LIFE HISTORY OF SCIRTES ORBICULATUS FABIUS
(Coleoptera: Helodidae)[1]

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In July 1937, some unknown aquatic insect larvae were found in the vicinity of the University of Virginia's Mountain Lake Biological Station, in Giles County, Virginia. On July 31, 1938, additional larvae were found, and a culture was established. Throughout August of that year weekly collections were made and specimens were added to the culture. This work was continued through the summers of 1938, 1939, and 1941. Larvae were first collected in the field on July 22 in 1939, and on August 1 in 1941. During the four summers observations were made on the feeding habits, locomotion, respiration, and ecdyses of the larvae, on pupation, and on the activities of the adults.

These insects were identified from reared adults as *Scirtes orbiculatus* Fabius, of the family Helodidae (=Cyphonidae). The larvae of this family of beetles are only poorly known. According to Comstock (1933) there are 32 species in this family in our fauna.

THE HABITAT

The larvae were found in an artificial pond on the J. K. Kessinger farm two miles southwest of Newport, Giles County, Virginia, and approximately ten miles south of the Biological Station. A few were located in two small lakes on the campus of Virginia Polytechnical Institute, Blacksburg. This campus is located some fifteen miles southeast of Kessinger's Pond, and separated from it by two mountain ranges. The region is in the southern Alleghanies, where the underlying limestone gives rise to numerous water-filled sink-holes. About ten such ponds in the vicinity were searched at various times, without discovery of the insect, either adults or larvae.

The limited distribution seems rather unique in view of the fact that the adults are active flyers and jumpers. Reitter (1909) mentions that the adults do not live where they emerge. In fact, sweeping of the vegetation on the pond banks by the writer yielded only eight adults. Lombardi (1928) records the fact that the Helodidae are not very common near Bologna, Italy, where she made collections. While she

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found them in great numbers in small, stagnant ponds, other waters nearby lacked them completely.

Kessinger's Pond is fed by strong cold springs. The settlement basin, approximately 90 feet in diameter, is formed by an earthen dam some three feet high. The overflow goes into a much larger and permanent pond that reaches a depth of about four and one-half feet. The surface is exposed to the sunlight and is shaded only on the east side. The banks are overgrown with sawgrass (*Cladium jamaicense* Crantz) and other low-growing hydrophytic plants. There is an extensive growth of the common pond lily (*Nymphaea advena* Ait.) on the western side. Drainage is through Spruce Run, the New River, and the Kanawha to the Ohio River. Life is abundant in and around the pond. The pond community seems well adjusted, after its ten years of existence.

The larvae were taken with a dip net in the shallow water near shore where dead vegetation had fallen into the water. Many were also found on floating sticks and boards that had been in the water long enough to acquire their own flora.

Careful observations were made in the native habitat as well as in the laboratory. The larvae were observed not far from shore crawling along the submerged stems or swimming with many pauses, ventral side up, just beneath the surface film. They move from one object to another several inches apart without rest. The swimming motion includes rapid leg movements and sidewise undulating motion of the body. At times the larvae literally walk beneath the film without undulation of the body. The larvae of *Scirtes tibialis* Guerin apparently have similar habits (Kraatz, 1918).

DESCRIPTION

Adult (fig. 1).—Blatchley's description of the adult (1910, p. 694) is as follows:

"*Scirtes* Illig. 1807. . . Head deflexed; antennae [11-jointed] slender, half as long as body; prosternum short, not prolonged between the coxae, which are prominent and contiguous; hind coxae suddenly dilated on inner side into small plates; hind femora oval, very much enlarged, the tibia with one long and a shorter spur; tarsi with fourth joint bilobed, the first joint of the hind ones as long as the other joints combined."

"*Scirtes orbiculatus* Fab. . . . Broadly oval, sparsely pubescent. Black or piceous, shining; elytra with an oblong-oval reddish-yellow spot on middle of suture; thorax with sides usually broadly reddish-yellow; femora piceous, tibiae, tarsi and antennae paler. Head and thorax sparsely, elytra more densely and coarsely punctate. Length 2.5–3 mm."

Larva (figs. 2–14).—The mature larva (fig. 2) measures 5.5–6 mm. in length, exclusive of the antennae. The body is dark brown to black in color, with light splotches along the faint dorsal median line of the thorax. The body is campodeiform, i. e., elongate, sub-cylindrical, tapering caudally, and is broadest at the metathorax. The body segments are distinct; the body is prominently hirsute, and small tubercles support numerous spine-like setae of medium length. The lateral margins of the thorax, especially of the pro- and mesothorax, are flared slightly, shield-like, and bear numerous long setae which are nearly as long as the segment is broad. The prothorax is nearly twice as broad as the mesothorax, which is only a trifle broader than the metathorax.

The most conspicuous structures of the head capsule (fig. 3) are the extraordinarily long, setaceous antennae. They are attached anterior and sublateral to the eyes and above the base of the mandibles. The antennae average 2.8 mm. in length, which is half the body length; sometimes they are nearly as long as the body. Many specimens were collected with part of the antennae missing. Each antenna is composed of three large basal segments and numerous smaller segments, totaling perhaps 100 to 115. Kraatz (1918) speaks of 120 to 125 antennal segments. The small segments bear minute sensory papillae; these papillae are irregular in distribution and extend nearly the entire course of the antenna. Of the basal segments (fig. 7), the first is half the length of the third and is scarcely longer than broad; the third is long and slender; the second is small and inconspicuous. A single spine, three-fourths as long as the segment, is present on the median anterior edge of the third segment; another minute spine is located on the ventral, anterior edge; a third small spine is on the lateral and distal edge of the third segment.

The labrum (figs. 3, 5) arises from a very small clypeus; it is broader than long, and crescent-shaped on the anterior margin with a spine at each point; there are usually four spines on the lateral margins. The labium (fig. 6) is not cleft to form a ligula; the labial palpi are simple, two-segmented, small, and about as broad as long; the mentum is not clearly distinct from the submentum. The distal edge of the labium is covered with many small hairs. The maxillae (fig. 4) are fairly well developed and bear five-segmented palpi, the joints of which are hairy; the palpi project beyond the head. The laciniae bear on the inner margins numerous long, stout hairs. This brush-like arrangement makes the maxillae quite effective in the active feeding process. The mandibles (fig. 8) are fairly well sclerotized and are elongate-triangular, with pointed tips and with the inner surface curved or sickle-shaped; a molar region with six teeth is located near the base. The mandibles have tufts of hair-like spines along the inner surface, while the outer margins are rather evenly covered with fine hairs. The hypopharynx is

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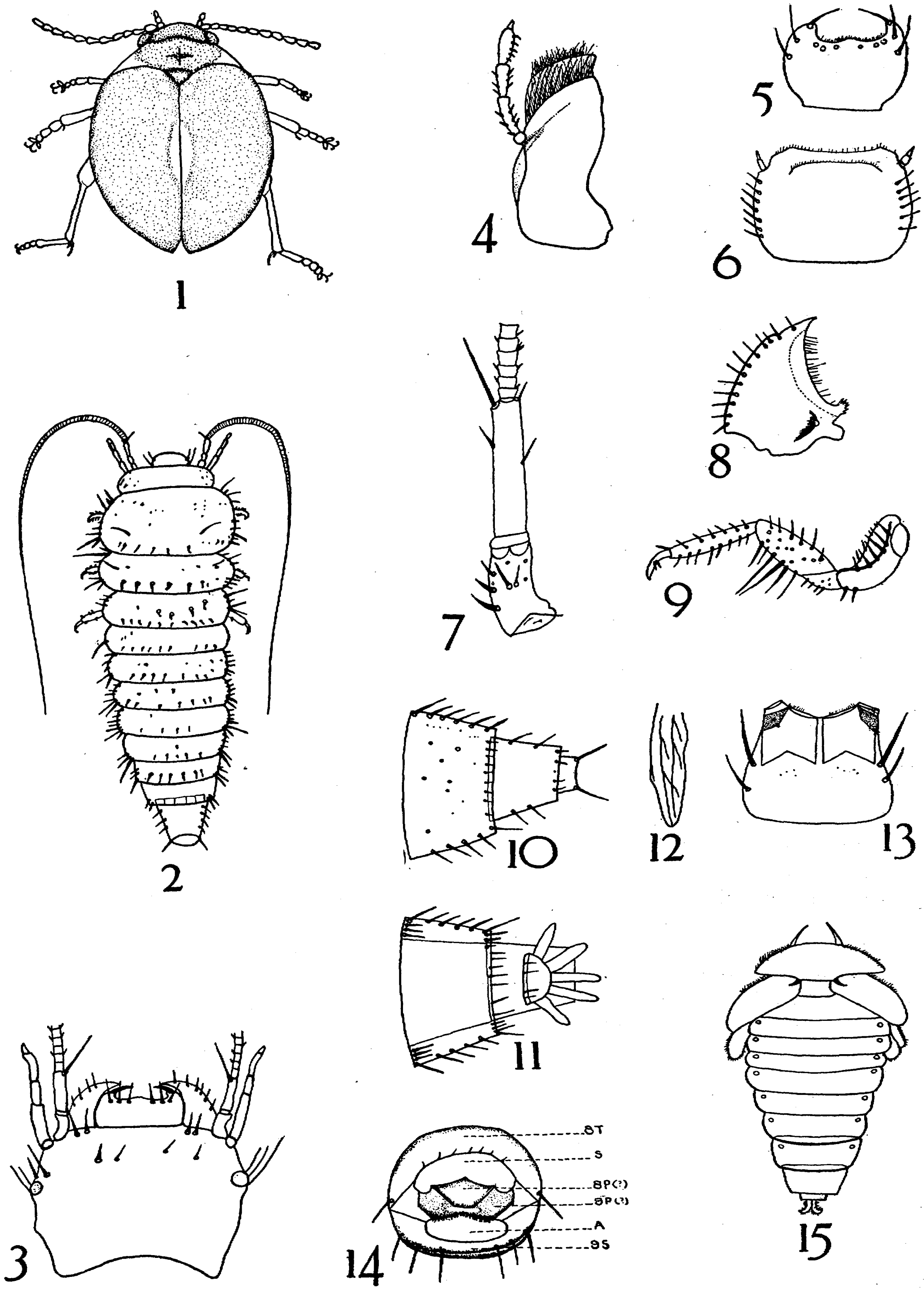
EXPLANATION OF PLATE

Scirtes orbiculatus Fabius. Figure 1. Adult, dorsal view (× 7½). 2. Mature larva, dorsal view (× 10). 3. Head of larva, dorsal view (× 30). 4. Left maxilla of larva, dorsal view (×35). 5. Labrum of larva, dorsal view (× 40). 6. Labium of larva, ventral view (× 40). 7. Basal segments of right antenna of larva, dorsal view (× 50). 8. Mandibles of larva (× 50). 9. Hind leg of larva (× 20). 10. Dorsal view of caudal end of larva showing seventh and eighth tergites and doubtful sclerite (ninth pleurite?) (× 20). 11. Ventral view of caudal end of larva showing seventh, eighth, and ninth sternites, seventh pleurite, and retractile rectal gills (× 20). 12. Distal end of tracheal gill showing minute tracheoles (greatly magnified). 13. Last dorsal sclerite of larva, with two small sclerites of doubtful origin (ventral view) (× 35). 14. View of caudal end of larva, posterior view: *S*=opening of eighth spiracle; *A*=anal opening; *9S*=ninth sternite; *8T*=eighth tergite; *8P(?)* and *9P(?)*=possibly eighth and ninth pleurites. 15. Pupa, dorsal view (× 7½).

PLATE I



strongly developed and bears five outwardly curving hooks, arranged in a circle about a central orifice.

The legs show all of the usual parts. The three pairs are very similar, the posterior pair being slightly larger. Each tarsus bears a single curved claw which is used by the larva in clinging to objects. There are two minute spines on the claw, arising on opposite sides from the middle of the claw. The outer surface of the coxa is somewhat excavated, and each edge of the excavation bears a row of fine spines. The trochanter is present but difficult to distinguish. The legs are moderately covered with hairs, those on the tibia being more numerous and stouter. A row of four or more hair-like processes, longer than the tarsal claw, extends along the ventral side of each femur.

The abdomen consists of eight distinct segments, the first five having the same width as the metathorax, the last three tapering off sharply; the seventh segment is from one-half to three-fourths as wide as the metathorax, and the eighth is one-fourth as wide. The eighth segment has the appearance of being telescoped within the seventh. Nine sternites and seven pleurites are clearly seen on the ventral side. The ninth sternite is modified as an anal covering. The abdomen is quite hirsute, and has an irregular transverse row of spine-like setae on each segment. There are about five lateral spines on each segment, some of which are as long as the segment is broad.

The Pupa (fig. 15).—The pupa is elongate-rounded and 5 mm. in length. It is at first a creamy white, later turning to a dark gray. The head is deflexed and has prominent black eyes; the antennae are free from the body and folded beneath the head; no ocelli were observed on the pupa or larva. A fine pubescence covers the entire body, and it is especially dense on the head. The prothorax has two dark spines on the posterior dorsal margin and a second larger and longer pair on the anterior margin. Spiracles are located dorso-laterally on all abdominal segments. Several pupa were observed with the larval exuvia still clinging to the caudal end; one such specimen reached maturity with both larval and pupal exuviae still clinging to it. This specimen seemed normal except for slightly misshapen elytra. This condition has also been reported by Kraatz (1918). The pupae are capable of vigorous jerking movement, when disturbed.

HABITS

Feeding Habits of the Larvae.—The larvae are vegetarians. No attempt to ingest animal life was observed; the larvae passed over minute snails, eggs, *Planaria*, Copepods and Protozoa. Kraatz (1918) states that the food of *Scirtes tibialis* is the duckweed, *Lemna minor*. *S. orbiculatus* larvae were never seen to eat plant leaves, but merely scraped more minute forms from the leaves and stems. The structure of the larval mouth parts is probably such that leaf-eating is not possible.

The larvae forage about on both upper and lower surfaces of submerged vegetation and other objects, sweeping with rapid motion of the maxillae as they move steadily forward. The maxillary palpi are quite active and appear to function as exploratory and sensory organs. The laciniae, or tooth-like parts of the maxillae, are quite broad; they are the most active scraping organs. The unusually long antennae constantly move about with a lash-like motion, and probably aid the larva's course, since they are undoubtedly sensory. At times the animals were observed to clean their antennae of debris by pulling them under an elevated fore leg.

Larvae were most often taken on blades of dead saw-grass that had dropped into the water and were thoroughly water-soaked. On such objects were found a heavy growth of *Oedogonium*, diatoms, *Pharmidium lamnisonum*, desmids, and other algae (identifications by J. C. Strickland).

Respiration of the Larvae. The gills are five (sometimes four) small, white, unevenly rounded, finger-like retractile processes in the rectum. The rectal opening is on the ventral side of the ninth sternite; this sternite is much smaller than the preceding ones and serves as an anal covering, and can be lowered to allow the gills to be everted. By using transmitted light on living specimens, minute thread-like tracheoles can be seen in the gills. The tracheoles are bathed by a constant stream of blood, as shown by the movement of the leucocytes.

There have been much discussion and confusion in the literature regarding the respiration of helodid larvae. From his observations the writer believes the tracheal gills function as auxiliary respiratory organs. This is in accordance with the observations of Lombardi (1928), who states that they are used particularly when the larvae are in unfavorable conditions.

As the larva approaches the surface, the caudal end is brought into contact with, and pushed through the surface film. An opening appears just below the eighth tergite, and air is taken into the tracheal chamber. Immediately on submerging beneath the surface film, a bubble of air is apparently forced out of the tracheal chamber. This agrees with Lombardi's observations. The bubble remains until the larva is ready to come to the surface again for air, at which time the caudal opening is first closed, releasing the bubble, then reopened above the surface film. At no time were the gills everted while the larva was obtaining air at the surface, but they were nearly always protruded while the larva was beneath the surface. In a dorsal view the gills are just ventral to the air bubble, but they are not in contact with it, as can be seen from a lateral view.

By way of experimenting with the respiration, a larva was placed in a weak chloretone solution (anesthetic). No effects were noted for fifteen minutes; then respiration obviously became more labored. The caudal opening of the eighth tracheal spiracle was pushed through the surface film at ever-increasing intervals to take in air. The outline of most of the larger trachea could be seen pulsating more rapidly in apparent effort to secure oxygen. Meanwhile the gills remained everted. Gradually the larva succumbed to the anesthetic, but was later revived for a short time by placing it in fresh water.

DEVELOPMENT

A larva 2 mm. in length, which had probably just hatched, was collected on the morning of August 27; its size increased very rapidly, and by 2:00 P. M. it had become darkened and sclerotized. Fourteen days later (Sept. 11) it molted the first time, and the second molt occurred fourteen days later (Sept. 24). No further molts were recorded for the following twenty-five days. On October 19 the larva crawled out of the rearing dish and disappeared. This one specimen was under constant observation for two months. Much of the time toward the end of this period the weather was very chilly, which probably affected the temperature in the rearing dish (which was located on an outside porch) more noticeably than in a natural pond.

The length of time between molts varied from seven to fifteen days (average, 10.1 days) in eight recorded molts (see Table I). The number of instars could not be definitely fixed, as most specimens had apparently undergone some molts when taken.

TABLE I

DAYS BETWEEN LARVAL MOLTS

Days	Number of Larvae
7	2
8	2
11	2
14	1
15	1
Average = 10.1	Total = 8

The larvae were reared in dishes placed in a larger receptacle of water. The larvae were provided with water-soaked saw-grass blades and a small piece of wood taken from the native pond, which provided support as well as a food supply. When the larvae crawled out of the rearing dish they could be easily detected in the larger receptacle, and were picked out and placed in a small amount of damp sphagnum moss in tumblers. One or two small sticks were provided as a support for the mature insects, and the tumblers were covered with cheese cloth. The larvae crawled into the moss and excavated small cavities in which they pupated. In six cases where single specimens were placed in small receptacles, the larvae crawled out before they were ready to pupate; when in groups, none were observed to leave the rearing dish until they were ready to pupate. Larvae 8 and 9 (see table II) used moss and mud in the construction of pupal chambers. The mud was near the consistency of that on the bank of the native pond. In each case the pupal chambers were formed in the edge of the mud.

Larva 12 (Table II) was allowed to pupate in a small stender dish containing moist sand. After exploring a bit, the larva settled down to making a depression in the sand. This was a long laborious process; it started in the early afternoon and was not nearly completed by late at night. The larva lifted each grain of sand in its mandibles and placed it in place, an activity very much like that of a mud-dauber wasp. The following day nothing was to be seen except a completely capped-over pupal chamber. Four days later the adult beetle broke through the frail wall of the pupal chamber. It would thus appear that the place of pupation is in the pond banks, above the water line. Lombardi (1928) describes *S. hemisphaericus* pupating in the pond bottom and the adult rising to the surface in an air bubble.

The long antennae of the larva (see fig. 2) are shed just before the time of crawling out for pupation. It is always the filamentous part, not including the three basal segments, that is shed. This probably facilitates pupation, as the antennae are out of the way when the larva is building the pupal chamber. The average pupal period for 22 specimens reaching maturity was four days (see Table II). Kraatz (1918) found the pupal period of *S. tibialis* (for nine specimens only) to be "about three days."

TABLE II

PUPATION AND EMERGENCE OF *Scirtes orbiculatus* F.

Lot No.	Number of Specimens		Dates		Duration of Pupal Stage (Days)	Length of Adult Life (Days)
	Larvae Pupating	Adults Emerging	Pupation of Larva	Emergence of Adult		
1938						
1	3	2	Aug. 24....	Aug. 29....	5	16
2	5	4	Sept. 4.....	Sept. 9.....	5	11
1939						
3	2	1	July 29.....	Aug. 2.....	4	12
4	3	3	July 29.....	Aug. 3.....	5	10
5	3	2	Aug. 10....	Aug. 14....	4	Missing Aug. 22
6	4	3	Aug. 11....	Aug. 14....	3	Missing Aug. 16
7	2	2	Aug. 14....	Aug. 17....	3	Missing Aug. 22
8	1	1	Aug. 20....	Aug. 24....	4	*
9	2	2	Aug. 22....	Aug. 27....	5	*
1941						
10	1	1	Aug. 4.....	Aug. 8.....	4	5
11	1	0	Aug. 8.....	....	....	....
12	1	1	Aug. 8.....	Aug. 13....	4	8
Total..	28	22			Average=4.3	Aver.=10.9

*Adult specimens preserved before death.

The newly emerged adult is light colored except for the black eyes; sclerotization and coloration takes place in a few hours, when the adult beetle becomes active. Activity seems to increase at night. The adults are good flyers, and extremely active jumpers due to the much enlarged hind femora.

The adults remained in the tumblers until death. The average life of the imago was 10.9 days (Table II). No evidence of feeding, copulation, or egg-laying was observed.

The fact that the majority of emergences occurred during the month of August would probably indicate that the natural peak in nature occurs in this month. It may be noted that there was a decided decrease in the number of larvae taken from the pond during the middle and last of August. Blatchley (1910) records the adults of *S. orbiculatus* in Stuben County, Indiana, June 17. The writer was unable to collect larvae before the last week in July during 1937, 1938, 1939, and 1941. Collections were made as late as August 16, but larvae were very scarce by that time.

Since eggs were not obtained, the ten-day incubation period recorded by Kraatz (1918) for *S. tibialis* may be used for purpose of estimate. From Table I the possible average time between molts is about 10.1 days; from one specimen observed to undergo four molts this would make approximately 40 days in the larval stage. Table II shows 4 days in the pupal stage and about 11 days in the imaginal stage. Summarizing, the lengths of the stages are: egg, 10 days; larva, 40; pupa, 4; imago 11; total 65 days.

SUMMARY

Observations on the life history and habits of *Scirtes orbiculatus*, a beetle of the family Helodidae, were carried on over four summers, during which time 27 adults were reared from larvae. The larvae are aquatic, and feed on microscopic plant life. They occur on dead vegetation in the shallow water of ponds, and in this study were found largely in Kessinger's Pond, two miles southwest of Newport, Virginia. The mature larvae are campodeiform, 5½–6 mm. in length, with antennae half as long as the body or longer. Respiration of the larvae is by means of a modified spiracle on the eighth segment, which is protruded above the surface film; the retractile rectal gills, which are true tracheal gills, serve as auxiliary respiratory organs. The duration of the life stages was found to be: egg, 10 days (estimated); larva, 40 days; pupa, 4 days; imago, 11 days; total, 65 days.

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CAUSES OF HEMLOCK MORTALITY IN NORTHERN MICHIGAN, by SAMUEL A. GRAHAM. University of Michigan, School of Forestry and Conservation, Bulletin No. 10. Pages 63, 19 figures, 6 x 9 inches, paper bound. Published by UNIVERSITY OF MICHIGAN PRESS, Ann Arbor, Michigan, 1943.

This bulletin discusses the ecological factors which have been responsible for the heavy hemlock mortality in northern Michigan in the last ten years, and recommends practices which will prevent much of this loss. This study is a good illustration of the fact that many of the problems of forest entomology are to be solved by proper methods of forest management.—D. J. B.