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D. C. L. Gosling

OBSERVATIONS ON THE BIOLOGY OF THE OAK TWIG PRUNER, *ELAPHIDIONOIDES PARALLELUS,* (COLEOPTERA: CERAMBYCIDAE) IN MICHIGAN

D. C. L. Gosling[1]

The oak twig pruner, *Elaphidionoides parallelus* (Newman) (Coleoptera: Cerambycidae), is rather common in southern Michigan where it attacks living oaks and other hardwoods. The damage it inflicts is rarely serious, but it may be considered a pest insect if only for the nuisance it creates for those who must clean up the often numerous small branches pruned from street, lawn, and park trees.

Published accounts of the habits of *parallelus* are seldom encountered, largely owing to the confusion of this species for many years with *Elaphidionoides villosus* (Fabricius) which it resembles closely. *E. parallelus* was described by Newman (1840) who placed it in the genus *Elaphidion.* However, Hamilton (1887) declared *parallelus* could not be separated from *villosus.* Casey (1912) resurrected *parallelus* and transferred it with *villosus* to the genus *Hypermallus.* Knull (1946) returned both species to *Elaphidion,* and Linsley (1963) placed them in the new genus *Elaphidionoides.* Both Knull and Linsley described the habits of *parallelus* simply as similar to those of *villosus.*

The most recent detailed treatment of the life history of *parallelus* was given by Packard (1890), only to be qualified by a footnote accepting Hamilton's interpretation that it was synonymous with *villosus.* Chittenden (1910), Craighead (1923, 1950), and others have published accounts of the habits of *villosus,* but it is difficult to evaluate to what degree their observations may have involved *parallelus,* since they did not recognize it as a distinct species. I cannot at this time corroborate their accounts of the habits of *villosus,* but I am able to describe those of *parallelus* in southern Michigan and record some observations of predators, parasitoids, and various symbionts.

METHODS

Infested twigs which had fallen to the ground were collected at two localities in St. Joseph County in southwestern Michigan. Such twigs were easily distinguished by the smoothly cut, "pruned" surface and the 2 mm opening, usually plugged with a wad of shredded wood, in the proximal end of the stem. The twigs used in Lot 2, as described below, were picked up around the edge of a small, 0.4 hectare oak and hickory woodlot near the west end of Klinger Lake in White Pigeon Township (R.11W.,T.8S.,S.11). Those in Lot 1 and Lot 3 were collected along an access road and around the edge of a clearing in a larger, 70 hectare woods at the west end of Tamarack Lake in Sherman Township (R.10W.,T.7S.,S.31). The portion of the woods where these twigs were collected was also dominated by oak and hickory. The three batches of infested twigs were handled as described below.

Lot 1: 75 twigs were collected in mid-July, 1976, tagged, and placed on the floor of the woods at 2 m intervals along a transect through a typical oak-hickory habitat. The twigs were left until mid-October when 67 were recovered, opened, and examined. Eight twigs were not recovered owing to the tags having been detached or destroyed by rodents.

Lot 2: 55 twigs were collected in early July, 1976, the leaves removed, and the twigs placed in a small rearing cage. The cage was kept in a sheltered location until autumn, and then transferred to a cool basement area for the winter and spring. These twigs were opened and examined in July, 1977.

Lot 3: 435 twigs were picked up at various times through July and early August, 1976, the leaves removed, and the twigs placed in screened, outdoor rearing cages. The twigs were opened and examined in July, 1977.

[1]R.R.1, Box 149, White Pigeon, Michigan 49099.

Information derived from these procedures was supplemented by examination of 303 specimens of *parallelus* and *villosus* from Michigan, contained in the collections of the University of Michigan Museum of Zoology, the Department of Entomology, Michigan State University, and the author.

RESULTS

The data from the three batches of infested twigs are summarized in Table 1. The twigs in Lot 1 were exposed to predation, and 31.3% of these twigs were chewed open by rodents and the larvae removed. The size of the marks made by the incisors of these predators indicated they were red squirrels (*Tamiasciurus hudsonicus* Erxleben), although no squirrel was observed attacking an infested twig. Red squirrels were present in the area where the twigs were placed, and in all other locations where this distinctive form of predation was observed. The twigs in Lot 1 also showed a high proportion (40.3%) of cases in which boring had been terminated prematurely and the larva removed from its gallery. The cause of this form of larval mortality has not been determined. No adult emergence figures are given for Lot 1 as these larvae and pupae were removed before that occurred.

Table 1. Observations of three lots of hardwood twigs infested by *Elaphidionoides parallelus*.

Result	Lot 1		Lot 2		Lot 3	
	Number	Percent	Number	Percent	Number	Percent
Adult emergence	-	-	50	90.9	207	47.5
Living larva or pupa	13	19.4	0	0	4	0.9
Dead pupa[a]	0	0	0	0	44	10.1
Dead larva[a]	3	4.5	1	1.8	57	13.1
Parasitized larva	3	4.5	0	0	31	7.1
Eaten by squirrels	21	31.3	-	-	-	-
Boring terminated[a]	27	40.3	4	7.3	92	21.3
Totals	67		55		435	

[a]Cause of mortality not determined.

The twigs in Lot 2 were effectively protected from attack by predators and parasitoids soon after they fell to the ground, and suffered no mortality attributable to these factors. Boring terminated through unknown causes was also relatively minor, and nearly 91% of the borers survived to adult emergence. However, only 10% of these adults exited successfully from their twigs, and about half the unsuccessful adults also failed to expand their elytra fully after emergence. This mortality was probably owing to the abnormally dry and cool conditions under which these twigs were stored.

Twigs used in Lot 3 were also protected from vertebrate predators, but were exposed to some attack by invertebrate predators and parasitoids. These twigs were stored under outdoor conditions which, although probably drier than normal, may have been associated with the high proportion of larvae and pupae found dead in their galleries. The actual cause of this mortality was not discovered but probably included fungus or virus infection. Two larvae and two pupae were found alive in twigs opened in July, 1977, after emergence of the rest of the brood. These might have completed their life cycle if left until the following year. Five adults failed to exit their twigs successfully after eclosion.

All adult beetles recovered from these twigs have been identified as *parallelus*; no

examples of *villosus* were found. *E. villosus* occurs in the localities used for this study, and was as commonly collected as *parallelus* at light traps operated near Tamarack Lake in July, 1977. The habits of *villosus* in this area are the subject of current investigation.

Adults of *parallelus* and *villosus* are shown in Figure 1. *E. villosus* adults can usually be identified by their larger size, pronotum as broad as long, and third antennal segment distinctly longer than fourth. Adult *parallelus* are usually more slender, pronotum longer than broad, and third and fourth antennal segments subequal. The shape of the pronotum alone cannot be used reliably to separate these species as both show great variation in this character as well as pronotal punctation and vestiture. A larva and pupa of *parallelus* are shown in Figure 2, and a larval head is shown in Figure 3.

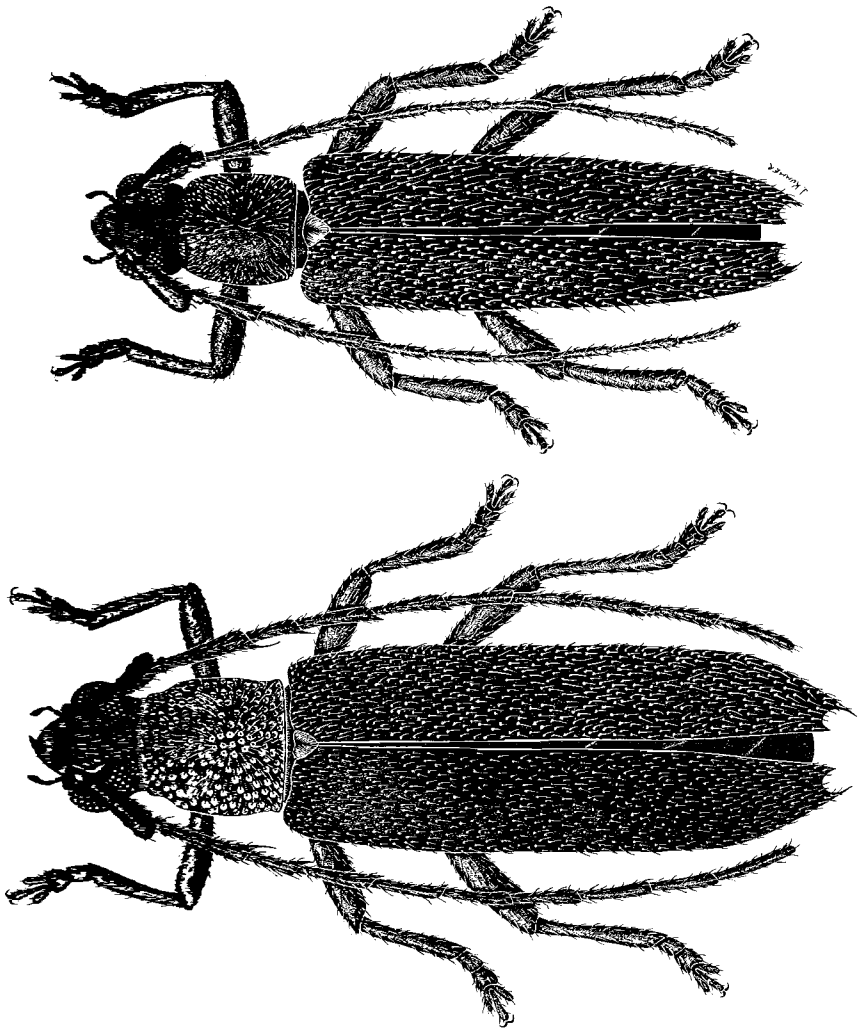

Fig. 1. Adult females of *Elaphidionoides villosus* (bottom) and *E. parallelus* (top).

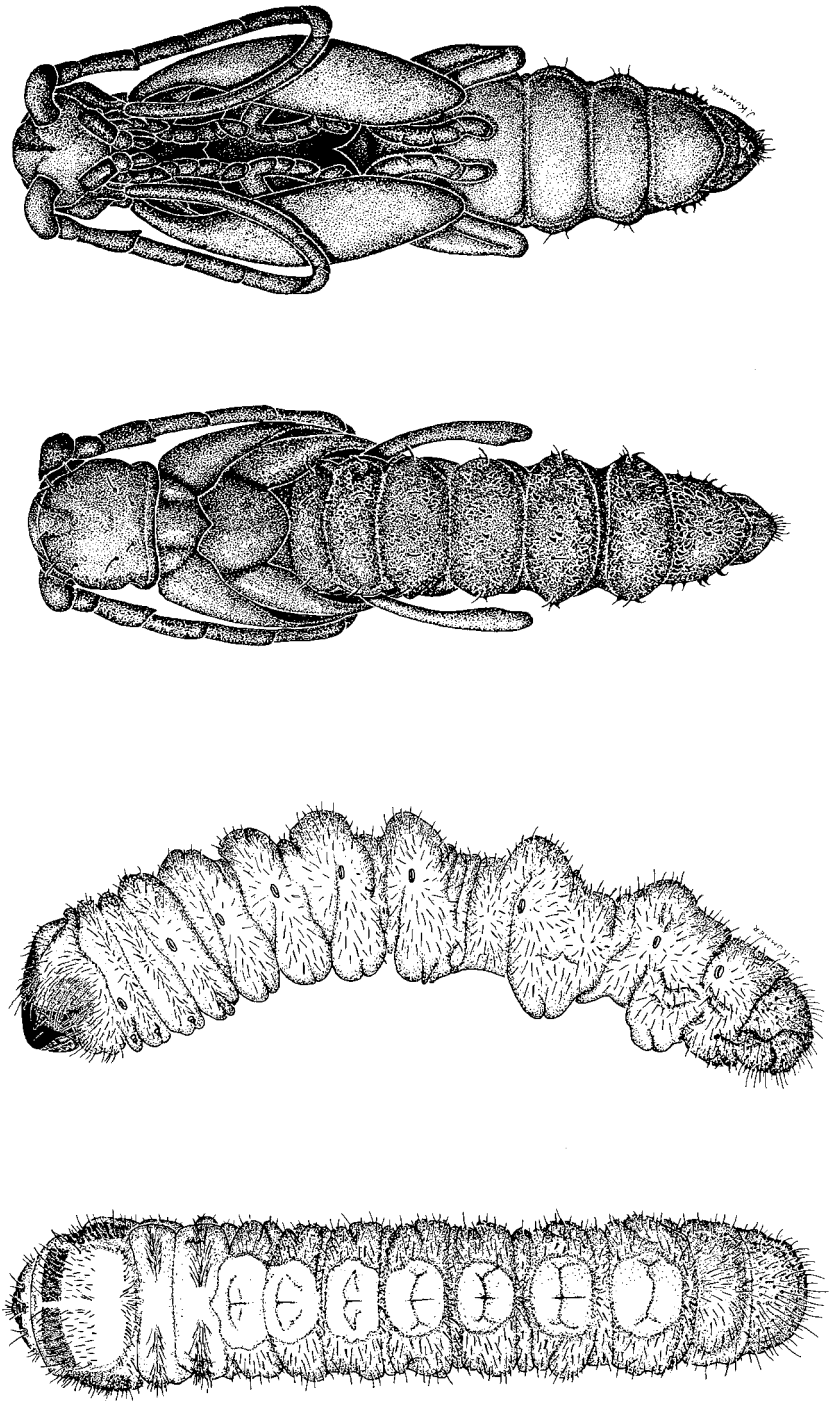

Fig. 2. Larva and pupa of *Elaphidionoides parallelus.*

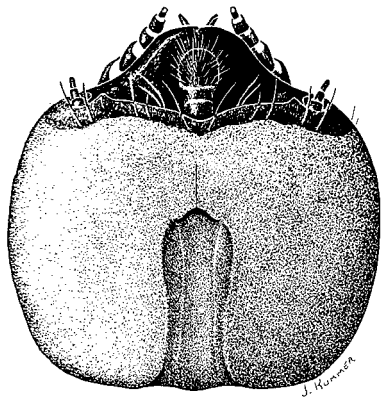

Fig. 3. Head of *Elaphidionoides parallelus* larva, dorsal view.

LIFE HISTORY

The following description of the life history of *parallelus* differs in some details from previously published accounts, and from those recorded for *villosus* to which it is supposedly similar. Most of these differences may result from the fact that the population in this study was from an area near the northern limits of the distribution of this species, and these observations may not be valid for other populations of *parallelus*.

E. parallelus is a twig pruner which attacks a variety of living hardwoods. In this area, black oak (*Quercus velutinus* Lam.) and red oak (*Q. rubra* L.) are the preferred host trees. More than 600 infested twigs were examined in the course of this study, all from black or red oak except 14 twigs from white oak (*Q. alba* L.) and four from pignut hickory [*Carya glabra* (Mill.) Sweet]. I have also reared *parallelus* from twigs of bur oak (*Q. macrocarpa* Michx.) in St. Joseph County, and Linsley (1963) records *Juglans, Malus, Prunus,* and *Vitis* as other host plants.

The adult female seems to prefer host trees located at the edge of a woods or in exposed situations in a fencerow, field, or lawn. This selection may be affected by an apparent preference for twigs at the ends of the middle branches of a tree rather than the lower branches or those in the crown. A typical oviposition site is at the base of the cluster of buds at the tip of a short (100-150 mm) twig, originating about 200 mm from the end of a branch that is, at that node, about 10 mm in diameter. Oviposition in southern Michigan presumably occurs in June and early July.

The larva bores beneath the bark of the twig and feeds on the woody portion of the stem. By the end of its first summer the larva will consume virtually all the woody part of the short twig, and extend its gallery into the node of the main branch where it will remain dormant through the winter. The following spring the larva resumes feeding, and excavates an extension of its gallery just beneath the bark of the branch. Here the larva opens a hole about 1 mm in diameter through the bark which it will use thereafter for expelling frass. During its second summer of feeding a larva will expel more than 1 gm of frass in this manner, allowing virtually no accumulation inside its gallery.

In early summer the larva bores a gallery proximad from the node, in the approximate center of the stem, for a distance of 20 to 30 mm. Here it makes its "pruning" cut, chewing away the wood in progressively larger arcs (but not as a flattened-spiral gallery) until only the bark of the branch remains. The larva then firmly plugs its gallery at this point with a wad of shredded wood. This cut is made in late June or early July in southern Michigan, and the branch is nearly always broken off by wind or rain shortly afterwards and falls to the ground.

The pattern of feeding by the larva during the rest of its second summer varies according to the size of the branch it occupies. If the branch is relatively stout, the larva

bores a gallery 3 mm in diameter, roughly down the center of the stem, for a distance of about 130 mm, occasionally more. The larva then creates a pupal chamber by firmly plugging the gallery with a single wad of shredded wood, 20 to 30 mm from the distal end. Pupation occurs in this chamber in September or later, the pupa oriented with its head toward the plug and the proximal end of the gallery. Adult emergence occurs the following June, and the beetle pulls the plug apart and makes its way down the gallery, exiting through the first appropriate opening. There are often two available; the hole made for expelling frass which is easily enlarged, and a second exit created if, as is frequently the case, the short twig hollowed out during the larva's first summer has broken off when the branch fell to the ground. The adult does not normally exit through the proximal end of the gallery, although presumably it would do so if that were necessary.

A larva occupying a slender branch will extend its gallery distad as long as there is an adequate woody portion in the stem. When there is little but bark surrounding its gallery, the larva will retreat into the main stem, sometimes plugging the abandoned portion with shredded wood, and proceed to bore into other, lateral twigs as necessary for adequate feeding. In this situation the larval galleries terminate in slender twigs and are not enclosed by wood at the ends. The larva consequently returns to a thicker part of the branch for pupation, where it creates a chamber by placing two firm plugs of shredded wood, the proximal one first, about 35 mm apart. The pupa in this situation is oriented with its head toward the distal end of the chamber, and the adult, after emergence, tears away the distal plug and exits through the bark of one of the slender twigs.

Nothing is known of the breeding habits of this species. Adults are nocturnal and are frequently attracted to lights in June and early July. They may be found in oak-hickory woods throughout the Lower Peninsula of Michigan (Gosling, 1973).

Numerous accounts have been published of the life history of *villosus*; the more recent ones based on Craighead (1923, 1950). With the exception of Hamilton (1887), the authors of these accounts state that the life cycle of *villosus,* and by inference of *parallelus* as well, takes only one year to complete. Although this may be true in other areas within the range of this species, in Michigan *parallelus* requires two years to complete its life cycle, as described above. The data from 243 specimens (excluding those reared in this study) collected in Michigan between 1891 and 1977, support this observation, and also show that *parallelus* is probably represented in this area by only a single brood (Table 2). Consequently, adults are usually present only in odd-number years, with occasional adults in other years probably the result of prolongation of the larval stage of some individuals through dry or otherwise abnormal conditions. I have observed in St. Joseph County that pruning of twigs was only evident in even-number years, as would be expected. Examination of 53 specimens of *villosus* collected in Michigan (Table 2) indicates this species probably is also single-brooded and normally requires two years to complete its life cycle in this area. This phenomenon should be of particular interest to persons concerned with the collection or control of these two species in Michigan.

The value of the pruning behavior of the larva to the survival of *parallelus* has not been considered in the literature, but that of *villosus* has been the subject of much speculation. Packard (1890) and others felt that the larva required the moister conditions provided when the twig is on the ground than would prevail if it were attached to the tree. Clarkson (1885) took the opposite view that pruning benefited the larva by cutting off the normal flow of moisture from the tree into the infested twig. Chittendon (1910) rejected both these theories and suggested that *villosus* amputated the twig it occupied to provide an appropriate exit for later use by the adult beetle. Insofar as *parallelus* is concerned this cannot be the case as the adult does not normally use that opening in leaving the twig.

An unusual behavior observed in a branch in which two larvae were boring simultaneously may offer a clue to the origins of pruning behavior. One larva excavated a gallery and made its pruning cut in the normal manner described above, while a second larva began boring atypically from the tip of the distal twig on the branch and simply continued its gallery down the stem. The first larva, possibly in response to the presence of the other borer, extended its gallery 50 mm distad and then made a reversed but

Table 2. Years in which *Elaphidionoides parallelus* and *E. villosus* have been collected in Michigan.

Odd-number Years Year - Number Collected			Even-number Years Year - Number Collected
Elaphidionoides parallelus			
1891 - 1	1927 - 1	1949 - 2	1910 - 2
1897 - 1	1929 - 2	1951 - 10	1920 - 2
1899 - 1	1931 - 9	1953 - 17	1922 - 7
1901 - 3	1933 - 8	1955 - 30	1924 - 10[a]
1907 - 1	1935 - 24	1957 - 3	1926 - 8[b]
1909 - 2	1937 - 4	1959 - 4	1936 - 3
1913 - 6	1939 - 13	1961 - 6	1944 - 1
1915 - 7	1941 - 3	1963 - 4	1950 - 1
1917 - 2	1943 - 1	1965 - 7	1956 - 1
1921 - 2	1945 - 2	1971 - 4	1970 - 1
1925 - 4	1947 - 5	1975 - 7	1974 - 1
		1977 - 10	
Totals		206	37
Elaphidionoides villosus			
1915 - 1	1931 - 1	1953 - 5	1920 - 1
1915 - 1	1933 - 4	1955 - 4	1922 - 2
1917 - 3	1935 - 1	1957 - 2	1924 - 1
1921 - 1	1939 - 1	1965 - 5	1930 - 1
1925 - 1	1941 - 1	1967 - 1	1938 - 1
1927 - 1	1947 - 1	1971 - 2	1948 - 1
	1951 - 1	1977 - 9	
Totals		46	7

[a]Includes nine reared specimens.
[b]Includes seven reared specimens.

otherwise typical pruning cut, severing the distal portion of the branch, before boring into a lateral twig. The second larva eventually also made a pruning cut at the proximal end of its gallery. It may be that the benefit derived by *parallelus* larvae from pruning behavior is simply isolation from potential competition with other stem-borers.

PREDATION

Townsend (1886) made observations in southern Michigan on oak and hickory twigs infested by *parallelus*, and recorded that after the twigs had fallen (in 1884) "nearly all of the larvae are destroyed by insectivorous birds, which extract them from their burrows, if they have not already been dislodged." Other authors refer to birds as predators of *villosus*, and the Downy Woodpecker (*Dendrocopus pubescens* L.), Blue Jay (*Cyanocitta cristata* L.), and Black-capped Chickadee (*Parus atricapillus* L.) have been recorded (Chittenden, 1910). However, I have not observed birds feeding upon *parallelus* larvae, nor found any indication on twigs examined in this study that a bird had

extracted a larva from its gallery. The only vertebrate predator observed was the red squirrel which, in localities where it was present, was a significant cause of larval mortality.

In this study a high percentage of larval mortality occurred soon after the twigs were pruned and fell to the ground, but I was unable to identify the cause(s). No signs of entry were apparent, except that in a majority of cases the plug of shredded wood was missing from the proximal opening to the gallery. It was not evident, however, if the plug had actually been removed by a potential predator or had been dislodged accidentally. Termination of boring was found about twice as often in twigs lacking the plug as in those with the plug intact, but absence of the plug was not always associated with larval mortality.

No remains of the larva were found in such twigs, and several authors who have recorded this phenomenon have speculated that the larva had fallen out as the twig came to earth after pruning. From my observations of the tenacious capabilities of these larvae, I do not believe it probable that a living larva could be so easily dislodged from its gallery. It does appear that a predator enters the larval gallery after a twig has fallen, and removes or totally consumes the larva. Ants would seem to be the most likely predators responsible for this frequent termination of boring.

PARASITISM

The larvae in 34 (6%) of the 557 twigs from the three lots described above were consumed by parasitoid insects. Four species were reared from 20 of the cocoons and puparia recovered from these twigs (Table 3). It was not possible to obtain a positive identification of the tachinid *Minthozelia ruficauda* Reinhard as only male flies were reared and the male of this species has not been described.[2] In terms of the number of larvae attacked, the braconid *Meteorus tibialis* Muesebeck was the most significant parasitoid of *E. parallelus* in this study. *Odontobracon elaphidivorus* Rohwer and *Bracon eurygaster* Brulle have been recorded as parasites of *E. villosus* (Linsley, 1963) and may also attack *E. parallelus.*

The normal degree of parasitism is probably higher than the 6% recorded here. It is probable that some of the larvae eaten by squirrels had been parasitized, and it is also possible that the presence of parasitoid larvae may have been overlooked when the twigs

Table 3. Adult parasitoids reared from cocoons or puparia associated with larvae of *Elaphidionoides parallelus.*

Parasitoid	Adults Reared	Larvae Consumed
HYMENOPTERA: Ichneumonidae		
Agonocryptus discoidaloides Viereck	1	1
HYMENOPTERA: Braconidae		
Iphiaulax eurygaster Brulle	7	1
Meteorus tibialis Muesebeck	15	15
DIPTERA: Tachinidae		
Minthozelia ruficauda Reinhard (?)	3	3

[2]Personal communication, C. W. Sabrosky, Systematic Entomology Laboratory, U.S. National Museum.

in Lot 1 were examined. It is interesting that none of the twigs in Lot 2, which were collected and enclosed soon after falling to the ground, contained parasitized larvae. This suggests that attack by parasitoids may be largely or entirely made after the twigs have fallen from the trees. If this is the case, it would be interesting to know how and when oviposition occurs, and what alternate hosts may be utilized by these parasitoids.

OTHER INTERSPECIFIC RELATIONSHIPS

Eight colonies of four species of ants were found inside twigs examined in this study, some of which may represent a form of commensalism. Four colonies of *Leptothorax curvispinosus* Mayr and one colony of *Tapinoma sessile* (Say) were encountered in the proximal portion of larval galleries, and there was no evidence that the ants had disturbed the borer larvae. In fact, the *Tapinoma* colony was removed from a twig containing an apparently healthy *E. parallelus* pupa. Two colonies of *Camponotus subarbatus* Emery and a colony of *C. nearcticus* Emery were found in the distal portion of larval galleries, and no traces of the borer larvae remained. There was no clear indication, however, that any of these species is predacious on *E. parallelus* larvae.

Several specimens of the pyralid moth *Zanclognatha jacchusalis* Walker were reared from pupae found on the screen bottom of the rearing cages containing the twigs in Lot 3, and one pupa found within a borer gallery. It seems probable that the pyralid larvae had been feeding on frass produced by the borers, although this was not observed. I could not determine how the pyralids entered the cages; presumably on or in the twigs as all leaves had been removed. The nature of this relationship remains uncertain, and may be only casual. A clearly casual relationship was demonstrated by potter wasps (Vespidae: Eumeninae) which utilized as nest sites the galleries in three twigs lacking proximal plugs.

Chittenden (1910) stated that twigs pruned by *villosus* "serve as a breeding place for hosts of other wood borers, many of which are injurious to shade trees and to standing timber." This seems improbable as the species of borers normally ovipositing in dead or dying hardwood twigs are not likely to injure healthy trees. I found only two twigs in which other cerambycid larvae were feeding, these just beneath the bark, and conclude that such secondary infestations are of little or no economic significance. The nature and extent of these possibly commensal relationships between species of Cerambycidae are being investigated.

CONTROL

It is doubtful that *parallelus* under normal circumstances ever inflicts sufficient injury, even to ornamental trees, to justify the use of the type of insecticides necessary to attempt control by that means. Anyone contemplating such an effort in Michigan should note that the adults will not be present until the year following that in which the damage is apparent. The most practical means of reducing future injury would be the simple expedient of gathering and burning the infested twigs, as has been suggested by several authors for control of *villosus*, especially if this is done as soon as possible after the twigs have fallen from the trees.

The present study indicates that most or perhaps all attack by parasitoids occurs during the borer larva's second summer of feeding, so twigs destroyed promptly after falling in late June or early July would be expected to contain few if any parasitoids. The destruction of twigs at a later time would be, to a degree, counterproductive by eliminating a relatively high proportion of parasitized larvae. Consequently, the recommendations that twigs be gathered in the winter (Felt, 1905; Duffy, 1960) or spring (Baker, 1972) would be less effective for control of *parallelus* in Michigan, and probably *villosus* as well.

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