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LIFE HISTORY AND HABITS OF THE DOGWOOD BORER, *THAMNOSPHECIA SCITULA* (LEPIDOPTERA: AEGERIIDAE) IN TENNESSEE

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Abstract

The dogwood borer, the larva of a clear-wing moth of the family Aegeriidae, is a serious pest of flowering dogwoods in Tennessee. Damage is caused by feeding in the cambium and phloem of the trunk and major limbs. Laboratory rearings and experiments as well as field investigations were conducted from April 1962 to July 1963. Ornamental nurseries throughout middle and east Tennessee provided the source of insects for study. The period of emergency of adults in Tennessee was determined as beginning about the last of April and continuing until the second or third week of October, with a peak of emergence in mid-May. Field and laboratory investigations revealed very little about the feeding, mating, and egg-laying habits of the adults. These activities did not normally occur with captive moths. The incubation period of eggs obtained from gravid moths captured in the field was from eight to nine days. Pupation occurred within the tunnels made by the feeding of the larvae. The length of the pupal stage was from eight to twelve days. Some of the natural enemies of the dogwood borer have been identified and listed. A parasitic fungus is the most frequently observed enemy in Tennessee.

Introduction

The dogwood borer, *Thamnosphecia scitula* (Harris), is the larval stage of a clear-wing moth of the family Aegeriidae (Sesiidae). This insect is, perhaps, the most serious pest of flowering dogwoods in Tennessee. The larva feeds just beneath the outer bark of the trunk and major limbs in the phloem and cambium, seriously injuring and often completely girdling and killing the trees. Damage by this insect to dogwood trees throughout the state is one of serious economic importance. Damage to trees in the lawns of home owners has caused a great deal of concern; however, the greater concern is now being shown by nurserymen, to whom this insect poses a serious economic threat, rendering worthless thousands of nursery trees in a single generation of the pest. This study, covering heavily infested nurseries throughout middle and east Tennessee, has attempted to add to knowledge concerning this serious pest.

Nomenclature

The dogwood borer is known by a number of common and scientific names, including pecan tree borer, pecan sesia, nine-bark borer, woody gall borer, oak gall borer, and dogwood borer. At least seventeen synonymic scientific names can be listed for this insect; however, the one appearing in this publication is the presently accepted one.

Englehardt (1946) recognized two geographical races of *T. scitula*, *T. scitula scitula* in the East, and *T. scitula corrusca* in the South. According to him, field investigations over a period of several years proved that *corrusca* represents the southern extension of the range of *T. scitula*, and for this reason can be considered only as a race. In biology and structure the two are said to agree perfectly. They differ only in minor coloration, and the change in coloration is gradual from coastal Virginia to Texas. These color changes are less pronounced inland in the hilly and mountainous country.

Description and Life Cycle

Adult. Unlike many members of the clear-wing moth family, such as the peach tree borer, the sexes of *T. scitula* are monomorphic. They are distinguishable only by one who has learned to recognize certain minor color markings. Since the male and female are similar, the following description will apply to both, occasional sex differences being pointed out.

The basic color of the moth is dark blue, giving it a black appearance. There are occasional yellow markings on the body. The dark thorax is marked dorsolaterally with a yellow line, and ventrally with a yellow patch. The abdomen is dark with yellow on the second and fourth segments dorsally. Unlike the male, segments five and six of the female are yellow ventrally. The anal tuft is marked laterally with yellow; more broadly in the female. The femora of both sexes are dark, the remaining leg segments mostly yellow. The palpi are completely yellow in the female, and yellow with black tips in the male. The antennae are completely black.

Wing span of male and female dried and spread specimens ranged from 16 mm to 18 mm. The total length of the moth, not including the antenna, ranged from 8 mm to 10 mm. The wings are nearly devoid of scales, a characteristic of the entire family. The fore wings are quite narrow. Dorsally the veins and margins are marked with dark scales. The outer margin and apex are fringed with long, dark scales. The hind wings are about twice as wide as the fore wings. The inner margin is fringed with long, yellow scales, becoming darker at the anal angle and continuing on the outer margin and apex. The female, when filled with eggs, is heavier in appearance than the male.

Observed in flight or alight the adults closely resemble, and are often mistaken for small wasps (Fig. 1). According to Metcalf and Flint (1962), they [i.e., the blue and yellow or orange Aegeriidae, especially those with bands across the slender abdomen] are believed to be mimics of the stinging Hymenoptera, which they closely resemble, and gain protection because they look like the stinging species. The role of the dogwood borer, which closely fits the above description, as a mimic has not been tested by the laws of mimicry, but no species which could serve as the model has been observed to occupy the same habitat.

Figure 1. Female adult. About 2 times natural size.

Adults are very difficult to observe in the field. They are small and very swift fliers. Long periods of observation of adults in infested nurseries revealed that they spend the daylight hours resting upon the leaves. They remain almost motionless for long periods of time except for slight movements of the antennae.

Adults were not observed to feed in the field, and in captivity they would not feed when offered water, sugar solutions, or beer. According to Wallace (1944) feeding is restricted to nectar of flowers, but no specific plants were named. He recorded the presence of a moth on an apple blossom, but it was not observed to feed.

Neither mating nor oviposition was observed. The moths were never observed to rest upon the trunks or limbs of the trees, where the eggs are laid. Since observations during the day did not reveal mating and egglaying, we inferred that they are noctural activities.

Emergence and Lifespan of Adults. The period of emergence of *T. scitula* probably varies as much as several weeks across the range of distribution, but no studies to the north of Connecticut or to the south of Virginia have been published to substantiate this notion. Underhill (1935) reported that in Virginia the period of emergence of *Synathedon scitula* (Harris) (=*Thamonsphecia scitula* (Harris)) was from the middle of May until the last of September. Wallace (1944) observed emergence in Connecticut from May to September.

In 1963 numbers of adults were observed in the field in the latter part of April. In 1962 living pupae were collected in the field as late as October 8. Adults emerged from those collections within a week. Adult emergence probably ceases in this state by the latter part of October.

No accurate method for determining peaks of emergence was developed, but visual observations of greater or lesser numbers of adults at different times was useful in estimating peaks. On May 13, 1963, adults were in one East Tennessee nursery in such large numbers that often two or three insects were resting on the leaves of a single tree. Such large numbers were not observed before or after that date. Wallace, in Connecticut, (1944) recognized a maximum emergence in late June and early July, a date much later than that observed in Tennessee. In the same nursery in which moths were numerous in May, only one was seen during field trips on June 27, July 1, and July 3.

Underhill (1935) reported that the life span of adults averaged nine days for females and seven days for males. Adults which were maintained in captivity during this study had an average life span of seven days, with a maximum of eleven days.

After emergence ceased in October, pupation could not be initiated by bringing larvae into the laboratory and maintaining them at warm temperatures. The only record of a winter emergence was on February 1 from a tree in a heated green-house. That adult, although apparently normal in every other aspect, was unable to fly and lived for only a day and a half.

Egg. The outline of the egg of the dogwood borer is more or less elliptical, being blunt on both ends. The chorion is covered with fine reticulations which are easily visible at 50X. The egg is about 0.5 mm long and 0.375 mm wide. When first laid it is pale yellow, turning only slightly darker before eclosion. The egg was the most difficult life stage to obtain. The mating habits or other requirements of the adults were such that copulation and oviposition did not occur in captivity. Numerous laboratory-reared moths (both sexes) were maintained in gallon jars containing small, freshly-cut dogwood logs, strips of cheesecloth and sucrose solution for feeding. Others were maintained in larger sunlit cages with living, potted dogwood trees. They were provided cotton balls saturated with sugar solution or beer. Under no laboratory conditions were eggs laid. Wallace (1944) maintained adults in a large screened cage. No mating was observed. One female did lay four eggs which did not hatch. Underhill (1935) reported obtaining small numbers of eggs, but most were infertile. Prior to 1934 none of the eggs which he obtained in cages hatched. In 1934 he had two lots of fertile eggs from a cage containing four females and three males. The incubation time for these in mid-July was eight to nine days. He noted that more eggs were laid on cut surfaces of the trunk than on the bark.

Because the eggs are extremely small, attempts to make field counts were unsuccessful. The only practical way to collect eggs was to cut trees and examine the trunks with a dissecting microscope. Eggs which were observed in this way were laid adjacent to wounds or on the frass produced by other borers. Since the date these eggs were laid was not known, it was impossible to determine the period of incubation.

Two eggs were laid on the sides of a large vial by one female which was captured in the field. The incubation periods for these two eggs at about 80 F was eight and nine days. Eighty-seven infertile eggs were dissected from the same female. Two other females were dissected which contained seventy-three and eighty eggs, respectively.

Larva. The destructive stage of *T. scitula* is an off-white to cream-colored larva with a reddish-brown head, having a resinous appearance. The prothoracic shield has two characteristic reddish-brown spots dorsally. The larvae range in size from a millimeter or less in length when newly hatched to 15 mm or more when mature (Fig. 2). Underhill (1935) reported that head capsule measurements indicated six instars. The number of crochets per row on the ventral proleg of the sixth abdominal segment is used in species identification. Beutemuller (1901) recorded 12 to 15 per row. According to Peterson (1948) there are 9 to 12 per row. It is apparent that this technique of species determination is not dependable. There are, however, good specific characters of the mandibles. These have been used for *T. scitula* by Wallace (1944) and for other members of this family by Peterson (1948). The larvae can endure extremes in temperature, especially low temperatures, for long periods of time; but they are extremely sensitive to slight variations in humidity.

Figure 2. Young larva and matura larva. About 25 times natural size.

Unlike many lepidopterous larvae they soon die from desiccation when exposed directly to the atmosphere. The niche of the dogwood borer includes a relatively high and constant relative humidity. From the time they enter the tree as young larvae until they emerge as adults, they remain sealed in their tunnels; the tree providing the necessary moisture. There is danger, however, that the sap from the wound which they inflict will cause their death by drowning. Such cases have been observed infrequently.

Should a break occur in the bark and expose them to the outside air, the larvae immediately seal it with bits of frass bound with silk. When removed from trees and placed in containers with pieces of bark, wood shavings, etc., they immediately seal a few pieces of the material around themselves, preventing their exposure and desiccation. Laboratory tests, in which larvae were exposed to relative humidities 35, 45, 79, 90 and 95% indicated that humidity greater than ninety per cent was necessary for survival of the larvae.

Winter mortality was found to be negligible in Tennessee. Larvae were able to survive in Canada, the New England states, and throughout the northern part of their range of distribution. Wallace (1944) observed that larvae hibernate in Connecticut in the cortex of trees. Observations throughout the winter in Tennessee failed to indicate hibernation of larvae. When temperatures fell below 38 to 40 F, larvae became sluggish and inactive, but when the temperatures again became sufficiently high they resumed their feeding; thus, they were apparently not in a true diapause. Larvae were removed from trees when the temperature was below 32 F. They were inactive and completely unresponsive to probing. Nevertheless, when warmed artificially, they become active. Even at freezing air temperature larvae which were on the sun-exposed side of trees were active, while those on the shaded sides remained dormant. A silken mat was often produced by the larvae between themselves and the outside bark during the winter. This mat perhaps had some insulating effect against cold.

Larval Food Habits. A study of the literature dating back to the beginning of the present century revealed an interesting history of the food habits of *T. scitula*. As early as 1904 the dogwood borer was recognized by Herrick (1904) as a pest of pecan. At that time it was not known to be a serious pest of dogwoods. Hence, it was then known as the pecan borer or pecan sesia. It was a borer of crown galls and other malformations on pecan trees, both wild and cultivated.

According to Englehardt (1932) the insect was developing adaptations as a bark and sapwood borer in pecans. Its distribution was not accurately reported at that time, but it was apparently established in many parts of the east and southeast. Southeastern Canada and New England should be added to the range as recorded by Beutenmuller (1901).

Underhill (1935) reported the discovery of the insect in dogwood trees in one nursery in Virginia. The infestation involved about 3000 one-year-old trees and 15,000 two-year-old trees. He also found the insect generally distributed in native dogwood there, though not common.

Englehardt (1946) reported that the most important economic damage was to pecan in the southern states. Since then the dogwood nursery industry and ornamental lawn plantings have increased many fold, and in most areas of the present range the most economically important host is dogwood. This is especially true in Tennessee and further north. The borer is, reportedly, still a serious pest of pecan in North Carolina, Florida, Georgia, and Mississippi.

Since the time of its establishment in dogwood, the borer has evidently made several adaptations. It became established as a crown borer and later adapted to feeding on the inner bark of the trunk. Wallace (1944) said that damage below ground level had never been observed in Connecticut. In 1961 serious damage was noted below ground level in one group of trees in East Tennessee. In November of 1962 several borers were removed from as far as three to four inches below ground level from two trees. The only recognizable difference between those larvae which were collected above ground level was the larger size of the subterranean larvae. Positive identifications showed that they were all the same species.

The dogwood borer has a long list of recorded hosts including oak, hickory, chestnut, dogwood, hazel, cherry, apple, willow, beech, myrtle, loquat, pecan, pine, mountain ash, birch, ninebark, bayberry, and rattan vines. The following discussion is confined to the study of the borer as it attacks flowering dogwood.

Although native dogwoods in their natural habitat have never been observed to be attacked by borers in Tennessee, when transplanted into lawns or grown from seeds in nurseries they become subject to serious attack. A change of habitat from the understory forest layer to the open apparently reduces vigor and increases susceptibility to attack by borers. All horticultural varieties are susceptible to attack, but the double white variety shows the greatest susceptibility. This variety is generally recognized by nurserymen to be weak. One-year-old trees in Tennessee are seldom attacked by borers, even though located adjacent to badly infested older trees. Two-year-old trees are occasionally attacked, and three-year-old and older trees were frequently attacked. Five- to eight-year-old blocks often approached 100 per cent infestation.

The degree of isolation of a block of young uninfested trees, with regard to established infestations, affects the initial infestation of that block. Since *T. scitula* does occur in a variety of wild and cultivated plants it would be virtually impossible to isolate totally a group of trees to prevent their initial infestation, but infestation can be slowed down within nurseries by planting trees as far as possible from large numbers of infested trees.

Dogwood trees attacked by borers usually are those which are wounded or diseased or are not vigorous. Nursery trees are frequently attacked by a pathogen which produces a cankerous growth on the trunk. The bark becomes rough and cracked in the diseased area and is preferentially attacked by borers. Some authors have stated that damage of borers was evident in swollen gall-like areas on limbs and trunks; however, they failed to point out that the galls often are produced by a fungus and are the cause rather than the effect of insect attack. Injuries such as those caused by bumping the trees with lawn mowers or cultivating equipment also provide openings through which borers gain access to the inner bark of the tree; nevertheless, an actual wound or infection is not always necessary to make a tree susceptible to attack. Numerous infested trees were observed in which the only noticeable injuries were those caused by the larvae themselves, which had apparntly gained entrance through normal bark.

Trees previously attacked by borers, unless killed, were usually highly susceptible to secondary attacks. Seldom was a tree with old damage free of larvae. Trees of nursery size seldom contained more than five or six larvae, but as many as 17 larvae were removed in late summer from a single tree one and one-half inches in diameter. Most of these larvae were feeding on or at the bases of the major limbs rather than on the main trunk.

Pupa. The transition stage (Fig. 3) is passed within a cocoon made of available materials, usually bits of frass stuck together with silk. When other materials (e.g., sawdust, bark, and wood shavings) are available to the larva, these are used in the construction of the cocoon (Fig. 4).

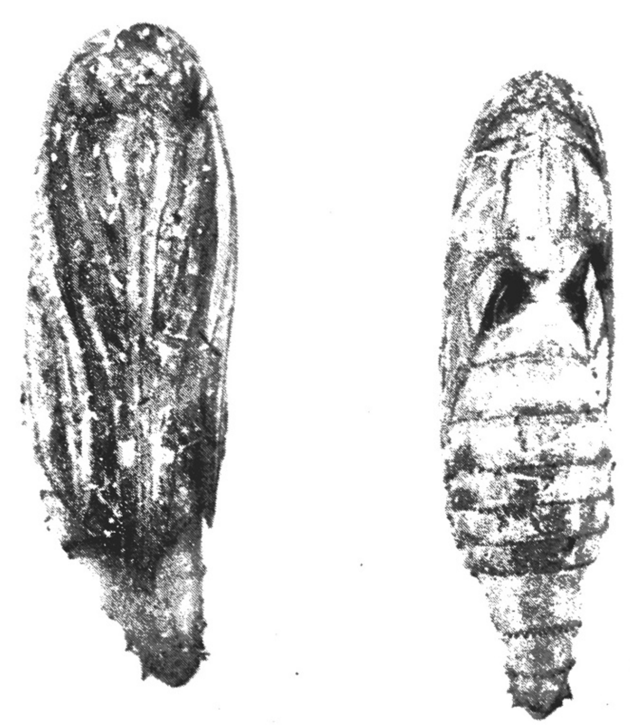

Figure 3. Ventral and dorsal views of the pupa. About 25 times natural size.

Pupation normally occurs just beneath the outer bark within the tunnel made by feeding. Underhill (1935) stated that pupae are sometimes found in the leaves and trash and rarely in the soil about the base of the nursery stock. In Tennessee they were not found to pupate outside of the trees.

Larvae of various sizes and weights removed from trees and artificially subjected to stress of decreased humidity either pupated or died. Numerous observations showed that both medium and large larvae would pupate when exposed to conditions of low humidity, but small ones would die. Apparently, borers could pupate prior to the last larval instar, though this was not proved conclusively.

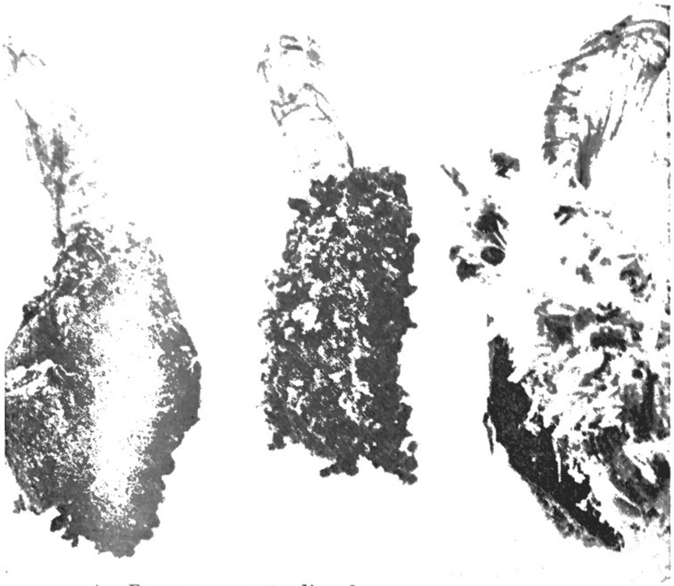

Figure 4. Pupa cases protruding from cocoons made of bark, frass, and sawdust. About 10 times natural size.

Pupae were highly sensitive to desiccation, as were the larvae. Newly pupated insects which were removed from their tunnels but left in their cocoons at room temperature and humidity emerged within the normal period. Those which were removed from their cocoons but maintained at room temperature and high humidity also emerged normally. All pupae which were removed from their cocoons and maintained at room temperature and humidity failed to emerge. Under laboratory conditions the average duration of the pupal stage in July was 10 days. The mode, however, was 11 days, with a range of 8 to 12 days.

After the transition from pupa to adult the insects free themselves by splitting the dorsal side of the head and thoracic regions of the pupal case. The adults then crawl to an opening in the bark through which they emerge, leaving behind protruding pupal cases (Fig. 5). Trees commonly have numerous pupal cases projecting from trunk and limbs.

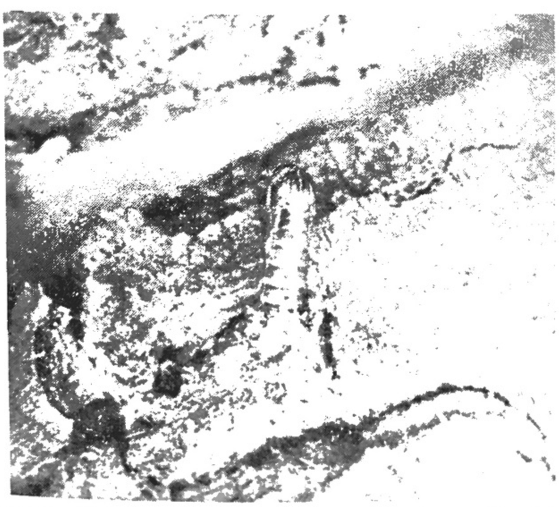

Figure 5. Pupal case protruding from trunk of tree. About 4 times natural size.

Recognition of Borer Damage. Probably the most easily recognizable early signs of borers in dogwood trees is the presence of frass which has been extruded from the tunnels on the trunk or larger limbs (Fig. 6). Cutting away the outer bark exposes the larval tunnels underneath (Fig. 7). After trees have been infested for a year or two the dead bark over the borer tunnels begins to peel, exposing the wood underneath. By that time the leaves curl. Completely girdled trees will, of course, die. Ironically, trees which bloom most profusely often are those which have been attacked by borers. Apparently increased blooming and fruit production are normal physiological responses to the stress of injury by borers.

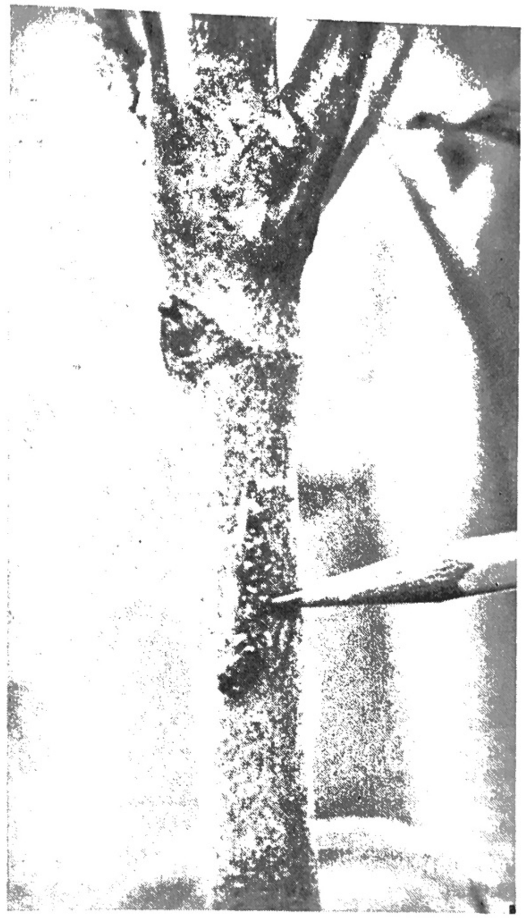

Figure 6. Infested tree, with frass extruded from larval tunnel. About natural size.

Natural Control. Predators, parasites, and diseases attack the dogwood borer in Tennessee, but their value in reducing numbers of the pest was not determined. An unidentified species of red mite was observed in close contact with the eggs. It was not determined if the bugs were egg predators. The most frequently observed enemy of the larva was a species of the fungus *Cordyceps,* possibly *C. elongata.* Several dead larvae, bearing signs of the fungus, were removed from trees. Only one species of internal parasite, a small braconid wasp, *Agathis buttricki* Vier., was reared from larvae in this study. Quite a variety of arthropods, not previously mentioned, were found living within the tunnels made by borers, especially after the tunnels

Figure 7. Portion of dogwood trunk with bark cut away revealing larval tunnels. About 2 times natural size.

were abandoned by the primary occupants. The relationships of these organisms was not ascertained. The list includes earwigs, ants, beetles, grasshopper eggs and newly hatched nymphs, collembolans, bugs, mites, isopods, and centipedes. Large numbers of ants (*Crematogaster sp.*) were removed from tunnels which also were occupied by dogwood borers. Apparently the ants did not attack the borers, but, perhaps, fed upon the sap or other materials within the tunnels. A frequent inhabitant of old, abandoned tunnels was a small curculionid weevil *Gymnaetron pascuorum* Gyll., new to Tennessee. Birds were not observed to feed on the larvae, nor did trees show any indications that birds removed the bark in search of larvae.

Sap from wounds produced by tunneling of the larvae infrequently filled the tunnels and killed the larvae, but it apparently was of little consequence as a means of natural control. Borers sometimes brought about self destruction, especially during summer and periods of drought, by girdling and killing trees, thus eliminating the humid environment necessary to their survival. Cannibalism was not observed, and since the larvae generally live singly within a tunnel, cannibalistic habits are probably not important in reducing their numbers, especially after they enter the tree. Large numbers of larvae kept together in salve cans did not show cannibalistic tendencies.

Summary

The life history of the dogwood borer was studied in heavily infested nurseries throughout middle and east Tennessee.

The period of adult emergence in Tennessee was determined as beginning in late April and continuing until the second or third week of October, with a peak emergence in mid-May.

Field and laboratory investigations revealed very little about the feeding, mating, and egg-laying habits of the adults. These activities do not normally occur with moths in captivity.

The incubation period for eggs obtained from gravid females captured in the field was eight to nine days.

The larva was found to feed for a period of about one year in the cambium and phloem layers of the trunk and bases of lower limbs of flowering dogwood trees. In the fall larvae ranged in size from small to large, due to the fact that eggs were laid over a period of several months. There was one generation each year.

Pupation occurred within the tunnels made by larval feeding. The duration of the pupal stage was eight to twelve days.

Native dogwoods in their natural habitat were not observed to be attacked by borers.

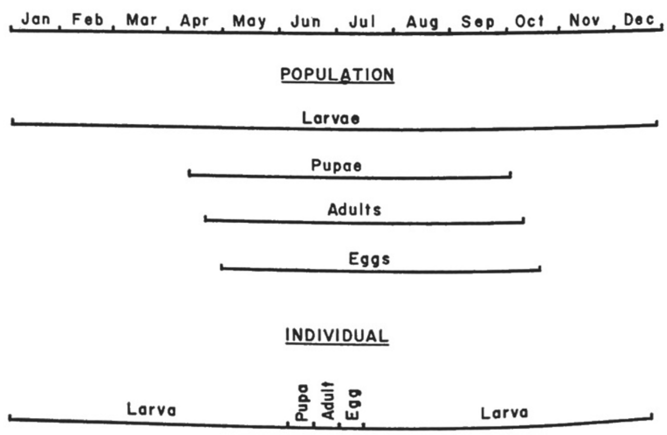

Figure 8. Comparison of the annual cycle of a population of dogwood borers with the life cycle of an individual borer.

Some natural enemies of the dogwood borer were found. A parasitic fungus was most frequently observed.

A diagrammatic representation delineates the annual cycle of population of dogwood borers in Tennessee, as compared with the life cycle of an individual borer (Fig. 8). The line segments representing an individual pupa, adult, and egg are brief as compared with the total length of these periods for the entire population.