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All Society correspondence (subscriptions, memberships, manuscripts, and any other business) should be directed to the Executive Secretary and Editor, Julian P. Donahue, Department of Entomology, Michigan State University, East Lansing, Michigan 48823, U.S.A.
THE INVENTION OF "SUGARING" FOR MOTHS IN NINETEENTH-CENTURY ENGLAND

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Those who find enjoyment in the books of P. B. M. Allan have had at least an introduction to the history of our familiar method of using artificial bait to attract nocturnal Lepidoptera (Allan, 1937, 1943, 1947). While the present paper was in manuscript, D. E. Allen's welcome contribution on the origin of the method came to hand (Allen, 1965); several historians of science have since added their comments (Allan, 1965; Wilkinson, 1965). The discovery of additional material in the publications of the early nineteenth century has made desirable a summary of what we now know about the development of "sugaring."

It is certain that the practice as we know it began in Victorian England, but we must look to a somewhat earlier date for the circumstances which sent collectors to the forest paths with molasses-pail and brush. Allen (1965) suggests that "the earliest observation of the attraction of sweets for moths and the value of this as a means of capturing nocturnal species" was made in 1831, yet it seems that earlier notices may be found. The standard "textbook" in the period directly preceding the advent of sugaring, Kirby and Spence's Introduction to Entomology (1815-26) mentions the feeding habits of moths more than once; nearly every serious collector was familiar with the work. In his popular volume of collecting techniques, Samouelle (1826) noted that "the most successful places for mothing are the skirts of woods under the wind, where there is abundance of plants in blossom, as it is the nectar of flowers on which they feed." Perhaps such observations led Abel Ingpen to suggest the first artificial bait. In a previously unnoticed passage of his Instructions for Collecting, Rearing, and Preserving British Insects he hinted that "sheets of paper smeared with honey water, beer, and sugar, or sugar sprinkled over them would answer the purpose" of attracting insects (Ingpen, 1827).

The adventure of 1831 mentioned by Allen (1965) is, however, of interest as it added more observational data to the store of knowledge which was to result in a more sophisticated modus operandi. One John Walton, collecting in the company of two friends, noted that moths were attracted in swarms to the ripe "berries" of the yew. When the entomologists returned to London they provided themselves with "bull's eye lanterns, forceps, &c" and sallied forth to take advantage of the discovery. Armed with the forceps, an early form of net much resembling a large pair of scissors with gauze-covered rings attached to the points, they took numerous rare species on the local yews. Walton continued to visit these trees each autumn. In 1833 he took over two thousand moths at the fruits and noticed a fact that was to assume great importance when the technique of artificial
The bait was fully developed: he was "more generally successful in capturing the rarer species when the nights were warm and rainy" (Walton, 1835). Part of the account is interesting enough to quote at length, as it details the "forceps technique" certainly used later at artificial baits.

I use a bull's-eye lantern, with a powerful lens, - the larger the better, a pair of forceps, such as are generally used by entomologists, having the sides and bottom covered with white gauze, and about six inches wide at the mouth when opened. Also I use a portable sliding rod, or one with two lengths, jointed like a fishing-rod, from six to nine feet long, and a small round net, made of white gauze or muslin, screwed or fixed on at the end, of about five to six inches diameter, and the same in depth. I then direct the rays of light upon the insect. If it is within reach I use the forceps, and take it very deliberately; if out of reach, but within the length of the rod, they are easily jarred into the small bag at the end of your rod, lowered down, and transferred into the forceps. In this way they are captured with certainty ... principally in consequence of that singular instinctive faculty which many insects possess ... of feigning death when alarmed ... If they happen to miss the net in the act of falling, they invariably drop lightly to the ground, and may be taken from the grass with the forceps.

Although made in 1831, Walton's discovery was not printed in the Entomological Magazine until 1835, two years after the appearance in the same journal of Edward Doubleday's famous account. Although Ingpen had suggested the use of sugar, Doubleday (1811-49), the eminent lepidopterist who was later to collect widely in America and undertake the magnificent Catalogue and Genera of Diurnal Lepidoptera, was the first to give a detailed report of taking moths at that medium. He and his equally noted brother Henry (1808-75), who Edward Newman perhaps rightly called the most important lepidopterist England had produced, lived at Epping where their father operated a grocery and hardware business. Edward's note advised collectors to "lay a sugar-hogshead, which has just been emptied, and to which of course some small quantity of sugar will still adhere, in an open space near a garden or field." After a few nights it would be "visited by numbers of Noctuae, amongst which will not unfrequently be found some of the rarer species." The moths would continue to visit the barrel, "particularly on moist evenings, as long as it retains any saccharine matter" (Doubleday, 1833). A list of sixty-nine species followed which had been taken by the method, presumably in the season of 1832. Writing almost fifty years later, W. F. Kirby (1882) credited the discovery to both Edward and Henry, explaining that they had seen the moths coming to empty sugar casks thrown into the grocery yard.

The curious technique was seized upon by other entomologists. J. C. Dale (1833) recommended heating the barrels as they would then attract moths "much sooner than when cold." Gauze "should be so placed as to prevent the moths from injuring themselves [i.e., to keep them from covering themselves with sugar], and a person should stand near with a net ready." It is known that sugar casks were so used as
late as 1841, for in his *Familiar Introduction to the History of Insects* Edward Newman described the method, also explaining that "East India sugar-bags have been employed for the same purpose, with very great success, and on these the moths may be captured with far greater facility than on a sugar-hogshead, which from its shape is less accessible." (Newman, 1841). These early methods caused collectors to recall having seen moths attracted to the bottles of sugar and water which were commonly placed to attract wasps (Dale, 1833); in a later paper Samuel Stevens (1843) reported a specimen of *Catocala fraxini* trapped thus in 1838.

Several other modes of artificial sugaring seem to have been developed in the 1830's. Allen (1965) has called attention to the activities of Prideaux J. Selby, but something more may be said about him. Selby (1788-1867) was an eminent naturalist, author of the *Illustrations of British Ornithology* and numerous papers on botany, entomology, and ornithology. In a paper of 1839 he reported "the use of honey, smeared upon some receptacle which is placed in situations supposed to be favourable to the flight of the moths." After some experimenting he found that "an old bee-hive . . . is preferred to any other article, as it offers a larger surface, and from its circular form allows the moths when settled upon it to be easily captured by the flappers [forceps]" (Selby, 1839). It may be remembered that Ingpen had suggested the use of honey, but Selby developed the method to perfection, keeping careful records of such pertinent data as species visiting the hive, their seasons of appearance, times of flight and proportion of sexes. He noted that no Sphingidae or Bombycidae were taken, but "many of the Geometridae and Tortricidae had been captured, and among them some of our rarest species." Allen (1965) dates Selby's experiments to 1835, but the evidence is slim; Selby himself does not mention using the method before 1836 (Morris, 1857). The document in question is his letter to F.O. Morris dated 17 April 1837 and published by the latter in the *Naturalist*. It is of interest as he definitely mentions the idea of painting trees with honey, but seems to reject it as "it would require a much greater consumption . . . Wasps, Bees and other insects would devour every particle during the day." Selby's method was reported by James Duncan in the introduction to his *British Moths, Sphinxes &c* (1836) and must have gained wide publicity through that popular work. In the second edition of his *Instructions*, Ingpen (1839) explained that an "empty sugar cask, or a tub, or beehive smeared both inside and out with sugar and water, or honey and water, will attract the Noctuidae, and some beetles." The tub was to be "elevated three or four feet from the ground, and placed near the border of a wood, or in a garden." He also recommended an early "sugar trap," in which the moths were captured on a plate of sweet matter placed under a pane of glass.

Cumbrous as the sugaring methods of the 1830's seem to have been, much experimental data were obtained from them, which led to the introduction in 1841 of our present practice of painting the trunks of trees with various sugar mixtures. The first notice of the "breakthrough" seems to be in a letter of Henry Doubleday to T.C. Heysham of Carlisle, first printed in 1888. It is dated 11 August 1841 and explains that "by taking some sugar and water and brushing it on the
trunks of trees, or sprinkling it on the bushes, you attract an immense number of moths, and about an hour after sunset they remain quite quiet, and with a light you may select what you want" (Christy, 1888).

Doubleday's practical discovery was reported by H. Noel Humphreys in his and J.O. Westwood's *British Moths and their Transformations*. The introduction, dated October, 1841, stated that "Mr. Doubleday has recently tried the experiment of brushing a mixture of sugar and water upon the bark of trees where moths are likely to abound, and found the plan perfectly successful, having captured immense numbers this season that way, many of them of the most rare and beautiful species" (Humphreys and Westwood, 1843-45). But the first number of *British Moths* was not published until 1843, and before then Doubleday had made his method known to other friends. The first report of it to actually appear in print was that of J.W. Douglas (1842), whose note dated 6 July 1842 was published in the rare first volume of Edward Newman's *Entomologist*. Douglas claimed that "the saccharine system of taking moths has proved very successful;" he had painted the posts in his garden every possible night, and "the moths came in droves." Strong sugar was suggested, and another step was taken towards the modern mixture: "treacle I find does equally well."

In August of the same year Henry Doubleday (1842) himself reported the capture of the rare *Polia occulta* "sucking sugar which I had placed on the trunks of some trees to attract moths." Samuel Stevens, a Hammersmith collector, described (1843) taking the magnificent *Catocala fraxini* in his garden, "feasting on the sweets that I had provided for him, on the trunk of an apple tree." Stevens apparently had some experience at the method, for he mentioned meeting *Catocala nupta* "frequently." Doubleday (1843) listed his numerous captures at Epping during the autumn of 1842, but it would seem that the exact nature of the mixture was revealed to only a small circle of friends. The dealer H.G. Harding (1883) reminisced that "there was a great desire among working entomologists to know how it was made, but the secret was retained by a few. All kinds of scents were tried, but were not found of much use. A man of the name of Courtney made some up, and sold it at one shilling and sixpence per pint"—a large sum in the mid-nineteenth century.

There is a curious footnote to the introduction of painting trees. For forty years there were no dissenters to Henry Doubleday's claim of priority to the method. Then in 1881 James English read a paper before the Epping Field Club in which he claimed to have originated the practice. English (1820-88), an Epping collector, had been hired by Henry Doubleday as an assistant naturalist in 1836; the two were fast friends until Doubleday's death in 1875 (Mays, 1961). In his paper, English explained that he had tried the sugar and water experiment in the summer of 1843 when Doubleday was in Paris. Henry's younger brother Edward was then at home in Epping, and English claimed to have received a compliment from him on the invention. When Henry returned "he was surprised in the extreme, and sent for me to learn the details. After a few nights' adventures with sugar he wrote to the late Edward Newman, telling of the utilization of sugar for the capture of moths. An article in the *Zoologist* sent the entomological world to the woods
with the sugar-can and lanthorn" (English, 1882).

After English's death Miller Christy (1888) vindicated Double-
day's claim, pointing out that the latter had used the method two years
before his trip to Paris in 1843, during which English claimed to have
invented it. Moreover Doubleday's first paper on the subject was writ-
ten long before the Paris voyage. Allan (1943) cast further doubt on
English's reliability in this and other areas. Allen (1965) accepted En-
glish's claim, inferring that he had forgotten the actual date. His pa-
per was followed by Allan's comment (1965) that it was "just as likely
that it was the Doubledays who 'introduced' sugaring to English as it
was the other way round." Although I agree with P. B. M. Allan, the
matter will probably never be solved to everyone's satisfaction. It
should, however, be noted that English's memory was poor indeed. His
insistence on Henry Doubleday being in Paris throws doubt on the ac-
count. Doubleday did not write his account to Newman after only a few
nights' sugaring; it was indeed a year before the note was transmitted.
What is known of Doubleday's character makes it unlikely that he would
take credit for the discovery of another collector. It is also strange
that English should keep quiet until after the death of all those who could
possibly testify to the truth of his claim.

By 1843 so many collectors had heard about the success of paint-
ing trees that there was a general demand for more details. J.W. Doug-
las remarked in a note dated 18 November 1843 that there had been no
account of how to use sugar, so that it was "not generally understood by
country entomologists." Douglas' explanation must be quoted in extenso
as it shows that the sugar-water or treacle method had become more so-
phisticated:

The strongest brown sugar, known as 'Jamaica foots,' is
mixed with hot water to the consistence of treacle, or somewhat
thinner, and a small portion of rum added and stirred in; the com-
position is then laid on the trunks of trees in favorable situations
with a painter's brush. I have found that it is better to make long
and narrow streaks than broad patches. . . . The sugar should be
put on the trees at dusk, before the moths fly; for I have repeat-
edly observed, that if used afterwards, there will not be nearly
so many come. With a lantern, suspended from the neck, and
thereby preserving an upright position during every movement,
the collector may visit the trees several times during an evening.
The greater number of moths will be found during the first hour,
but some species are only taken late at night. . . . Some per-
sons boil the sugar and water, and think it an advantage, but I
have not yet tried it. Of the efficacy of the rum I am sure, hav-
ing more than once seen one collector use it, and another at the
same time sugar without it, when the former would obtain double
the number of Noctuae.

The account (Douglas, 1844) is notable for the first mention of
the now universal addition of rum to the mixture. The editor of the
Zoologist, Edward Newman, received a number of replies to it, some
claiming great success and others reporting none. Samuel Stevens
noted that he found beer to be more useful than water; Newman (1844) remarked that "not only moths, but woodlice, earwigs and slugs by night, and flies, bees, wasps and butterflies by day, are attracted to the sweets." The Rev. W.T. Bree (1844) was one of those who found sugar to be of little value, but it is no wonder, as his paper suggests that he visited the trees only after the sun was up. C.S. Gregson (1844) conducted a comparative test between fine white sugar and "some from the lower side of a West India hogshead; it was very dark brown, and smelled very strong of rum." He concluded that the reason "so many have not succeeded, has been, that they have used sugar without any smell." Gregson called attention once more to warm, moist nights as the best for sugaring, recommending a "mizzly rain" as beneficial.

Thus collectors had noticed the importance of temperature and humidity to the sugaring process at an early period; the journals of the 1840's contained a number of papers on the subject. Typical was that of J. Pemberton Bartlett (1845) who emphasized the role of the air in carrying the scent; he observed that "want of success more frequently arises from the state of the atmosphere, than from the mixture used." Periods just before or after rain were best, and windy, cold nights were to be avoided. Many substitutes were suggested for the rum, such as essential oils and vinegar, while paste, putrid soap suds and dried apples were put forth at various times as replacements for the entire mixture, but the concoction of beer, sugar, molasses, and rum held its own against all comers, so that by 1857 H.T. Stainton could write in his Manual of British Butterflies and Moths of "the revolution that has been caused in our cabinets, by rare Noctuae being taken in abundance at sugar." Revolution it was, for many insects thought rare were found to be quite common, and new species were constantly being discovered at sugar. The journals seem to indicate that Henry Doubleday continued as the leading exponent of bait at mid-century (Newman, 1875; Doubleday, 1875); W. F. Kirby (1882) reported that "the trunks of the trees along Mr. Doubleday's field are (or were lately) entirely blackened in many places with the sweet mixture daubed over them night after night for years." These were the seventeen limes Doubleday (1875) claimed to have sugared "for more than thirty years in every month, except the four winter ones."

Those English collectors who had not known of sugar before were introduced to it by the two most popular amateur's manuals of the nineteenth century, Joseph Greene's The Insect-Hunter's Companion (1863) and H. Guard Knaggs' The Lepidopterist's Guide (1869). Greene summarized the many papers in the Zoologist, Entomologist, and Entomologist's Weekly Intelligencer, averring that sugar was "the best way of obtaining Noctuae;" he used a simple mixture of treacle and rum himself. Knaggs praised sugar as "the great medium employed in this country;" equal parts of dark sugar and molasses were to be boiled with enough stale beer to facilitate brushing. Rum was to be added at the last moment. He described a "sugaring net" constructed in the form of a Y, the two extremities being connected with a string of cat-gut and the device being furnished with a bag "which will readily adapt itself to the shape of a tree or other object against which it may be pushed." Sugaring nets of the period had a short handle so that they
could be held with the stomach against the tree being worked. They effectively caught insects which fell during the bottling process. By the eighteen-sixties, naturalist shops stocked "sugaring tins" fitted with a brush in the cap, and many other devices were invented to facilitate the process as amateur entomology reached its height in the late nineteenth century.

No writer has described Victorian sugaring as superbly as Furneaux (1894). By that decade collectors were so numerous that the "card method" was used; he describes it in Butterflies and Moths: "I have sometimes seen cards, bearing the names of the collectors and the date of working, tacked on to baited trees and fences, thus establishing their temporary exclusive rights to the use of their runs." Furneaux cautioned that "each entomologist has a moral right to a run he has baited, and that it is considered ungentlemanly, if not unjust, to take insects from sugar laid by another." I well remember, as a youth, mixing my first pot of bait according to Furneaux's old directions that "odour rather than purity is to be the guide," and shuddering in anticipation when reading that "if there is such a person as a nervous entomologist, that individual should on no account go a sugaring in lonely spots on dark nights." That bit of English advice was just as applicable to American forests in the early 1940's.

Despite such warnings, Victorian sugaring had its lighter moments. A humorous note in an early number of the Entomologist's Monthly Magazine recounted the experience of one Edward Hopley, who upon examining his bait in South Devon found "at the foot of one of the trees a melancholy object for compassion and warning. The common bat (Vespertilio pipistrellus) lay in prostrate humiliation before me." On attempting to lift the inebriated bat, "a rollicking one-sidy flounder or two, accompanied by a hiccupy squeak, affirmed 'all right' so unmistakeably, that, solemnly registering one more vow against the Cincinnian cup," Hopley "lifted him carefully by the collar of his coat, and deposited him in the broad space made by the branches of a noble oak-tree." When he returned several hours later, his "jovial brother collector had departed" (Hopley, 1867).

Although there is little evidence to document its early progress, the practice of sugaring reached America in the first half of the nineteenth century. What is known of its arrival and use here during the pioneer days of American entomology will be recounted in a future issue of The Michigan Entomologist.

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INTERFERENCE OF THE SNAIL PHYSA SAYII WITH EQUILIBRIUM IN TROPISTERNUS GLABER (COLEOPTERA: HYDROPHILIDAE)

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On January 9, 1964, a larva of the hydrophilid beetle *Tropisternus glaber* (Herbst) was removed from an aquarium and placed in a finger bowl of water along with a sprig of coontail (*Ceratophyllum demersum* Linnaeus). The plant provided support for the larva to reach the water's surface. By accident rather than design it harbored the snail *Physa sayii* (Tappan), individuals of which were clinging to its leaves.

On January 17, a *Drosophila* larva was given to the beetle, which immediately grabbed the prey, moved to the vegetation, and began ingesting the meal. A second larva was offered when the first was finished. The hydrophilid took it, too, with the mandibles, but this time did not move toward the vegetation. It thrust its anal spiracle up to the water's surface and began moving about through swimming movements of the legs and of the body, but no attempt was made to eat the second prey. As a result of the beetle's vigorous movements, a snail not previously noted was dislodged from the side of the finger bowl. The snail extended its foot and attached itself to the dorsal thoracic region of the beetle. It then proceeded to crawl the length of the beetle larva before falling off the animal's posterior.

Following the above events, the *Tropisternus* was noted to be in distress. Its body was coated by mucus wherever the snail's foot had made contact, and its legs were inextricably bound together by viscous strands of mucus. The unfortunate larva began violent contractions of the body, while attempting to keep the anal spiracle to the water's surface. When its legs came in contact with the surface film, air bubbles attached to the mucous coating on them. The bubbles subsequently buoyed the venter, leaving the larva in a state of imbalance. The insect continued its contortions, became separated from the surface film, and fell to the bottom of the finger bowl. The observer attempted rescue by moving the larva to the *Ceratophyllum* at the surface, where it continued twisting and contracting the anterior portion of its body while still attempting to separate its legs. After a time it became motionless and dropped the fly larva. It resumed the twisting and contorting and again fell to the bottom of the finger bowl. Its contortions continued, with periodic lapses, but surface film contact was never regained. Finally the *Tropisternus* died from suffocation.
RELATIONSHIPS BETWEEN THE MANDIBLES, FEEDING BEHAVIOR, AND DAMAGE INFLECTED ON PLANTS BY THE FEEDING OF CERTAIN ACRIDIDS (ORTHOPTERA)¹

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In 1960 the author described three fundamental patterns of feeding in Orthoptera and their allies and emphasized the close correlation that exists between the insects' mouthpart structure, food, and feeding pattern. An article by Anderson (1964) made reference to these described patterns and discussed possible modifications of them. To the author's knowledge these are the only reports available that make other than casual mention of the characteristic damage by Orthoptera to food plants. Numerous other papers include figures that depict orthopteran damage, and still others verbally describe the damage inflicted by various economically important species. In all these reports at least one basic consideration has been all but ignored: the possible relationships between mandibular form, pattern of use, and the resulting damage to food plants. Findings with respect to this topic are given below.

METHODS

Living grasshoppers were caged individually, together with their food, in small glass chambers placed on the stage of a binocular dissecting microscope through which feeding could be observed in minute detail. Other grasshoppers were photographed as they fed. The 16 mm camera used was a Ciné-Kodak Special II, with a 63 mm f2.7 lens and an 8-inch extension tube, and set at 64 frames per second. Illumination was provided by three microscope lamps fitted with heat filters to protect the insects. To assure immediate feeding all experimental animals were denied access to food for twelve hours prior to a test.

OBSERVATIONS

The 21 acridids studied are listed in Gangwere (1960). In every case the feeding pattern the grasshoppers exhibit fits the type called margin-feeding; that is, feeding at the margins of leaves or flowers or sometimes along a midrib, fold, or other prominence. In so doing, a rather invariable sequence of activities is followed.

A grasshopper, given access to coarse grasses, usually begins by straddling the leaf edge. The animal swings its head forward and upward, bringing its hypognathous mouthparts into their most forward

¹ Contribution No. 146 from the Department of Biology, Wayne State University, Detroit, Michigan 48202.
position. The head then moves in a backward and downward path while the mouthparts cut food from the leaf edge (Fig. 3). This downward and backward movement of the head during incision never varies, for the apically located incisor dentes of the mandibles must come into contact with the food first. (If the animal tried to eat using a forward and upward movement, the molar dentes would meet the food first and be unable to incise it properly.) By these actions a small, concave excavation is made in the leaf margin (Fig. 6, cut no. 1). It is deepened and elongated during successive swaths (Fig. 6, cut no. 2). When the excavation has been enlarged to a point where it cannot be deepened easily, the first phase of the insect's feeding has been completed. The second and more extensive phase begins as the animal moves a short distance forward to an intact portion of the leaf, where it begins feeding anew. Here it undertakes another backward- and downward-directed swath until a fair-sized piece has been partially loosened. This morsel is then completely removed by a combination of incision by the mandibles and splitting of the grass between the parallel veins (Fig. 6, cut no. 3). A later series of "bites," parallel to, but deeper than the last, together with splitting, brings the excavation down to or even well below the midrib (Fig. 6, cut no. 4). All subsequent feeding proceeds in the same step-like fashion, and the resulting excavation is angulate (Fig. 6, cuts nos. 5, 6, 7).

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EXPLANATION OF FIGURES

Fig. 1. Dorsal aspect of the left mandible of the cantantopine Melanoplus a. angustipennis, showing the forbivorous-type adaptation.

d = incisor lobe.

Fig. 2. Dorsal aspect of the left mandible of the truxaline Syr bubula admirabilis, showing the graminivorous-type adaptation. (Abbreviation as in Fig. 1.)

Fig. 3. Frontal view of a grasshopper head showing the relationships between its mouthparts and a grass leaf on which it is feeding. This is an example of margin-feeding. gal = galea; lbp = labial palpus; lbr = labrum; lca = lacinia; mdb = mandible; mxp = maxillary palpus; pgl = paraglossa.

Fig. 4. Section of a grass leaf showing the angulate, comparatively even-margined cut caused by the graminivorous-type mandibles of the truxaline Syr bubula admirabilis.

Fig. 5. Section of a grass leaf showing the somewhat irregular cut caused by the herbivorous-type mandibles of the oedipodine Spharagemon collare.

Fig. 6. Section of a grass leaf eaten by a graminivorous grasshopper. The numbers on this diagrammatic figure indicate the general sequence of feeding: areas labelled nos. 1 and 2 are removed by the early concave cuts and those labelled nos. 3 to 7 by the later angulate cuts.

Fig. 7. Section of a forb leaf showing the escalloped, irregular cut caused by the oedipodine Spharagemon b. bolli. This damage is (continued on next page)
EXPLANATION OF FIGURES (continued from preceding page)

typical of that produced on forbs by either herbivorous-type or forbivorous-type mandibles.

Figs. 4-7. The solid arrows indicate the feeders' forward progression and the dotted ones the direction taken by the mouthpart swaths.
The pattern of damage discussed above is characteristic of graminivorous grasshoppers. Acridids with different food-habits deviate from this pattern in the damage they inflict on their food plants, though the feeding sequence remains much the same; examples are found among woody plant foliage-feeders and forb-feeders. They eat ovoid, net-veined leaves rather than leaves that are linear and parallel-veined. Because of the venation, they are unable to remove morsels by a combination of incision and splitting between veins. The cut made—by incision only—is necessarily escalloped and irregular.

The inability of forbivorous acridids to leaf-split accounts only in part for the character of the damage they inflict. Damage is also a result of the shape of the mandibles. Mandibles exhibiting the forbivorous-type adaptation, as in many cantantopines, have an armature of irregular, sharp dentes (Fig. 1); those characterized by the graminivorous-type adaptation, as in the truxalines and acridines, have dentes in the form of parallel ridges often fused or worn into a semicontinuous cutting edge (Fig. 2); and those having the herbivorous-type adaptation, as in many oedipodines and some cantantopines, are intermediate between the preceding two, both in form and function. These three kinds of mandibles cause plant damage ranging from the escalloped and irregular cut (Fig. 7) caused by forbivorous-type mandibles to the intermediate one (Fig. 5) produced by herbivorous-type mandibles to the angulate and comparatively even-marginated one (Fig. 4) made by graminivorous-type mandibles. The damage, thus inflicted, is sometimes of sufficient specificity to enable one to diagnose the taxonomic group to which the feeder belongs.

Finally, it is possible to determine the gross direction that a grasshopper moved during feeding as well as the direction taken by the individual mouthpart cuts. One need only locate the frayed portion of the animal's excavation. Fraying, produced by the early cuts when splitting is impossible and the mouthparts are in a relatively unfavorable position for efficient incision, indicates the early, more posterior part of the excavation, while the smooth portions and angulations are later and more anterior. Once the direction of individual cuts is established, one can easily deduce the feeder's forward progression; almost always it is opposite in direction to the cuts.

ACKNOWLEDGEMENTS

Professors I. J. Cantrall, Museum of Zoology, University of Michigan, Ann Arbor, Michigan, and W. L. Thompson, Department of Biology, Wayne State University, kindly read the manuscript of the foregoing report. Mrs. Patricia DeBlois, also of Wayne, typed the final copy of the manuscript. To these persons the author is indebted.

LITERATURE CITED

A NEW SPECIES OF MNIOES (HYMENOPTERA: ICHNEUMONIDAE) FROM THE UNITED STATES

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This is the first record of the genus *Mnioes* in the United States. Previously described species are all Neotropic. Townes described the genus in 1946, placing *Lampronota*? *jucunda* Cresson, 1874, and *Meniscus*? *orbitalis* Cresson, 1874, in it. The new species described here has been collected from several areas in the United States. This study was made while the author was a graduate student at The University of Michigan, Ann Arbor, Michigan.

*Mnioes lunatus*, new species
(Figure 1)

**FEMALE:** Front wing 6.8 ± 0.1 mm long; ramellus absent; apical transverse carina of propodeum very weakly represented and bending posteriorly; claws strongly pectinate; body length 10 to 11 mm.

Antenna, head, and thorax black; flavescent to white: annulus on antenna, face except for patch on each side of middle and these patches connected to orbits, orbits except for interruption on hind margin and at lower corner of eye, propodeum except for median patch, anteroventral margin of pronotum, patch on top of pronotum behind collar, hind dorsal corner of pronotum, lunate mark on center of mesoscutum, tegula, spot on each side in axillae of mesoscutum, spot at dorsal corner of mesopleuron, large, irregular, lateral patch on mesopleuron extending ventrally to median suture of mesosternum, mesepimeron, scutellum, postscutellum, large patch on posterior portion of lower metapleural, large irregular block-on propodeum (with the opening anterior) and sometimes with two spots within the opening, basal one-fourth and apical broad margin of first tergite, small basal corners and broad apical margin of second tergite, apical margins of fifth, sixth, seventh, and eighth tergites with width of margin progressively increasing from fifth to eighth, anterior coxa, patch on middle and hind coxae, apical one-third of first segment of hind tarsus, second segment of hind tarsus except upper apical one-third to one-half, and basal and apical margins of third segment of hind tarsus; apical one-third of mandible, median band on first and second tergites, usually spot on lateral margin of third tergite, apical margin of second trochanters and basal margin of femora of middle and hind legs, and remainder of tarsi dark ferrugineous to black; remainder of abdomen and legs light ferrugineous; wings hyaline, iridescent; stigma yellow and translucent.

**MALE:** As in female, except: front wing 6.0 to 7.0 mm long; discoidella vein weakly represented and not reaching wing margin.
Claws moderately pectinate; body length 8.0 to 9.5 mm.

Flavescent to white: front of pedicel and scape, head, pronotum, propleurum, mesopleurum, upper and lower divisions of metapleurum, basal one-third to one-half and apical one-fourth of first tergite, basal corners and wide apical band of second tergite, usually apical bands on the third, fourth, seventh, and eighth tergites, middle coxa, spot near base of hind coxa, and second, third, and usually all of fourth segments of hind tarsus; remainder of antenna, pedicel, scape, frons, vertex, occiput, remainder of mesoscutum and axillae, groove above speculum and sometimes extensions of it anterior to and onto prepectus and rarely laterally to pit on mesopleurum, sometimes pit on mesopleurum, anterior groove of metapleurum, remainder of propodeum, metasternum, carinae and suture between metapleurum and propodeum, median band on first tergite, basal two-thirds of second tergite, usually spot on lateral margin of third tergite, sometimes upper portion of fourth segment of front tarsus, fifth segment of front tarsus, upper portion of third and fourth and whole of fifth segments of middle tarsus, apical margin of second trochanter and basal margin of femur of hind leg, apical one-third of hind tibia, basal one-third to one-half of first segment of hind tarsus, sometimes top of fourth segment of hind tarsus, and fifth segment of hind tarsus, black; remainder of legs and abdomen pale to dark ferruginous.

DIAGNOSIS: This species is colored much like *Mnioes jucundus*, from which it differs in having: upper and lower margins of face black; one white patch on each side of face and this usually connected to orbit; orbit usually interrupted by black on hind and lower margins of eye; upper part of cheek whitish, without a blackish area extending from up-

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**Fig. 1.** *Mnioes lunatus* ♀, new species, illustration of holotype. a, side view; b, head; c, propodeum and two tergites; d, length of ovipositor in relation to body. (Drawings by Kakuzo Yamazaki)
per part of cheek to occipital carina so as to completely interrupt the
white on lower part of hind orbit; apical one-third of mandibles ferru-
gineous; propleurum with median black patch; hind dorsal corner of
pronotum, narrow stripe on pronotum behind collar, spot in axillae of
mesoscutum, mesepimeron, block-U design on propodeum (with the
opening anterior) and occasionally with two spots within the opening,
and basal corners of second tergite, white; apical margins of fifth,
sixth, seventh, and eighth tergites with increasing amounts of white
from fifth to eighth, apical one-third of hind basitarsus white, second
segment of hind tarsus white except for upper apical one-third to one-
half, basal and apical margins of third segment of hind tarsus white,
apical margin of second trochanter and basal margin of coxae of mid-
dle and hind legs dark ferrugineous to black. Stigma light yellow and
translucent.

This species differs from *Mnioes orbitalis* in having: orbit in-
terrupted by black on hind and lower margins of eye, apical one-third
of mandibles dark ferrugineous to black, white spot behind collar on
top of pronotum, dorsal hind corner of pronotum white, lunate mark on
mesoscutum white, axillae of mesoscutum with white spot on each side,
pronotum with a white block-U design, tips of four anterior tarsi not
black; claws pectinate.

**HOLOTYPE:** ♀, Takoma Park, Maryland, July 18, 1942, H.
and M. Townes (Townes Collection).

**PARATYPES (16):** COLORADO: Mountains, August to Septem-
ber, 2♀, Carpenter (MCZ). INDIANA: Spencer, Owen Co., June 28,
1925, 1♂, E.G. Anderson (Univ. of Minn.). KENTUCKY: Golden Pond,
Trigg Co., June 10 to August 10, 1964, 1♂, 1♀, S.G. Breeland (Townes
Collection). Sanborn, Harlan Co., no date, 1♀, collector unknown
(MCZ). MARYLAND: Takoma Park, Montgomery and Prince Georges
Cos., July 12, 1947, 1♂, D. Shappirio (Townes Collection). NORTH
CAROLINA: Southern Pines, Moore Co., May 17, 1918, 1♂, collector
unknown (AMNH). Wake Co., July 18, 1951, 1♀, H. and M. Townes
(Kennedy Collection). OKLAHOMA: Hugo, Choctaw Co., June 21, 1934,
1♂, A.E. Pritchard (Canadian National Collection). SOUTH CAROLINA:
Greenville, Greenville Co., July 4, 1933, 1♂, H. Townes (Kennedy
Townes (Townes Collection). VIRGINIA: Falls Church, Falls Church
Co., July 6, 1♂, 1♀, N. Banks (MCZ). Glencarlyn, Arlington Co.,
July 14, 1♀, N. Banks (MCZ).

(NOTE: AMNH = American Museum of Natural History, New
York; MCZ = Museum of Comparative Zoology, Harvard University,
Cambridge, Massachusetts.)

**LITERATURE CITED**


Townes, H. 1946. The generic position of the Neotropic Ichneumonidae
(Hymenoptera) with types in the Philadelphia and Quebec Museums,
described by Cresson, Hooker, Norton, Provancher, and Viereck.
A NEW NEARCTIC TRICLISTUS (HYMENOPTERA: ICHNEUMONIDAE)

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When Townes and Townes (1959) revised the genus Triclistus along with the rest of the Nearctic Metopiinae, they decided not to describe what was thought likely to be an additional new species, because only one male specimen was known. More recently, additional specimens, both males and females, were collected. From the females, which are even more distinctive than the males, it was easily seen that the species described below is indeed a new one.

TRICLISTUS MINUTUS, new species

DIAGNOSIS: This species differs markedly from other Nearctic species in a majority of the characters used in its description. Especially notable among these are its very small size (length of front wing less than 3 mm), the brown to very dark brown hind coxae and femora, the absence of a dorsal groove on the lamella between the antennal sockets, the long frons (ratio of length to width), the extremely large notch in the female subgenital plate, and the presence of a groove separating the clypeus from the face.

T. minutus does not clearly fit in either the Podagricus or Crassus Groups in the Townes classification. In the first couplet of their key for males, the ratio of tibial spur length to width and the size and proximity of facial punctures are used to differentiate the groups. The tibial spur measurements of T. minutus agree more with those of the Crassus Group, whereas its facial punctures are more nearly like those characterizing the Podagricus Group. Only because of their dark coxae, one might, upon superficial analysis, mistake T. minutus for T. podagricus (Gravenhorst) or T. brunipes (Cresson) of the Crassus Group. T. minutus females, however, will key to the Crassus Group, and the only females in this group with hind legs colored anything like those of T. minutus are T. brunipes and T. adustus Townes (males of the latter unknown). Both occur in western North America, while T. minutus has been collected only in Michigan and Virginia, although it is rather rare and consequently may have a range larger than is now known. T. adustus more closely resembles T. minutus than does T. brunipes. However, T. minutus is easily distinguished from T. adustus with the description provided here, and in absence of the description could only be mistaken for T. adustus by someone not familiar with the latter.

DESCRIPTION: Front wing 2.4 to 2.8 mm long; face weakly mat, its punctures small and crowded, in female densely hairy and very
sharply convex in profile, moderately hairy and profile more evenly rounded in male; clypeus separated from face by a rather distinct groove; frons very long in female and quite long in male, the distances from the lower rims of the antennal sockets to the vertex being 2.0 to 2.4 (females) and 1.75 to 2.00 (males) times the distance between the eyes at the lower rims of the antennal sockets; lamella between antennal sockets not grooved above; temple moderately convex, very shiny, with punctures extremely sparse and unevenly distributed; metapleurum without hairs, coarsely mat, its ventral part longitudinally wrinkled; median longitudinal carinae of propodeum distinct, blunt, and straight; areola not constricted basally, not separated from median basal area, the two together forming a long, narrow, subrectangular area which is narrower basally; costula absent; hairs sparse in region of second lateral area of propodeum; hind spur of hind tibia (including its hairs) 5.0 to 7.0 times as long as wide; second segment of hind tarsus 2.0 to 2.3 times as long as wide; first tergite 1.5 to 1.7 times as long as wide, its dorsal carinae extending 0.74 to 0.85 its length; last segment of hind tarsus without a subapical ventral tooth or tuft of hairs on inner side; apical notch of female subgenital plate extremely large, 0.7 to 1.4 times as deep as wide.

Background coloration black. Flagellum ferruginous above, somewhat paler below, its first segment sometimes paler; pedicel and scape stramineus to pale yellow; apical half of mandible ferruginous; palpi pale stramineus to pale yellow; tegula stramineus to ferruginous, yellow basally; front and middle legs fulvous, the apical half of middle femur more or less infuscate, especially behind. Hind leg with brown to very dark brown femur, the latter more or less pale basally; hind tibia yellowish basally, ferruginous medially, infuscate apically; hind tarsus mostly pale ferruginous, with basal 0.4 to 0.7 of first segment paler.


HABITAT and COLLECTION: In Michigan T. minutus was taken with sweep nets throughout the summer on The University of Michigan's Edwin S. George Reserve. They were collected on an abandoned farm site, an upland field with gravelly soil and a grass-herb plant cover. It is surrounded by oak-hickory woodlands which are encroaching on the field at its edges.
ACKNOWLEDGEMENTS

I am particularly indebted to Dr. H. K. Townes for his guidance and the use of his collection of *Triclistus*. I also wish to thank Professor F. C. Evans of The University of Michigan, Department of Zoology and Miss L. Walkeley of the U.S. National Museum for lending me specimens of *T. minutus*.

LITERATURE CITED

RELATIVE SUSCEPTIBILITIES OF THREE PONDEROSA
PINE SOURCES TO EUROPEAN PINE SAWFLY
(HYMENOPTERA: DIPRIONIDAE) ATTACK IN MICHIGAN

Louis F. Wilson

INTRODUCTION

Accidentally introduced into New Jersey about 1925, the European pine sawfly, *Neodiprion sertifer* (Geoffroy), now inhabits most of the Northeastern and North Central States and Ontario, Canada. Red pine, *Pinus resinosa* Aiton, and most other native and exotic pines within its range are susceptible to attack. Few attack records are available for ponderosa pine, *P. ponderosa* Douglas ex Lawson, because this pine is uncommon in eastern North America. Soraci (1939) observed egg clusters and larval feeding on planted red and ponderosa pine in New Jersey; Benjamin *et al.* (1955) found egg clusters on ponderosa pine in Illinois and recorded more intensive attacks on red pines nearby. However, quantitative data on the relative susceptibility of ponderosa pine to sawfly attack have never been reported.

Because it is highly probable that *N. sertifer* will someday establish itself farther west, where ponderosa pine is abundant, information about ponderosa pine susceptibility to sawfly attack is of interest. In light of this need the following research was undertaken. It compares attacks on three ponderosa and one red pine seed source.

MATERIALS AND METHODS

Ponderosa pine seedlings from three sources in Oregon (*viz.*, Deschutes, Rogue River, and Wallowa-Whitman National Forests), were outplanted in the spring of 1960. They are examples of the Pacific Coast variety, *P. ponderosa* var. *ponderosa*, which differs somewhat from the more easterly and southerly varieties (varieties *scopulorum* and *arizonica*) not represented in the study. See Wells (1964).

Seedlings from all three sources and red pine seedlings from Michigan were planted together in clearings surrounded by large red and Scotch (*P. sylvestris* L.) pines in three Michigan counties (Ottawa, Oceana, and Clinton). Two experimental blocks of 80 seedlings each were established at each locality. Each block had five 4-tree plots representing the several seed sources set out in a completely randomized design. Unfortunately, the Rogue River plots had to be replanted in 1961 because of heavy mortality the first year.

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1 Insect Ecologist, North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture. The author is headquartered at the Station's field office, which is maintained in cooperation with Michigan State University, in East Lansing, Michigan 48823.
All trees in each infested block were checked annually from 1962 to 1965, during which the egg clusters were counted. Only the two Clinton County blocks were found attacked by the sawfly.

**VARIATION IN SAWFLY ATTACK**

Red pine was attacked more heavily than was ponderosa in all 4 years. Attacks increased 400 percent in 1965, and differences in attack that year became apparent among the ponderosa pine seed sources (Table 1). The 1965 data and the combined 4-year data revealed large differences (significant at the .01 level) between red pine and the three ponderosa pines. *P. ponderosa* 'Deschutes' had fewer attacks than either *P. ponderosa* 'Rogue River' or *P. ponderosa* 'Wallowa-Whitman' (Table 1).

Lyons (1964) and Wright *et al.* (1966) have shown that European pine sawfly attacks are often directly related to tree height, so further tests were made after height adjustment, because the replanted Rogue River pines were much shorter than the others (Table 1). The results of the analyses, however, remained the same. Interestingly, the *P. ponderosa* 'Deschutes' trees were among the tallest trees but still the least susceptible to attack.

**TABLE 1.** Number of European pine sawfly egg clusters on all plots and mean tree height for ponderosa and red pine seed sources, Clinton County blocks.

<table>
<thead>
<tr>
<th>Cultivar name of species of Pinus</th>
<th>1962</th>
<th>1963</th>
<th>1964</th>
<th>1965</th>
<th>all years</th>
<th>Mean tree height</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. ponderosa</em> 'Deschutes'</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>55</td>
</tr>
<tr>
<td><em>P. ponderosa</em> 'Rogue River'</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>16</td>
<td>19</td>
<td>35</td>
</tr>
<tr>
<td><em>P. ponderosa</em> 'Wallowa-Whitman'</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>16</td>
<td>21</td>
<td>58</td>
</tr>
<tr>
<td><em>P. resinosa</em> 'Michigan'</td>
<td>9</td>
<td>14</td>
<td>12</td>
<td>41</td>
<td>76</td>
<td>46</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>11</td>
<td>14</td>
<td>19</td>
<td>77</td>
<td>121</td>
<td>--</td>
</tr>
</tbody>
</table>

---Table 1

*a* The analysis of variance showed highly significant differences between red and all ponderosa pines.

**DISCUSSION AND CONCLUSIONS**

The mechanisms underlying the obtained variation in sawfly attack were not fully determined in the study. Host conditioning may have been partly responsible for the red pine preference; most of the sawflies that attacked the test trees developed on red pines surrounding the experimental blocks. However, at one location some very likely had developed on nearby Scotch pines, too.

Randall (1965) found that sawfly-resistant Scotch pine varieties have wider needles than do susceptible ones. Ghent (1959) reported that *N. sertifer* will not oviposit on needles wider than 2 mm. Needles of ponderosa or red pine are narrower than those of Scotch pine, so this could not account for differences in susceptibility observed here.
It is possible a minimum needle width could also be responsible, but this was not checked.

The location of the plots was examined in order to explain the apparent low susceptibility of *P. ponderosa* 'Deschutes'. In the intensively attacked block, border plots of all trees combined had more egg clusters than did inner plots. Only two of five *P. ponderosa* 'Deschutes' plots were on the border, whereas the other sources each had four border plots. However, when only border plots are considered, *P. ponderosa* 'Deschutes' trees still had less than one-fourth as many egg clusters as either of the other two ponderosa sources.

Considerable speculation exists about the role that pine resins play in the attraction of sawflies. The quantity and quality of compounds in pine oleoresin vary considerably among pines and among sources in ponderosa pine (Mirov, 1961). Smith (1963) tested several ponderosa sources and reported great variability in resin volatilities at room temperature. Definitive studies are needed to test the importance of differential volatility of resin in causing host resistance.

Whatever mechanisms are involved, Michigan red pine was preferred for oviposition over the three Oregon sources of ponderosa pine. In addition, *P. ponderosa* 'Deschutes' was very lightly attacked, indicating possible inherent resistance compared to the two other ponderosa seed sources.

**LITERATURE CITED**


THE DAVID-GARDINER METHOD OF FEEDING

LEPIDOPTEROUS LARVAE ON A SEMI-SYNTHETIC DIET

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One of the most interesting entomological developments in recent years has been the introduction of semi-synthetic diets for feeding lepidopterous larvae. Vanderzant and Reiser (1956a, 1956b) reared pink bollworms (*Pectinophora gossypiella*) on such a medium. The medium was subsequently modified by Ignoffo (1963), who experimented with mass-rearing of the cabbage looper (*Trichoplusia ni*), and by others. The method showing the most spectacular results is that of David and Gardiner (1965), which, since its publication, has been proven suitable for a number of species with diverse feeding habits. Although not a universal pabulum for larvae, the David-Gardiner formula deserves to be better known in America as it solves two of the problems encountered in rearing many larvae; *viz.*, it provides (1) a readily available food which may be (2) sterilized to eliminate disease.

The announcement of the formula mentioned only its use in rearing larvae of *Pieris brassicae*, but Dr. B. O. C. Gardiner (personal communication) has shown that a number of other species may feed successfully on his "artificial leaves." One must admit that a formula on which *Philosamia ricini*, *Arctia caja*, *Pieris brassicae*, *P. napi*, *P. rapae*, *Panaxia dominula*, *Vanessa atalanta*, and even the orthopteran *Carausius morosus* (a privet-feeder) may all be reared surely has even wider potentiality of which amateur breeders could well take advantage. The method may solve the problem of rearing larvae when the food-plant is unknown, not indigenous, or (as is more common) not readily available. Plans are being laid by a private concern to market the formula, but meanwhile Dr. Gardiner has kindly given permission to communicate it to *The Michigan Entomologist* so that it may be of use in the coming season. Some skill in laboratory techniques is necessary in its preparation, but this should not deter the "home experimenter" who may wish to try a simpler adaptation.

**FORMULA**

(a) Distilled water

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td>110 ml</td>
</tr>
<tr>
<td>Potassium hydroxide, 4 molar</td>
<td>1.8 ml</td>
</tr>
<tr>
<td>Casein (light white soluble)</td>
<td>12.6 g</td>
</tr>
</tbody>
</table>

(b) Sucrose

<table>
<thead>
<tr>
<th>Substance</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>12.6 g</td>
</tr>
<tr>
<td>Wheat germ</td>
<td>10.8 g</td>
</tr>
<tr>
<td>Cabbage (dried powder, see Note 1 below)</td>
<td>5.4 g</td>
</tr>
<tr>
<td>Salt mixture (see Note 2 below)</td>
<td>3.6 g</td>
</tr>
<tr>
<td>Cellulose powder, Whatman Chromedia, CF11 grade</td>
<td>1.8 g</td>
</tr>
</tbody>
</table>
(c) Choline chloride (10% w/v solution) 3.6 ml
Methyl parahydroxybenzoate (15% w/v in 95% ethanol) 3.6 ml
Formaldehyde solution (10% w/v solution) 1.5 ml
Vitamin stock (see Note 3 below) 0.8 ml

(d) Distilled water 200 ml
Agar (fine Japanese powder) 9 g

(e) L-Ascorbic acid 1.5 g
Aureomycin (veterinary grade) 0.8 g

NOTES

(1) The cabbage leaves are prepared by drying in thin layers in a ventilated oven at 105°C for 15-20 minutes. They may then be ground by hand and passed through a 60-mesh sieve, or ground in a Christy-Norris mill fitted with an 0.5 mm mesh screen.

(2) The salt mixture is composed in grams as follows: CaCO₃, 120; K₂HPO₄, 129; CaHPO₄·2H₂O, 30; MgSO₄·7H₂O, 40.8; NaCl, 67; KI, 0.32; FeC₆H₅O₇·6H₂O, 11; MnSO₄·4H₂O, 2.0; ZnCl₂, 0.10; CuSO₄·5H₂O, 0.12.

(3) The vitamin mixture is composed in mg as follows: nicotinic acid, 600; calcium pantothenate, 600; riboflavin (B₂), 300; thiamine hydrochloride (B₁), 150; pyridoxine hydrochloride (B₆), 150; folic acid, 150; D-biotin, 12; cyano-cobalamine (B₁₂), 1.2; 100 ml water.

PROCEDURE

David and Gardiner (1965) may be quoted for the precise method of combination: "The ingredients listed in (a) are placed in a blender with a capacity of 800 ml. and thoroughly mixed together. The mixed solids (b) are then added with further blending. The solutions (c) are next added, separately, while the blender is running. Meanwhile, the agar solution (d) has been prepared in a water bath. It is cooled to 70°C and added to the mixture. Finally, the ingredients (e) are added and the whole medium is thoroughly blended." The original directions for feeding may also be followed, as they have continued to be successful, but the jars may be replaced with locally available wide-mouthed bottles of a comparable size: "The warm medium was poured into sterilized 1 lb. jam jars to a depth of about 0.5 in. and while still warm each jar was tipped and twisted so as to coat some of the sides. As soon as the medium was cool the jars were turned upside down to prevent unnecessary contamination. They can be conveniently stored at about 12°C. After the larvae were introduced the jars were kept on their sides so that comparatively little frass fell on the medium. Whatman No. 1 filter paper was first used to close the jars as this reduced evaporation and prevented the medium drying out too rapidly, but when the larvae reached the fifth instar the paper was changed for a piece of . . . gauze as more ventilation was now necessary to prevent conditions in the jars becoming too humid and sticky. About 15 fifth instar
larvae can be kept in a jar and of course more younger larvae."

It will be recalled that the larvae described are those of *Pieris brassicae*, as it would hardly do to keep 15 fifth instar saturniid larvae in a jar of the described size. For extremely small larvae, the authors recommend specimen tubes, and in all cases suggest that the medium be renewed weekly; the paper on *brassicae* may be consulted for further details. Dr. Gardiner has recently informed me by letter that the food should be successful on all normally polyphytophagous arctiids, noctuids, and others if suitable feeding stimulants are added.

LITERATURE CITED


REVIEW

A NATURALIST'S GUIDE TO ONTARIO. W.W. Judd and J.M. Speirs (eds.). Published for the Federation of Ontario Naturalists by University of Toronto Press. 210 pp., 6 1/8 x 9 1/4 in. 1964. Price: cloth, $4.95; paper, $1.95.

This book fills a long-time need and is a truly worthwhile endeavor. The first chapter is an excellent general discussion of the geology of Ontario by W. M. Tovell (illust. with 3 maps and table). Chapter 2 is an outline of the vegetation and fauna by J. B. Falls and J. H. Soper; forest regions are mapped and described with lists of characteristic plants and typical vertebrates.

The next 148 pages are "regional guides"—concise descriptions of many Ontario localities of general interest to naturalists. These are contributed by numerous individuals, nature clubs, and the Ontario Department of Lands and Forests. Included are most important provincial parks and other natural areas. The plan of these "guides" is similar to Pettingill's familiar books on bird finding. Directions to the locality are followed by remarks on interesting species found there. Comments on the geology of several areas (especially Niagara Falls) are most helpful. Information on camping and the addresses of local naturalists' organizations are included.

Descriptions range from the shore of Hudson Bay (don't travel there without reading the sections on "Cape Henrietta Maria" and "Hudson Bay Lowlands") to southernmost Point Pelee, but most are in the south and readily accessible by road. One can scarcely visit Ontario without encountering points of interest included in this guide. I noted the omission of the Kettle Point, Ipperwash, Pinery Park, Grand Bend region, but Dr. Judd assured me that, at the time the guide was prepared, the editors had no one to write this section. I assume that additional regional guides will be included in future printings.

Separate indices to "species of interest" and "points of interest" are very useful but need a few minor corrections (e.g., prickly-pear is indexed as "Pear, Prickly") and additions (a number of items mentioned in the text are not indexed). The exclusive use of common names does not delight the biological mind, but helpfully, many of the plants are associated with scientific names in Chapter 2.

The widespread and peculiar tradition that naturalists are primarily interested in plants and vertebrates (especially birds) is generally followed. Even though Dr. Judd is a well-known entomologist, the sole invertebrate mentioned in the index is the "European praying mantis." It would be unreasonable to suggest that a book of this nature contain much information about that vast majority—the invertebrates. But it might be nice to include a number of particularly interesting species to cheer the invertebrate zoologist as he reads the long lists of birds, plants and mammals.

The book has a pleasant format and is easy to read. It is enhanced by Sylvia Hahn's artistic illustrations. The editors and authors deserve an accolade for undertaking such a difficult task and bringing it to such a fruitful conclusion. Its faults are all slight and A NATURAL-
SPECIAL NOTICE

The Michigan Entomological Society has decided to dispose of several volumes of the PAPERS and ANNUAL REPORT of the Michigan Academy of Science, Arts, and Letters which we inherited from the former Detroit Entomological Society. These items are being offered only to libraries in the state of Michigan. A letter announcing the sale, dated 19 May 1966, was mailed to all major Michigan libraries. If your library does not have these items, your recommendation to acquire them will be appreciated.

In the event no library in Michigan makes an acceptable bid, the items will be sold to the highest bidder. If you are interested in purchasing these books please contact the Society.

The items for sale are:

1. PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE, ARTS, AND LETTERS, volumes 1-14, complete, bound in red buckram.
2. ANNUAL REPORT OF THE MICHIGAN ACADEMY OF SCIENCE, ARTS, AND LETTERS, 1st-22nd (1900-1921), complete, bound in red or black; and 23rd-44th, unbound, complete except for 34th-35th.

We understand that present volumes of the PAPERS are being sold for $10 each. Early volumes of the PAPERS will soon be reprinted, at an approximate cost of $15 per volume.

The deadline for receipt of bids from Michigan libraries is 15 August 1966. The minimum bid for Items 1 and 2 (they will NOT be sold separately) is $175, F.O.B. East Lansing.

Please mail bids to the Michigan Entomological Society, Department of Entomology, Michigan State University, East Lansing, Michigan 48823.
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Papers dealing with any aspect of entomology will be considered for publication in The Michigan Entomologist. The major area of interest is the Upper Great Lakes Region, but papers of non-regional nature and papers dealing with other regions will be considered. Considering the range of interests among members, we seek to include the widest possible variety of subject matter within the field of entomology. Notes on techniques useful to teachers, hobbyists, or professionals are welcomed.

Manuscripts are judged on their entomological merit and clarity of presentation, and their acceptability is determined without special regard for repetition of authors, length, or subject matter. Authors need not be members of the Society to submit papers, but papers by Society members are given priority.

Manuscripts are ordinarily published in their order of acceptance, with allowance as necessary for the maintenance of diversity within our space limitations. In the interests of diversity, accepted articles of over 10 printed pages may be divided into two or more issues, unless the extra pages can be subsidized at cost (approximately $5.00 per page). Subsidized papers of 28 or more printed pages will be published, without delay, as single issues.

Illustrations are encouraged, without arbitrary limitations on quantity. Photographs should be 8 x 10 inch glossy, while drawings, charts, graphs, and maps may be of any suitable size (but allow for reduction). There is no charge for illustrations.

The Style Manual for Biological Journals should be consulted, and its recommendations on form and style should be adhered to rigidly. [It is available, at $3.00 per copy, from the American Institute of Biological Sciences, 2000 P. Street, N.W., Washington, D.C. 20036.] Above all, avoid a pedantic style. Scientific accuracy and lucid, interesting writing are not mutually exclusive. Remember that your audience has a wide range of interests and backgrounds.

Manuscripts should be neatly typed, double-spaced, with wide margins, on white 8 1/2 x 11 inch paper. CAREFULLY CHECK MANUSCRIPTS FOR ACCURACY BEFORE SUBMISSION, because our method of printing does not provide a proof which can be sent to authors. Titles should be explicit, and should identify the order and family being dealt with. The author of each species mentioned must be given in full at least once in the text. A common name for each species or group should also be given at least once, when such a name exists. The format of references should follow the style used in recent issues.

Each author or co-author will receive 25 gratis copies of the issue in which his (their) paper appears. Additional reprints may be ordered, as separates, upon acceptance of the paper.

Send all manuscripts to the Editor, Julian P. Donahue, Department of Entomology, Michigan State University, East Lansing, Mich. 48823.