponding to data in tables at these points, and amount of copper found at the several sampling points. (c) refers to core samples.

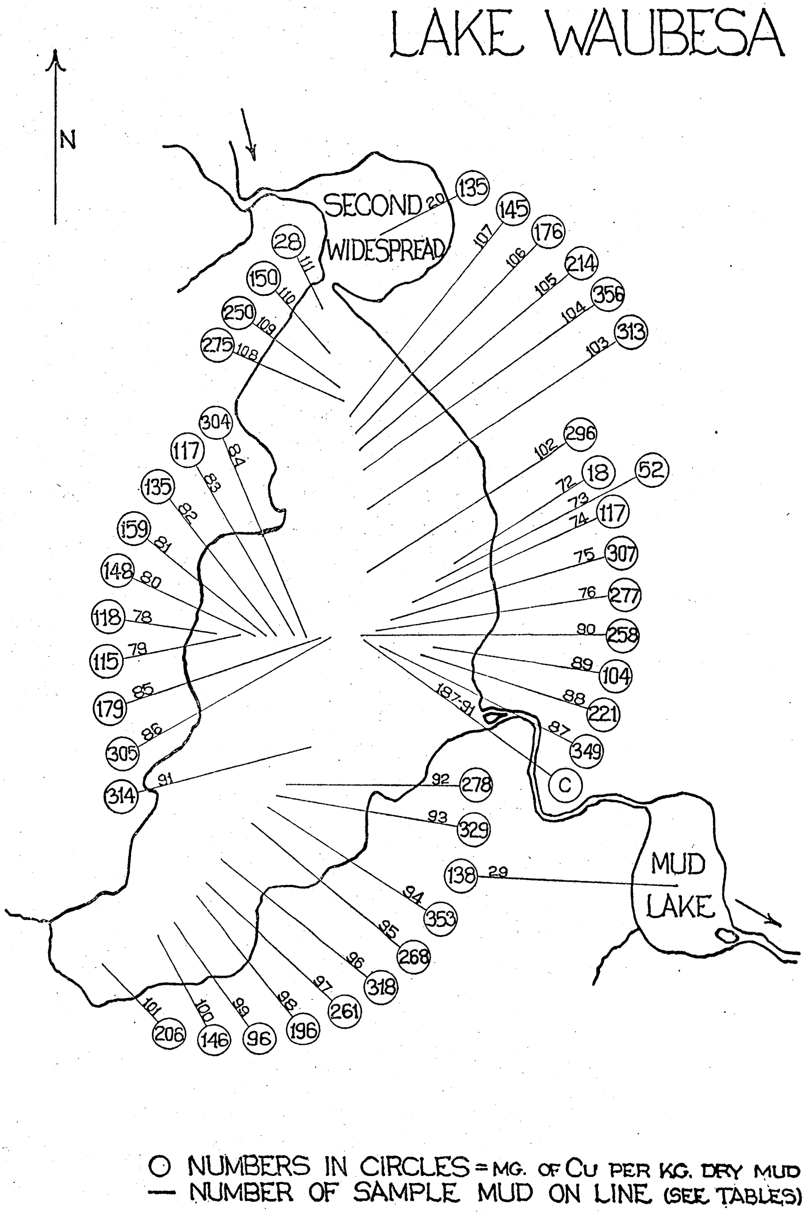

FIG. 5.—Outline map of Lake Waubesa showing location of sampling points, sample numbers corresponding to data in tables at these points, and amount of copper found at the several sampling points. (c) refers to core samples.

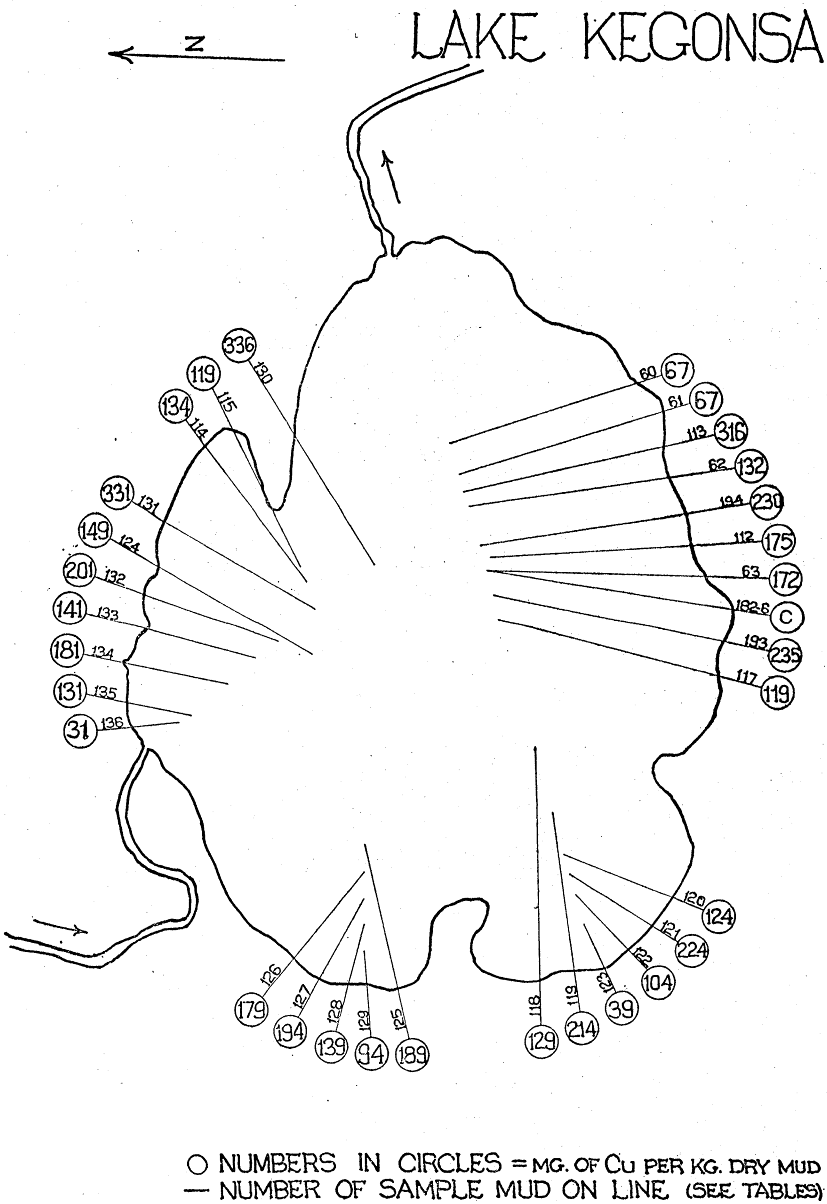

FIG. 6.—Outline map of Lake Kegonsa showing location of sampling points, sample numbers corresponding to data in the tables at these points, and amount of copper found at the several sampling points. (c) refers to core samples.

is about three feet thick in the deep part of the lake, while at the periphery the deposit thins out to nothing. We can offer a calculation of the amount of mud in the lake which contains excess copper by *assuming* that we have a cone of mud approximately five square miles in area at the base and three and one-half feet deep in center; this assumption may be far from true, however, since no attempt was made to "cone sample" the lake bottom systematically. On this basis, as a beginning, we have a cone of 140 million square feet at base with a maximum height of about 3.5 feet containing deposited copper. Furthermore, there should be (1/3 h a = volume; h = height and a = area of base) approximately 160 million cubic feet of mud deposit in this lake, allowing for the 0.44 square mile of shore area which has little mud deposit. From Dr. Sawyer's report the mud is approximately 15 percent solid matter by weight, and considering the solid matter to have a specific gravity of 2.5, we arrive at an approximate figure of eight pounds for the average weight of one cubic foot of mud, or, on a dry basis, of 12 pounds per cubic foot. At 12 pounds per cubic foot and 160 million cubic feet of deposit we arrive at 1,920 million pounds of deposited mud on a dry basis. The arithmetical average of the 71 copper determinations made on muds from Lake Monona is 420 milligrams of copper per kilogram, or 200 milligrams (0.2 g.) per pound, of dry mud. On this basis there were found 384 million grams, or 840,000 pounds, of copper calculated as the metal. Since 1.5 million pounds of copper sulfate as $CuSO_4.5H_2O$, or 375,000 pounds calculated as copper, were put into the lake the calculation is obviously in error. It can be assumed that most of the copper-bearing deposit is found in the deeper water and not over the entire bottom; so, if the major part of the deposit of mud is located on the floor of the center one-third part of the area of the lake, its magnitude will be of the order of 50 million cubic feet or 600 million pounds. Thus we arrive at a total of 120 million grams of copper calculated as metallic copper, or about 260,000 pounds, found deposited in the lake as compared to 375,000 pounds applied. Although the total amount of copper deposited in the lake muds must probably remain unknown, *it appears* that by far the greatest amount of that copper applied remains as a deposit in the mud of the lake.

A study of the equilibrium of this deposited copper with that in solution in the overlying water has not been attempted in this work. Preliminary experiments tend to confirm the theory that the total alkalinity and the pH of the overlying water control this solubility to a large extent, and because of the magnitude of these factors the precipitated copper is of very low solubility and this solubility probably does not permit resolution of the copper in sufficient quantity to be of value in algae control.

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1. MOORE, GEORGE T. and KELLERMAN, KARL F. 1904. A method of destroying or preventing the growth of algae and certain pathogenic bacteria in water supplies. Bulletin 64:15–44, Bureau of Plant Industry, U. S. Department of Agriculture.
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4. WOODBURY, LOWELL A., PALMER, ROBERT C., and WALTON, GRAHAM. 1938. Tolerance of fish to copper sulfate. Unpublished report to Committee for Chemical Treatment of Lakes and Streams, State of Wisconsin. (Authors have a copy of this report on file.)

PROCEEDINGS OF THE ACADEMY

Seventy-Sixth Annual Meeting

The seventy-sixth annual meeting of the Academy was held in the Biology Building at the University of Wisconsin, Madison, Wisconsin, on Friday and Saturday, April 12 and 13, 1946. Three other organizations participated jointly in the meeting, —Wisconsin Junior Academy of Science, Wisconsin Archeological Society, and the Wisconsin Section of the American Chemical Society. The Academy section met in Room 102 Biology Building, the Wisconsin Archeological Society in Room 356 Biology Building and the Wisconsin Section of the American Chemical Society in Room 301 Biology Building. The annual business meeting and election of officers was held on Friday afternoon, followed by a tea at the home of Mrs. E. B. Fred. The following program of papers was presented.

Academy Section

Friday morning

Dr. E. B. Fred, University of Wisconsin, Address of Welcome; Norris F. Hall, University of Wisconsin, A Wisconsin Chemical Pioneer—The Scientific Work of Louis Kahlenberg; C. A. Elvehjem and W. A. Krahl, University of Wisconsin, Pellagra and Corn; George Urdang, American Institute of the History of Pharmacy, How Chemicals Entered the Official Pharmacopœias; Aaron J. Ihde, University of Wisconsin, Who discovered sulphur monochloride?; A. D. Hasler and L. V. Whitney, University of Wisconsin, An "Electric Eye" for Detecting Schools of Fish.

Academy Section

Friday afternoon

John H. Kolb, University of Wisconsin, Background and Foreground of Wisconsin's Rural Communities; Leonard A. Salter, University of Wisconsin, Do We Need a New Land Policy?; Scudder H. Mekeel, University of Wisconsin, Where is Social Science?

Academy Section

Saturday morning

H. E. Reed, Burgess-Manning Company (Introduced by B. S. Reynolds), The Industrial Utilization of the Cattail Spike; Wm. D. Lewis and H. A. Schuette, University of Wisconsin, Typha Seed Oil—preliminary report; E. A. Birge, Wisconsin Geological and Natural History Survey, The Lakes of Vilas County, Wisconsin; Karl U. Smith, University of Wisconsin, Development of Behavior in the Loggerhead Turtle; Helen T. Ness, Echo L. Price and Helen T. Parsons, University of Wisconsin, The Availability of Thiamine in Dried Yeasts; H. F. Wilson, University of Wisconsin, Electrostatic Effects Produced in Dust Clouds Made with Finely Ground Minerals of Various Composition; John C. Neess, University of Wisconsin (Introduced by A. D. Hasler), A Contribution to the Ecology of the Bluntnosed Minnow in an Artificial Pond; T. E. Allen and R. K. Chapman, University of Wisconsin, Stimulation and Suppression of Some Vegetable Plants by DDT Sprays and Dusts; K. R. Johansson, University of Wisconsin, The Role of Diphtheroids in Bovine Trichomoniasis: Preliminary Studies; John Lilly and Mary Jane Bradford, University of Wisconsin, Studies of Sugar Content and Acidity of Corn as Related to Resistance to the European Corn Borer; Bernice Cooper, State Teachers College, Superior, The Abbe Prevost and the English Latitudinarians (By title); C. L. Fluke and F. M. Hull, University of Wisconsin, Revision of the Cartosyrphus Flies of North America (Syrphidae) (By title).

Chemistry Section

Saturday morning

Harry Posvic, Reduction Products of some Diphenyl Acids; Calvin L. Stevens and S. M. McElvain, The Ortho Esters of Phenylacetic Acids and Their Behavior; Warren J. Close and A. L. Wilds; The Synthesis of Compounds Related to the Female Sex Hormone Equilenin; Kurt Rorig and S. M. McElvain, Condensation of Benzaldehyde with 1-Methyl-4-Piperidone; B. S. Schweigert and C. A. Elvehjem, Nutritive Factors Needed by the Monkey; W. R. Ruegamer and C. A. Elvehjem, Potassium Deficiency in the Dog; R. W. Rivett, J. J. Johnson and

W. H. Peterson, Anti-biotics by Molds; Joseph Farber and Paul Bender, Studies on Anthracene Transannular Peroxide. I. Frequency Dependency for the Formation of Peroxide and Polarographic Analysis of the Peroxide.

Archeological, Folklore, and Museums Section

Saturday morning

Dorothy Moulding Brown, What Americana Meant to Charles E. Brown; Sylvester Adrian, A Tavern Museum in Muir Land; Albert O. Barton, Early Contemporaries of Ella Wheeler Wilcox; F. G. Cassidy, Pecatonica and Koshkonong Place Name Origins; Herb Peters, Wisconsin's Only Covered Bridge Museum; Dorothy Kundert, Monroe County Folktales; Mitchell Red Cloud, Black Hawk Recollections; Mrs. Hope Nuzum, Black Hawk Trail Marking; Mrs. Willis Tyler, Aztalan Museum Happenings; Palmer Daugs, Aztalan Site Study; Cal Peters, Prairie du Chien Museum; Walter Bubbert, Wisconsin's Colorful Market Days; Theodore Mueller, A Milwaukee Legend of "Yellow Dead" Island; Rollo Jamison, Beetown Tavern Museum; Walter Bubbert, Census of Wisconsin Museum.

Junior Academy Section

Saturday afternoon

Robert Zusy, St. John Cathedral High School, Milwaukee, Backyard Insect Collecting; Anita Kaufman, Chemistry Club, Lincoln High School, Wisconsin Rapids, The Importance of Soil Analysis; Melborne Rabedeau, Seminar Club, Mary D. Bradford High School, Kenosha, Cold Light; Kathryn Masterson, Science Club P. J. Jacobs High School, Stevens Point, Applications of Atomic Energy; Patricia Kasper, Dolores Demski, Mercedes Ironside, Mercy Science Club, Mercy High School, Milwaukee, Blood Will Tell; Robert Bard, Nature Club, Appleton High School, Appleton, Astronomy Hobby; Lawrence Maurer, Seminar Club, Mary D. Bradford High School, Kenosha, Hydroponics; James Check, Science Club, P. J. Jacobs High School, Stevens Point, Lift and Drag Coefficients of Airfoil Sections.

Annual Academy Lecture

The annual Academy dinner was held Friday evening, April 12, at the Memorial Union. Seventy-eight members and guests were present. Two addresses were made. President H. A. Schuette presented his presidential speech on "Harm in the pot no more." Bruce S. Wright, Lt. Commander R.C.N.V.R. gave an illustrated talk on "The British Commandos."

Academy Business Meeting

The annual business meeting was held in the Biology Building on Friday afternoon, April 12, 1946.

The committee on nominations: H. C. Bradley (Chairman), A. W. Schorger, Banner Bill Morgan, W. C. McKern, and P. W. Boutwell presented the slate of officers for the next Academy year. The election results are shown on the cover of this Transactions.

The following persons were elected to life membership in the Academy: Richard Fischer, Madison; Ruth Marshall, Wisconsin Dells, W. S. Marshall, Madison; C. E. Allen, Madison; E. R. Maurer, Madison; and F. E. Turneaure, Madison.

Elected to honorary membership were Alexander Wetmore, Frank Lloyd Wright, and Esther Forbes.

Treasurer's Report

April 1, 1946

Receipts

Carried forward in Treasury, April 1, 1945	$1,726.12
Receipts from the Junior Academy	101.00
Receipts from dues April 1, 1945 to April 1, 1946	1,052.79
Sale of publications	285.57
Interest on endowment	92.50
Total Receipts	$3,257.98

Disbursements

Check cleared for payment April 2, 1945	$ 100.00
Purchase of U. S. Savings Bonds, Series G	300.00
Allowance to Secretary-Treasurer	200.00
Printing for Junior Academy	33.50
Purchase of Directory for Junior Academy	.75
Stamps, envelopes, postal cards, return cards, express charges, mimeograph material for newsletter	90.00
Printing for the Academy	34.10
Student help for wrapping, transactions	26.00
Safe Deposit Box	3.60
Printing cost for Volume 35, 1943	1,317.94
Total disbursements	$2,105.89
Balance, April 1, 1946 $1,152.09	

Banner Bill Morgan
Secretary-Treasurer

The accounts of the Academy were found to be in order and as reported above for the date April 1, 1946.

Auditing Committee
Raymond J. Roark (*signed*)
Clement C. Williams (*signed*)

ENDOWMENTS AND ASSETS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

1.	U. S. Treasury Coupon Bond 1692B	$1,000.00
2.	U. S. Treasury Coupon Bond 12894D	500.00
3.	U. S. Savings Bond Registered Series G—M1696059G	1,000.00
4.	U. S. Savings Bond Registered Series G—C1563347G	100.00
5.	U. S. Savings Bond Registered Series G—C1563348G	100.00
6.	U. S. Savings Bond Series F—D494206F	500.00
7.	U. S. Savings Bond Series F—M989457F	1,000.00
8.	U. S. Savings Bond Series G—C3389339G	100.00
9.	U. S. Savings Bond Series G—C3457898G	100.00
10.	U. S. Savings Bond Series G—C3512841G	100.00
11.	U. S. Savings Bond Series G—C3560656G	100.00
12.	U. S. Savings Bond Series G—C3564110G	100.00
13.	U. S. Savings Bond Series G—C4154481G	100.00
	Total Amount of Endowment	$4,800.00
14.	U. S. Savings Bond Series G—C2386504G	$ 100.00
15.	U. S. Savings Bond Series G—C2386505G	100.00
16.	U. S. Savings Bond Series G—C2386506G	100.00
17.	U. S. Savings Bond Series G—C2386507G	100.00
	Current Assets Invested in U. S. Bonds	$ 400.00
18.	Savings Account No. 3262, 1/1/46	$1,010.00
	Total	$6,210.00

BANNER BILL MORGAN
Secretary-Treasurer

The contents of the safety deposit box and the savings account were found in order and as reported above for the date April 1, 1946.

Auditing Committee
RAYMOND J. ROARK
CLEMENT C. WILLIAMS

THE CONSTITUTION OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

(April 11, 1947)

Article I—Name and Location

This association shall be known as the Wisconsin Academy of Sciences, Arts and Letters, and shall be located at the city of Madison.

Article II—Object

The object of the Academy shall be the promotion of sciences, arts and letters in the state of Wisconsin. Among the special objects shall be the publication of the results of investigation and the formation of a library.

Article III—Membership

The Academy shall include four classes of members, viz.: life members, honorary members, corresponding members and active members, to be elected by ballot.

1. Life members shall be elected on account of special services rendered the Academy. Life membership may also be obtained by the payment of one hundred dollars and election by the Academy. Life members shall be allowed to vote and to hold office.

2. Honorary members shall be elected by the Academy and shall be men who have rendered conspicuous services to science, arts or letters.

3. Corresponding members shall be elected from those who have been active members of the Academy, but who have removed from the state. By special vote of the Academy men of attainments in science or letters may be elected corresponding members. They shall have no vote in the meetings of the Academy.

4. Active members shall be elected by the Academy or by the council, and shall enter upon membership on payment of the first annual dues.

Article IV—Officers

The officers of the Academy shall be a president, a vice-president for each of the three departments, sciences, arts and letters, a secretary, a librarian, a treasurer, and a custodian. These officers shall be chosen by ballot, on recommendation of the committee on nomination of officers, by the Academy at an annual meeting and shall hold office for one year.

Their duties shall be those usually performed by officers thus named in scientific societies. It shall be one of the duties of the president to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

Article V—Council

The council of the Academy shall be entrusted with the management of its affairs during the intervals between regular meetings, and shall consist of the president, the three vice-presidents, the secretary, the treasurer, the librarian, and the past presidents who retain their residence in Wisconsin. Three members of the council shall constitute a quorum for the transaction of business, provided the secretary and one of the presiding officers be included in the number.

Article VI—Committees

The standing committees of the Academy shall be a committee on publication, a library committee, and a membership committee. These committees shall be elected at the annual meeting of the Academy in the same manner as the other officers of the Academy, and shall hold office for the same term.

1. The committee on publication shall consist of the president and secretary and a third member elected by the Academy. They shall determine the matter which shall be printed in the publications of the Academy. They may at their discretion refer papers of a doubtful character to specialists for their opinion as to scientific value and relevancy.
2. The library committee shall consist of five members, of which the librarian shall be *ex-officio* chairman, and of which a majority shall not be from the same city.
3. The membership committee shall consist of five members, one of whom shall be the secretary of the Academy.

Article VII—Meetings

The annual meeting of the Academy shall be held at such time and place as the council may designate. Summer field meetings shall be held at such times and places as the Academy or the council may decide. Special meetings may be called by the council.

Article VIII—Publications

The regular publication of the Academy shall be known as its Transactions, and shall include suitable papers, a record of its proceedings, and any other matter pertaining to the Academy. This shall be printed by the state as provided in the statutes of Wisconsin.

ARTICLE IX—AMENDMENTS

Amendments to this constitution may be made at any annual meeting by a vote of three-fourths of all members present; *provided*, that the amendment has been proposed by five members, and that notice has been sent to all the members at least one month before the meeting.

BY-LAWS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS AND LETTERS

1. The annual dues shall be two dollars for each active member, to be charged to his account on the first day of January of each year. Five dollars, paid in advance, shall constitute full payment for three years' annual dues.

2. The annual dues shall be remitted for the secretary-treasurer and librarian during their term of office.

3. As soon as possible after January first of each year the secretary-treasurer shall send to members statements of dues payable, and in case of non-payment shall, within the succeeding four months, send a second and, if necessary, a third notice.

4. The secretary-treasurer shall strike from the list of members the names of those who are one year or more in arrears in the payment of their dues, and shall notify such members of this action offering at the same time to reinstate them upon receipt of the dues in arrears plus the dues for the current year.

5. Each member of the Academy shall receive the current issue of the Transactions provided that his dues are paid. Any member in arrears at the time the Transactions are published shall receive his copy as soon as his dues are paid.

6. The fee received from life members shall be set apart as a permanent endowment fund to be invested exclusively in securities which are legal as investments for Wisconsin trust companies or savings banks. The income alone from such fund may be used for the general purposes of the Academy.

7. The secretary-treasurer shall receive annually an allowance of two hundred dollars for services.

8. The secretary-treasurer shall be charged with the special duty of editing and overseeing the publication of the Transactions. In the performance of this duty he shall be advised by the committee on publication.

9. The Transactions shall contain in each volume: (a) a list of the officers of the Academy, (b) the minutes of the annual meeting and (c) such papers as are accepted under the provisions of Section 10 of these By-Laws and no others.

10. Papers to be published in the Transactions must be approved as to content and form by the committee on publication. They must represent genuine original contributions to the knowledge of the subject discussed. Preference shall be given to papers of special interest to the

state of Wisconsin and to papers presented at a regular meeting of the Academy. The privilege of publishing in the Transactions shall be reserved for the members of the Academy.

11. The Constitution and By-Laws and the names and addresses of the members of the Academy shall be published every third year in the Transactions. The Constitution and By-Laws shall also be available in reprint form from the secretary-treasurer at any time.

12. Amendments to these By-Laws may be made at any annual meeting by vote of three-fourths of all the members present.