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TECHNICAL PUBLICATION NO. 10
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THE NEW YORK STATE COLLEGE OF FORESTRY
AT
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I. Notes on Insects Bred from the Bark
and Wood of the American Larch

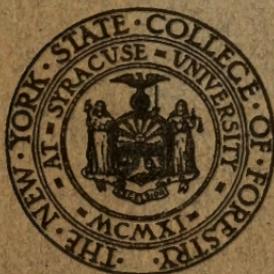
BY

M. W. BLACKMAN and HARRY H. STAGE

II. On the Insect Visitors to the Blossoms of Wild Blackberry and Wild Spiraea—A Study in Seasonable Distribution

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M. W. BLACKMAN



Published Quarterly by the University
Syracuse, New York

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Monograph



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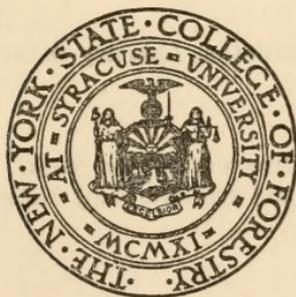
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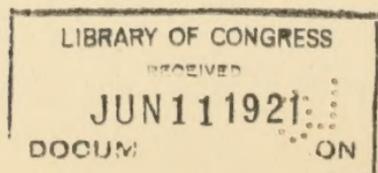
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No. 10, 1918.

- I. Notes on Insects Bred from the Bark and Wood of the American Larch. By M. W. Blackman and Harry H. Stage.
- II. On the Insect Visitors to the Blossoms of Wild Blackberry and Wild Spiræa: A Study in Seasonal Distribution. By M. W. Blackman.

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I. NOTES ON INSECTS BRED FROM THE BARK
AND WOOD OF THE AMERICAN LARCH —
LARIX LARICINA (Plu Roc.) Koch.

By

M. W. BLACKMAN, Ph. D., and HARRY H. STAGE, M. S.

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NOTES ON INSECTS BRED FROM THE BARK
AND WOOD OF THE AMERICAN LARCH —
LARIX LARICINA (Du Roc) Koch

By M. W. BLACKMAN, Ph. D., and HARRY H. STAGE, M. S.

Several years ago the senior author was impressed by the fact that in comprehensive reports upon forest insects, such as those of Packard ('90), Hopkins ('93, '99) and Felt ('06) a considerable number of boring insects are recorded from pine, spruce and several other conifers but only a very few are reported from the American larch. For instance, Packard ('90) mentions only three borers in larch — *Dendroctonus* sp. (doubtless *D. simplex*), *Hylesinus opaculus* (probably *Polygraphus rufipennis*) and *Tomicus (Ips) pini*, — although he treats at considerable length thirty-three insects affecting the trees in other ways. Hopkins ('93) in his Catalogue of Forest and Shade Tree Insects of West Virginia mentions no insects from larch, while Felt ('06) lists but three boring insects from larch — *Leptura sub-hamata* Rand, *Tomicus (Ips) pini* Say and *Tomicus (Ips) caelatus* Eich. More recent papers by Swaine ('11) and by Hewitt ('12) dealing with larch insects list *Dendroctonus simplex* Lec., *Ips balsameus* Lec., *Dryocoetus autographus* Ratz., *Dryocoetus* n. sp. and *Ips caelatus* Eich. as borers attacking recently felled larches or trees weakened by the defoliation of the sawfly.

As it was believed that this paucity of forms known to inhabit the bark and wood in the larch was due at least in part to lack of study of this tree as a host for boring insects, it was decided to take the first opportunity of making such a study. Such an opportunity was offered when the junior author on his return from his home reported the presence of many dying and dead larch near Crittenden, Erie county,

N. Y. He was persuaded to return immediately and to ship to the laboratory a liberal amount of material showing as great a variety of conditions as possible.

On account of the fact that the infested larch was at a considerable distance from Syracuse (about one hundred and thirty-one miles) the ideal method of procedure in such studies — which should consist of field work and insectary work so co-ordinated as to check each other and to give the best results — were necessarily modified. The field work was reduced to a minimum and all field observations were made by the junior author at such odd times as opportunity offered. However, the work was so planned and conducted that the results obtained were in no way weakened. In fact, in a study of this sort the field work aside from the actual collecting of the infested wood, can be dispensed with much more readily than the insectary work; which, on the other hand, is indispensable because of the impossibility in the present state of our knowledge of identifying the immature stages of many boring insects.

The method followed consisted in bringing to the laboratory generous samples of various parts of infested trees. A careful and full record of the character and history of each lot was kept and each lot was placed in a separate breeding cage. The cages were then placed out of doors so that the conditions would be normal and as near as possible what they would have been if left in their original location. The breeding cage used consists of a strong, well-constructed frame of 2 x 2 cypress. The top is covered with fine copper wire mesh, while the sides are sheets of glass lowered into grooves in the frame. To the bottom of the frame is attached a metal flange which may either be fitted into an especially constructed base or may be pressed down into the soft earth. In most of our work the latter method was used and this was true of all of the outdoor breeding work. In these cages the sticks were propped up with one end resting upon the loose soil or embedded in it, and, except in very dry weather, the wood absorbed enough moisture from the loose earth to keep it in fit condition for the insects living within. When

the weather was too dry, water was occasionally sprinkled on the pieces of wood to prevent conditions from becoming too unfavorable. In any event the conditions were doubtless as uniformly favorable as they would have been had the material remained undisturbed in its natural environment.

The various breeding cages were examined daily and all insects which had emerged were kept separate with full data. As the exact source of each insect emerging was scrupulously recorded it was an easy matter later to find the various sorts of insects associated in the same pieces of wood and in similar wood from other trees or regions of trees. By supplementing such data with later study of the wood it is often possible to secure evidence to establish either absolutely or probably that certain insects bear the relation of parasite and host to each other. Whenever practicable the exit hole made by an emerging insect was found and marked with the same lot number as the insect which came from there. Later this burrow was opened and the character of the larval mine and pupal chambers studied. Specimens of several sorts of larvæ were also taken at intervals; and, by a later careful comparison of such records of adults, burrows and larvæ as was thus obtained, it was often possible to connect absolutely the various stages of the insect and the burrow it produced.

DESCRIPTION OF WOODLOT FROM WHICH THE LARCH WAS SECURED

With the exception of five pieces obtained from Wanakena, N. Y., all of the infested larch used in this study was secured from near Crittenden, N. Y. Crittenden is twenty-one miles east of Buffalo, in the northwestern part of Erie county. The woods from which the larch was taken is one of considerably larger dimensions than is usually met with in that section. The tract comprises about one hundred acres. The larger part of it is owned by the New York Central Railroad, the rest belonging to the adjoining farms.

The greater number of tree species in this tract belong to the climax forest type — the principal ones being hard-

maple, beech and hemlock. On the higher areas a few white pines are scattered among the hardwoods. Only in two areas is the larch to be found. This tract of timber is practically in a virgin condition, doubtless owing to the fact that it is owned by the railroad. The area has apparently never been lumbered and presents fairly good forest conditions — that is the general conditions are excellent for tree growth.

As previously stated the larch is to be found in two separated areas, a western group having between thirty and fifty trees, and an eastern one of between four and five hundred trees. These two areas, which are lower and therefore moister than the surrounding woods, are about two hundred and fifty yards apart and between them is a dense undergrowth consisting principally of poison sumach, willow, etc. In these areas, the larch predominates, the total number of larch outnumbering all other species of trees combined. All sizes of larches are present, from saplings up to trees of about 14 inches D. B. H. Reproduction is good although of course many of the smaller trees have been killed by suppression due to shading.

A number of the larger larch trees (6 inches D. B. H. and up) have been weakened or killed each year for a number of years by the removal of the bark by farmers. A decoction made by steeping this bark is thought to make an excellent spring tonic for horses and is used by the farmers of this locality for that purpose. On all parts of the tract, trees may be found from which more or less bark has been stripped — these often being completely girdled from the ground up to a height of about six feet. Trees completely girdled in this way are of course killed immediately while trees stripped of their bark on one side only, are not killed outright but are greatly weakened. Both dead and weakened trees serve as favorable breeding places for many different sorts of insects, and it is with insects entering the tree under such conditions that we deal with principally in this paper.

Aside from these trees killed or weakened by the stripping off of the bark, the larch trees are under conditions such as exist in practically virgin timber. This means that many

of the trees have reached their maximum growth — have become matured — and some such trees are deteriorating more or less rapidly. The presence of the excellent breeding places offered by the girdled larch had resulted in an increase of many insect enemies — several of which have increased beyond the danger level. These are already successfully attacking and killing not only the trees weakened by stripping off part of the bark but also apparently have in the last year or two killed a number of trees which were over-mature but were otherwise uninjured. Indeed the conditions here are in many respects similar to those reported by Swaine ('11) in a larch wood near St. Anne's, Que. There several trees had been allowed to remain in the forest after felling and these had acted as an excellent breeding place for a number of scolytid beetles. Several of these were bred up to such numbers that they were able to attack and kill the living larches remaining. Of the five bark beetles breeding in this larch, including *Dendroctonus simplex*, *Ips balsameus*, *Ips caelatus*, *Dryocoetes autographus* and *Dryocoetes* sp., Swaine considers only the first two as serious enemies of the larch.

In the larch woods at Crittenden, the trees which had been girdled by farmers in obtaining bark, had acted in much the same manner — as incubators for a number of insects breeding in dying or dead larch. The numbers of several of these had increased beyond the danger level and they were able to attack and kill trees over-mature and deteriorating. Several of the trees from which most of the material for this study was derived had apparently been killed in this manner.

In our study Trees I and X, as described later, were trees weakened by over-maturing and their death is believed to have been caused or at least much hastened by insect work. Insects found in both of these trees and in others under nearly similar conditions included the scolytids *Polygraphus rufipennis* and *Eccoplogaster piccae*, the cerambycid *Asemum moestum*, always working very near the base of the tree, and the melandryid *Serropulpus barbatus*. *Dendroctonus simplex* was present in the bark of the basal twenty feet of the

trunk of Tree I and of others examined in 1915 and 1917, but no sigus of it were to be found in Tree X. There can be little doubt that these insects working in the trunk together with a number of borers which typically attack the branches and the uppermost parts of the trunk such as *Neoclytus longipes*, *Leptostylus sex-guttatus*, *Pogonocherus mixtus*, and the three species of *Chrysobothris* — *C. blanchardi*, *C. sex-signata* and *C. dentipes* — greatly hasten the death of many weakened trees. *Melanophila fulvoguttata* and *Phymatodes dimidiatus* are two other borers which are often associated with them (the latter only in the lower trunk) the first of these being a well-known enemy of weakened spruces and hemlocks.

However, in the bit of woodland studied, these insects are not working unhampered, but natural forces are at hand which to some extent at least are tending toward the re-establishment of the normal balance of forces and toward the return to a more favorable condition for the larch. The work of woodpeckers is much in evidence and seems to be an efficient agency in reducing to some extent the numbers of the brood of several of the more numerous bark-boring insects. The birds seem to work in two ways — first by making small conical holes through the bark into the sapwood to obtain the larvæ of the larger species of beetles which have gone there to hibernate or to pupate, and secondly by removing practically all of the bark on large areas of the trunk to uncover the brood (larvæ, pupæ and young adults) of the bark beetles.

In some cases this work reached an unusual degree of efficiency. For instance one particular tree forty or fifty feet high and about 14 inches in diameter, had had nearly all of the bark removed from the ground to the very tip. (Figs. 5, 6.) This tree had been heavily infested with *Dendroctonus simplex*, *Polygraphus rufipennis* and other borers, but only a small per cent of the original infestation had survived the woodpeckers' thorough search for food. Of course all of the infested trees had not been so thoroughly gone over by the birds and a number of such trees had

apparently not been found by them at all. However, it is safe to say that the woodpeckers were an efficient force, working toward the return of the normal balance of nature which had been upset by the breeding of certain species of insects above the danger level, due to the girdling, season after season, of a number of the larches by farmers. It is not believed that the woodpeckers will be able unaided to reduce the numbers below the danger level, as long as more trees are girdled each year, but should this practice cease it is possible that they would be able eventually to obtain the upper hand and that conditions would return to normal.

FIELD WORK

The field work consisted in locating the infested trees, securing as many species of insects from them in the field as possible, noting the condition and probable date of death of the host tree, and securing all other data that was thought might be of value. The fact that many of the trees had been partially stripped of their bark by woodpeckers in search of grubs was made use of in readily finding such trees under winter conditions. The infested trees were cut down and samples of the various parts of the trunk, of the top and of the branches were selected. These different lots were labeled and shipped to the laboratory where they were placed in outdoor breeding cages as recorded previously.

The larger part of the material was obtained in the field April 28 and 29, 1916, but from this time till April, 1917, as occasion offered smaller lots were added. The material placed in breeding cages and from which insects were bred out was derived from eleven different trees showing a variety of different conditions. Some of these samples were from standing trees only recently dead, some from standing trees dead 1, 2 or more years and some from trees which had been blown over several years.

In the following pages these various trees are described and the insects derived from each are listed. The material from the first eight of these trees was shipped from Critten-

den April 29, 1916, while the rest was obtained later, at various times, as indicated.

TREE NO. I was a large larch of about 14 inches D. B. H. and about 50 feet high. It had probably died late in 1914 from unknown causes as it had not been stripped of its bark. It was the one tree found in the spring of 1916 which contained living specimens of *Dendroctonus simplex*. The lower part apparently had survived longer than the branches as the lower trunk was still somewhat sappy. This tree was rather interesting from the fact that a large part of the bark from the ground to the tip had been removed by woodpeckers in search of various bark boring insects. Under the portions of bark still adhering many specimens of *Polygraphus rufipennis* and *Dendroctonus simplex* still remained, but it needed only a casual examination of the bark to discover that a very large percentage had been uncovered and destroyed by the birds.

More material was taken from this tree than from any other one source. In one cage was placed the first segment of the trunk, the lower end of which was taken from only 6 inches above ground. The bark on this section was riddled by the burrows of *D. simplex* and *P. rufipennis* and the sapwood contained many larvae of *Asemum moestum*. These latter were so numerous that just above the root 6 larvae were taken from an area of the wood only 6 inches square. In addition to these, three other species were bred from this section of the tree: the buprestid *Melanophila fulvoguttata*, the weevil *Dryophthorus americanus*, and a small fly *Polenia rudis*.

In another cage was placed the next section of the trunk taken from 18 inches above ground. In the field *D. simplex*, *P. rufipennis* and the larva of a clerid, apparently *Phyllobanus dislocatus*, and of a cerambycid, *Asemum moestum*, were taken. The adults of all of these and in addition of *Serropalpus barbatus* were bred from this wood.

In another cage was placed a section of the trunk from 3 feet above ground, this and the two pieces already described having been continuous and forming the base of the tree.

From it were derived *P. rufipennis*, *D. simplex*, several specimens of *Phyllobaenus dislocatus* and two hymenopterous parasites,—a small undetermined chalcid and *Spathius tomici*,—these being parasitic upon the bark beetles. It is worthy of note that *A. moestum* so numerous in the first segment and still present in the second is no longer found in this section beginning three feet above ground.

In another cage was placed a portion of the trunk taken from 30 feet above ground. Burrows and specimens of *P. rufipennis* were quite numerous but none of *D. simplex* occurred this far up. In the breeding cage this section of trunk yielded in addition to *P. rufipennis*, one specimen each of the clerid *P. dislocatus*, the lampyrid *Podabrus diadema* and a small undetermined chalcid.

Another sample was taken of the trunk at its extreme tip about 50 feet above ground. *P. rufipennis* was taken from this in the field and the engravings were nearly as numerous proportionately as in other regions of the trunk (Fig. 2). No other insects came from this section of the tree in the cages although the bark shows exit holes of both cerambycids and buprestids. These had apparently emerged before the sample was placed in the breeding cage, showing that the tip of the tree had probably begun to die earlier than the lower part—this being in line with the conditions found in the lower branches where *E. piceae* was breeding and in the lower trunk which was still sappy in some parts.

Numerous specimens of the limbs of this tree were taken. These are from 1 to 2 inches in diameter and are from a height of from 18 to 45 feet above ground. The bark upon these limbs is thin with only a small scaly and corky layer and was apparently quite dry and clung tightly to the wood. Some of the burrows in it, however, contained drops of resin showing that the bark had been attached while still sappy. In the field these samples yielded *P. rufipennis* and the larvae of a clerid, of a buprestid and of a small cerambycid. This material was kept out doors in two separate breeding cages (there being too much for one) during the summer till September 28, and the following insects emerged during

that time: *P. rufipennis*, *Eccoptogaster piccae*, *P. dislocatus*, a small moth *Epicallima argenticinctella* Clem., several undetermined psocids, and several parasitic hymenoptera — *Cheirpachus* sp., *Heterospilus* sp., *Spathius tomici*, and also another hymenoptera *Prosopis* sp.

On September 28 this material was moved into the laboratory, the contents of one cage being placed in tight storage boxes while that of the other was left in cages indoors. During January, February and March of 1917, this material both in the breeding cages and storage boxes again became active and gave rise to a large number of species not previously taken from it. These are the two-year forms and their parasites and comprise the following insects: the cerambycids — *Pogonocherus mixtus*, *Leptostylus sex-guttatus*, *Xeoclytus longipes*; the buprestids — *Chrysobothris blanchardi*, *C. sex-signata*, *C. dentipes*, *Melanophila fulvoguttata*, and *Anthaxia quercata*; the hymenopterous parasites — *Phasgonophora* sp., *Odontaulacus bilobatus* and *Atoreutus astigmus*; and the small fly — *Pollenia rudis*.

TREE No. II was a larch of about 8 inches D. B. H. in the west group of trees of this species. It had been killed by having the bark removed from near the base in 1914. No insects were taken from this tree in the field, but a segment about 20 feet from the base was seen to be infested and this was placed in a breeding cage to breed out the inhabitants. The insects derived from this material are *P. rufipennis*, *Phyllobaenus dislocatus*, the supposedly parasitic fly *Medeterus* sp. and the siricid *Urocerus albicornis* represented by a female and a male. Samples of this one region of this tree were the only ones brought from the field.

TREE No. III was killed by the bark having been peeled off of it — probably in 1914. Above the peeled portions the bark was well riddled by the engravings of *P. rufipennis* and also contained the larvae and burrows of several cerambycids, of species unknown at the time the material was examined in the field. A sample of the trunk of this tree about six inches in diameter taken from about five feet above ground

was placed in a breeding cage and the following specimens were bred from it: The cerambycids *Phymatodes dimidiatus* and *Leptostylus sex-guttatus*; the clerids *Phyllobaenus dislocatus* and *Cymatodera bicolor* which were preying upon *P. rufipennis* principally; six hymenopterous parasites including the two large pimplid forms *Rhyssa lineolata* and a new species of *Pseudorhyssa*, both of them apparently parasitic upon *Phymatodes dimidiatus*, and four smaller forms; three species of *Doryctes* (all probably new) and *Eurytoma* sp. Of these the three species of *Doryctes* are probably parasitic upon *P. dimidiatus* and the latter on *P. rufipennis*.

TREE NO. IV was a tree which was still living but much weakened. One of the larger roots which was exposed and free of the ground for several inches had been dead about two years (killed 1914). The bark was rather thick and still adherent, although the wood was beginning to decay. Examinations of this root in the field showed the presence of adults of a scolytid — *Dryocoetes americanus* — and the larva of a cerambycid which later proved to be *Leptura vittata*.

This root was removed without felling the tree and was confined in a breeding cage. During the summer two adults of *Leptura vittata* and two specimens of a small fly — *Phorbia fuscipes* — were taken from this cage.

This material was left in the breeding cage out of doors until November 2, when it was brought in and gone over thoroughly. The bark was removed, disclosing the burrows and dead adults of *Dryocoetes americanus*, also a living clerid larva of unknown species. Deeper in the wood were found the larvae of *Leptura vittata* and the adults of the small weevils *Dryophthorus americanus*. The sample of root was placed in a tight storage box, and later gave rise to one specimen of *L. vittata*. This was found dead January 13, 1917, and the exact date of emergence was unknown. However, from the general date of its appearance in the laboratory it would have appeared under natural conditions in May or early June.

TREE No. V had been dead probably three years (since 1913). The tree was about seven inches D. B. H. The lower trunk had been injured upon one side many years before (at least ten years), probably by having part of the bark removed. However, it had not been entirely girdled and the tree had survived. The uninjured bark had partly overgrown the injury but not entirely — the result being that finally the sapwood exposed and all of the heart wood was well along in decay. (Figs. 29, 30.)

Two specimens were taken from the wood of this tree in the field — an adult of the elaterid *Adelocera brevicornis* from the decayed heart wood, and a larva of *Serropalpus barbatus* from the sounder wood. The old burrows of *P. rufipennis* were numerous, but no living specimens remained.

Samples of this tree from two regions were shipped to Syracuse and placed in breeding cages. Several segments of the trunk from four to ten feet from the base contained considerable dead sapwood and heart wood well along in decay. Another sample from twenty feet above ground contained only sound wood. These samples yielded the following insects during the summer: The cerambycids *Phymatodes dimidiatus* and *Asemum moestum*; the melandryid *Serropalpus barbatus*, these coming from the more recently killed wood; the tenebrionid *Tenebrio tenebriodes* and the weevil *Dryophthorus americanus* coming from the decaying wood. In addition two hymenopterous parasites were bred out — the large *Rhyssa lineolata* which is parasitic upon *P. dimidiatus* and a small undetermined chalcid possibly parasitic on *Dryophthorus americanus*.

TREE No. VI was killed by peeling probably late in 1913. When examined April 29, 1916, in the field it contained no living *P. rufipennis*, although abandoned burrows of this scolytid were very numerous. These abandoned burrows had been utilized by the small scolytid *Crypturgus atomus*, which habitually starts its own burrows from those of other bark-boring beetles. This one species was the only form taken from this tree in the field. When confined in the breeding cage samples of this tree taken from one foot above ground

and ten feet above ground yielded numerous specimens of *Serropalpus barbatus* and nothing else.

TREE No. VII was one which had been felled by the wind about four years previously (1912), but the trunk was still free of the ground. The bark was quite loose and showed evidence of some decay. Burrows of *P. rufipennis* were numerous, but of course the insects responsible for them had long since left this tree. In the field a few larvae of "scavenger beetles," species undetermined, were found, and also several larvae of a cerambycid, which was later shown to be *Monohammus scutellatus*. A sample taken from the trunk about forty feet from the base (the trunk had, however, been recumbent but free of the ground for several years) yielded two specimens each of *M. scutellatus* and *Serropalpus barbatus*. No other forms were bred from this material.

TREE No. VIII was a small tree about ten feet high and having a D. B. II. of two inches. It had been killed by shading. No insects were taken from this tree in the field. The bark was quite dry and tight and altogether it did not form a breeding place which would be suitable for many wood-boring or bark-boring insects. From the general character of the wood and bark one would expect insects to arise from it similar to those coming from the limbs of larger trees. In fact this expectation was realized when in the breeding cage three specimens of *Leptostylus sex-guttatus* and one of *Chrysobothris sex-signata* appeared. Later examination of this stick revealed a few burrows of *P. rufipennis*, but these were not normal and in only one or two cases were any larval galleries present.

All of the preceding material was shipped to the laboratory from Crittenden, N. Y., on April 29, 1916. In addition to this, material which was obtained at other times or other localities is listed below.

TREE No. IX was obtained from the College Forest near Wanakena, N. Y. This tree of about five inches diameter

had been blown down by a heavy windstorm late in May, 1916. The roots still adhered and the lower part of the tree was still alive and green in August. The tree had fallen across a trail, however, and the top about five feet from the base had been sawed off to clear the trail. In August this top was found to be heavily infested by *Polygraphus rufipennis* and several sections of the trunk from eight to twenty feet from the base were shipped to Syracuse and there placed in a breeding cage on August 18. During the rest of the season the following insects were taken from this cage: numerous adults of *P. rufipennis*, a specimen of a small chalcid of undetermined species, *Erytoma* sp. and *Spathius tomici*. On October 24 some of the bark was removed, disclosing numerous young adults of *P. rufipennis* and also the larva of a clerid undetermined and the larva of an unknown cerambycid. The material was left out of doors until early in January, 1917, when it was brought into the heated basement, and later, in February, was transferred to a cool room, where it remained till June, when it was again transferred to an outdoor breeding cage. On July 3, 11 and 18, specimens of *Neoclytus longipes* emerged. All of the evidence from other sources goes to show that this cerambycid is one which normally requires two years for the completion of its life history. It is believed that the normal life history was shortened by the treatment the material received. The outdoor conditions from which it was removed early in January corresponded to the first winter, the month in the heated basement where the temperature varied from about fifty degrees to seventy-five degrees corresponded to the second summer and the low temperature in the storage room from February to June simulated the second winter. It is worthy of note that the specimens of *Neoclytus longipes* from this material are rather undersized although normal in other respects. The three specimens in question measure 7, 8 and 8 mm. respectively, while those from other lots of larch were from 9 to 9.5 mm. The length mentioned by Blatchley as characteristic of this species is from 9 to 11 mm.

During July there was also evidence of the presence of a larvæ of *Monohammus*, probably *M. scutellatus*, in the continued casting out of the coarse "sawdust" characteristic of this genus.*

TREE NO. X was a large tree about eighteen inches D. B. H., which was not observed to be infested with insects in April, 1916, when the material from most of the other trees was obtained. This tree had not been killed by stripping of the bark. It stood in a rather moist situation in a dense part of the wood about fifty feet from Tree I. It had died from causes unknown probably late in 1915, or early in 1916. When examined in January, 1917, it still contained the brood of *Polygraphus rufipennis* and of *Eccoptogaster piceae*, which must have entered the bark during the summer of 1916. The wood was still quite sappy and contained resin pockets with the contents still unhardened. Also the bodies of several adults of *E. piceae* were found embedded by a copious flow of pitch in their egg galleries showing that the tree had been attacked while still partly alive.

A large part of the trunk of this tree from near the ground up to the very tip had had much of the bark removed by woodpeckers in search of the contained brood. Much of this barking had been done quite recently, for when the tree was found on January 5, 1917, the fresh chips covered the surface of the snow. The first samples from this tree were taken at this time. These, consisting of strips of the sapwood with adherent bark, were brought in with the hope of breeding out specimens of *Eccoptogaster piceae*, the brood of which, together with that of *Polygraphus rufipennis*, were found in the trunk near the ground. In addition to these two scolytids, the larvæ of *Serropalpus barbatus* was also

* During the winter of 1917-18, this material was examined and found to contain living cerambycid larvæ. It was stored in a cool store room and in the following May and early in June gave rise to a number of specimens of *Neoclytus longipes*, a single *Monohammus scutellatus*, a single *Chrysobothris dentipes*, several specimens of *Xylotrechus undulatus* Say and to a number of hymenopterai parasites which are apparently *Odontaulacus bilobatus*. *X. undulatus* had not been previously bred from larch.

taken in the field from near the base of the tree. In the breeding jar these chips gave rise to specimens of *P. rufipennis*, *E. piceae*, the predator *Phyllobaenus dislocatus* and the parasite *Phasgonophora* sp.

On February 26 this tree was felled and samples were taken from the trunk at various levels. The first section was taken from about eight feet above ground and gave rise to the following insects when placed in the breeding cages. The two scolytids *Polygraphus rufipennis* and *Eccoptogaster piceae* with the hymenopterous parasites *Rhyssa lineolata*, *Doryctes* sp. a., *Spintherus pulchripennis*, *Spathius tomici*, *Spathius* sp., an undetermined pteromalid and the parasitic fly *Medeterus* sp.; the predator *Phyllobaenus dislocatus*, which preys indiscriminately upon all scolytids and upon other small bark-boring insects; the cerambycid *Phymatodes dimidiatus*, which was parasitized by *Doryctes* sp. and *Rhyssa lineolata*; the melandryid, *Serropalpus barbatus*; and the siricids *Urocerus albicornis* and *Sirex abbotii*. Examination of the base of this tree in the field showed numerous larvae of *Asemum moestum*.

A second section of the trunk taken about twenty feet from the base of the tree yielded exactly the same association of insects. *A. moestum* is of course missing just as at the eight-foot level. This form, as we have already seen, is one attacking only the basal part of the tree trunk and has not been found higher than a few feet from the ground.

The third region of the trunk included all of it above a point thirty feet from the ground and consisted of six pieces each a little less than two feet long. The insects taken from this material included the two scolytids and their parasites and predators as in the lower trunk, *Serropalpus barbatus* and *Urocerus albicornis*.

TREE No. XI was a small tree of about three inches D. B. II. which had been killed several years before (probably 1913) by shading. The wood was partly decayed by a "dry rot" and contained numerous specimens of the curculionid *Stenocellis brevis*. The wood was in such condition February 26, 1917, that it could be easily pulverized between

the fingers. No other insects were taken from this tree in the field and none were bred from it.

INSECT ASSOCIATIONS IN LARCH WOOD AND BARK

It is a well-recognized fact that in many cases certain species of insects not only live exclusively upon certain species of trees, but also that in many cases it is just as true that a certain insect is to be found only in a definite region of a tree. This, however, by no means holds for all species of bark or wood inhabiting insects, for many seem to attack indiscriminately any part of the tree from the trunk to branches an inch or even less in diameter, just as many insect forms attack a large number of tree species with no apparent preference.

There are doubtless several factors which influence the choice by the insects of certain regions for breeding purposes. Perhaps the most important of these is the character of the bark, but actual height from the ground is an important factor in the case of some insects, especially such as are clumsy fliers.

The character of the bark may apparently influence oviposition in several ways. The actual thickness of the bark on the lower trunk of large trees undoubtedly deters many borers from ovipositing on account of the mechanical difficulty or even impossibility some find in piercing the thick outer layers and placing their eggs where the young on hatching will find the proper nourishment. Entirely aside from this factor of the thickness of the bark offering mechanical resistance to the oviposition of certain forms, the bark on the trunk has thicker layers of the edible and more or less fibrous and spongy inner bark, and this absorbs a greater amount of moisture and retains it longer. This maximum of moisture, while it offers conditions which are favorable or even necessary for the proper development of some species of borers, is just as truly unfavorable for other species. We shall presently see that certain borers are characteristically found in the thin-barked tops and limbs which in the next summer

after the death of the tree appear to be absolutely dry, but which nevertheless apparently offer conditions which are ideal for certain two-year forms. Moisture conditions during the second summer in the trunk and in the thinner barked limbs is so extremely different that one would hardly expect to find any forms in common between them. As a matter of fact this expectation is nearly realized, for of the two-year forms, or of forms occurring under the bark during the second summer after the death of the tree, only two species were bred both from the limbs and from the lower or middle-trunk.

The Lower Trunk in Dying or Recently Killed Larch Trees. The trunk region itself can be subdivided into two or more regions or habitats upon the basis of the insects found therein. In the dying or recently killed trees *Dendroctonus simplex* is perhaps the most characteristic bark beetle inhabitant of the lower trunk. It was not found in the bark at a greater distance than twenty feet from the ground and was most numerous in the lower ten feet. In felled trees, however, *D. simplex* occurs throughout the trunk even around the bases of the branches. Apparently, then, the limiting factor here is distance from the ground, and doubtless the clumsy build of the beetle and its rather poor powers of flight are responsible.

Another bark beetle often found in the lower trunk is *Polygraphus rufipennis*. It breeds in all regions of the trunk and even in the tops and larger limbs. It is worthy of note that when it occurs in the same tree trunk as *D. simplex* it is much less numerous in the lower regions of the trunk where the latter species occurs, than it is in the middle and upper trunk. This is not true of trees not infested by *D. simplex*. The explanation of this seems apparent. The *Dendroctonus* enters the tree slightly earlier than *Polygraphus*, which on finding the lower trunk already occupied by numerous broods of the other species, seeks other parts of the tree to construct its brood burrows. In trees infested by both it is interesting to note that as we go farther and farther from the ground the burrows of *D. simplex* become

fewer and fewer in number and those of *P. rufipennis* become correspondingly numerous, until at a height of about twenty feet *D. simplex* no longer occurs and *P. rufipennis* is correspondingly numerous.

A somewhat similar condition holds for another bark beetle — *Eccoptogaster piceæ*. This scolytid breeds most often in the thin-barked tops and limbs of the larch. However, sometimes it is also found in the thicker-barked, lower trunk, as was the case in Tree X. In this tree it was more numerous in the upper trunk and tops, but some brood burrows containing living brood were found at a distance of only a few feet from the ground, where the inhabitants of the bark were predominately *P. rufipennis*.

Still another bark beetle occasionally found in the lower trunk of the larch during the first summer after the death of the tree is *Crypturgus pusillus*, although this form is a more characteristic resident of the bark during the second year. This minute beetle seems always to construct its brood-burrow as an offshoot from the burrow of some other beetle. Usually the burrows so utilized are made by some other scolytid — in the larch most commonly by *P. rufipennis* — the entrance of this beetle being used in gaining access to the inner bark. In other host trees the entrance burrows of other scolytids are often utilized and in *Abies balsameus* several cases have been observed where the tunnels of *Monohammus scutellatus* had been so invaded, entrance to the burrows being gained by way of the "ventilation openings" through which the "sawdust" of this sawyer was cast out. In the larch, however, the only species with which *Crypturgus* has been observed to associate itself are *P. rufipennis* and *D. simplex*.

Several species of predaceous beetles were found associated with these scolytids in the bark. The most common of them is the ubiquitous *Phyllobaenus dislocatus*, which is the most common clerid beetle bred from wood infested by bark-boring insects in this region. It has been found associated with all four species of bark beetles mentioned above, and specimens of larvae as well as adults have been taken from bark infested

with *Polygraphus rufipennis* and *Dendroctonus simplex* especially. The clerid *Cymatodera bicolor* and the lamperid *Podabrus diadema* were also bred from bark infested with *P. rufipennis*. Both of these are perhaps predaceous, although no reference to the food habits of the latter species was found in the literature.

A number of hymenopterous parasites were also bred from material containing the brood of these various species of scolytids. Of these the most common is *Spathius tomici*, which was constantly associated with *P. rufipennis*, *E. piceae* and *D. simplex*. It was especially numerous in Trees I, IX and X. Of these Tree IX was from near Wanakena and of scolytids contained only the brood of *P. rufipennis*. Tree X contained numerous brood not only of this bark beetle but also of *E. piceae*. Tree I contained all three scolytids and all regions of the tree gave rise to specimens of this small parasite. There can be no doubt that *S. tomici* is parasitic on both *P. rufipennis* and *E. piceae*, as different lots of material which were practically pure cultures of either one or the other of these species yielded the parasite when placed in a breeding jar or cage. We cannot state so definitely that *D. simplex* serves as its host, for the reason that the *Dendroctonus* infested material from which the parasite was bred contained also the brood galleries of *P. rufipennis*. However, it seems very likely that a considerable number of small bark beetles may act as host for *Spathius tomici*.

Heterospilus sp., *Spathius* sp., *Spintherus pulchripennis*, and *Cheiropachus* sp. were obtained from material containing both *P. rufipennis* and *E. piceae*, and each may be parasitic upon either one or both of these bark beetles. *Eurytoma* sp. was bred from material containing the brood of *P. rufipennis* and is probably parasitic upon it. Several specimens of a small undetermined chalcid were obtained from material containing *P. rufipennis* and *D. simplex* and may be parasitic on either one or both of these or may be a hyperparasite upon their parasitic forms. A number of specimens of *Medeterus* sp. were bred from material containing large numbers of *P. rufipennis* and some *E. piceae*.

M. nigripes Loew. has been previously recorded by Hopkins (1899, p. 450) as a parasitic enemy of the larvæ of *P. rufipennis*.

Other boring insects which oviposit in the lower trunk of the larch either while it is dying or during the first summer after death, include the cerambycids *Asemum moestum*, *Monohammus scutellatus*, *Phymatodes dimidiatus*, and *Leptostylus sex-guttatus*; the buprestid *Melanophila fulvoguttata*; the melandryid *Serropalpus barbatus*, and the two siricids *Urocerus albicornis* and *Sirex abbotii*. Of these, *Asemum moestum* and *Phymatodes dimidiatus* seem to be the only forms which were bred exclusively from the lower trunk. *A. moestum* is a sapwood borer and was found only in the lowermost few feet of the lower trunk. The eggs are often laid in trees which are merely weakened and without a doubt the work of the numerous larvæ in the bark and sapwood greatly hastens the death of the tree. However, oviposition may also occur in recently killed trees, and as the insects require at least two years to develop, the adults are often bred from trees dead two years or slightly more.

Phymatodes dimidiatus, the other cerambycid, which was found to breed only in the lower trunk of larch, is more typically a dead tree form. Eggs may be laid either in trees recently killed or in those dead as much as a year. The life history requires a single year for its completion and the larvæ burrows in the inner bark until it reaches full growth. This species may be associated with *A. moestum* then during either the first or second year of the latter's life cycle.

Monohammus scutellatus, *Leptostylus sex-guttatus*, and *Melanophila fulvoguttata* are three forms which may breed not only in the lower trunk but also in other regions of the tree. All three are two-year forms, the larvæ of which feed in the inner bark and sapwood, and which enter the wood only when preparing to hibernate or to pupate. *M. scutellatus* and *M. fulvoguttata* are characteristically trunk inhabiting forms, but on occasion do breed in the tops or limbs of trees. Indeed, more specimens of the latter were obtained from limbs than from the trunk. *Leptostylus sex-*

guttatus, on the other hand, most commonly breeds in the tops and limbs when it infests larch. There can be little doubt that it prefers the thin-barked parts of the tree.

The melandryid *Serropalpus barbatus* is the wood-boring insect most often found in and most characteristic of injured, dying, or recently dead larch. It was bred in considerable numbers from Trees I, V, VI, VII, and X. The larvae are wood-boring insects which live two or possibly more seasons in the sapwood or heartwood. This species is found throughout the trunk, but is most common in the lower trunk below the lowest branches.

The siricids *Urocerus albicornis* and *Sirex abbotii* occur more or less throughout the trunk even up among the branches. It is probable that they may even breed occasionally in the larger branches. However, these forms are all typically inhabitants during the larval state, of the wood of the part of the trunk free of limbs, as is shown by the fact that of twenty-five specimens of the two species bred from larch, all but four were from the tree below the level of the first still adhering limbs.

There are several parasites which were bred from wood or bark containing one or more of these borers. These include *Rhyssa lineolata*, *Pseudorhyssa* sp., *Odontamerus canadensis*, and three species of *Doryctes*, all of which are apparently new. These six species, four of which are new, were derived from three distinct lots of material in three separate breeding cages. They were associated with *P. dimidiatus*, *M. scutellatus*, *L. sex-guttatus*, *A. moestum*, *S. barbatus*, the two predators *Phyllabaenus dislocatus* and *Cymatodera bicolor* and with *Tenebrio tenebriodes* and *Dryophthorus americanus* (the latter two inhabiting dead and partly decayed wood in one of the lots). However, of these numerous wood and bark-inhabiting forms only two (*P. dimidiatus* and *S. barbatus*) were derived from all three lots, thus establishing the probability that one or both of them served as hosts for these parasites.

A later detailed study of all of the material in these lots was made with very interesting results. When the bark was

carefully removed, bit by bit, forty-five cocoons were exposed in one lot consisting of a piece about six inches in diameter and two feet long. Nine of these were twelve mm. or more in length and all the rest were below ten mm. Several of the latter were about nine mm. long and all of the rest smaller than 7.5 mm. The smaller ones were found in the burrows of *P. rufipennis* only and were doubtless the cocoons of *Spathius tomici* which had emerged the previous season before the material was brought to the laboratory. The cocoons of the two larger sizes, however, were found only in the burrows of *P. dimidiatus*, although careful search was made in the burrows of other species in both the wood and in the bark. The identity of these burrows was absolutely established by the finding in several of the pupal chambers of dead adults which had never emerged. In the same pupal chambers were found the cast larval skins, the mandibles and head armature of which are quite characteristic. Close to each of the parasitic cocoons, the larval remains of the host were found and these on comparison with the larval casts found in pupal chambers containing dead adults of *P. dimidiatus* established absolutely the identity of the parasitized form.

By comparing the sizes of the adult hymenoptera taken from this material it was readily established that *Rhyssa lineolata* and *Pseudorhyssa* sp. come from the larger cocoons in the burrows of *P. dimidiatus* (the cocoons of the two being indistinguishable) while the species of *Doryctes* and probably also *Odontaumerus canadensis* came from the cocoons about eight to nine mm. long, found in the burrows of the same borer.

The Upper Trunk in Dying or Recently Killed Larch Trees contained the same borers with several exceptions as did the lower trunk. Those occurring in this region include the scolytids — *P. rufipennis* and *E. piceae* and their predators — *P. dislocatus* and *C. bicolor*, and parasites — *Spathius tomici*, *Spathius* sp., *Spintherus pulchripennis*, *Phasgonophora* sp., *Cheiropachus* sp. and *Heterospilus* sp.; the

cerambycid — *Monohammus scutellatus*; the melandryid — *Serropalpus barbatus*; and the two siricids *Urocerus albicornis* and *Sirex abbotii*. There can be no doubt that *Leplostylus sex-guttatus* and *Melanophila fulvoguttata* may also breed in this upper trunk region, as each of these is found both in the lower trunk and in the tops and branches, but the limited amount of material confined in our breeding cages did not give rise to any. *L. sex-guttatus* breeds by preference in the thin barked tops and limbs and would therefore be more likely to be found in the upper trunk than in the lower. *M. fulvoguttata* on the other hand is more typically a trunk-inhabiting form and in spruce and hemlock is found throughout the trunk region and only to a lesser extent in the tops and limbs. It is likely that its preferences in larch would be similar but the small number bred from larch does not allow us to draw an adequate conclusion.

D. simplex, as previously stated, is confined entirely to the lower trunk of standing trees, but may breed in the upper trunk of felled trees. The limiting factor here is then very apparently height from ground rather than the character of the bark. The cerambycids *Asemum moestum* and *Phymatodes dimidiatus* are two other beetles which have been bred only from the lower trunk. Of these the former is practically confined to the lowermost part of the trunk and none were bred from wood more than three or four feet from the ground. *P. dimidiatus* while not confined to such a limited area of the lower trunk was not obtained from wood more than ten feet from the ground.

The Tops and Limbs of Dying or Recently Killed Larch Trees.— The tops and limbs of recently killed larch present conditions quite different in several respects from those in the trunks. In the first place they are inaccessible to a number of forms which are clumsy fliers. Aside from this, the much thinner bark allows the beetles more ready access to the inner bark and sapwood. The inner bark, however, neither furnishes so plentiful an amount of food as does the thick bark nor does it retain so much moisture. However, the thin-barked parts of the tree seem to offer conditions

which are more suitable for many forms than are to be found in other parts of the tree. This is indicated by the fact that five species of borers were obtained exclusively from tops and limbs while a number of other species taken from other regions occur also in the thin-barked parts. Of these latter two in particular show a decided preference for the newer growths.

Most of these forms which characteristically inhabit thin-barked regions are species requiring two years for the completion of their growth. During the second summer of this period the moisture conditions in the thin-barked parts are strikingly different from that existing in the thick-barked regions. Indeed it is hardly conceivable how the bark or sapwood here can be of use as food during times of drought when these parts are apparently dessicated, and indeed it may well be that during such periods the larva ceases feeding and becomes more or less torpid. But however that may be, it is a fact that regions showing such conditions are apparently sought by a considerable number of species in preference to other parts of the tree where moisture conditions are different. Other factors may enter into this choice and it is possible that these may determine the beetle's choice of breeding places, but our data seem to indicate that this question of lack of excessive moisture is one of the determining factors. This applies not to the forms requiring only a single year for their life cycle, but to those which remain under the bark for two years.

A total of ten species of *boring beetles* were bred from thin-barked larch. This includes two scolytids, three cerambycids and five buprestids. The scolytid most characteristic of larch limbs and tops is *Eccoptygaster piceae*. This seems to be its favorite breeding place and study of old engravings shows conclusively that there is a larger percentage of larvæ reaching full growth here than in the trunk region. This is especially true of the tops of a diameter of from $1\frac{1}{2}$ to $3\frac{1}{2}$ inches, although the larger limbs also offer favorable conditions. The other scolytid *P. rufipennis*, while often numerous in the tops and occasionally in the limbs is typi-

cally a trunk-inhabiting form and is probably found in the limbs only when crowded out of other regions of the tree or when more suitable breeding places are lacking.

The cerambycids bred from limbs and tops in the order of the number of each obtained are *Pogonocherus mixtus*, *Neoclytus longipes* and *Leptostylus sex-guttatus*. These are all three two-year forms. Another species which is almost certain to breed in larch tops is *Monohammus scutellatus*, although none were actually taken. In pine, spruce, and balsam this sawyer breeds in all parts of the tree from the base to limbs an inch in diameter, and it doubtless will on occasion breed in larch limbs as well as in larch trunks.

Of the ten borers actually bred from thin-barked larch, five are buprestids. These are *Melanophila fulvoguttata*, *Anthaxia quercata*, *Chrysobothris sex-signata*, *C. dentipes*, and *C. blanchardi*. Of these only one species, *M. fulvoguttata*, was bred from any other region of the tree. All of these forms live for two seasons as larvæ under the bark, but groove both bark and sapwood. They enter the wood only to pupate at the completion of their larval growth.

Associated with these borers are the predator *Phyllobaeus dislocatus* and various parasites. *P. dislocatus* doubtless invades principally the burrows of the bark beetles *P. rufipennis* and *E. piceae*, but both larvæ and adults have been found in the burrows of cerambycids and buprestids. The parasites *Spathius tomici*, *Heterospilus* sp., and *Cheiropachus*, which are probably parasitic upon one or both of these bark beetles were bred from cages containing limbs and tops and emerged at approximately the same time as their supposed hosts.

Three other parasites of a somewhat larger size were obtained from this material, namely — *Odontaulacus bilobatus* Prov., *Atoreutus astigmus* Ashm., and *Phasgonophora* sp. These are not only larger in size but also emerged a season later than did the bark beetles and the other parasites mentioned. Therefore it is believed that these are parasitic upon the larger sized species (flatheads and roundheads) listed above. It has been impossible to assign these to their

hosts, even provisionally, as it was not practicable to identify the species with the cocoon (their size being so nearly similar) nor was it possible absolutely to identify the burrows in which the cocoons occurred owing to some extent to their not having been completed by the dying larva. Therefore it is not safe to make any more definite statement than that cocoons, which from their size were probably those of one or more of these forms, were found both in burrows which had been made by *P. mixtus* and also in other burrows made by *C. blanchardi*.

Perhaps the most striking difference between the larch trunk association and that in the limbs and tops is shown when it is stated that the latter includes five buprestids (just half of the borers actually taken from thin-barked wood) while the trunk association includes but one of this family. Thus the buprestids characterize the thin-barked-larch association and this might well be spoken of as the buprestid or flat-headed-borer association.

All of the borers working in the limbs and tops are bark-borers as distinguished from wood borers. By this it is meant that the larvæ work in the inner bark and outer sapwood, grooving both with their burrows, although making their pupal chamber in the wood. One would expect to find in such a location in thin-barked wood either very flat borers or rather small ones. This perhaps is correlated with the fact that such a great per cent of the larvæ here are of the flathead type and that the remaining forms (*P. mixtus*, *I. sex-guttatus* and *N. longipes*) are all quite small and of slender form.

Decaying Larch.—No very thorough data regarding the later insect inhabitants of dead larch is at hand, but the few observations made should be here recorded. From Tree No. IV was obtained a piece of root several inches in diameter and a foot or more long. This had been dead several years as shown by the fact that the wood had begun to decay. The bark, however, was still adherent and had served as the breeding place for *Dryocoetes americanus*, the young adults of which were found in the inner bark next to the sapwood.

The wood served as a breeding place for the cureulionid *Dryophthorus americanus*, the cerambycid *Leptura vittata* and an unidentified elaterid. The larvæ of *L. vittata* tunnels longitudinal burrows in the sapwood and outer heartwood thus hastening decay materially. From the same region of this punky wood adults of *Dryophthorus americanus* were removed the following fall (November 2, 1916). These had not appeared in the breeding cages during the summer but there was evidence that they had bred in the wood two or more generations without change of host.

Several specimens of the fly *Phorbia fuscipes* Lett. were also bred from this root. The larvæ probably lived either under the decaying bark or in the punky wood as scavengers although they may possibly have been parasitic upon some of the other insect inhabitants.

Our records also furnish data of several other species of insects from decaying wood or from wood dead several years. Tree V had been partly stripped of its bark several years before its death and the exposed wood had never been overgrown. This wood was well along in decay and contained the burrows of former insect inhabitants, probably *Serropalpus barbatus* among others. In the field a single adult of *Adelocera brevicornis* was taken from this punky wood and in the breeding cage it gave rise to adults of the cossoninid *Dryophthorus americanus* and the tenebrionid, *Tenebrio tenebriodes*. Other specimens of *Dryophthorus americanus* were found under similar conditions in other trees and in the same sort of wood numerous specimens of another cossoninid, *Stenocellis brevis*, were taken.

The following tables will show something of the relations of these various insects to each other as well as something of their habits and the character of the material in which they breed.

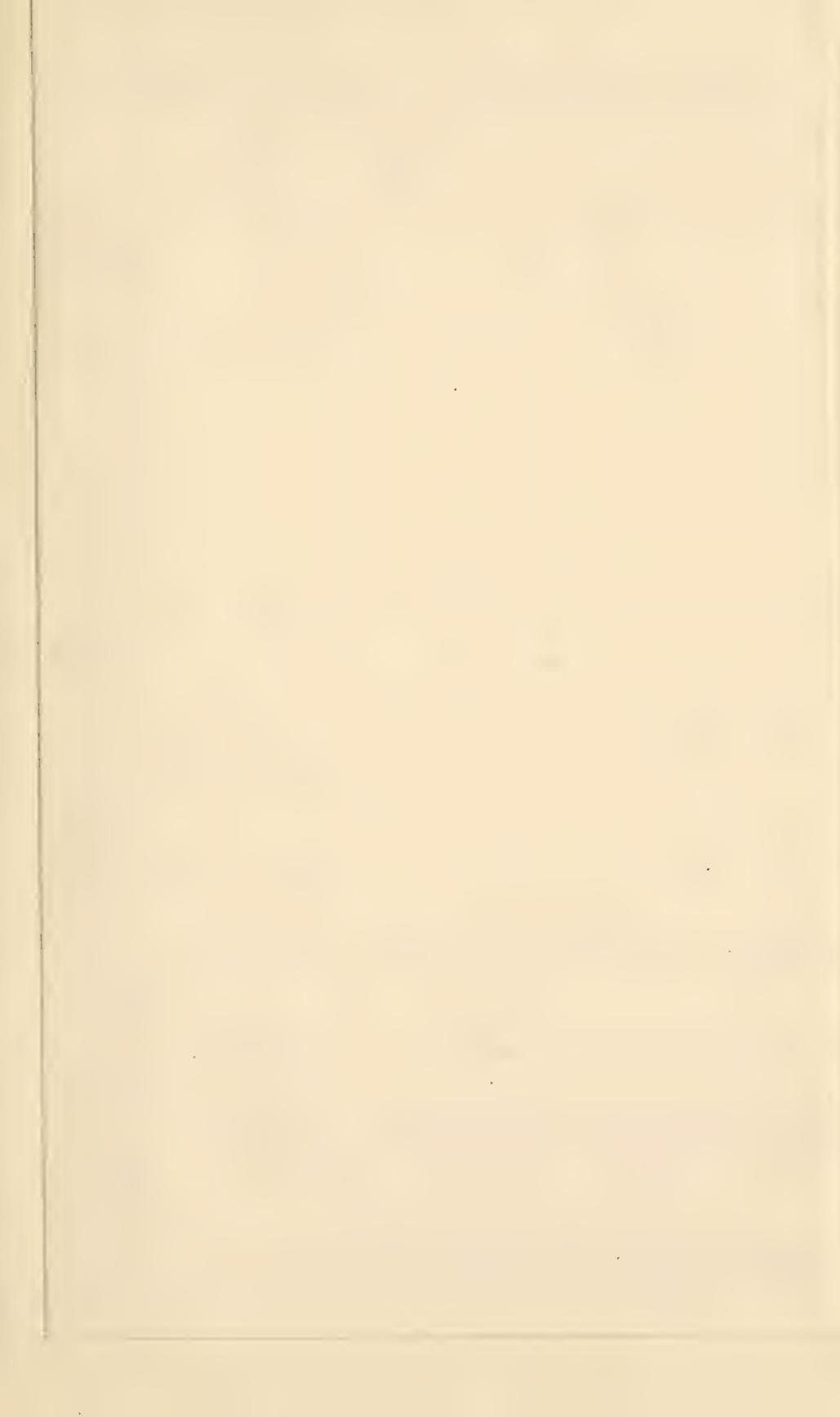
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ECOLOGICAL ASSOCIATIONS OF VARIOUS PREDATORS AND PARASITES IN LARCH.

NAME OF PREDATOR OR PARASITE	BORERS WITH WHICH ASSOCIATED	CERTAIN OR PROBABLE HOST	PREDATORS AND PARASITES ASSOCIATED
<i>Phyllobacnus dislocatus</i> Say.	<i>Polygraphus rufipennis</i> , <i>Dendroctonus simplex</i> , <i>Phymatodes dimidiatus</i> , <i>Eccoptogaster picea</i> , <i>Crypturgus pusillus</i> , <i>Leptostylus sex-guttatus</i> , <i>Xocolytus longipes</i> , <i>Pogonocherus mixtus</i> , <i>Melanophila fulvoguttata</i> , <i>Chrysobothris blanchardi</i> , <i>Chrysobothris dentipes</i> , <i>Chrysobothris sex-signata</i> , <i>Anthaxia quercata</i> , <i>Serropalpus barbatus</i> , <i>Sirex abbottii</i> , <i>Urocerus albicornis</i> .	<i>P. rufipennis</i> , <i>D. simplex</i> , <i>E. picea</i> , Probably others.	<i>Cymatodera bicolor</i> , <i>Podabrus diadema</i> , <i>Spathius tomici</i> , <i>Heterospilus</i> sp., <i>Cheirpachus</i> sp., <i>Eurytoma</i> sp., <i>Rhyssa lineolata</i> , <i>Pseudorhyssa</i> sp., <i>Doryctes</i> sp., a, b, c, <i>Phasgonophora</i> sp., <i>Odontaulacus bilobatus</i> , <i>Atoceutus astigmus</i> , Small chalcid (undetermined), <i>Medeterus</i> sp.
<i>Cymatodera bicolor</i> Say.	<i>Polygraphus rufipennis</i> , <i>Phymatodes dimidiatus</i> , <i>Leptostylus sex-guttatus</i> .	<i>P. rufipennis</i> .	<i>Phyllobacnus dislocatus</i> , <i>Doryctes</i> sp., a, b, c, <i>Pseudorhyssa</i> sp., <i>Eurytoma</i> sp., <i>Rhyssa lineolata</i> .
<i>Podabrus diadema</i> Fab.	<i>Polygraphus rufipennis</i> .	<i>P. rufipennis</i> .	<i>Phyllobacnus dislocatus</i> , Small chalcid (undetermined).
<i>Rhyssa lineolata</i> Kirby.	<i>Phymatodes dimidiatus</i> , <i>Leptostylus sex-guttatus</i> , <i>Aesum moerulum</i> , <i>Serropalpus barbatus</i> , <i>Urocerus albicornis</i> , <i>Sirex abbottii</i> , <i>Polygraphus rufipennis</i> , <i>Eccoptogaster picea</i> .	<i>Phymatodes dimidiatus</i> .	<i>Phyllobacnus dislocatus</i> , <i>Cymatodera bicolor</i> , <i>Pseudorhyssa</i> sp., <i>Doryctes</i> sp., a, b, c, <i>Eurytoma</i> sp., <i>Spathius tomici</i> , <i>Spathius</i> sp., <i>Pteromalid</i> (undetermined), <i>Medeterus</i> sp.
<i>Pseudorhyssa</i> sp.	<i>Phymatodes dimidiatus</i> , <i>Leptostylus sex-guttatus</i> , <i>Serropalpus barbatus</i> , <i>Polygraphus rufipennis</i> .	<i>Phymatodes dimidiatus</i> .	Same as above except the last three.
<i>Odontamerus canadensis</i> Prov.	Same as for <i>Pseudorhyssa</i> sp. above.	<i>Phymatodes dimidiatus</i> .	Same as for <i>Pseudorhyssa</i> sp. above.
<i>Odontaulacus bilobatus</i> Prov.	<i>Melanophila fulvoguttata</i> , <i>Chrysobothris blanchardi</i> , <i>Chrysobothris sex-signata</i> , <i>Chrysobothris dentipes</i> , <i>Anthaxia quercata</i> , <i>Pogonocherus mixtus</i> , <i>Xocolytus longipes</i> , <i>Leptostylus sex-guttatus</i> , <i>Polygraphus rufipennis</i> , <i>Eccoptogaster picea</i> .	<i>Chrysobothris blanchardi</i> , <i>Melanophila fulvoguttata</i> , <i>Pogonocherus mixtus</i> .	<i>Phyllobacnus dislocatus</i> , <i>Phasgonophora</i> sp., <i>Cheirpachus</i> sp., <i>Atoceutus astigmus</i> , <i>Heterospilus</i> sp., <i>Spathius tomici</i> , <i>Pollenia rudis</i> .
<i>Spathius tomici</i> Ashm.	Same as above; also <i>Dendroctonus simplex</i> , <i>Phymatodes dimidiatus</i> , <i>Serropalpus barbatus</i> , <i>Urocerus albicornis</i> , <i>Sirex abbottii</i> .	<i>P. rufipennis</i> , <i>E. picea</i> , <i>D. simplex</i> .	Same as above, except <i>Pollenia rudis</i> .
<i>Spathius</i> sp.	<i>Polygraphus rufipennis</i> , <i>Eccoptogaster picea</i> , <i>Phymatodes dimidiatus</i> , <i>Serropalpus barbatus</i> , <i>Urocerus albicornis</i> , <i>Sirex abbottii</i> .	<i>Polygraphus rufipennis</i> , <i>Eccoptogaster picea</i> .	<i>Phyllobacnus dislocatus</i> , <i>Spathius tomici</i> , <i>Rhyssa lineolata</i> , <i>Spilotherus pulchripennis</i> , <i>Doryctes</i> sp., a, Undetermined pteromalid, <i>Medeterus</i> sp.
<i>Doryctes</i> sp., a, b, c.	<i>Phymatodes dimidiatus</i> , <i>Leptostylus sex-guttatus</i> , <i>Polygraphus rufipennis</i> , (Sp. also with <i>Eccoptogaster picea</i> , <i>Serropalpus barbatus</i> , <i>Urocerus albicornis</i> , <i>Sirex abbottii</i>).	<i>P. dimidiatus</i> .	<i>Phyllobacnus dislocatus</i> , <i>Cymatodera bicolor</i> , <i>Rhyssa lineolata</i> , <i>Pseudorhyssa</i> sp., <i>Eurytoma</i> sp., (Sp. also with <i>Spilotherus pulchripennis</i> , <i>Spathius</i> sp. and <i>Medeterus</i> sp.)
<i>Heterospilus</i> sp.	Same as for <i>O. bilobatus</i> above.	<i>P. rufipennis</i> , <i>E. picea</i> .	Same as for <i>O. bilobatus</i> .
<i>Atoceutus astigmus</i> Ashm.	Same as for <i>O. bilobatus</i> above.	<i>Chrysobothris blanchardi</i> , <i>Pogonocherus mixtus</i> .	Same as for <i>O. bilobatus</i> above.
<i>Spilotherus pulchripennis</i> Cwld.	Same as for <i>Spathius</i> sp. above.	<i>Polygraphus rufipennis</i> , <i>Eccoptogaster picea</i> .	Same as for <i>Spathius</i> sp. above.
<i>Eurytoma</i> sp.	<i>Polygraphus rufipennis</i> , <i>Phymatodes dimidiatus</i> , <i>Leptostylus sex-guttatus</i> , <i>Xocolytus longipes</i> .	<i>Polygraphus rufipennis</i> .	<i>Phyllobacnus dislocatus</i> , <i>Cymatodera bicolor</i> , <i>Rhyssa lineolata</i> , <i>Pseudorhyssa</i> sp., <i>Doryctes</i> sp., a, b, c.
<i>Phasgonophora</i> sp.	Same as for <i>O. bilobatus</i> above.	<i>Chrysobothris blanchardi</i> .	Same as for <i>O. bilobatus</i> above.
<i>Cheirpachus</i> sp.	Same as above.	<i>P. rufipennis</i> , <i>E. picea</i> .	Same as above.
Small pteromalid (undetermined)	Same as for <i>Spathius tomici</i> .	<i>P. rufipennis</i> , <i>E. picea</i> , <i>D. simplex</i> .	Same as for <i>Spathius tomici</i> .
<i>Medeterus</i> sp.	<i>Polygraphus rufipennis</i> , <i>Eccoptogaster picea</i> , <i>Phymatodes dimidiatus</i> , <i>Serropalpus barbatus</i> , <i>Urocerus albicornis</i> , <i>Sirex abbottii</i> .	<i>P. rufipennis</i> .	<i>Phyllobacnus dislocatus</i> , <i>Spathius</i> sp., <i>Doryctes</i> sp., a, <i>Rhyssa lineolata</i> .



ECOLOGICAL RELATIONS AND ASSOCIATIONS OF THE VARIOUS BORERS IN LARCH.

NAME OF BORER	REGION OF TREE	CONDITION OF TREE WHEN BOER WAS LAID	TIME REQUIRED FOR LIFE HISTORY	LOCATION OF LARVAL BURROW	LOCATION OF PUPAL CHAMBER	DATE OF EMERGENCE	ASSOCIATED BORERS	ASSOCIATED PREDATORS	ASSOCIATED PARASITES
<i>Dendroctonus simplex</i> Lec.	Lower trunk.	Living, dying or recently dead.	One or two generations per year.	Inner bark.	Inner bark.	May 25, 26.	<i>Polyporus rufipennis</i> , <i>Cryptorhynchus pusillus</i> , <i>Aeromium moratum</i> , <i>Melanophila fulvopunctata</i> , <i>Serropalpus barbatus</i> .	<i>Phyllobaenus dislocatus</i> .	<i>Spilothus foveolatus</i> (undet.), both probably parasitic on <i>P. rufipennis</i> .)
<i>Polyporus rufipennis</i> Kirby.	Entire trunk and sometimes tops and limbs.	Dying or recently dead (sometimes one year).	One generation per year.	Inner bark.	Inner bark.	May 20, 25, June 2, Oct. 24.	<i>Dendroctonus simplex</i> , <i>Cryptorhynchus pusillus</i> , <i>Leptostylus piceae</i> , <i>Aeromium moratum</i> , <i>Monochamus scutellatus</i> , <i>Phymatodes dimidiatus</i> , <i>Panocherus nitidus</i> , <i>Leptostylus sex-punctatus</i> , <i>Arcticia longipes</i> , <i>Serropalpus barbatus</i> , <i>Melanophila fulvopunctata</i> , <i>Chrysothrix dentipes</i> , <i>Chrysothrix sex-striata</i> , <i>Chrysothrix blanchardi</i> , <i>Anthazia quercata</i> , <i>Urecesus albicornis</i> , <i>Sirex abditus</i> .	<i>Phyllobaenus dislocatus</i> , <i>Cymatodera bicolor</i> , <i>Paludus discauda</i> .	<i>Spilothorus pulchripennis</i> , <i>Spilothus foveolatus</i> , <i>Spilothus</i> sp., <i>Heterospilus</i> sp., <i>Chrysothrix</i> sp., <i>Phaenocarpa</i> sp., <i>Pteromalid</i> (undet.), <i>Meteorus</i> sp.
<i>Ecopiptaster piceae</i> Swaine.	Entire trunk and limbs, but especially thin-barked portions.	Dying, recently dead.	One generation per year.	Inner bark.	Inner bark.	June 6, July 8, 12, 21.	Same as above except <i>D. simplex</i> , <i>A. moratum</i> , and <i>M. scutellatus</i> .	<i>Phyllobaenus dislocatus</i> .	<i>Spilothorus pulchripennis</i> , <i>Spilothus foveolatus</i> , <i>Heterospilus</i> sp., <i>Chrysothrix</i> sp., <i>Meteorus</i> sp.
<i>Cryptorhynchus pusillus</i> Gyll.	Trunk (possibly in tops and limbs also).	Dead.	One generation per year.	Inner bark.	Inner bark.	Taken from bark April 29, Sept. 15.	<i>Dendroctonus simplex</i> , <i>Polyporus rufipennis</i> , <i>Ecopiptaster piceae</i> , <i>Aeromium moratum</i> , <i>Serropalpus barbatus</i> .	<i>Phyllobaenus dislocatus</i> .	None taken.
<i>Dryocoetes americanus</i> Hlop.	Exposed root.	Dead.	One generation per year.	Inner bark.	Inner bark.	June 8 (from burrow April 22, Sept. 28).	<i>Leptura vittata</i> , <i>Diplophthorus americanus</i> .	None taken.	None taken.
<i>Diplophthorus americanus</i> Hodel.	Root and lower trunk.	Dead and decaying.	Probably one generation per year.	Decaying wood.	Decaying wood.	July 3, 7 (from wood Nov. 2).	<i>Dryocoetes americanus</i> , <i>Leptura vittata</i> , <i>Tenebrio lineatorides</i> , <i>Adelocera brevicornis</i> , <i>Stenocleis brevis</i> .	None taken.	None taken.
<i>Stenocleis brevis</i> Dob.	Trunk.	Exposed decaying wood.	Probably one generation per year.	Decaying wood.	Decaying wood.	(From wood April 5, 29, Feb. 29).	<i>Diplophthorus americanus</i> , <i>Tenebrio lineatorides</i> , <i>Adelocera brevicornis</i> .	None taken.	None taken.
<i>Phymatodes dimidiatus</i> Kirby.	Lower trunk.	Recently dead.	One generation per year.	Inner bark and sapwood.	Outer sapwood.	May 26, 30, 31, June 8, 15.	<i>Polyporus rufipennis</i> , <i>Leptostylus sex-punctatus</i> , <i>Aeromium moratum</i> , <i>Serropalpus barbatus</i> , <i>Urecesus albicornis</i> , <i>Sirex abditus</i> .	<i>Phyllobaenus dislocatus</i> , <i>Cymatodera bicolor</i> .	<i>Rhyssa lineolata</i> , <i>Panocherus</i> sp., <i>Doryctes</i> (three undescribed), <i>Odonotaenrus canadensis</i> , <i>Eurytoma</i> sp.
<i>Aeromium moratum</i> Hald.	Base of trunk.	Dying or recently dead.	One generation in two years.	Sapwood and heartwood.	Outer sapwood.	May 20, June 15.	<i>Dendroctonus simplex</i> , <i>Polyporus rufipennis</i> , <i>Ecopiptaster piceae</i> , <i>Phymatodes dimidiatus</i> , <i>Melanophila fulvopunctata</i> , <i>Serropalpus barbatus</i> .	None taken.	None taken.
<i>Monochamus scutellatus</i> Say.	Trunk and tops.	Recently dead.	One generation in one or two years.	Inner bark and sapwood.	Sapwood or heartwood.	June 5, 20.	<i>Ecopiptaster piceae</i> , <i>Polyporus rufipennis</i> , <i>Serropalpus barbatus</i> .	None taken.	None taken.
<i>Leptura vittata</i> Oliv.	Exposed root.	Dead.	One generation in two years.	Sapwood and heartwood.	Outer sapwood.	June 15, 28.	<i>Dryocoetes americanus</i> , <i>Diplophthorus americanus</i> .	None taken.	None taken.
<i>Leptostylus sex-punctatus</i> Say.	Trunk, tops or limbs (usually thin-barked parts).	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	July 6, 8.	<i>Polyporus rufipennis</i> , <i>Ecopiptaster piceae</i> , <i>Panocherus nitidus</i> , <i>Arcticia longipes</i> , <i>Phymatodes dimidiatus</i> , <i>Melanophila fulvopunctata</i> , <i>Chrysothrix blanchardi</i> , <i>Chrysothrix sex-striata</i> , <i>Chrysothrix dentipes</i> , <i>Anthazia quercata</i> .	<i>Phyllobaenus dislocatus</i> , <i>Cymatodera bicolor</i> .	<i>Phaenocarpa</i> sp., <i>Dolichocentrus albiflavus</i> , <i>Tortricus astigmus</i> .
<i>Neocyttus longipes</i> Kirby.	Tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	July 3, 11, 18.	<i>Polyporus rufipennis</i> , <i>Ecopiptaster piceae</i> , <i>Leptostylus sex-punctatus</i> , <i>Panocherus nitidus</i> , <i>Chrysothrix blanchardi</i> , <i>Chrysothrix sex-striata</i> , <i>Chrysothrix dentipes</i> , <i>Melanophila fulvopunctata</i> , <i>Anthazia quercata</i> .	<i>Phyllobaenus dislocatus</i> .	Same as above.
<i>Panocherus nitidus</i> Hald.	Tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 15 to July 15.	Same as for <i>Leptostylus sex-punctatus</i> .	<i>Phyllobaenus dislocatus</i> .	Same as above.
<i>Melanophila fulvopunctata</i> Hald.	Trunk, tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 10, 13, 24.	In the trunk — <i>Dendroctonus simplex</i> , <i>Polyporus rufipennis</i> , <i>Aeromium moratum</i> , in the top and limbs — Same as for <i>N. longipes</i> , above.	<i>Phyllobaenus dislocatus</i> .	Same as above.
<i>Chrysothrix blanchardi</i> Horn.	Tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 15 to July 15.	Same as for <i>N. longipes</i> , above.	<i>Phyllobaenus dislocatus</i> .	Same as above.
<i>Chrysothrix dentipes</i> Germ.	Tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 15 to July 15.	Same as for <i>N. longipes</i> , above.	<i>Phyllobaenus dislocatus</i> .	Same as above.
<i>Chrysothrix sex-striata</i> Say.	Tops and limbs (also thin-barked trunk 2 1/2 in. dia.).	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 15 to July 15.	Same as for <i>N. longipes</i> , above.	<i>Phyllobaenus dislocatus</i> .	Same as above.
<i>Anthazia quercata</i> Fabr.	Tops and limbs.	Dying or recently dead.	One generation in two years.	Bark and sapwood.	Outer sapwood.	June 22.	Same as for <i>N. longipes</i> , above.	<i>Phyllobaenus dislocatus</i> .	Same as above.
<i>Serropalpus barbatus</i> Schall.	Entire trunk.	Injured, dying or recently dead.	One generation in two years.	Sapwood.	Outer sapwood.	June 5, 6, 7, 8, 13, 15, 19, July 12, 10, Aug. 3.	<i>Dendroctonus simplex</i> , <i>Polyporus rufipennis</i> , <i>Ecopiptaster piceae</i> , <i>Cryptorhynchus pusillus</i> , <i>Aeromium moratum</i> , <i>Phymatodes dimidiatus</i> , <i>Panocherus nitidus</i> , <i>Melanophila fulvopunctata</i> , <i>Sirex abditus</i> .	<i>Phyllobaenus dislocatus</i> .	None taken.
<i>Urecesus albicornis</i> Fabr.	Entire trunk.	Recently dead.	One generation per year.	Sapwood and heartwood.	Sapwood.		<i>Polyporus rufipennis</i> , Same as for <i>Serropalpus barbatus</i> , <i>Phymatodes dimidiatus</i> , <i>Serropalpus barbatus</i> , <i>Sirex abditus</i> .	<i>Phyllobaenus dislocatus</i> .	None taken.
<i>Sirex abditus</i> Kirby.	Entire trunk.	Recently dead.	One generation per year.	Sapwood and heartwood.	Sapwood.		Same as for <i>U. albicornis</i> , above.	<i>Phyllobaenus dislocatus</i> .	None taken.
<i>Tenebrio lineatorides</i> Beau.	Lower trunk.	Decaying wood.	No new data.	No observations.	No observations.	July 7.	<i>Diplophthorus americanus</i> , <i>Adelocera brevicornis</i> .	None taken.	None taken.
<i>Adelocera brevicornis</i> Lec.	Lower trunk.	Decaying wood.	No new data.	No observations.	No observations.	April 28 (from wood in hole).	<i>Tenebrio lineatorides</i> , <i>Diplophthorus americanus</i> .	None taken.	None taken.

DISCUSSION OF SPECIES

In the following pages each of the species of insects bred from larch are discussed in some detail. In writing this discussion all of the material upon the habits and biology of each species which was available has been read and much of it incorporated. In addition considerable new material in the way of biological notes will also here be found, in fact, for a number of species practically all of the account here given is new and in all except a few cases much of it is new.

I. *Dendroctonus simplex* Lec.

Dendroctonus simplex is distributed throughout the north-eastern part of the United States and eastern part of Canada apparently occupying the same range as its host plant, the eastern or American larch. Its most southern range is reported by Hopkins ('98, p. 343), who has taken it from West Virginia. He also ('09, p. 120) records it from several localities in Michigan, Maine, New Hampshire and Canada. Swaine (1910 a, p. 81) also reports having seen specimens of this species from Mackinac, Man., and (1909, p. 99) records it from Colorado, California and New Mexico. That the record for the latter three localities is a mistake is claimed by Hopkins ('09, p. 118).

This species apparently confines its attacks to the American larch *Larix laricina*, Hopkins ('09, p. 120) although Swaine ('09, p. 99) gives *Larix* and *Picea* as hosts.

Dendroctonus simplex attacks injured, dying and felled trees, excavating long, slightly winding egg galleries in the inner bark which slightly groove the surface of the wood. The eggs are placed in groups of three to six or more, alternately along the sides of the galleries (Fig. 1). The larval galleries are short and extend out perpendicularly from the main egg gallery. According to Hopkins ('09a, p. 104) "The broods occupy the bark of stumps and logs and the trunks of standing trees from the ground to the branches or on into the tops. Fresh attacks on living trees cause a flow of resin or red boring dust in the loose bark and around

the base of the trees. This species is capable of extensive depredations on the largest and best larch, but apparently prefers to infest injured, dying and felled trees."

The winter is passed principally in the adult stage, within the inner bark of trees and stumps in which the larvæ have spent the preceding summer. Activity begins with the first warm weather in the spring. There is apparently but one generation annually, although under certain circumstances there may be at least a partial second generation. The larvæ of the first generation begin to transform to the adult stage at Crittenden during August, and by the first of September practically all the brood are callow adults.

In our work this species was taken during three successive seasons but in each year was found only in one tree. In the springs of 1915 and 1916 the wintered-over brood was found under the bark of the lower part of the trunk associated with *Polygraphus rufipennis*. No pitch tubes were seen and while the egg galleries in many cases did contain some pitch, there was not evidence of a copious flow of the material. In mid-summer, 1917 (July 24), a large larch tree was observed which had numerous streams of pitch from one to seven inches long running down the bark. No pitch tubes were present but this material came from recently made burrows of *D. simplex*. On examining the inner bark, many dead bodies of the adults were found embedded in the pitch which completely filled many of the egg galleries. Other egg galleries had been kept free of pitch by the work of the adults. The larvæ were nearly full grown but no pupæ were observed.

This tree was about one foot in diameter. A strip of bark about ten inches wide and five feet long had been removed from one side. The tree was still quite green but had made practically no growth during the season. The streams of pitch were present upon the bark from the base to a height of about fifteen feet. A few -- but only a few -- burrows of *Polygraphus rufipennis* were found on this tree but the attack of this insect seemed to have been unsuccessful on account of their inability to combat the excessive flow of resin. In Tree No. I also *P. rufipennis* was found associated

with *D. simplex* near its base, but as the *P. rufipennis* became more numerous farther from the base the *D. simplex* became less abundant and above twenty feet none were to be found. In this tree no pitch tubes were present showing that the tree was either dead or in a very weakened condition at the time of the entrance of the beetles.

Adults of *D. simplex* were taken from their burrows in the field on April 5 and April 22. They were taken from the breeding cages under natural conditions on May 25 and 26. Swaine records (1910, p. 81) finding the egg-tunnels containing eggs in the outer ends and larvæ of all sizes boring in the bark on July 10. On August 6 these tunnels were occupied by grown larvæ. Pupæ, recently transformed adults as well as emergence holes were present. Eggs of a second brood were found as late as August 26. This variation in life history is no more than should be expected. No dogmatic statements concerning the seasonal history of an insect can safely be made, for life cycles are more subject to variation than are structural details. It would seem to be axiomatic that a physiological process should be more readily altered by unusual environmental influences than would be anatomical structure, yet some of our entomologists speak of the seasonal histories of insects as if they were immutable.

D. simplex is usually not preceded in larch by any other insect but in some cases may be. Trees injured by blaze scars or by abrasions often attract *Serropalpus barbatus*. Diseased or weakened trees also may be infested by *Asemum moestum* or *Melanophila fulvogutta* even before the entrance of the brood of *D. simplex*. As we have already seen *P. rufipennis* is a bark beetle often associated with *D. simplex* in the bark.

The predator *Phyllobaenus dislocatus* is often found not only in the burrows but also is frequently seen actively scurrying over the bark of infested trees. *Spathius tomici* and an undetermined chalcid have been bred from material containing both *D. simplex* and *P. rufipennis*. The former of these is certainly parasitic upon *P. rufipennis* and may well parasitize *D. simplex* also.

Polygraphus rufipennis Kirby

Polygraphus rufipennis has a wide range throughout the greater part of the United States and Canada. It has been recorded from Alaska, from many regions of Canada and from throughout the northern and eastern United States, extending as far south as Georgia and Louisiana (Hamilton, 1894, p. 35); Packard (1890, p. 721) reports it from Colorado and from Tacoma, Washington; and Fall and Cockerell (1907, p. 217) have found it in New Mexico. Correlated with its wide distribution, *P. rufipennis* breeds in a variety of host trees. Packard (1890, p. 722) records it from white pine and Rocky Mountain pines and spruces, Hopkins (1899, p. 249) reports it in spruce, larch and scrub pine and Felt (1906, p. 386) has found it associated with *Dryocoetes* sp. in spruce and with *Pityogenes punctipennis* ("*Tomicus balsameus*") in balsam. The senior author has numerous specimens of this insect from red spruce (*Picea rubens*) associated with two species of *Dryocoetes*, *Pityogenes punctipennis*, *Ips caelatus*, *Crypturgus pusillus* and other forms and has also taken it from stumps of white pine in company with the latter two species. In the Northeastern United States the red spruce is the favorite host tree.

Dr. Hopkins (1899, pp. 246-251) has given us the fullest and one of the earliest accounts of the biology of this insect. He says: "The adults emerge in May and June, and are attracted to the stumps, trunks and tops of recently felled trees and such trees as are weakened in vitality from the attack of insects like that of the destructive pine bark beetle [*Dendroctonus frontalis*], diseases or any other cause. They then commence to excavate their entrance galleries through the outer bark This entrance burrow is extended to the outer surface of the inner soft bark, where a broad cavity is excavated which is utilized as a nuptial chamber. In the meantime the female which appears to do the greater part of the first excavating, is joined by a male which stations himself in the entrance gallery to keep out enemies and objectionable visitors [doubtless also other males], and to render assistance in expelling the borings. The female then

excavates a gallery from one edge of the nuptial chamber through the inner bark to the wood, thence through the inner layer of bark, usually at right angles to the bark fibers, for a distance of one or two inches. Along the sides of this so-called brood or egg-gallery, she deposits her minute, pearly white eggs in a succession of small notches. By the time the first female has her egg-gallery fairly started, one to three other females are admitted, and each excavates a similar egg-gallery in different directions from the nuptial chamber. Before all of the galleries are finished, the first eggs commence to hatch into minute white grubs, which burrow through the inner bark, on which they feed. By the time all the eggs have hatched, the surrounding bark is filled with these grubs of various ages and sizes, and soon, all of the bark from the inner to the outer layer, for a radius of two to four inches, is completely perforated with their irregular burrows. In the meantime, the male guards the entrance and the females either rest in the nuptial chamber or egg-galleries or emerge to enter the bark in another place to start a new brood. When the grubs and larvæ have attained their full growth, they excavate a broader cavity at the end of their burrow or mine, in which they change to the pupæ stage, thence to the adult and either emerge from the bark and start a second brood, or remain until the following spring. Probably two or three broods may occur in one season, commencing with the first eggs deposited in the spring, but my observations lead me to believe that owing to the shortness of the season at the high elevations occupied by the spruce of this State [West Virginia] there is generally but one brood."

But little can be added to the observations upon the phases of the activity of *P. rufipennis* covered in the above account. However, observations upon the behavior both of this species and of other species of polygamous beetles leads us to doubt very much if the female ever normally starts the excavation of a brood burrow. In all cases, observed by the senior author where the burrow was started by a female the excavation was continued as a simple gallery with no sign of a

nuptial chamber. In most cases such burrows were for feeding purposes only, with not only the nuptial chamber lacking but also with the egg niches omitted. In a few cases where the female operating had been removed from a burrow already occupied by a male and several females she constructed egg niches in the side of the independent burrow and deposited eggs therein, but made nothing resembling either a nuptial chamber or a nuptial recess. In fact in such burrows it was necessary for her to back out at the entrance in order to turn around, no place in the gallery being wide enough for this manoeuver.

Some interesting observations have been made upon the proportion of the sexes as they occur in their burrows in larch and the bearing of this upon fecundity. This work is based on a careful study of fifty engravings and burrows — all the uninjured ones available in the material at hand. Had more engravings in larch been available they would have been used, although it is believed that a study of a greater number would not have materially changed the general results.

The following tables based on the study of fifty engravings are self-explanatory:

Number of engravings having one-egg gallery	6
Number of engravings having two-egg galleries	22
Number of engravings having three-egg galleries	14
Number of engravings having four-egg galleries	6
Number of engravings having five-egg galleries	2

Total number of egg galleries studied.....	126
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Minimum length of egg gallery.....	4	mm.
Maximum length of egg gallery.....	60	mm.
Average length of egg gallery.....	24.55	mm.
Average length of egg gallery in uniramous type.....	*34	mm.
Average length of egg gallery in biramous type.....	26.36	mm.
Average length of egg gallery in triramous type.....	22.38	mm.
Average length of egg gallery in quadriramous type.....	26.37	mm.
Average length of egg gallery in quinquiramous type....	18	mm.

* In one case the single egg gallery measured 60 mm. in length which in so small a number would unduly raise the average. If this case is left out of consideration the average length would be 28.8.

Minimum number of egg niches in egg gallery.....	1
Maximum number of egg niches in egg gallery.....	53
Average number of egg niches in egg gallery.....	20.84
Average number of egg niches in uniramous gallery.....	29.4
Average number of egg niches in biramous gallery.....	25.36
Average number of egg niches in triramous gallery.....	18.52
Average number of egg niches in quadriramous gallery...	16.10
Average number of egg niches in quinquiramous gallery..	14.3

It would seem from the above that each female produces a larger number of eggs when her mate serves no other females, *i. e.*, under conditions of monogamy. However, in order to get at what might be styled the *individual efficiency* the total number of eggs in all the egg-galleries of the burrow should be divided by the total number of individuals (male and females) in the burrow. The following results then appear:

Number of eggs		Male		Females		Eggs per Individual
29.4	÷	(1	+	1)	=	14.7
50.72	÷	(1	+	2)	=	16.91
55.56	÷	(1	+	3)	=	13.89
64.40	÷	(1	+	4)	=	12.88
71.5	÷	(1	+	5)	=	11.91

Thus the following facts appear: The greater the number of females in a burrow, the greater is the total average number of eggs per burrow but the less per individual female. Under average conditions the males outnumber the females in the ratio of two and one-half to one and the greatest reproductive efficiency is shown in burrows containing one male and two females. Should the sexes occur in nature in equal numbers the greatest efficiency would be shown in burrows having one of each sex, for then each female on an average would deposit 29.4 eggs although the individual efficiency is only half that amount; while in a biramous burrow each female lays, on an average, 25.36 eggs, but the individual reproductive power is greater than in the former case. However, if in nature the females should outnumber the males at the ratio of four to one or five to one the greatest number of eggs would be produced by their breeding in the same ratio.

It is perhaps worthy of remark that in engravings of *P. rufipennis* in spruce observed both in the Adirondacks and Catskills there is a greater preponderance of females than in the larch material from Crittenden. The exact significance of this can only be guessed at, but to one who has for a number of years spent several weeks in each of these regions at the season of the year when the greater number of these insects are establishing themselves in their new breeding quarters, an explanation which has occurred to the senior author may appeal with some force. The young adults are leaving their old hosts and entering new ones during the early and middle parts of June when violent rains are a nearly daily occurrence. It is the male which first leaves the old host and which makes the entrance burrow and prepares the nuptial chamber in the new host, while the female does not emerge from the old host until several days later. During the early construction of the new burrow the males are exposed to various dangers, and to one who knows in general the habits of bark beetles it is very apparent that in a rainy season, many lose their lives by the very frequent and violent rain storms. On the other hand the females, leaving the protection of the old host later, are not subject to so many dangers as a large percentage of them find nuptial chambers already prepared for their reception.

Thus if the sexes occur in about equal proportions in the old host as has been shown to be the case in *Pityogenes hopkinsi*. Swaine (Blackman, 1915), the preponderance of females over males in the new brood chambers would vary with the occurrence of storms at the time of transferring from old to new host. It is believed that the more equable climate in Erie county, N. Y., from which region the infested larch was obtained had allowed a larger number of males to establish their new breeding quarters than is usually possible in the Adirondacks and Catskills where violent storms are of nearly daily occurrence.

Hopkins (1899, p. 248) has said that: "Probably two or three broods may occur in one season — but my observations lead me to believe that . . . there is generally but

one brood." We agree thoroughly with this statement. In New York it is within the possibilities for two or even two and a half generations to occur in one season but under field conditions it is doubtful if this possibility is ever realized. It is certain that a single generation is the rule and that occasionally a partial second generation is to be found — this second generation wintering over as partly grown larvæ. In larch, adults have been taken from under the bark on February 9, 29, April 22, 29, and October 24, and have been bred out in cages throughout the latter part of May and the early part of June. Larvæ were obtained from beneath bark April 22, 29, and October 24. In the Adirondacks the eggs of the main generation which has wintered over in the adult stage are laid throughout June, the exact date at which laying begins being of course dependent upon the season and varying from year to year.

P. rufipennis is associated with a great variety of other insects, borers, predators and parasites — the actual relations sometimes being quite close while in other cases they are quite remote. The scolytids *Dendroctonus simplex*, *Eccoptogaster piceæ*, the cerambycid, *Phymatodes dimidiatus*, and the two siricids, *Urocerus albicornis* and *Sirex abotii* are often associated with *P. rufipennis* throughout their life history. Of these the four beetles are inhabitants of the bark and therefore are influenced by each other much more than they are by the siricids which spend their larval life in the wood entirely. In general perhaps, each of these bark-inhabiting species is influenced adversely in that their food is limited by the presence of the other. However, under some conditions the association may be of mutual advantage. For instance it is apparently true that *P. rufipennis* is ordinarily unable to breed to advantage in a living tree yet when such a tree is attacked simultaneously by *D. simplex*, *P. rufipennis* and *E. piceæ*, or by the first two of these, its resistance is more readily overcome and it not only serves as a more favorable breeding place for these forms but for others as well. It is believed the *D. simplex* is able to kill weakened larch unaided but no cases were observed where it

had attacked living trees unaccompanied by the ubiquitous *P. rufipennis*.

The relations of this bark beetle with the various species requiring two years for their life cycle is complicated by the fact that the association may be with either the first or the second year of the life of these beetles. Our data shows that the cerambycid *Asemum moestum* and the melandryid *Serropalpus barbatus* may be associated with *Polygraphus* during either the first or second year of their life history. In other words either of these forms may enter the tree at least a year earlier than *P. rufipennis* or may enter during the same season. Neither of these would affect the bark beetle directly as they are both wood borers throughout their larval life. Those which precede it would aid in weakening the resistance of the living tree, thus making it a more suitable host for various bark beetles, while those which enter at the same time would have little or no either direct or indirect effect.

The large majority of two-year forms, however, enter the larch during the same season as *P. rufipennis*. This list includes the cerambycids — *Monohammus scutellatus*, *Leptostylus sex-guttatus*, *Pogonocherus mixtus*, *Neoclytus longipes*; and the buprestids, *Melanophila fulvoguttata*, *Chrysobothris dentipes*, *C. sex-signata*, *C. blanchardi* and *Anthaxia quercata*. All of these feed under the bark and therefore act the rôle of robbers by eating the inner bark before the smaller bark-beetle larvæ can complete their growth. In some cases also they may kill the smaller brood outright (Hopkins, 1899, p. 410) when they by chance meet them under the bark.

The associated predators and parasites are mentioned in another connection and it will suffice to say here that the predators include *Phyllobaenus dislocatus*, which appears to be ever present in infested larch, *Cymatodera bicolor*, and *Podabrus diadema*. The parasites include *Spathius tomici*, *Spathius* sp., *Heterospilus* sp., *Cheiropachus* sp., *Eurytoma* sp., *Spintherus pulchripennis*, a small undetermined pteromalid and the parasitic fly *Medeterus* sp.

Eccoctogaster piceæ Swaine

Eccoctogaster piceæ has been previously recorded from only two localities — Hudson, Quebec (Swaine, 1910, p. 33), and from Steuben county, Ind. (Blatchley and Leng, 1916, p. 589). Swaine obtained his specimens from the brood burrows in the branches of white spruce (*Picea canadensis*) while Blatchley and Leng record it from tamarack (*Larix laricina*).*

Swaine (1910) accompanies his original description of this insect with notes upon its habits and descriptions of its engravings. Full grown larvæ and pupæ were abundant in the latter part of May and the adults began emerging in the laboratory June 6 and egg-laying began early in July. Regarding the burrows he says: "The egg-tunnels deeply score the wood lengthwise of the grain. The tunnels are divided into two portions by a nuptial chamber, situated usually near the middle, and from the nuptial chamber a short, oblique tunnel leads to the entrance-hole above. From ten to thirty eggs are laid in shallow niches along each side of the tunnel, and well packed in with fine bits of wood. The larval galleries arise from the tunnels in a fairly regular manner, but soon through their windings cross each other in every direction, but still show a general tendency to follow the grain of the wood, which they deeply score."

Our study of a large number of engravings of *E. piceæ* bring out some additional facts. In the first place, the egg-galleries in larch at least are normally not only considerably longer than those figured by Swaine but also contain a considerably larger number of egg-niches as will be readily seen by referring to the tabulated data given later. In a study of the engravings certain facts appear at first sight. The number of egg-galleries in a single burrow varies from one to three, by far the greater number of engravings having two egg-galleries (Fig. 7). This means, doubtless, that

* Engravings which were undoubtedly made by this species have been observed by the senior author in *Picea rubens* in the region of Cranberry Lake, but specimens of the beetles have never been obtained from this host.

normally two females and one male occur in a brood burrow. The beetles breed by preference in tops, *i. e.*, in the upper part of the trunk among the limbs where the bark is thin but they may occur anywhere in the trunk or limbs. When in the trunk, the entrance gallery leads from the outside obliquely upwards through the bark to the nuptial chamber which is excavated nearly entirely from the sapwood. This is usually roughly triangular in shape with one of the angles continuous with the entrance and the other two above.

The first egg-gallery constructed is apparently invariably upward, proceeding with the grain of the wood from one of the upper angles of the nuptial chamber (Figs. 9, 10). The second egg-gallery starts from the other upper angle, but immediately turns downward and as soon as it clears the nuptial chamber proceeds nearly, but usually not exactly parallel with the grain of the wood in a direction opposite the first gallery (Figs. 7, 8). When a third gallery is present it arises from the side of the nuptial chamber opposite to the second, turns outward and downward nearly with the grain of the wood but diverging slightly (Figs. 7, 9).

It is interesting to note that the upper egg-gallery, *i. e.*, the one first constructed, is longer (or longest) in sixty per cent of burrows having two or three galleries. In seventy-three per cent the upper gallery contains the larger number of egg-niches, showing a greater fecundity of the female first fertilized over those fertilized later. This data is based on careful measurements and counts of one hundred brood burrows. Further study shows that the average length of the first (upper) egg-galleries is 30.34 m. m. and of the latter ones is 23.67 m. m.; the average number of egg niches in the first egg-galleries is 38.12 and of the lower only 24.75.

In gathering this data burrows having three galleries were used as well as those having two, and in the former cases *both* lower galleries were included. It might be objected that this would seem unfair as one of the three is so likely to be abnormal, it being logical that if the second contains fewer eggs than the first, the third would contain fewer than the second. There being no way to determine which of the

lower galleries was first constructed, the upper gallery was compared in fourteen engravings with the lower gallery having the most egg-niches. The average for the upper gallery is 33.64 eggs and for the lower gallery 29.07 eggs. Of the fourteen burrows the greater number of eggs is found in the upper gallery in eight cases, in one of the lower ones in five cases, and one case shows the two equal.

The eggs are laid in May and June and the beetles prefer dying or very recently dead trees in which to breed. They often, however, breed in bark which is still quite sappy, and cases have been found where the excessive flow of pitch in the egg-gallery has caused the gallery to be abandoned. Other cases are numerous where a considerable amount of pitch had exuded into the egg-gallery but where the beetle had been able to overcome the resistance of the tree and to rear its brood.

An attempt was made to induce reared material to re-enter larch anew in order that their habits and life history could be studied more in detail. Material containing the brood of *E. picæ* was brought into the laboratory on January 5 and February 26, 1917. The larvae, which were in various stages from half-grown to nearly full-sized larvae, readily transformed and emerged in large numbers as adults. Larvae which were observed to be full-grown and ready to pupate were removed from the bark and placed in slender dishes upon slightly moistened sawdust. A number of these pupated and transformed to adults while under observation. Full notes were taken of all observations. The length of the pupal stage under laboratory conditions was found to be about nine to eleven days. Extracts from the notes on one individual are given below.

A larva pupated May 20. During its pupal stage it showed little activity, practically the only movement being a wriggling motion of the abdomen. This pupa transformed into the adult stage at 8:45 A. M. on May 31. The newly emerged adult showed considerable motion of the head and legs and contraction and expansion of the abdomen. It would seem to contract as much as possible with head bent

downward and then thrust out its abdomen, head and legs in a "stretching" movement. The true wings were extended at full length and the elytra were in a nearly normal position. The true wings were apparently gradually drawn up under the elytra and folded. This was accomplished by expansion and contraction (lengthening and shortening) of the abdomen. During this process, which required several hours, the true wings remained very flabby, even at the main supporting veins. They apparently were kept moistened by some substance which did not harden. At 1 P. M. the tips of the true wings were still visible, but by 8 A. M. the following day they had been entirely retracted to their normal adult position. By this time the callow adult was able to walk very feebly, but did not attain its full strength until a day or two later. At the time the young adult arises, the head and prothorax shows considerable color as does the metasternum and the pygidium. The elytra, abdomen and legs were a faint yellowish brown. All these parts gradually grew darker, but the insect had not yet attained its full color a week later (June 6).

Although determined efforts were made to induce the new generation of adults to enter new larch, we were unsuccessful. At first young adults were confined in cages with suitable pieces of wood, but they refused to breed in it. As it is a well-known fact that other species of *Eccoctogaster* feed for a time upon new growth of their host tree, young adults were confined with portion of limbs, including new growth and new leaves. However, they resolutely refused either to feed upon this material or to breed either in freshly killed or less recently killed larch, and we were therefore unable to make thorough observations upon their habits and behavior. A few broods were, however, started in the old parent host, but these were not discovered until November, 1917, and therefore were of no value except as they prove that these small scolytids may breed for two successive years in the same host.

A careful study of the engravings give the results tabulated below:

Number of engravings studied.	156
Number of engravings having one-egg gallery.	25
Number of engravings having two-egg galleries.	111
Number of engravings having three-egg galleries.	20
Total number of egg galleries.	307
Minimum length of egg galleries.	2 mm.
Maximum length of egg galleries.	90 mm.
Average length of egg galleries.	27.36 mm.
Average length of egg gallery in uniramous burrow.	34.00 mm.
Average length of egg gallery in biramous burrow.	27.97 mm.
Average length of egg gallery in triramous burrow.	22.35 mm.
Minimum number of egg niches in one egg gallery.	2
Maximum number of egg niches in one egg gallery.	126
Average number of egg niches in one egg gallery.	30.65
Average number of egg niches in egg gallery of uniramous burrow	40.36
Average number of egg niches in egg gallery of biramous burrow	31.54
Average number of egg niches in egg gallery of triramous burrow	23.46
Average number of egg niches in entire uniramous engraving.	40.36
Average number of egg niches in entire biramous engraving.	63.08
Average number of egg niches in entire triramous engraving.	70.38

Thus it would appear that just as in *P. rufipennis* each female of *E. piceæ* produces a greater number of eggs when she shares her mate with no other female. Here also, however, the greatest individual reproductive efficiency is shown in burrows occupied by one male and two females and the least when more than two females are present. This is shown by the following data:

Number of egg niches	·	Occupants of burrows			Eggs produced per individual
		Male	Females		
40.36	÷	(1	+	1)	= 20.18
63.08	÷	(1	+	2)	= 21.03
70.38	÷	(1	+	3)	= 17.59

The larval burrows start out at right angles to the egg-gallery. At first they are parallel to each other but soon become winding in their course, often crossing and recrossing each other. They are rather longer than is usual for the

larval burrows of scolytids of their small size. The data tabulated below will give the facts obtained by a careful measurement of forty larval mines:

Minimum length of larval burrow.....	58 mm.
Maximum length of larval burrow.....	103 mm.
Average length of larval burrow.....	75.8 mm.

Of the forty burrows measured nineteen were between 60 and 79 mm. long, ten were less than 70 mm. long, three were between 80 and 89 mm. long, five were between 90 and 99 mm. long, and three were more than 100 mm. long.

The same beetles are associated with *E. piceæ* as with *P. rufipennis* with the exception of those found typically only in the lowermost part of the trunk. These include *Dendroctonus simplex*, *Monohammus scutellatus*, and *Asemum moestum*. Of these probably the latter is the only one which would not likely to be associated with *E. piceæ*, as it is found only a few feet at most from the ground. *E. piceæ* is found more often associated with *P. rufipennis* than with any other insect. The latter starts its burrows somewhat earlier in the season and naturally when it is present in numbers sufficient to occupy all or nearly all of the bark of the entire trunk the presence of its brood often very much limits the available breeding places of the former. Thus, in most of the trees studied *E. piceæ* had been thus excluded from the trunk even well up in among the branches and was not found except in the tops and in the less desirable limbs. In other cases where the earlier infestation of the *P. rufipennis* was not so heavy, the two small scolytids were found associated in the upper, middle and even to some extent in the lower trunk. In such cases it is interesting to observe that the brood of *E. piceæ* becomes more and more numerous in the upper trunk as that of *P. rufipennis* becomes less so.

Of the other associated borers the relations with the five species of buprestids which are characteristic of the insect association in the tops and limbs are perhaps most close. These in their relation to *E. piceæ* must be classified as robbers, it being understood that this relation on the part

of the larger borers, is a more or less casual or incidental one, in that the presence of their burrows in the inner bark destroys material which would otherwise serve as food for the scolytids. The fact that the most usual direction of these larger burrows is longitudinal increases the likelihood of disaster to the small larvae. On the other hand, the fact that the flatheaded and roundheaded larvae are two-year forms, is to the advantage of *E. piceæ* in that the latter is usually associated in the first year of the life of the two-year forms, when the larvae of these are small and comparatively not so voracious — it being a well-known fact that by far the greater per cent of the burrow is made during the latter part of a borer's life history.

Phyllobanus dislocatus is the only predator found associated with *E. piceæ*. The parasites associated include *Spathius tomici*, *Spathius* sp., *Spintherus pulchripennis*, *Heterospilus* sp., *Cheiropachus* sp., an undetermined pteromalid, and the fly *Medeterus* sp. It is impossible to state which of these are parasitic upon *E. piceæ*, but a number of cocoons were found in the burrows of this scolytid as well as in those of *P. rufipennis* in the same material, but we are unable to connect these up with the adults arising from them.

Crypturgus pusillus Gyll. (*C. atomus* LeConte)

Crypturgus pusillus is cosmopolitan in its distribution. Ratzeburg (1839, pp. 196) recorded it from Germany, Barbey (1913, pp. 143) has taken it in France, and E. P. Stebbing (1904, pp. 498) has written a short account of its habits as he observed them in North and West Himalaya. It has also been recorded from Japan by Swaine (1909, pp. 44), and in North America Packard (1890, pp. 727) reports the distribution as extending from Canada to Massachusetts and New York. Later literature has extended the range over a considerable portion of northeastern North America, specifically given as Canada and Maine south to West Virginia and westward to Ohio (Felt, 1906, pp. 360).

The European host trees as listed by Nüsslin (1913, pp. 259) are spruce, pine, fir and larch. E. P. Stebbing (1914, pp. 498) adds blue pine (*Pinus excelsa*) and spruce (*Picea morinda*) from India. In America the host trees recorded are: white pine, balsam fir, hemlock (Packard, 1890), pitch pine, scrub pine, yellow pine, table mountain pine, black spruce and Norway spruce (Hopkins, 1893, 1899).

This minute bark beetle, one of the smallest of our scolytids, has a very characteristic habit. It usually gains entrance to the inner bark in which it constructs its breeding quarters through some previously made opening. This is usually either the entrance hole or exit hole of the abandoned burrow of some other scolytid. However, a number of cases have been observed in which the burrow utilized in this manner was still occupied by its original constructors and their brood. In several other cases newly started colonies of *C. pusillus* were observed which were constructing their breeding quarters in balsam fir as an off-shoot from the mines of small larvae of *Monohammus scutellatus*. In these latter cases the so-called "ventilation openings" through which the coarse "sawdust" of this sawyer is extruded served as the place of entrance.

However, in most cases access to the inner bark is obtained through the burrows of another scolytid. Thus it appears always to enter the bark later than other bark borers and often does not enter until a season later. In larch it was found most frequently making its engravings from the abandoned burrows of *P. rufipennis*, although it was also associated with those of *D. simplex* and *E. piceæ* in a like manner. In several cases it was found associated with the living brood of the two former of the species mentioned. The brood of this insect have never been taken by us from really dry bark, but always from bark containing considerable moisture. For this reason it is to be found associated with the burrows of *E. piceæ* only in the thicker barked regions of the trunk, and as this latter is usually prevented from breeding in such places by the earlier preemption of

these parts by *P. rufipennis*, the association of *C. pusillus* and *E. piceæ* is not common.

The burrows of *C. pusillus* are in the inner bark but are seldom on the surface of the sapwood. Usually as has been pointed out by Stebbing (1914, p. 500) a thin layer of the innermost bark remains between the egg-gallery and the surface of the wood, so that often infested bark may be stripped off without discovering the brood.

In attacking the bark the beetles seem to assemble in the burrow of some other insect in groups or colonies comprising from five or six to as high as thirty or more individuals. Perhaps the smaller numbers are more common, but several examples of colonies of twenty or thirty have been observed and recorded in our field notes and several engravings made by such groups have been obtained. Two of such engravings are especially interesting. One, from spruce (Fig. 12), shows twenty-two egg-galleries radiating from the nuptial chamber of an abandoned burrow of *P. rufipennis*, while several more originate from the one egg-gallery made by the original inhabitant. In another case taken from larch (Fig. 13) twenty-five egg-galleries of *C. pusillus* originate from the nuptial chamber of *P. rufipennis*.

The question suggests itself whether these groups of from six to thirty or more individuals represent a family or a colony made up of a number of families. Stebbing believes that the groups represent family groups consisting of one male and six or more females, while other writers are non-committal on the subject. With no conclusive evidence upon the subject, we are inclined to the view that these groups represent colonies of numerous individuals of both sexes. We are not prepared to state whether or not this species is polygamous, but believe that the relations existing in these colonies are more or less indiscriminate.

Various authors seem to agree in describing the egg-galleries of this insect as short, sinuous burrows about one-half inch long (Packard, 1890, p. 825; Stebbing, 1914, p. 499). Our observations do not entirely agree with these, however. Where the beetles are relatively few in number

and where their egg-galleries arise from an egg-gallery of a larger form (Fig. 11), the brood burrows constructed are likely to be relatively short. The reason for this is believed to be that these small beetles tend to live socially in a common "assembly chamber" and where this is of adequate size for the members occupying it, the burrowers do not extend their mines to any great distance from the general meeting place: *i. e.*, each female may construct several short galleries. On the other hand, when the numbers are greater and the central assembly chamber inadequate to accommodate all members of the colony at once, the females are likely to construct their egg-galleries longer and to lay all of their eggs in one gallery. Indeed, in some cases, the gallery as finally made may represent the joint work of several females. This very likely is the case in the branched galleries which are by no means uncommon in the larger engravings having numerous egg-galleries, several of which may be seen in Figs. 12 and 13.

In the material at hand, the length of the egg-galleries varies from less than half an inch to two and three-fourths inches. No satisfactory counts of the number of larvae to a gallery could be made because the numerous larvae had destroyed most of the egg niches with their winding larval mines. These larval burrows are not on the surface of the sapwood but in the middle region of the inner bark.

Our observations seem to indicate that this insect spends the winter usually in the beetle stage, as adults begin to appear under the bark during the late summer, and these emerge the following spring. In the region of Cranberry Lake, the senior author has taken a number of colonies of these just after they had invaded the abandoned or still occupied burrows of other insects. In one case (June 9, 1915) a group of about twenty individuals were observed in the burrow of a larva of *Monohammus scutellatus*. Only a few of these had started egg-galleries, the remainder being grouped together in a little recess in the side of the burrow of the roundheaded borer near the ventilation opening.

Several bark beetles have already been mentioned as associated with *C. pusillus* in larch. In addition to these *Asemum moestum* and *Serropalpus barbatus* were bred from the same material, but these being wood-boring forms, their relations to the minute scolytid would not be at all close. *Phyllobaenus dislocatus* is the only predator associated and no parasites were bred from the same material.

Dryocoetes americanus Hopkins.

Dryocoetes americanus, according to Hopkins (1915, p. 51) is the eastern North American species which has heretofore been confused with *D. septentriones* and *D. autographus*. It has been recorded as the latter species, from Alaska, Hudson Bay Territory, Lake Superior, New Jersey, southwestern Pennsylvania, Virginia and West Virginia (Felt, 1906, pp. 672). It is probably found through the Rocky Mountain region also, for Fall and Cockerell (1907, pp. 217) lists it among the Coleoptera of New Mexico, and Hopkins (1915, pp. 51) states, "Specimens from the Rocky Mountain region show minor differences that are hardly distinctive enough to justify the designation of a different species." Several species of coniferous woods have served as hosts for this scolytid. It was first recorded from red spruce (*Picea rubens*) in West Virginia in 1890 by Dr. Hopkins. In 1891 he reported a parasite — *Spathius canadensis* Ashm.—from the bark of dead *Piceae* [*Abies*] *excelsa* in mines of *D. autographus*. Later it was taken from partly living and dead bark of black and Norway spruce and had also been found in pitch pine (Hopkins, 1899, pp. 445). It has also been taken from white pine and red spruce by the senior author at Cicero Swamp, N. Y., in September of 1914; at Cranberry Lake, N. Y., in June, 1915 and 1916; and in Greene Co., N. Y., in 1914 and 1915.

Very little in detail is recorded about the habits of this insect. It has generally been considered as preferring greatly weakened or dead bark in which to make its burrows. Another prominent characteristic is that the beetle almost

invariably attacks the lower portion of the tree, even extending its galleries several inches below ground in extreme cases (Hopkins, 1899, p. 252). In the larch studied the insects were found under the thin bark of one of the larger roots that was free of the soil for a short distance. No definite pattern was noticed in the burrows, however, only a very few specimens were taken and the material upon which to base any opinion regarding the engravings was quite insufficient.

In the Adirondaek and Catskill regions this species is one of those most often found breeding in the stumps and trunks of felled spruce and white pine. Immense numbers are found in spruce, especially where this is of a size having thin bark and where it is on or near the ground. Skidway timbers and other similar structures near the ground are very often infested. Other bark beetles often found associated in spruce and pine are *P. rufipennis*, *Ips pini*, *Ips cælatus*, *Pityogenes punctipennis*, *Hylurgops pinifex*, and *Dryocoetes affaber*. Adults have been taken by the senior author from their old burrows in the bark at various times from September to July. New colonies are established during June and early July in the Canadian Zone regions of New York.

Only a few insects were found actually associated with *D. americanus* in larch, doubtless because the only larch found infested was an exposed dead root of a living tree which on account of its size did not offer breeding facilities for many insects. *Leptura vittata* was bred from the same material, some of the adults of this two-year form emerging the same year and some the year following the emergence of the *D. americanus*. The larva of an unidentified elaterid, possibly predaceous, was taken and a fly *Phorbia fusciceps* Zett. was bred from this material, while a small portion of exposed and decaying wood yielded adults of the weevil *Dryophthorus americanus*.

Dryophthorus americanus Bedel.

The range of this cossoninid includes Eastern Canada and the Eastern United States as far south as Florida and as far west as Wisconsin. It has been reported as occurring specifically in *Pinus rigida* (Chittenden, 1890, p. 172) and in general as being found under the bark and in decaying wood. (Insect Life, Vol. 1, p. 198.)

Very little specific information can be culled from the literature regarding the habits and life history of this insect. Further than that the adults may be obtained from beneath the bark and in the dead wood (especially of pine) during the winter and early spring, no information seems to be at hand. Specimens were obtained by us from three separate lots of material. In one case under bark killed only the previous year and infested with *D. simplex* and *P. rufipennis*. The small weevils perhaps fed upon the inner bark which as yet had only begun to decay. In both the other cases, exposed and decaying wood was the part infested (Figs. 29, 30). Here the beetles were taken from their burrows, which ran in all directions through the punky wood, without conforming to any discoverable pattern.

Adults were taken from breeding cages after emerging from their larval hosts July 3 and 7, 1916. Other specimens were taken from their burrows November 2, 1916.

Insects obtained from the same material include *Dryocoetes americanus*, *Leptura vittata*, *Stenocellis brevis*, *Tenebrio tenebriodes*, the elaterid *Adelocera brevicornis*, an unknown elaterid larva and the fly *Phorbia fusciceps*. Of the beetles mentioned all but *Dryocoetes americanus* are wood-inhabiting forms and may bear very important relations to each other. The association with *L. vittata* and *Dryocoetes americanus* is perhaps not so common as with the other three beetles, though doubtless the larvae of the cerambycid prepare the wood for its later occupancy by the cossoninid. Its occurrence in the same bark with *D. simplex* and *P. rufipennis* is still less to be expected and perhaps may be explained by the individual of *Dryophthorus americanus* hibernating in the abandoned portion of the burrows of one

of these scolytids. Perhaps the association with *Stenocellis brevis* is the most common, due to the fact that their habits and food are similar. However, any actual relations which the two forms may have are doubtless accidental or casual.

Stenocellis brevis Boh.

Stenocellis brevis ranges from New England and Canada to Michigan and Kansas and south as far as Florida (Blatchley and Leng, 1916, pp. 545). This cossoninid has been taken from a great variety of host trees. Packard (1890) lists it from dead wood of elm (pp. 284), wood of butternut (pp. 342), partly rotten stump of red maple (pp. 391), and from linden (pp. 381). Chittenden (1890, pp. 99) in addition to these records it from basswood, beech, birch, sycamore and willow. Hickory and poplar were added to the list by Harrington (1896, p. 75). Felt (1906, pp. 494) adds ash, and Blatchley states that Zabriskie has found it in apple wood (1916, pp. 545). It has been taken by the authors from larch, hickory, apple and horsechestnut. No specific record has heretofore reported it from coniferous woods so far as can be learned from the literature.

From observations in the field as well as from literature on the subject it appears that decaying wood or at least exposed dead wood is necessary for the insect's welfare. The burrows have been seen in apple and horsechestnut where the outer wood was still very hard and contained no evidence of fungi. In larch, however, it was found in one instance in the decayed wood of a small tree, about three inches in diameter, where the wood was soft and in such condition that the fibres could be readily pulverized between the fingers. In a second case they were taken from dead sapwood caused by the peeling of a strip of the bark down the trunk of a larch about fourteen inches in diameter. At this time both adults and larvae were found scattered through the galleries, the adults occasionally found in groups of three or four in enlarged chambers in the wood. The sapwood had begun to decay and the live bark had started to close over the wound, which had apparently been made about six years previously.

The beetles were taken from one to five feet above the ground. This was as far up as the tree had been peeled. They were found under much the same conditions in apple and horsechestnut wood.

It is believed that the beetles may possibly remain in the wood for a period of two or more years. At least they have been observed in a horsechestnut tree for two consecutive years. Evidently the insect lives in a somewhat social or colonial manner, as several groups of three or four were found in the enlarged burrows. The galleries are about 1.5 mm. to 2 mm. in diameter and extend irregularly up and down the tree with many transverse galleries connecting the longitudinal ones. Occasionally wider galleries occur. In the instances observed the wood was more or less riddled by the galleries. The eggs are probably laid in the primary gallery and the larvæ bore out into the wood in all directions. Adults have been taken from larch February 26, April 28; larvæ on April 28. Blatchley (1916, pp. 545) has taken the adults June 15 to July 30, beneath bark and by sifting rotten wood.

It is quite probable that *Serropalus barbatus* often precedes *S. brevis*, especially in weakened trees, and its galleries make the wood a more suitable breeding place not only for this cossoninid but for other forms living in decaying wood. It is also possible that *Asemum moestum* may precede *S. brevis* in a like manner. Both of these forms would bear a very important relation to the curculionid by preparing the wood for its purposes.

Insects actually associated with *S. brevis* were *Dryophthorus americanus*, *Tenebrio tenebriodes*, and *Adelocera brevicornis*. These all from dead wood which had begun to decay and which was more or less riddled with insect burrows. *S. brevis* may be preceded by any one of a great variety of forms attacking the dying or newly killed tree. It seems to prefer rather dry, punky wood, and perhaps for this reason seldom or ever enters the wood still covered by the bark. When it is preceded in the wood by the larvæ of such forms as *Leptura vittata*, *Asemum moestum*, or *Serro-*

palpus barbatus, the wood is in a condition more than usually favorable for its uses due to the burrows already present and to the introduction of decay by their presence.

Phymatodes dimidiatus Kirby.

Hamilton (1894, p. 31) records the distribution of *Phymatodes dimidiatus* as Unalaska, Vancouver, Washington, Idaho, through the Rocky Mountains to Mexico, thence across the northern part of the continent to Maine and Massachusetts. Hopkins (1893a, p. 192) reports it from Washington and Felt (1906, p. 669) from various points in New York and New Jersey. Evidently spruce has been practically the only host recorded for this cerambycid (Hopkins, 1899, p. 438), although it undoubtedly breeds in other species, especially in the Rocky Mountains. Davis (1891, pp. 81) states that he has taken it "from oak posts of a summer house." The senior author has taken the adults from beneath the bark of spruce in the Adirondacks.

P. dimidiatus lives during the greater part of its larval existence directly under the bark, excavating its winding galleries for the most part in the same direction as the grain of the wood. The eggs are laid during June under the small flakes of bark or injured places and even occasionally in the deserted or still occupied burrows of *P. rufipennis* in trees that have been killed the previous year. The larva, from the first grooves the sapwood, the burrow becoming deeper and wider as the larva becomes larger (Figs. 14, 15). However, during its larval existence the burrow is always directly under the bark, and it is not until the insect is ready for pupation that it extends its burrows into the sapwood. Just before it transforms into the pupal stage, which may occur either before or after hibernation, the larva burrows for about a quarter of an inch below the surface of the sapwood and here enlarges its mine to form a pupation chamber. Before pupation, however, the larva burrows up to the bark and packs the end of the gallery with coarse frass so that the adult when it is ready to emerge may work its way out with a minimum amount of labor. The rest of the larval mine is

packed with fine, dust-like frass. Winter is most usually passed either in the larval or adult stage.

One year is usually required in this locality for the completion of its life history. However, it should be realized that this represents only the normal condition in the locality in which this form was studied (Crittenden and Syracuse). It is quite likely that it may occasionally, or even may usually, require two years for its development in the colder regions of the State. Dogmatic statements regarding the length of larval life are dangerous. Adults emerged May 26, 31 and June 8 and 15, 1916, from larch killed during 1914. The eggs of *P. dimidiatus* had doubtless been laid in 1915, as was shown in one case by the relation of the larval burrows of this species to the engravings of *P. rufipennis* occurring in the same material.

P. dimidiatus may be preceded in the bark of larch by several insects, notably by *P. rufipennis* mentioned above, by *Dendroctonus simplex*, *Eccoptogaster piceæ* and by *Asemmum moestum*. On the other hand, it may in other cases enter the tree during the same season as any or all of these. It seems rather to prefer trees (whether spruce or larch) which are thoroughly dead, and, therefore, when any of the above species precede it in the bark they by so doing benefit rather than injure it as a place of breeding for *P. dimidiatus*. On the other hand, where the larvæ of this cerambycid occur in the same material as the brood of the various scolytids mentioned, it may be injurious to the latter by robbing them of their food. Other borers which have been bred from the same material include the cerambycid *Leptostylus sexguttatus*, the melandryid *Serropalpus barbatus*, and the two siricids *Urocerus albicornis* and *Sirex abbotii*.

Two predators, *Phyllobaenus dislocatus* and *Cymatodera bicolor*, were associated with *P. dimidiatus*. The parasites derived from the same material include *Rhyssa lineolata*, *Pseudorhyssa* sp., *Odontamerus canadensis*, *Eurytoma* sp. and three apparently new species of *Doryctes*. The relations of these parasites have previously been discussed

(p. 32) and it has been pointed out that of these all but *Eurytoma* sp. are probably parasitic upon *P. dimidiatus*.

Asemum moestum Hald.

Asemum moestum has been recorded from Canada southward to Florida. It is known from Lake Superior and Packard (1890, pp. 697) has taken it from Colorado and states that it undoubtedly breeds in coniferous trees in the Rocky Mountain region. LeConte believes that it occurs in Alaska (Packard, 1890, pp. 697). The host trees include white pine (Packard, 1890, pp. 697), yellow pine and spruce (Hopkins, 1899, pp. 438). Apparently larch has never been recorded as a host, but it is likely that this borer will be found in a large number of coniferous trees throughout its range.

This beetle lives in the larval stage in the base of the trunk. We have never bred it from wood more than a few feet from the ground. It is then, as will be readily seen, most often found in the stumps of its host trees in regions which are being lumbered. The adults will apparently deposit their eggs only in green, sappy material, and our observations show that it very often enters the larch even before this shows any visible signs of weakness — sometimes a full year before the entrance of *Dentroctonus*.

The young larvæ on hatching burrow into the sapwood and often extend their mines deep into the heartwood. These mines, which are somewhat flattened in cross section, are more or less winding in their course, but with the general direction more usually longitudinal. The larvæ are often very numerous, in one case six larvæ of various sizes being taken from a space about six inches square. This beetle ordinarily requires two years to complete its larval growth and the probabilities are that occasionally a longer time is necessary. The pupal stage is passed in an enlarged chamber at the end of the larval burrows. This is constructed in the sapwood quite close to the bark. The adult emerges through an oval hole in the bark. Beetles emerged from larch May 29 and June 15, 1916. Numerous other adults

have been taken by the senior author at Cranberry Lake, N. Y., during June and early July, both on the wing and from the wood of both pine and hemlock.

A. moestum is one of the primary insect enemies attacking the weakened tree. It is often associated in either its first year or second year with *Serropalpus barbatus*, which is also a wood inhabiting form. Quite often the burrows of these two forms occur in the same section of wood, although the melandryid, of course, bores the wood of a greater region of the trunk. Other beetles found to occur in the same samples of the trunk are *Dendroctonus simplex*, *Polygraphus rufipennis*, *Eccoptogaster piceae* (occasionally), *Phymatodes dimidiatus* and *Melanophila fulvoguttata*. These may be associated with *A. moestum* during either the first or second year of the latter's life; or in the case of *M. fulvoguttata*, the two forms may occur in the same trunk throughout two years. It should be borne in mind, however, that *A. moestum* seldom or never spends any considerable time between the bark and the sapwood, and therefore its relations with these forms (other than *S. barbatus*) are usually more apparent than real. However, where it enters the tree a full season ahead of its associates, as often occurs, there can be no doubt that its presence in any considerable numbers greatly weakens the tree and makes this a more attractive host for those forms entering later. This is especially true in the case of the bark beetles because the larvæ of *Asemum*, working in the wood, while they weaken the tree's resistance, do not destroy the inner bark.

Monohammus scutellatus Say.

Monohammus scutellatus is distributed throughout Canada and the Northern part of the United States from coast to coast, as far north as the Hudson Bay and Yukon regions (Hamilton, 1894, p. 31) and as far south as New Mexico and West Virginia (Hopkins, 1893, p. 195).

The hosts most usually recorded for this cerambycid are white pine and spruce. In the Cranberry Lake region and

also in the Catskills the senior author has most often taken it from balsam fir. There can be no doubt, as is indicated by its distribution, that a large number of conifers may serve as host. In larch this beetle was bred only from the trunk region, but doubtless also occurs in the tops and larger limbs. In other hosts it occurs most often in regions having comparatively thin bark. Thus in white pine it is most usually found in the tops and limbs, while the two sister species *M. confusor* and *M. titillator* are more common in the trunk. In spruce this is true to a lesser extent, due to the thinner bark, and in balsam any part of the trunk and the limbs down to a diameter of less than an inch are likely to contain larvae, although they are here perhaps more common in the trunk.

The eggs are laid in material in a variety of different conditions. Eggs still unhatched and newly hatched larvae have been taken from a balsam tree which was still entirely alive and green but slightly injured by lumbering operations. On the other hand, living, callow adults have been taken from their transformation chambers in balsam which had been down and dead at least four years. The larch from which specimens were bred was in similar condition when brought to the laboratory, the bark being loose and the tree having been dead three or four years. However, in other recently killed larches the larvae have been found and burrows in such material from which the larvae have been removed by woodpeckers are numerous.

The adults of this beetle are abroad throughout most of the summer and may oviposit at any time between the first of June and the first of September. However, the height of the breeding season is during July and August. On July 8, 1914, the senior author took twenty-one specimens of this insect in a few minutes while eating his lunch in a small, recently-made clearing near the summit of Twin Mountain, Greene Co., N. Y. These beetles were at the time creeping over the bark of recently felled balsam and spruce. Several pairs were taken in copulation, and in one case the female was ovipositing although still attended by a male.

Some interesting observations upon the breeding habits were made by Mr. A. J. MacNab, a graduate student in the laboratory, and these are supplemented by other observations made by the senior author at various times. On February 1 some branches from a tree which had been cut the preceding winter were brought into the laboratory and placed in a breeding cage. On March 7 adults of *M. scutellatus* began to emerge. Some fresh pine from one to two inches in diameter, was placed in a breeding jar and the beetles were introduced, the bottom of the jar being covered with a layer of moist earth for the purpose of keeping the humidity more constant and to furnish a suitable footing for the beetles.

When this jar was placed in the sunlight, or when the bright light from a tungsten bulb was directed upon the jar, the females climbed to the top of the pine sticks and made attempts to fly. They were followed by the males, all of the beetles showing apparent excitement. After being exposed to the heat and light of the tungsten bulb for about an hour, copulation began. In this process the male mounts the female, grasping her around the prothorax with his forelegs, which are especially modified for this purpose, at the same time bending his abdomen downward and forward so as to bring the genital openings together. The penis is then extruded and sexual connection is established if the female denotes her willingness by opening the space between the last dorsal and ventral plates of the abdomen. When she is not ready for sexual intercourse, she often tries to escape, and sometimes an especially ardent male may be carried all over the limb for ten or fifteen minutes before the female becomes complaisant or until he is dislodged.

Copulation lasts a variable length of time. In several cases where the time was noted, it lasted from half a minute to considerably more than three minutes and was accompanied by a pumping movement of the abdomen of the male. The same male often copulates with the same female or with other females repeatedly. In one case, after a union lasting over three minutes, the connection was broken, but the male still clung to his mate and was dragged or carried all over the

limb for five minutes before he was finally dislodged. Perhaps the most peculiar case illustrating the ardency of the male was the following: It being desired to examine the anatomy of the penis, a pair of beetles in copulation was chosen and the penis of the male was grasped with a pair of forceps and removed from the body. The male was then replaced in the jar with his mate. For a few minutes he rushed about in an excited manner acting as if in considerable pain. In a short time, however, he quieted down and his behavior became more normal. Just eighteen minutes after the amputation of his penis he again mounted the female and attempted copulation.

During actual copulation the female, however anxious she may apparently have been to escape, remains stationary or nearly so. She usually behaves with the greatest apparent indifference, very often continuing to feed by biting off bits of pine bark. Both males and females feed readily in captivity on the bark of fresh pine limbs, although perhaps the female is more voracious.

In depositing her eggs the female usually chooses a point near the juncture of twig with the limb or some location which has been roughened by having the bark chewed off in feeding (Fig. 17). In either case she bites away the outer bark constructing what might be spoken of as a shallow pit which extends into the inner green bark. She then turns around, places the end of her ovipositor in this shallow cavity and pushes it deeper and deeper into the inner bark in a direction parallel to the bark fibres. In four cases the depth of this egg puncture was measured and was found to vary from five and a half to seven and a half millimeters. Sometimes several eggs are deposited in punctures arising from one pit. In such cases they are arranged radially around the common point of entrance. In some cases no pit is constructed, but the ovipositor is thrust through the thin, outer bark as far as possible into the inner, green bark. The process of oviposition was timed in several cases and requires on an average about two minutes.

Small sections of the bark containing eggs, the time of depositing of which was known, were placed in a moist chamber for incubation. The incubation period in the laboratories was about twelve days. An egg laid at 4 p. m. March 8 hatched March 20 and others required a similar length of time.

Adults bred in the laboratory and confined in captivity with abundance of proper food lived from fourteen to thirty-one days, the average being between fourteen and twenty days. The male from which the penis had been removed lived the longest period of any — thirty-one days.

The larvæ burrow between the bark and the sapwood, grooving each about equally. The galleries are irregular, sometimes becoming rather long and winding, while in other cases they are confined to a small area. Very soon after hatching the larva makes an opening to the outside through the bark. This is always small, never being large enough for the passage of the larva's body, and is used in thrusting out the chips or "sawdust" of the sawyer, the larval mine near this opening being kept clear of this material (Fig. 16). Often this frass will collect to form piles of considerable size under the infested logs, resembling piles of sawdust. Some time during the summer the larva carries its mine into the sapwood, often for a depth of several inches when the burrow is in the trunk. This mine is used as a retiring chamber and, on occasion later, as a hibernating chamber and eventually as a pupation chamber. The winter may be passed as a full-grown larva or as a larva in any stage of its growth.

The length of the larval life varies quite remarkably from one to three years. Normally the larvæ complete their growth and transform to the adult in a single year, but in some cases this may be unduly lengthened by several causes. Numerous cases have been noted where blown-over balsam trees which happened to lie in locations to which the sun never has access have contained the same generation of larvæ for two and even three years. The larval period may also be unduly lengthened by other unusual conditions. On two separate occasions, once in the Adirondacks (balsam) and

once at Syracuse (pine), infested wood known to contain full-grown grubs was barked and one year later still contained living larvæ or young adults. The barking of the wood created an unusual condition in several respects, but especially it rendered the wood more subject to desiccation, and this abnormal dryness was doubtless the factor which retarded the development of the larvæ. It is interesting that the larvæ and young adults under these conditions were apparently normal in all respects except as regards time of emergence.

As the larva continues to grow the "retiring burrow" in the sapwood is enlarged from time to time to accommodate its larger bulk, and when the larva reaches full growth this is carried deeper into the limb or trunk to form the pupation chamber. This, in burrows in the trunk, may lie in the heartwood several inches from the bark. Always before pupation a passageway, circular in section, is extended outward toward the bark, usually ending a fraction of an inch from the inner bark. This is to act as an exit for the adult when it emerges. The larval entrance to the pupal chamber is then plugged with excelsior like frass and the larva pupates in the deeper part of the burrow. The emergence hole through the bark is nearly exactly circular in outline and from 4.6 to 6.5 mm. in diameter (Fig. 16).

Eccoptogaster piceæ and *Polygraphus rufipennis* precede *M. scutellatus* in larch and *Serropalpus barbatus* was bred from it the same season.* In balsam it is most often associated with *Pitogenes punctipennis* Lec. and with *Urocerus albicornis*. In pine *M. scutellatus* is often associated in the limbs with the sister species *M. titillator*, *Ips pini* Say, *Pitogenes hopkinsi* Swaine, and others, and in the trunks with *M. titillator*, *M. confusor*, *Ips longidens* Swaine, *Graphisurus faciatus* De G., *Rhagium lineatum* Oliv., *Pytho americanus* Kirby, etc.

* In Tree IX it was associated with *Polygraphus rufipennis*, *Neoclytus longipes* and *Xylotrachus undulatus*.

Leptura vittata Oliv.

Leng (1890, pp. 199) has recorded the habitat of this cerambycid as Canada, New York, New Hampshire, Maine, Massachusetts, Pennsylvania, Virginia, Georgia, Alabama, Louisiana, Illinois and Wisconsin. Very little is known regarding its host trees, and evidently larch is the first wood from which this insect has been bred. Blatchley (1916, pp. 1059) has taken the adult from the foliage of Virginia creeper and other shrubs. The senior author has taken it in large numbers from the blossoms of wild spiræa in the Catskill mountains during July and August.

Specimens of this insect were bred from a partly decayed piece of root that had been free of the ground for some time. The tree from which it came was still alive. The root was covered with thin bark and is about four inches in diameter. Adult specimens of *Dryocetes americanus* were taken from beneath the bark in the spring before *L. vittata* emerged. Only a small piece of root was studied, but some half dozen larvæ and adults were derived from it. Apparently the life history is not completed in one year, for wood confined in the breeding cage produced adults both in the early summer and in the following winter in the laboratory. It is very likely, however, that two years are sufficient for the completion of the various stages of its development. The larvæ burrow through the sapwood and frequently they are found deep in the heartwood. The pupal chambers, however, are found directly under the bark. The larval burrows are very similar to those of other cerambycids burrowing in the sapwood of trees. Fine dust-like frass is tightly packed in the larval burrows, while in the pupal chambers we find each end packed with the characteristic excelsior frass. Adults emerged June 15 and 28 in the outdoor breeding cages and January 10 in the laboratory the following winter.

Dryocetes americanus and *Dryophthorus americanus* and an unknown elaterid larvæ were found associated. *Phorbia fusciceps*, a fly, was also taken from the wood, but had probably emerged from decaying fungi. No associated parasites were obtained.

Leptostylus sex-guttatus Say.

Leptostylus sex-guttatus has been recorded from Canada, Massachusetts, New York, New Jersey, Pennsylvania, District of Columbia, Ohio, Michigan, Wisconsin and New Mexico (Leng and Hamilton, 1896, p. 119). Blatchley (1910, p. 1072) reports it also from Indiana. Apparently little is definitely known regarding the larval host of this cerambycid. Beutenmüller (1896, p. 79) states that it "breeds in the wood of locust." Wickham (1897, p. 152) says that it "may be taken on freshly cut pine," and Morris (1916, p. 197) records having taken a number of specimens from a fallen pine. Our record from larch is apparently the first time it has been recorded as having actually been bred from a conifer. It has also been bred from the limbs and trunk of white pine by Mr. A. J. MacNab, a former student working in our laboratory. This beetle has been found to breed only in the thin-barked parts of the larch and the female seems to show a preference for the freshly killed or weakened tops or limbs in which to deposit her eggs. However, three specimens were also obtained from the trunk of a small tree about two inches in diameter which had been killed by shading.

Upon hatching the larva begins to construct its larval gallery between the inner bark and sapwood. At first this grooves both bark and sapwood to an equal extent, but as the larva increases in size a greater per cent of the depth of the burrow is excavated from the wood and a less per cent from the thin bark, so that when the larva reaches full size about nine-tenths of the thickness of the larval mine is in the sapwood. The course of the larva is very tortuous (Fig. 18) and is sometimes unusually long for a borer of its size, even though it be a two-year form as in the present case. In one case where all parts of the larval mine could be readily traced it measured 290 mm. to the entrance of the pupal chamber.

At the end of the second season the larva reaches full growth, but before pupating it bores into the sapwood, usually not more than a half inch from the surface to construct

a pupation chamber. It usually continues this burrow parallel to the surface for about 40 to 50 mm., then extends it upward to a point just beneath the bark. The pupal chamber for about half its length is solidly packed with fine frass, as was the entire larval burrow. However, the "sawdust" in the entrance to the pupal burrow is of a lighter color than that in the larval mine, because it is derived entirely from the sapwood, whereas the latter comes partly from the bark. The adult on arising gnaws through the thin layer of sapwood left by the larva, perforates the bark and emerges through an oval exit hole about $2\frac{1}{2}$ by 3 mm. in diameter.

The following borers were associated with *L. sex-guttatus*: *Polygraphus rufipennis*, *Eccoptogaster picea*, *Pogonocherus mixtus*, *Neoclytus longipes*, *Phymatodes dimidiatus*, *Melanophila fulvoguttata*, *Chrysobothris blanchardi*, *C. sex-signata*, *C. dentipes*, and *Anthaxia quercata*. All of these except the two scolytids and *P. dimidiatus* are two-year forms and live in the limbs and tops during the same two seasons. *P. rufipennis* and *E. picea* are associated with these larger borers usually only during the first year. Occasionally, however, second broods of each of these are reared in the old host. Although this may perhaps occur more commonly in the breeding cages than in nature, examples under both conditions were found. The brood of either of these scolytids is likely to be robbed of their food or actually killed outright by the larvæ of *Leptostylus sex-guttatus* or any of the other round-headed or flat-headed borers mentioned above. This is especially true during the second year of the larval life of the large forms. In this connection it is interesting to note that two sister species of *L. sex-guttatus*, *L. aculipes* and *L. macula*, have been reported in similar roles in connection with two other scolytids (Schwarz, 1890, p. 165).

The inter-relations of the larger borers are variable and more or less accidental. The simultaneous presence of several specimens either of the same species or of different species in the same region may be of advantage in overcoming the resistance of the dying or weakened tree. If the tree is already so weakened as to offer no considerable danger

to the developing larvæ, the presence of several is of no importance. On the other hand, so many larvæ, either of the same (Fig. 27) or different species, are sometimes present as to reduce the amount of available food to such an extent that the resulting insects are underfed and therefore undersized. It is likely that occasionally this condition becomes so acute as to result in the actual starvation of some of the larvæ.

Predators associated are *Phyllobaenus dislocatus* and *Cymatodera bicolor*. These are doubtless more dependent for food upon the associated scolytids, but it is believed that they may also feed upon the smaller flat-headed and round-headed borers, especially when these are young. The adults would experience difficulty in gaining access to the larvæ on account of the closed burrows packed with frass, so they would probably only occasionally be able to attack them. However, the larvæ of clerids are well-known inhabitants of the burrows made by other insects, and without doubt they occasionally prey upon both cerambycid and buprestid larvæ.

Three parasites were associated with *L. sex-guttatus* and the other round-headed and flat-headed borers occurring in limbs and tops. These include *Phasgonophora* sp., *Atoreutus astigmus* and *Odontaulacus bilobatus*, specimens of each of which emerged at about the same time as the two-year borers. No conclusive evidence definitely associating any of these with their host is at hand.

***Neoclytus longipes* Kirby.**

Neoclytus longipes has been recorded from Canada, Virginia and Texas by Leng (1887, p. 8). No definite statement regarding its host was found, but Wickham (1897, p. 152) and Morris (1916, p. 198) have taken the adult from freshly cut pine.* This borer was obtained by us from larch brought both from Crittenden and from near Wana-kena, showing a wide distribution in the State.

* The senior author has taken numerous specimens from the surface of the bark of freshly cut balsam and spruce.

This cerambycid requires two years for the completion of its life history. As noted above, it was bred from material from two different sources. That derived from Crittenden consisted of the limbs of Tree I. This was confined during the entire summer of 1916 and during this time gave rise to only two borers, *Polygraphus rufipennis* and *Eccoptogaster piceæ*. It was then removed to the laboratory November 2, where the temperature conditions were such as to induce the larvæ to resume work. Adults of *N. longipes* emerged January 30 and March 16.

The second lot of material derived from Wanakena consisted of tops 2-4 inches in diameter of Tree IX, which had been blown down during May, 1916, and had become infested between that date and the middle of August. This material was confined in breeding cages outdoors till early in January, 1917, when it was brought into the laboratory, but was again removed to a cold room in the latter part of February, where it remained till June. It was then placed in an outdoor breeding cage, and on July 3, 11 and 18 specimens of *N. longipes* emerged. Thus this form, which normally requires two years for the completion of its life history, was induced to emerge a season earlier by the treatment the material received. It should be noted in this connection that the specimens thus treated are slightly undersized, measuring respectively 7, 8 and 8 mm., while those from the other lots of larch were from 9 to 9.5 mm., being entirely normal in size.

N. longipes deposits its eggs in larch which is either dying or recently dead. The larvæ excavate deep, rather narrow burrows in the sapwood just under the bark. The larval mines are very long (Figs. 19, 20), in three cases where they could be accurately measured being 445 mm., 485 mm. and 568 mm. These measurements are rather too small than too large, as no attempt was made to measure the smaller curves in the course of the grooves. The entire burrow is packed full of rather fine frass by the larva, which, on becoming full grown, burrows into the wood to construct a pupation cavity (Figs. 19, 20). This chamber in the wood is also

much longer than usual, varying in cases observed from 45 mm. to 120 mm. This pupation chamber is solidly packed with fine frass for the greater part of its length — only from 20–30 mm. being free of this material — and in spite of its excessive length it usually does not lie more than half an inch from the surface of the bark, although it may lie deeper. On emerging the adult gnaws through the surface and leaves the wood through a nearly circular hole slightly more than 2 mm. in diameter.

Larch is attacked by *N. longipes* the same season that it is attacked by *P. rufipennis* and *E. piceæ*, and thus the larvæ are often associated with the brood of these scolytids throughout their first year of life. It was also associated with the following insects emerging at about the same time: *Leplostylus sex-guttatus*, *Pogonocherus mixtus*, *Chrysobothris dentipes*, *C. sex-signata*, *C. blanchardi*, *Melanophila fulvoguttata* and *Anthaxia quercata*. In the material studied these forms were never so numerous that the burrows interfered with each other seriously, and therefore the interrelations were probably not at all important in an adverse way. However, in dying or sappy bark presence of a greater number of specimens, up to a number where additional ones would interfere with the available supply of food, is of a distinct advantage in overcoming the resistance of the tree. So long as these all worked in a similar region it would make no difference whether the larvæ represented a number of species or were all of one species.

Phyllobaenus dislocatus was the only predator derived from material containing *N. longipes*. It is probable that this is more usually dependent upon the associated scolytids for its food, but it is by no means improbable that it will attack the larvæ of any of these smaller round-headed and flat-headed borers whenever it can gain access to their burrows. The same three parasites were associated with *N. longipes* as with *L. sex-guttatus*.

Pogonocherus mixtus Hold.

Pogonocherus mixtus has been reported from Canada and from nearly every region of the United States except the Southeastern States. Leng and Hamilton (1896, p. 135) give the distribution as "Canada, Maine, New Hampshire, Massachusetts, New York, New Jersey, Pennsylvania, Michigan, Wisconsin, Missouri, Kansas, Colorado, Montana, Idaho, California, Arizona." This species has been taken from beneath the bark of willow (Caulfield, 1881, p. 60) and "beneath the bark and on the dead limbs of pine (Blatchley, 1910, p. 1081). We have bred it both from the "shaded out" limbs of white pine and from the limbs of larch.

The eggs are deposited in recently dead thin-barked larch or pine. Cracks or other injuries in the bark were utilized by the female in ovipositing. In one case in pine the ovipositor had apparently been thrust into the entrance to the burrow of *Pityophthorus* sp. in gaining access to the inner bark. The larva on hatching works directly beneath the bark, grooving the sapwood deeply. The burrows at first are both narrow and shallow, but those made by the full-grown larva are from 4 to 7 mm. wide and slightly more than 2 mm. deep. The course of the larval gallery is only slightly winding, as shown in Fig. 21, and usually the burrow loops back upon its course so that the entrance to the pupal chamber often lies not far from the origin of the burrow. The burrow is rather short, usually from 110 to 125 mm. long. The pupal chamber is carried diagonally into the wood for a depth of 12 to 15 mm. The larva then plugs the opening loosely with medium-fine shreds of wood and pupates. Apparently before pupating the larva has arranged itself with its head directed back toward its larval burrow for the adult on emerging invariably (so far as our observations on fifteen cases go) removes the obstructing frass and emerges through a nearly circular opening in the bark covering the larval mine. The insect requires two years for the completion of their growth and the adults begin to emerge about the middle of June.

Associated borers, predators and parasites are the same as for *Leptostylus sex-guttatus* (see page 75), with the exception of *Phymatodes dimidiatus*.

Melanophila fulvoguttata Hare.

Melanophila fulvoguttata is distributed throughout eastern Canada and United States from Labrador (Sherman, 1910, pp. 193) to North Carolina (Blanchard, 1889, pp. 193) and is common as far west as the Lake Superior region (LeConte, 1859). The host trees most commonly attacked are the hemlock and spruce, of both of which this species is a serious enemy. In addition Harris (1862, p. 50) records having taken the adults from the trunks of white pine during June. It was bred by us, both from the branches and the trunk of larch and has been taken by the senior author from both hemlock and red spruce in the Cranberry Lake region of New York.

M. fulvoguttata deposits its eggs in the bark of the trunk and limbs of weakened, dying or dead hemlock, spruce or larch. It may also breed in balsam fir and white pine, but no definite data is at hand to prove this. The larval mines of this flat-headed borer are rather wide, shallow and winding in their course, and where the larvæ are numerous, as is very often the case in dying hemlock or spruce, these larval burrows cross and recross each other, making it difficult or impossible to follow the course of any particular one. Two years are required for the completion of the life history. The adults emerge at any time during the summer, having been taken by the senior author in the Adirondacks at various times between June 15 and September 1.

M. fulvoguttata may occur under the bark of any part of the tree from the base of the trunk to limbs an inch in diameter. It may therefore be associated with any of the boring insects attacking the same tree. In our work it was found actually associated in the trunk region with *Dendroctonus simplex*, *Polygraphus rufipennis* and *Asemum moestum*; and in the limbs and tops was bred from the same material as *P. rufipennis*, *Eccoptogaster piceæ*, *Leptostylus sex-guttatus*,

Pogonocherus mixtus, *Neoclytus longipes*, *Chrysobothris blanchardi*, *C. sex-signata*, *C. dentipes* and *Anthaxia quer-cata*. The associated predators and parasites were the same as for *N. longipes*.

Chrysobothris blanchardi Horn.

The distribution of *Chrysobothris blanchardi* was reported by Horn (1886, p. 94) as Massachusetts, District of Columbia and Lake Superior region. Blatchley (1910, p. 791) records specimens from two counties in Indiana. This species has been recorded as a borer in white pine in Massachusetts by Blanchard (1889, p. 31) and as occurring "on scrub pine" (Blatchley, 1910, p. 791). Blanchard's data was derived from specimens actually cut from white pine during July and August.

Chrysobothris blanchardi was obtained only from the branches and tops of larch. The eggs are laid under the bark of weakened, dying or recently dead trees. The larval burrows are rather long and flattened in cross section, but considerably narrower than in several of the sister species, including those mentioned later. Although there is much variation in the burrows, yet it is usually true that at first the larval mine is likely to be longitudinal and nearly straight, or at most only wavy in its course, while that made by the nearly full-grown larva later is likely to be very tortuous, often crossing and recrossing its own former path. (Figs. 23, 24.) The entire burrow is tightly packed with frass and that derived from the bark and from the sapwood is often so arranged as to form alternate dark and light striæ, as shown in Fig. 25. The material for this is derived by the larva alternately excavating from the bark and from the sapwood, and this is arranged to form the curved striæ by the abdomen of the borer, which is habitually curved, the loop being pressed against the packed frass to afford leverage while the larva is rasping off the woody fibres. Pupation takes place in a shallow chamber extending longitudinally with the wood fibre and lying just under the surface of the

sapwood. The adult leaves the pupal chamber through the same opening as that through which the larva gained access, and on reaching the level of the bark, there constructs an oval emergence hole. Two years are required for the completion of the life history.

The associated insects are the same as for *Neoclytus longipes* given previously and it seems unnecessary to repeat the list here.

Chrysobothris sex-signata Say.

Chrysobothris sex-signata, according to Horn (1886, p. 112), "Occurs from New York to Virginia, westward to Nebraska and Indian Territory." Blanchard (1889, p. 31) records it as occurring in New England but as "rather scarce." Blatchley (1910, p. 791) also speaks of it as scarce in Indiana, although he lists it from five countries.

No record of this insect actually having been bred from a conifer was found, but Blanchard (1889, p. 31) has beaten it from pitch pine. Chittenden (1889, p. 219) records it as having been "cut from a beech tree in which it had bred." Smith (1909, p. 293) reports it "on beech, birch and chestnut." This species, like many others of the same genus — and indeed many other genera of buprestids — doubtless breeds indiscriminately in a large number of trees, both broad-leaved and coniferous. The authors have not only obtained a number of specimens from larch, but also have bred large numbers from hickory.

The female chooses the same sort of material in which to deposit her eggs as does *C. blanchardi*. The burrow made by the larva is quite variable. Sometimes it is only moderately coiled as in Fig. 26, while in other cases it is so tortuous that it is impossible to trace its course throughout its entire length, owing to the fact that the larva crosses and recrosses its old track. The burrows, when they can be traced, are usually readily distinguishable from those of *C. blanchardi* by their being actually broader and relatively shallower. The length of the burrows of *C. sex-signata* is more often less than those of the sister species, but this varies

somewhat, dependent both upon the ultimate size of the individual making the burrow and upon the width of the burrow itself. In *C. sex-signata* the gallery leading to the pupal chamber is also noticeably wider — *i. e.*, is a flatter oval in cross section — than in the other species. The general character of the burrow of this species is well shown in Fig. 26, although it should perhaps be stated that it is rarely that the entire course of the larval mine is so readily to be seen as it is there. This species requires two years for its life history, the adults emerging in midsummer. Our record includes specimens emerging nearly daily from June 21 to July 30.

The associated insects are the same as for *Neoclytus longipes*.

Chrysobothris dentipes Germ.

Chrysobothris dentipes seems to occur throughout the greater part of southern Canada and the timbered areas of the United States. The earliest record of a host plant for this flat-head is that of Harris (1862, p. 42), who says that it "inhabits the trunks of oaks". This is confirmed by Fitch (1859, p. 793) and by Packard (1890, p. 60). Blanchard (1889, p. 31) and Crittenden (1889, p. 219) record it as common on pine and the latter concludes that "it is doubtful if it breeds in any but coniferous trees". This latter view seems to us not at all well taken, on account of the definite records from oak and in view of the well known fact that several species of this genus attack a large number of both coniferous and broad-leaved trees and even shrubs with little apparent preference. Packard (1890, p. 680) has taken dead adults of this species from beneath the bark of pine and Felt (1906, p. 657) records it from hard pine. It has been bred in our laboratory not only from larch but also from white pine.

In depositing their eggs the adults of *C. dentipes* choose much the same sort of material as do the other species already treated. They prefer the thin barked portions of larch and pine which is either weakened, dying or recently killed. Pine "slash" affords excellent conditions and they will

breed in such material in immense numbers. Larvæ were also numerous in pine limbs which had been suppressed by shading and in the upper part of pines weakened by shading and killed by the attacks of other insects such as *Dendroctonus valens* and *Ips longidens*.*

The eggs were laid in larch that was not yet entirely dead, as was indicated by the fact that in some cases the early portions of the burrows are filled with frass saturated with pitch. This frass is arranged and packed by the abdomen to form the curved striæ mentioned in connection with *C. blanchardi* and evidence to indicate that the pitch was successfully manipulated by the larva is furnished by curved bands of pitchy frass alternating with other bands devoid of excessive resin. Still other cases were observed of burrows which had been made by this species several years before the death of the limb. These had been partly filled with pitchy frass and had thus been, to some extent, preserved from decay. The bark, however, had later been removed by some unknown cause and the burrows partly overgrown by the attempt at repair on the part of the tree.

The burrows made by the larvæ of *C. dentipes* are broader than those of any of the other species of flat-head borers in larch — fully twice as broad on an average as are those of *C. blanchardi*. The course varies greatly. In one case in larch the burrow is longitudinal and nearly straight throughout the greater part of its length of nearly twenty inches (495 mm.)—this doubtless being due to the larva having met no obstructions in its course. In another case a piece of pine top nine inches long and slightly more than two inches in diameter contained fifteen larvæ. The burrows in this piece are very tortuous (Fig. 27), often crossing and recrossing each other, so as to make it impossible to trace any particular one in its entirety.

This insect requires two years for the completion of its life history. The larvæ on reaching full growth burrow

* For the information relative to *C. dentipes* in white pine we are indebted to the notes of Mr. A. J. MacNab, a former graduate student in the department.

diagonally into the sapwood (either of pine or of larch), and often continue their burrows for a considerable distance through the sapwood parallel to the surface. Usually in larch the larva, after it has burrowed several centimeters, carries the mine up to the surface of the sapwood, then retreats down into it and pupates. The adult on arising emerges by continuing the burrow made by the larva up through the bark. In pine, where the sapwood is much softer and more readily worked, the larva often burrows for a considerable distance before it pupates. In one case the burrow was followed in its entirety for a distance of 13 cm. between the point of entrance and the emergence hole of the adult—the pupal chamber being 10.5 cm. from the entrance hole of the larva. All of the burrow except the pupation chamber is filled with frass. It will be apparent that the burrows of *C. dentipes* can be readily distinguished from those of other flat-headed larvæ occurring in larch by the facts just mentioned—*i. e.*, that the larva typically burrows through the sapwood for some distance before pupating, and that the adult does not follow the larval burrow back to the bark but constructs a new exit in order to reach the outside.

Insects associated with *C. dentipes* in larch are the same as those listed for *Neoclytus longipes*. Where insects are excessively numerous, as shown in Fig. 27, whether they are of the same or of different species, it is of course apparent that they are injurious to each other, to such a degree as they limit the food available for all.

Anthaxia quercata Fabr.

Anthaxia quercata is reported by Horn (1882, p. 110) as being distributed throughout the Middle, Southern and Western States and California. This includes the distribution of *A. cyanella*, which is the female of the same species. This species has been bred by Chittenden (1889, p. 219) from chestnut twigs and he has likewise taken the male from the leaves of chestnut and chestnut oak. Blanchard (1889, p. 31) reports it as common in oak shrubs; Felt

(1906, p. 578) has taken it from the leaves of scrub oak, and Smith (1909, p. 293) reports the "larva in grape and chestnut." We find no previous record of its having been obtained from a coniferous species.

The females of this small buprestid deposit their eggs in dying or recently killed larch — and other trees — choosing limbs of a diameter of from three-fourths of an inch to one and a half inches. The larval burrows, in common with those of most flatheads, are considerably broader than they are deep. They are constructed immediately under the bark, grooving both bark and sapwood, but nearly all of their depth is excavated from the sapwood. The course of their burrow is at first longitudinal and is not excessively tortuous. (Fig. 22.) The width of the burrow at the start is about one millimeter and by the end of the first year this has about doubled. The burrow made by the larva during its second season is much more variable both in diameter and in direction. The final result may be a very tortuous burrow which repeatedly crosses and recrosses its own course, or it may consist of an irregular broad area, as shown in Fig. 22. The entire larval mine is tightly packed with frass, and that derived from the bark and from the sapwood is usually so arranged as to form alternate dark and light bands or striae just as in *C. blanchardi*.

The larva completes its growth during the second summer and then constructs a shallow pupation chamber in the outer sapwood. This extends diagonally down into the wood for a distance of from 6 to 9 mm. The larva apparently pupates with its head toward the larval burrow, egress from the pupal chamber being obtained through the larval entrance. Exit of the larva through the bark is made through a small oval (sometimes nearly semi-circular) opening, which can be readily distinguished from those of the other buprestids by its small diameter.

Insects associated with *Anthaxia quercata* form the typical limb association and comprise *Neoclytus longipes* and the species previously listed as bred from the same source.

Serropalpus barbatus* Schall (*striatus* Hell.)

According to Hamilton (1889, p. 152; 1894 a, p. 33) *Serropalpus barbatus* is distributed throughout Central and Northern Europe, Siberia and the Northern part of North America, extending through the Rocky Mountains as far as New Mexico. In the East it occurs at least as far south as West Virginia (Hopkins, 1893, p. 203).

The European hosts recorded for this melandryid by Judeich and Nitsche (1895, p. 1304) are silver fir, Scotch fir and pine. In America Hopkins has taken it from spruce (1893, p. 203) and from balsam (Felt, 1906, p. 671), and Smith (1909, p. 365) reports having taken it "at light and from dry fungus." The senior author has cut larvæ, pupæ and adults from the wood of balsam, spruce and hemlock in the vicinity of Cranberry Lake, N. Y. We bred numerous specimens from larch, which tree apparently has not previously been recorded as a host.

S. barbatus was first mentioned in forestry literature by Ratzeburg in 1863, but its work was not adequately described and illustrated until Erne gave a rather complete account of its habits in 1892. According to the latter's observations (Judeich and Nitsche, 1895, p. 1804), the adult is nocturnal in its habits and at this time all of its activities are carried on. In the daytime it conceals itself in the moss on the trees and in the ground cover. Erne believed that the life history required three years, while Wachtel (also cited by Judeich and Nitsche) states that the life cycle is completed in two years. Our own observations show that under the climatic conditions of Central New York two years is sufficient. We have, however, already pointed out the danger in making dogmatic statements regarding duration of life history, as such processes are subject to much variation even in the same general locality, being dependent upon the actual temperature and moisture conditions existing in the particular tree or other material infested.

* Descriptions of the adult, larva and pupa of this species are given by Judeich and Nitsche (1895, p. 1303).

S. barbatus in ovipositing in larch chooses either trees which are dying or which have recently died, or living trees from which part of the bark has been peeled (this latter being in line with its common name of "blazed tree borer"). Occasionally oviposition occurs in living trees — most often in injured or dead parts of the bark. In several cases adults emerged from recently dead larch the same year as *Polygraphus* and *Eccoptogaster* — indicating that it must have entered this material a year earlier than did the scolytids, while the trees were still alive. Usually only the lower trunk is attacked, but several specimens have been bred from the trunk up among the limbs as much as thirty feet from the ground.

The larval stage of *S. barbatus* is spent nearly entirely in the sapwood. As soon as they are hatched, the larvæ burrows from the bark into the sapwood and continues mining this part of the tree for two seasons. The larval burrows are very irregular in their course, winding this way and that and showing no discoverable pattern. It is noticeable, however, that a greater part of the length of the burrow is in the soft spring wood and it will often extend for several inches, either longitudinally, circumferentially or diagonally, without leaving a single ring of growth. The burrow is oval in cross section, the long diameter, which is about twice the shorter diameter, being tangential, *i. e.*, confined to one layer of "spring wood." The entire larval mine is packed full of a very fine dust-like frass.

Before transforming to the pupa the burrow is extended by the full-grown larva, which reaches a length of 25 mm. to a level not more than a half inch from the bark and a slightly enlarged chamber is here constructed parallel to the surface of the sapwood. However, before transforming, the burrow is extended to the surface of the sapwood, so that the adult may emerge without having to bore through the wood. Field notes of the senior author, dated Cranberry Lake, June 10, 1915, read as follows: "Numerous adult beetle and two larvæ taken from sapwood of a small dead hemlock. Adults were taken from chambers extending

inward one-half inch and thence either downward or to the side about one inch. These chambers had been opened to the inner bark, but not through this, and the openings through the surface of the sapwood were not large enough for passage of beetle. When removed the beetles were quite lively and active." The beetle emerges through a circular hole in the bark. Our records of emergence outdoors extend from June 5 to August 3, as follows: 1916, June 6, 7, 8, 13, 15; July 1, 6; August 3; 1917, June 5, 19, and July 12. In the Adirondacks the senior author took adults from hemlock wood June 10, 1915, and balsam June 26, 1915. Pupæ were cut both from spruce and balsam June 27, 1915. Larvæ were obtained from hemlock June 10 and from spruce June 27, 1915. Individuals of *S. barbatus* differ greatly in size, specimens we have varying from 6.5 mm. to 18 mm.

Insects associated with *Serropalpus barbatus* include the scolytids — *Dendroctonus simplex*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Crypturgus pusillus*; the cerambycids — *Asemum moestum*, *Monohammus scutellatus* and *Phymatodes dimidiatus*; the buprestid — *Melanophila fulvoguttata*, and the two siricids — *Urocerus albicornis* and *Sirex abbotii*. None of these habitually precede *S. barbatus* in the wood, but occasionally *D. simplex* and *A. moestum* may attack the tree first. Most often, perhaps, the melandryid is the first insect to enter the living tree — entrance for the egg being gained through some mechanical injury such as a blaze or other abrasion. In weakened trees *Serropalpus* is likely to deposit its eggs at about the same time as *A. moestum* and before any of the other insects listed above. In such cases the adults of both of these two-year forms emerge at the same time as do those of *D. simplex*, *P. rufipennis*, *E. piceæ*, *P. dimidiatus*, *U. albicornis* and *S. abbotii*, all of which are one-year forms entering the tree a year later. In other cases all of the associates listed above enter the tree during the same season and the one-year forms will then have been gone an entire year before the emergence of *S. barbatus* and the other two-year forms — *A. moestum*, *M. scutellatus* and *M. fulvoguttata*.

The presence of *S. barbatus* and of other wood-boring forms in a tree serves to prepare the wood for other insects which otherwise could not utilize it, or at least would not be likely to utilize it. This was especially noticeable in Tree V, which had been partially peeled a number of years before its final death. The presence of the burrows in the wood not only affords the insects mechanical entrance to the wood, but also so promotes decay as to make it fit material for such forms as *Adelocera brevicornis*, *Tenebrio tenebriodes*, *Dryophthorus americanus* and *Stenoscelis brevis* to inhabit. After decay has started any or all of these forms may enter the exposed wood and the two latter at least may continue to breed in it for several generations.

Phyllobaenus dislocatus is the only predator bred from the same material as *S. barbatus*. On account of the character of the burrows of the latter and because of their being filled with fine sawdust it is not likely that any close relation exists between these two forms. No evidence of parasites upon *S. barbatus* was found.

Urocerus albicornis Fabr.

(Det. by S. A. Rohwer)

According to Bradley (1913, p. 19) the geographical range of *Urocerus albicornis* extends "From British Columbia, Northern Ontario, Nova Scotia and Newfoundland, south to Pennsylvania, Washington and Northern Idaho." Hopkins (1893 a, p. 215) reports it also from West Virginia. This species was recorded by Packard (1890, p. 733) as attacking pine. Later Hopkins (1893, p. 215) found the larvæ in the sapwood and heartwood of injured and dying hemlocks, while Felt (1906, p. 667) mentions spruce and fir as host trees. The senior author has taken it from the wood of spruce, fir and hemlock in the Adirondacks.

The adult female of *U. albicornis* prefers freshly killed wood in which to oviposit. This is very apparent in the Adirondacks, where females of this horntail are often seen about recently felled spruce and fir. On one occasion the

senior author observed three specimens at one time hovering about spruce recently felled and stripped for pulp wood and which was at that time being piled upon a skidway.

Entomological literature contains numerous mention of this insect as a wood borer, but apparently no data is available as regards length of larval and pupal life history. Our data, while not absolutely conclusive, shows that usually the life history is completed in one year. This, however, is doubtless subject to considerable variation, dependent not only upon the general climatic conditions but also upon the exact individual conditions in each case.

The eggs are deposited by the females in the bark of dying or recently felled coniferous trees. Preference is shown for recently felled trees, but failing these, trees dying or even dead are used for ovipositing. The larvæ on hatching bore directly into the wood, in which they construct their mines throughout their entire larval existence. These burrows run in all directions through the wood and are closely packed with a very fine dust like frass. In general they are very much like the mines of *S. barbatus*, but can be distinguished by the fact that they are nearly exactly circular in cross section, while those made by the melandryid are oval.

Adults of this siricid emerged in our outdoor breeding cages during June and July. In all, twelve specimens were obtained — comprising two females and ten males. Of these one male and one female were obtained in July, 1916, from Tree II. The other female and the nine males were obtained from the lower, middle and upper trunk regions of Tree X. Mr. Rohwer of the Bureau of Entomology in identifying these specimens makes the following statement regarding the males: "At present there are no characters known which definitely separate the male of *Urocerus albicornis* Fabr. from the male of *Urocerus flavicornis* Fabr. and it is impossible to be positive as to the above determination." However, the fact that the males were bred from the same material as the known females of *U. albicornis* and emerged at about the same time would make the presumption very strong that they belong to this species. These specimens

show considerable variation not only in size but in coloration. In size the five males still in our possession vary from 12 mm. to 18 mm. The differences in coloration, which are quite striking, consist in a variation in the relative amount of yellow upon the antennæ, abdomen and legs.

Borers associated with *U. albicornis* are *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Phymatodes dimidiatus*, *Serropalpus barbatus* and *Sirex abbotii*. As *U. albicornis*, which is typically a one-year form, attacks weakened, dying or very recently killed trees, its life history in the wood coincides with or overlaps that of each of these forms. The two scolytids usually enter the bark rather early in the same season, and are therefore likely to have been established a month or more before the eggs of the siricid are laid. *P. dimidiatus*, also a one-year form, probably enters the tree about the same time as the *Urocercus*, but as its burrows are entirely in the bark, the two forms have no direct or very definite relations. *S. barbatus* and *Sirex abbotii* are both wood-boring forms similar to *U. albicornis*, but the relations are never likely to be close. No case was observed where these various wood-eating larvæ were present in such number as seriously to interfere with each other's chances of obtaining food. The occupancy of the wood by the larvæ of *Sirex abbotii* and of *U. albicornis* coincides nearly exactly. *Serropalpus*, however, is a two-year form and its larvæ may have lived in the sapwood an entire year before the advent of the other borers and during this time may have performed a very important function in overcoming the resistance of a weakened tree.

While a number of parasites were bred from the same material as *U. albicornis*, no evidence of any close relation between them and the siricid was found, though many burrows were examined for cocoons. The predator *Phyllobaenus dislocatus* was obtained from the same material, but no reasons for believing it predaceous upon *U. albicornis* were found.

***Sirex abbotii* Kirby.**

(Det. by S. A. Rohwer)

The distribution of *Sirex abbotii* is given by Bradley (1913, p. 13) as Georgia. No record of host trees has been found in the literature. It is very likely that this species will be found to breed in about the same trees as *S. cyaneus*, which occurs in spruce and fir, but which perhaps has a more northern range.

All our specimens of this siricid were bred from larch material derived from Tree X, the same tree from which most of the specimens of *U. albicornis* were obtained. The specimens of *S. abbotii*, however, emerged from the lower and middle trunk region only. Otherwise the habits seem to be practically identical with those of the other siricid. A total of thirteen specimens were obtained, ten of these being males and three females. Mr. S. A. Rohwer, who in identifying them has examined one of the females and a number of the males, says: "The above record for a female of *Sirex abbotii* Kirby is the first association of a female with this species. The female is very close to *S. cyaneus* Fabr. and may be under that name in collections." The specimens emerged in our cages during June and July (June 9; July 6, 12, 13, 16, 17, 18).

Sirex abbotii belongs to the same association as *U. albicornis* and bears the same relations with its associates as does the other siricid.

***Tenebrio tenebriodes* Beauv.**

Tenebrio tenebriodes is probably distributed throughout the entire northeastern part of the country, as it has been reported from Pennsylvania (Hamilton, 1895, p. 341), New York (Felt, 1906, p. 493) New Jersey (Smith, 1909, p. 359) and Indiana (Blatchley, 1910, p. 1251). Further than the fact that this insect is usually found under decaying bark or in other similar locations very little is known regarding its habits. Felt (1906, p. 493) records it "under decaying willow, butternut and basswood bark in early

spring." Smith (1909, p. 359) has taken it "Under bark of trees, among rubbish in barns and outbuildings." Blatchley (1910, p. 1251) speaks of it as "Common beneath bark."

It will be seen from the above references that no definite statements regarding the breeding habits or food habits of this beetle was found in the literature. It apparently is not known whether it breeds under bark or whether it merely hibernates there. The fact that the adults are taken constantly in the spring or early summer from under bark does not afford evidence to support either view. Nor does the fact that it has been taken from a variety of different species of tree offer any real evidence — it being a well-known fact that insect inhabitants of wood well along in decay, usually show little preference for any particular species. The evidence we have to offer is quite scant and inconclusive, but it points toward *T. tenebriodes* being a true inhabitant of decaying wood throughout its life. The material (Tree V) was confined in breeding cages late in April and the adult beetle did not appear in the cage until July 7. Had it been merely hibernating in the wood, it would likely have been found earlier.

The material from which *T. tenebriodes* was derived consisted of the decayed heartwood of Tree V which had been peeled many years ago (Figs. 29, 30). This exposed wood had at one time apparently served as the breeding place of *S. barbatus* which, however, had emerged a number of years before the material was confined in the cage. Two other insects were taken from this wood — *Adelocera brevicornis* (taken from the wood in the field April 28) and *Dryophthorus americanus* (July 3). *A. moestum*, *P. dimidiatus* and *S. barbatus* were bred from this same tree but emerged from the sounder more recently killed portion.

***Adelocera brevicornis* LeConte**

Adelocera brevicornis is perhaps distributed over the greater part of eastern United States and Canada. Adams (1909, p. 196) gives the geographical range as Ottawa, Canada; Michigan; Lake Superior. Smith (1909, p. 284)

reports it from The Palisades, N. J. Blatchley (1910, p. 715) records that this species "is known from Michigan and Wisconsin."

The only reference to the habits we have been able to find is the general statement regarding the genus by Smith (*loc. cit.*), that all the species occur under dead bark. We obtained but one specimen from larch and this was taken from punky wood April 28. It is believed that *A. brevicornis* breeds in decaying wood and under decaying bark, but we can offer no real evidence for this view.

The insects associated in the decayed wood are *Tenebrio tenebriodes* and *Dryophthorus americanus*. If *A. brevicornis* breeds in such surroundings it would also often be associated with *Stenoscelis brevis*. The recently killed part of the same tree contained *Phymatodes dimidiatus*, *Asemum moestum* and *Serropalpus barbatus*.

Phyllobænus dislocatus Say.

Phyllobænus dislocatus has been reported from various parts of the United States: Hopkins (1893, p. 187), West Virginia; Hamilton (1895, p. 335), Pennsylvania; Felt (1906, p. 503), New York; Schaffer (1908, p. 127), Arizona; Wolcott (1909), Wisconsin and Ohio; Smith (1909, p. 303), New Jersey; and Blatchley (1910, p. 859), Indiana.

This small clerid has been reported as associated — doubtless in the capacity of a predator — with a large number of bark and wood-inhabiting forms derived from a variety of different trees. Hopkins (1893, p. 187) states that it "Attacks *Polygraphus rufipennis* in Black Spruce and *Pityophthorus consimilis* in Sumach (*Rhus glabra*) and with *Scolytus regulosus* in Apple bark." According to Felt (1906, p. 449), LeConte reared it from hickory twigs containing *Chramesus hicoloræ*. Felt (1906, p. 503) reared it from hickory limbs infested with *Chrysobothris femorata*, and *Magdalis olya*. Blackman (1915, p. 54) records having bred *P. dislocatus* from limbs of pine containing *Pityogenes hopkinsi* and no other borer, and Chapin (1917, p. 29)

obtained several specimens from twigs of *Rhus glabra* associated with the cerambycids *Liopus fascicularis*, Harr. and *Psenocerus supernotatus* Say and the scolytid *Pityophthorus consimilis* Lec.

From the fact that *P. dislocatus* is constantly found in the burrow of a great variety of other insects, there can be little doubt that it is predaceous upon a large number of species. In larch it was bred from practically every lot of material placed in the breeding cages and therefore a list of probable associates in larch would include practically all of the forms bred from larch, including parasites and other predators as well as the true borers (see table on p. 38). It is indeed possible that this clerid may on occasion be predaceous upon all of these various forms. Even such forms as the larvæ of *Monohammus scutellatus*, which when well grown would conceivably be very well able to defend themselves would, when small, be comparatively helpless if attacked by an active, full-grown larva or by an adult of *P. dislocatus*. Furthermore, on account of its burrow being open from the time the larva is hatched, this round head would seem to be particularly subject to attack by predators.

Perhaps the greatest difficulty in the way of *P. dislocatus* being freely predaceous upon all of these insects, lies in the fact that typically the burrows of all of the flatheaded borers and most of the roundheaded borers in larch are entirely devoid of opening to the outside (except accidental openings) and in the further fact that the larval burrows are filled with more or less firmly packed frass. Occasionally, free access to such larval burrows may be had, however, through the egg-galleries of associated scolytids, at places where these latter passageways are crossed by the burrows of the larger larvæ.

However, we are certain that in most cases *P. dislocatus* preys principally upon scolytids. It is by no means unusual, on opening a burrow of *P. rufipennis* or other scolytid, to find the original inhabitants all dead and the burrow uncompleted. In such cases, the remains are likely to consist of the mere external shell of the scolytid, all of the soft parts

having been devoured by the predator. Most usually the opening through the hard outer shell is through the posterior abdomen, this apparently being the most vulnerable point of attack. In one instance on opening the burrow a larva of *P. dislocatus* was discovered with its head thrust into the body of a recently dead *P. rufipennis* as far as the prothorax. When the clerid larva was removed the body of the scolytid showed fresh signs of having been eaten. There is also good evidence to show that both larvæ and adults feed quite readily on the dead and dried bodies of scolytids and even upon those which must be well along in decay. Thus this clerid acts as a scavenger as well as a predator.

The scolytids with which *P. dislocatus* have been found constantly associated in larch are *Polygraphus rufipennis*, *Dendroctonus simplex*, *Eccoptogaster piceæ* and *Crypturgus pusillus*. It was actually taken from under the bark among the burrows of each of these scolytids and there can be little doubt that it acts in the capacity of a predator and scavenger in the burrows of all of these forms. It is believed that as a predator *P. dislocatus* (and other clerids) most often attack the adults rather than the larvæ of scolytids. The larva or adult of the predator in order to reach the scolytid larva would either have to construct a new burrow of its own through the bark or would have to clear the larval burrow of frass and enlarge it. On the other hand the adults are quite accessible. When in the brood-burrow, the predator can reach them readily through the entrance to the nuptial chamber, while the young adults for a considerable time before emergence are readily accessible through the "ventilation openings" in their feeding galleries.

Cymatodera bicolor Say.

Cymatodera bicolor was described from a specimen from Arkansas and Horn (1888, p. 224) gives its range as "The Middle and Gulf States." It has later been reported by Wickham (1895, p. 249) from Ontario and Quebec, by Smith (1909, p. 302) from New Jersey, by Leng (1908,

p. 27) from Arizona and (1910, p. 77) from Georgia, and by Blatchley (1910, p. 850) from Indiana.

The most definite statement regarding the habits of this clerid is furnished by Hopkins (1893a, p. 185) when he lists it as predaceous and states that it occurs with *Phlæosinus dentatus* in cedar bark. In larch it was found associated with the borers *Polygraphus rufipennis*, *Phymatodes dimidiatus* and *Leptostylus sex-guttatus*, with the clerid *Phyllobanus dislocatus* and with the parasites *Rhyssa lineolata*, *Pseudorhyssa* sp., *Eurytoma* sp., and several undescribed species of *Doryctes*. *C. bicolor* may be predaceous upon any of these but is more likely to feed habitually upon the scolytid *P. rufipennis*. It probably also acts as a scavenger in obtaining part of its food.

Podabrus diadema Fab.

The geographical range of *Podabrus diadema* is given by Adams (1909, p. 199) as Ottawa, Canada; Mt. Washington, N. H.; Vermont; New York; New Jersey; Western Pennsylvania; Michigan; Wisconsin; Iowa. Smith (1909, p. 299) reports it from New Jersey.

Nothing regarding the habits of this lamproyid was found in the literature but we believe that it acts as a predator and as a scavenger. Regarding the sister species *P. regulosus* Blatchley (1900, p. 830) states that it "Occurs on the leaves and flowers of various shrubs and herbs. One was noted feeding on a winged plant louse."

Only one specimen of this beetle was bred from larch. It emerged on June 15, 1916, from a section of the trunk of larch about thirty feet from the ground, infested heavily with the brood of *P. rufipennis*. The only other insects bred from this lot aside from the scolytid already mentioned were *P. dislocatus* and a small undetermined chalcid. It is likely that *P. diadema* inhabits the burrows of *Polygraphus*.

Rhyssa lineolata Kirby.

(Det. by S. A. Rohwer)

According to Merrill (1915, p. 147) the geographical range of *Rhyssa (persuasoria) lineolata* is very wide, extending "Through Europe to Canada and the United States in the West, and the Himalayas in the East." Merrill (*loc. cit.*, pp. 144-147) has reviewed at some length what is known regarding the habits of this species and it seems undesirable to repeat this here. It has been reported as parasitic upon *Sirex spectrum*, *Sirex (Urocerus) cyaneus* and *Monohammus*, while other species occurring in Europe are parasitic upon several species of *Xyphydria*.

In our larch material there can be no doubt that *R. lineolata* is parasitic upon *Phymatodes dimidiatus*. The reasons for this statement have been cited on p. 32 and seem conclusive. The fact that cocoons large enough to have served the pupa of *R. lineolata* and *Pseudorhyssa* sp. occurred only in the burrows of *P. dimidiatus* and that no cocoons of any sort were discoverable in the mines of *S. barbatus*, the only other insect common to the three lots of material would seem to be conclusive. Of the three lots from which this parasite was bred only one gave rise to any siricids, *U. albicornis* and *S. abbotii* being obtained from this lot, and an investigation of their burrows showed the entire absence of parasitic cocoons.

While we cannot state too strongly our certainty that *R. lineolata* in our material was parasitic upon *P. dimidiatus*, we do not in any sense wish to cast discredit upon observations which have shown it to be probably parasitic upon quite different insects. Indeed, it is nearly certain that this species is parasitic upon many wood and bark-boring forms. In fact, the senior author has removed an adult from the wood of hemlock where it was associated with adults of *Urocerus albicornis* and with larvæ and pupæ almost certainly belonging to the same species. As the adult parasite which was alive and ready to emerge was removed from a burrow similar in all respects to those from which the speci-

mens of *U. albicornis* were taken there can be little doubt of its being parasitic upon this species also.

In larch the associated insects in addition to *Phymatodes dimidiatus* are, *Leptostylus sex-guttatus*, *Asemum moestum*, *Serropalpus barbatus*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Urocera albicornis*, *Sirex abbotii*, *Phyllobænus dislocatus*, *Cymatodera bicolor*, *Pseudorhyssa* sp., *Doryctes*, sp., a, b, c, *Eurytoma* sp., *Spathius tomici*, *Spathius* sp., and an undetermined pteromalid.

Pseudorhyssa sp.

(Det. by S. A. Rohwer)

Four specimens of this new species of *Pseudorhyssa* were bred from the trunk of Tree III from five to seven feet above ground. Of these three specimens were retained by Mr. Rohwer and one is in our collection. This species also is parasitic upon *Phymatodes dimidiatus*, as was shown by a careful study of all of the burrows in the material from which it was bred. The adults emerged in the outdoor breeding cages on May 24 and 25.

Insects associated with it aside from *P. dimidiatus* already mentioned as its host, include the borers; *Leptostylus sex-guttatus*, *Serropalpus barbatus* and *Polygraphus rufipennis*; the predators, *Phyllobænus dislocatus* and *Cymatodera bicolor*; and the parasites *Rhyssa lineolata* *Eurytoma* sp., and three species of *Doryctes*.

Odontaumerus canadensis Prov.

(Det. by S. A. Rohwer)

No references to this ichneumonid were found in the literature examined by us. It was bred from Tree III and was associated with *Phymatodes dimidiatus*, *Leptostylus sex-guttatus*, *Serropalpus barbatus* and *Polygraphus rufipennis*. It is most probably parasitic on *P. dimidiatus*. This cerambycid had been very numerous in the tree trunk, and cocoons of a size which would be made by this parasite, were present in its burrow and none of a suitable size were found in any others in this lot of material.

Predators associated include *Phyllobænus dislocatus* and *Cymatodera bicolor*. The parasites present in the same material were *Rhyssa lineolata*, *Pseudorhyssa* sp., *Eurytoma* sp., and three species of *Doryctes*.

Odontaulacus bilobatus Prov.

(Det. by S. A. Rohwer)

According to Bradley (1908, p. 124) this ensign-fly has been taken in Quebec and West Virginia. No reference to the host of this species was found in the literature, but Hopkins (1893, p. 216) states that the sister species *O. abdominalis* was bred from hemlock infested with *Melanophila fulvoguttata*.

In larch *O. bilobatus* was associated with the buprestids, *Melanophila fulvoguttata*, *Chrysobothris blanchardi*, *C. dentipes*, *C. sex-signata* and *Anthaxia quercata*; the cerambycids, *Pogonocherus mixtus*, *Neoclytus longipes*, *Leptostylus sex-guttatus*; the scolytids, *Polygraphus rufipennis* and *Eccoptogaster piceæ*; the clerid *Phyllobænus dislocatus*; the hymenopterus parasites, *Atoreutus astigmus*, *Spathius tomici*, *Phasgonophora* sp., *Cheiropachus* sp., and *Heterospilus* sp., and the fly *Pollenia rudis*. Of these the two scolytids, *P. rufipennis* and *E. piceæ*; and the parasites *Spathius tomici*, *Heterospilus* sp. and *Cheiropachus* sp., emerged the first year while the others and *O. bilobatus* were associated throughout two years. Specimens of *P. dislocatus* were taken from these limbs of larch both seasons. Of the associated borers it is most likely that either *C. blanchardi*, *M. fulvoguttata* or *P. mixtus* acted as host for this parasite, although it is possible that the host may have been one of the other flat-headed or round-headed borers.

Spathius tomici Ashm.

(Det. by S. A. Rohwer)

This small braconid has been reported as parasitic upon *Dryocoetes* [*autographus*] *americanus* Hopkins in spruce bark by Hopkins (1893, p. 145) and upon *Pityogenes*

punctipennis Lec. [*Tomicus balsameus* Lec.] by Felt (1906, p. 379).

S. tomici was bred from several lots of larch material and was associated with the scolytids, *Dendroctonus simplex*, *Polygraphus rufipennis* and *Eccoptogaster piceæ*. There can be little doubt that it may be parasitic upon the larvæ of any or all of these small beetles. Cocoons which from their size probably gave rise to this small parasite were found in the larval burrows of both *P. rufipennis* and *E. piceæ*, but were especially numerous in those of the former, and specimens were bred from other lots of material containing no other scolytid than *P. rufipennis*. The clerid *Phyllobænus dislocatus* and the parasite *Phasgonophora* sp., *Cheirpachus* sp., *Heterospilus* sp., *Atoreutus astigmus* and *Odontaulacus bilobatus* were also bred from the same materials as were a number of cerambycids and buprestids.

Spathius sp.

(Det. by S. A. Rohwer)

An unidentified species of *Spathius* was bred from the upper part of the trunk of Tree X in considerable numbers. In this material it was associated with the scolytids, *Polygraphus rufipennis* and *Eccoptogaster piceæ*; the cerambycids *Phymatodes dimidiatus*; the melandrycid, *Serropalpus barbatus*; and the siricid *Urocerus albicornis*. It is undoubtedly parasitic upon one or both of the scolytids mentioned.

The predator *Phyllobænus dislocatus*; the parasitic hymenoptera *Spathius tomici*, *Rhyssa lineolata*, *Doryctes* sp., *Spintherus pulchripennis* and an unidentified pteromalid; and the parasitic fly *Medeterus* sp., were also bred from the same material.

Doryctes sp., a, b, c

(Det. by S. A. Rohwer)

Various species of this genus have been recorded as parasitic upon wood-boring larvæ (Riley, 1890, p. 350; Hopkins, 1893a, p. 222; Chittenden, 1893, p. 248). A number of unidentified specimens, probably representing several new

species, were bred from larch material. All of them were associated with *Phymatodes dimidiatus* and probably emerged from cocoons found in the burrows of this cerambycid. Other borers associated were *Leptostylus sexguttatus*, *Serropalpus barbatus*, *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Urocerus albicornis* and *Sirex abbotii*. Other associated insects were *Phyllobænus dislocatus*, *Cymatodera bicolor*, *Rhyssa lineolata*, *Pseudorhyssa* sp., *Eurytoma* sp., *Spintherus pulchripennis*, *Spathius* sp., and *Odontamerus canadensis*. The adults of *Doryctes* emerged in the cage between May 25 and June 5.

Heterospilus sp.

(Det. by S. A. Rohwer)

Species of this genus have been recorded by Ashmead (1896, p. 214) as parasitic upon a coleopterous larva (from Dr. A. D. Hopkins' records) and by Viereck (1916, p. 238) from the galls of *Eurosta solidaginis*.

The species here in question came from larch June 2, 1916. It was bred from limbs of Tree I, emerging at the same time as the adults of *Polygraphus rufipennis* and *Eccoptogaster piceæ*. It is nearly certainly parasitic upon the first of these scolytids and probably upon both of them. It was bred from the same material as the various buprestids and cerambycids already recorded as characteristic of the larch limb association, but emerged a full season ahead of these and is therefore nearly certain to be parasitic upon one or both of the scolytids mentioned above, which were emerging at the same time. Other insects associated and emerging at about the same time are the clerid *Phyllobænus dislocatus* and the two hymenoptera *Spathius tomici* and *Cheiropachus* sp. Additional parasites emerging a year later are listed in the table on page 38.

Astoreutus astigmus Ashm.

(Det. by S. A. Rohwer)

No references to this insect were found in the literature at hand. We bred but one specimen and it emerged from the limbs of Tree I at about the same time as *Melanophila fulvoguttata*, *Chrysobothris blanchardi*, *C. sex-signata*, *C. dentipes*, *Anthaxia quercata*, *Pogonocherus mixtus*, *Neoclytus longipes*, *Leptostylus sex-guttatus* and *Phyllobanus dislocatus*. The bark-beetles *Polygraphus rufipennis* and *Eccoptogaster piceæ* emerged in some numbers the preceding summer and one specimen of the latter emerged the same season (being derived, perhaps, from the brood of a second generation started in the cages the previous summer). No definite statement regarding the exact relations of *A. astigmus* can be made but it is evident that it is more likely to have been parasitic upon one of the two-year forms—buprestids or cerambycids.

Other insects derived from the same material include *Phasgonophora* sp. and *Odontaulacus bilobatus*, two parasites emerging at about the same time, and *Cheirropacus* sp., *Heterospilus* sp., *Spathius tomici* and *Pollenia rudis* which emerged a season earlier.

Spintherus pulchripennis Cwfd.

(Det. by S. A. Rohwer)

Hopkins (1893a, p. 227) reports an unidentified species of this genus as parasitic upon *Polygraphus rufipennis* in spruce bark. Our specimens from larch were obtained from one tree only (Tree X) where they were associated with the borers—*Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Phymatodes dimidiatus*, *Serropalpus barbatus*, *Urocerus albicornis* and *Sirex abbotii*. This species emerges during the early season at the same time as *P. rufipennis* and *E. piceæ*, upon one or both of which it is doubtless parasitic.

The predator *Phyllobanus dislocatus*, the hymenoptera *Spathius tomici*, *Spathius* sp., *Rhyssa lineolata*, *Doryctes* sp., an unidentified pteromalid and the fly *Medeterus* were also bred from the same lots of material.

Eurytoma sp.

(Det. by S. A. Rohwer)

A number of species of this genus have been found by Dr. Hopkins to be parasitic upon the larvæ of various scolytids and other wood and bark-inhabiting insects (Hopkins, 1893a, p. 324; Ashmead, 1894, pp. 323-327).

Specimens of this small eurytomid were bred from two larch trees (Tree III and Tree IX) where it was associated with the borers *Polygraphus rufipennis*, *Phymatodes dimidiatus* and *Leptostylus sex-guttatus*, all of which emerged at about the same time. From Tree IX, *Neoclytus longipes* was also bred but it emerged a year later than the parasite. The only insect in common between these two lots was *P. rufipennis* and its burrows were also the only ones which contained cocoons from which so small a parasite would be likely to come. It is very likely that *Eurytoma* sp. is a parasite upon this small scolytid. The adults emerged in the outdoor cages June 5 and July 28, 1916. Other insects bred from the same material are *Phyllobænus dislocatus*, *Cymatodera bicolor*, *Rhyssa lineolata*, *Pseudorhyssa* sp. and several species of *Doryctes*.

Phasgonophora sp.

(Det. by S. A. Rohwer)

The only reference to the host of a species of *Phasgonophora* we found is that of Smith (1909, p. 649) in which he states that *P. sulcata* has been bred from *Papilio* sp. Our specimens were bred from larch limbs which had been confined since the spring of the preceding year. They were associated with the following two-year forms and emerged at about the same time: *Melanophila fulvoguttata*, *Chrysobothris blanchardi*, *C. sex-signata*, *C. dentipes*, *Anthaxia quercata*, *Pogonocherus mixtus* and *Leptostylus sex-guttatus*. This species is probably parasitic upon *C. blanchardi* and possibly upon others of the associated borers as well.

Other insects bred from the same source include *Phyllobænus dislocatus*, *Cheiropachus* sp., *Atoreutus astigmus*, *Heterospilus* sp., *Spathius tomici* and *Pollenia rudis*.

Cheiopachus sp.

(Det. by S. A. Rohwer)

The only reference to a host of a member of this genus seems to be that given by Hopkins (1893, p. 148) in which he states that *C. colon* Linn is parasitic upon *Scolytus regulosus*, the fruit bark beetle.

We bred our specimens from the limbs of Tree I. The parasites emerged in the outdoor cages May 24 and 30, 1916, at about the time when the adults of *Polygraphus rufipennis* and *Eccoptogaster piceæ* were emerging from the same material. The only other insects from this material during the summer of 1916 were *Phyllobænus dislocatus*, *Spathius tomici* and *Heterospilus* sp., although in the following year the typical association characteristics of larch limbs and tops emerged. There can be little doubt that this small pteromalid is parasitic upon one or both of the scolytids associated, it being nearly certain that *E. piceæ* at least is so affected.

Prosopis sp.

(Det. by S. A. Rohwer)

This small black and yellow bee was bred from an outdoor cage containing part of the limbs of Tree I on June 5, 1916. Members of this genus of which the habits are known, habitually breed in the pith of various weeds and pithy shrubs. Just what the relations of this small bee was to the larch is not known, but had it been only hibernating there, it would seem as if it would have appeared in the cage considerably earlier than it did. The cage contained no punky wood in which it might have bred, but several of the sections of limbs did contain the abandoned burrows of *C. dentipes* and other borers, and these borings were filled with closely packed frass. It will be readily seen that a burrow in the wood packed with frass offers conditions somewhat similar to those in pith, and it seems possible or even probable that the specimen taken had actually bred under such conditions.

Associated insects emerging at about the same time include *Polygraphus rufipennis*, *Eccoptogaster piceæ*, *Phyllobænus*

dislocatus, *Cheirpachus* sp., and *Epicallima argenticinctella*, a small moth. Insects emerging the following season comprise those borers in larch limbs and tops which require two years for their development, and the parasites upon these.

Medeterus sp.

(Det. by C. T. Greene)

A number of specimens of this small fly were bred from larch wood from a variety of different sources. However, this larch material was all similar in that it was infested with *Polygraphus rufipennis* or with both this bark beetle and *Eccoptogaster piceæ*. Small larvæ which may be the immature stage of this fly are common in the engravings of both these scolytids. Hopkins (1899, pp. 268, 450) concluded that *M. nigripes* is a primary parasite of the larvæ of *P. rufipennis*.

Associated insects in addition to the two scolytids already mentioned are *Phymatodes dimidiatus*, *Serropalpus barbatus*, *Urocerus albicornis*, *Sirex abbotii*, *Phyllobænus dislocatus*, *Spathius tomici*, *Spathius* sp., *Doryctes* sp., and *Rhyssa lineolata*.

Phorbia fusciceps Zett.

(Det. by C. T. Greene)

This small anthomyid fly is well known from the habit the larvæ have of attacking the roots of radishes, cabbages, beans, etc. It has also been said to destroy the eggs of locusts and has been suspected of being parasitic upon the beet web-worm. Howard (1894, p. 272), however, believes this latter relation is very doubtful.

Our specimens of this species were bred June 28 and July 6 from an exposed dead root of a living tree. The bark of this root was still adherent and was infested with *Dryocoetes americanus*. The wood was beginning to decay and part of it was riddled by the mines of the larvæ of *Leptura vittata*. *Dryophthorus americanus* and the larva of an unidentified elaterid were present. It is likely that this fly

was breeding in the decaying bark and probably feeding upon the decaying inner bark or the fungi developing therein.

Pollenia rudis Fabr.

(Det. by C. T. Greene)

There can be little doubt that our specimens of this fly bred upon decaying matter in the bark. They emerged under outdoor conditions in the middle and latter part of September, 1916. The insects bred from the same lot of material are *Polygraphus rufipennis*, *Dendroctonus simplex*, *Dryophthorus americanus*, *Asemum moestum*, and *Melanophila fulvoguttata*. It is likely that the fly in question breeds in the decaying frass in the burrows of most any bark or wood-boring insect, and therefore we would expect in a larger number of breeding cages to obtain it from material derived from all regions of the tree and find it associated in this material with practically all of the borers.

Epicallina argenticinctella Clem.

(Det. by Carl Heinrich)

This small moth belonging to the family *Oecophorida* was taken from a cage containing part of the limbs of Tree I. But one specimen was obtained and it appeared in the cage July 7, 1916. It is not known whether the larva had lived in the wood or whether it had gone there to hibernate. However, the latter is rendered unlikely by the fact that the limbs confined in this breeding cage were obtained from a standing tree at a distance of from 18 to 45 feet from the ground. This, together with the fact that members of this family are known to breed in "decayed wood and other dead material" (Smith, 1909, p. 560), makes the presumption that this moth had spent its larval life in the limbs more likely. The date of emergence (July 6) still further strengthens this view.

In conclusion the authors wish to express their gratitude to several sources for assistance received. Our thanks are due to Dr. E. P. Felt, State Entomologist of New York, and his two assistants, Mr. Young and Miss Hartman, for their courtesies in placing the identified specimens in the State Museum at our disposal for comparison. We wish also to thank Dr. A. D. Hopkins for his kindness in placing his corps of specialists at our disposal in identifying specimens of *Hymenoptera*, *Diptera* and *Lepidoptera*. We wish also to thank these gentlemen directly: Mr. S. A. Rohwer for identifying the *Hymenoptera*, Mr. C. T. Greene for identifying the three *Diptera*, and Mr. Carl Heinrich for naming the moth. Such help is indispensable in problems such as this and we are indeed grateful for it.

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II. ON THE INSECT VISITORS TO THE BLOSSOMS OF WILD BLACKBERRY AND WILD SPIRÆA — A STUDY IN SEASONAL DISTRIBUTION.

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A STUDY IN SEASONAL DISTRIBUTION.

By M. W. BLACKMAN, Ph. D.

No one who has collected insects during July and August in localities where the wild spiræa or meadow sweet (*Spiræa latifolia* Borkh.) is abundant can have failed to have observed what an excellent bait or trap the flowers of this plant furnish for the collector. This attractive quality has been taken advantage of for several years by the author both in the Catskills and the Western Adirondacks. In both of these regions insects are attracted to the flowers in great numbers, but this is much more noticeable in the former locality than in the latter. One of the striking characteristics of the insect fauna of the Catskills is the great relative abundance of the several genera of long-horned beetles commonly known as the lepturids (*Lepturini*). These are attracted to the blossoms of wild spiræa in surprising numbers — not only as regards individuals but also as regards species — and can readily be captured while feeding there.

These beetles and also other insects have been collected by the author from spiræa in the Catskills at various times during the summer of 1913, 1914, 1915 and 1917. During the first two seasons the specimens taken from wild spiræa were not always kept separate from those taken under other circumstances, but definite data was preserved for all specimens taken in 1915 and 1917. In the former year (1915) the collections from spiræa were made on only two dates at an interval of two weeks (August 1 and August 15). When these two collections were pinned and placed side by side, the difference in the relative abundance of several species in the two lots was so striking as to suggest the desirability of a more detailed and systematic study of the insects visiting the blossoms of spiræa and other plants, with a view to

obtaining data on the seasonal distribution and seasonal succession of certain insect forms. Such data was obtained during the past summer (1917) and is here presented.

These observations were made at the Catskill Forest Experiment Station of the New York State College of Forestry, near Tannersville, N. Y. The region covered is that extending north from the experiment station for about three-quarters of a mile and lying along each side of the road known locally as the County road. This varies in elevation from 2,150 feet at the experiment station to about 1,950 feet where the County road joins the main road to Elka Park. The area covered consists of about half wooded land and half clearing, and is bordered both on the east and on the west by more extensive forests which have not been lumbered for many years. The cleared land consists of irregular areas on each side of the road from which each year a sparse crop of hay is harvested. This yearly mowing keeps down young trees and also suppresses shrubs such as wild spiræa, blackberry and raspberry. Thus these shrubs are to be found only along the margins of the clearing, surrounding occasional isolated trees and large rocks, and in several swampy areas. The impression should not prevail, however, that the wild spiræa is either scanty or scattered, for such is far from being true. The area covered includes many thousands of the shrubs. Often a small clearing is bordered by a continuous fringe of wild spiræa, and in one case a solid block of this shrub covering about a half acre occurs in one semi-swampy area.

It will thus be seen that conditions here are ideal for many insects, especially such as feed upon pollen in their adult stage and live in dead or decaying wood in their larval condition. The adjacent forests, especially that towards the east, has been practically unmolested for years, and the numerous dead and decaying trees, which are always present in considerable numbers in undisturbed timber lands, serve as an excellent breeding place for the larvæ of the very forms which as adults are characteristically feeders upon pollen. Thus it happens that these insects, notably the lepturids —

existing under conditions which are favorable both to the larval and to the adult stages — are strikingly more numerous than in any other region of the State with which the author is acquainted.

In obtaining the data for this study the insects were collected from the flowers of approximately the same area at intervals of a week. Where the weather made it impossible to make the rounds at the stated day, the data was obtained the following day or the nearest favorable day succeeding. Thus a record was obtained of each seven-day period during the season. Most of the collections were made during the warmest part of the day between 1:30 and 3:30 P. M., when the insects supposedly were feeding in their maximum numbers, and all were made on bright, sunshiny days favorable to the insects. It was impracticable to take every insect seen on the blossoms on the day of collection, as some of them inevitably escaped, but it is believed that approximately the same proportion of those active at each period were taken. No insects were collected from spiræa or blackberry at times other than the stated interval except in a few cases where it was desired to record certain special data. The collections were made at intervals of a week, because there is good reason to believe that the life span of at least most of the insects which actually feed upon the honey or the pollen of flowers (which would include all but the casual visitors to spiræa blossoms) normally extends over more than that length of time.

Before tabulating and discussing the results of this study it might be well to say a few words regarding certain controlling natural factors such as climatic conditions. Both the summers of 1915 and 1917 were unusual in the lateness of the season — the former being remarkable for the cool weather as well as for the excessive rainfall during July and August in particular. Thus while in 1913 the wild spiræa was in full bloom and nearly at its maximum during the first week in July, and in the following year was at its best during the second and third weeks in July, in 1915 and 1917 the first blooms did not appear in the region studied until the middle

of July (first blossom in 1917 seen on July 13), and the maximum was not reached until the first week in August.

A comparison of the data collected during these four years makes unescapable the conclusion that one can foretell the relative abundance of any one of a number of species, not in terms of the calendar date, but of the condition of the blossoms which furnish them food. Thus the blossoms of wild spiraea (and doubtless other blossoms sought by insects) act as an indicator by which we may determine the seasonal distribution of certain insects depending upon them for food. In a sense the condition of the blossoms and the relative number of certain insect visitors are co-ordinated. Perhaps a more exact statement of the real relations might be made as follows: The relative abundance of the insect in the case of many lepturids and of some others, is really determined by the relative advancement of the season, and this is indicated by the condition of the blossoms upon which the insects depend for their adult food. In other words, while this synchronism works to the advantage of the insect and doubtless also to that of the plant, we cannot assume that the relation of cause and effect exists, but must rather look upon the two as separate phenomena both of which are dependent upon the same cause, the advancement of the season. Evidence leading to this conclusion will be found later, in the notes on a number of species.

In the following tabulations all of the insects mentioned were taken from wild spiraea blossoms except those of the first two weeks and a few in the third week of July, 1917, which are from the blossoms of wild blackberry. As soon as the spiraea blossoms appeared in any numbers, the pollen-eating insects seemed to desert the berry blossoms and to feed nearly exclusively upon those of the spiraea. Thus the berry blossoms, although not the favored food supply of a number of these insects, seem to serve to tide the insects over till a better source is available. It is worthy of note in this connection that several of the lepturids had passed their maximum before the appearance of the richer supply of pollen, but the greater number of individuals, even of these species,

on the appearance of the spiræa blossoms, showed a decided preference for these.

The blossoms of mountain azalea (*Rhododendron canescens* [Michx.] G. Don), which were in full bloom during the latter weeks of June, 1917, attracted quite a number of insects, but these were entirely or nearly entirely honey-feeding forms such as certain bees, moths and butterflies. Pollen-eating forms did not seem to be attracted to them.

Other flowers which coincide more or less with spiræa in their period of inflorescence include especially the "pearly everlasting" (*Anaphalis margaritacea* [L.] B. & H.) and several species of golden rod, notably the early golden rod (*Solidago juncea* Ait.), the wrinkled-leafed golden rod (*Solidago rugosa* Mill.), the white golden rod or silver rod (*Solidago bicolor* L.) and the flat-topped golden rod (*Solidago graminifolia* [L.] Salisb.). The flowers of all of these seem to exert an equal attraction to the honey-loving insects as do those of spiræa, but this is not true as regards the pollen-eating insects, although some of them, such as *Chaulignathus pennsylvanicus*, for instance, which occur in late August, must, on account of the rapid decline of the spiræa, depend upon the golden rod for most of their food. The species of golden rod most popular not only with this lamperid, but also with bees, yellow-jackets and hornets, is the flat-topped species, *Solidago graminifolia*. These began to appear in considerable numbers during the latter part of August (about August 24 in 1917) at a time when the spiræa was beginning its rapid decline.

In the following pages will be found some additional data and certain conclusions regarding a number of the species mentioned in the above table. Also notes on a few species not taken in 1917 but found on spiræa during some previous summer are added. It will be readily seen, both from the table and from these notes, that most of the abundant and interesting beetles on spiræa belong either to the subdivision of *Cerambycidae* known as the *Lepturini* or to the family *Mordellidae*. Both of these groups are well known flower frequenters and there can be no doubt that they depend upon

the pollen of flowers for their food. The richness of spiræa blossoms in this material is doubtless the reason for its popularity with these insects.

NUMBER OF SPECIMENS OF COLEOPTERA TAKEN EACH
WEEK, JULY 1-SEPTEMBER 1, 1917.

Species	July 1-7	July 8-14	July 15-21	July 22-28	July 29- Aug. 4	Aug. 5-11	Aug. 12-18	Aug. 19-25	Aug. 26- Sept. 1
<i>Leptura mutabilis</i> Newn.	8	3	1						
<i>Leptura pubera</i> Say.	11	8	5	7					
<i>Leptura sphaericollis</i> Say.	2								
<i>Pachyta monticola</i> Rand.	1								
<i>Leptura lineola</i> Say.	1	1	4	1					
<i>Leptura vittata</i> Oliv.		4	6	13	4	8	3		
<i>Leptura nana</i> Newn.			1						
<i>Leptura proxima</i> Say.			2	9	16	15	15	3	
<i>Leptura vagans</i> Oliv.			1		1		2	1	1
<i>Strangalia luteicornis</i> Fabr.			1	1		1			
<i>Leptura rubrica</i> Say.				7	13	1	4	1	1
<i>Leptura plebeja</i> Rand.				1					
<i>Typocerus velutinus</i> Oliv.				5	14	17	12	5	3
<i>Leptura cordifera</i> Oliv.				2	1	5	3	4	1
<i>Leptura canadensis</i> Oliv.						1	17	9	3
<i>Oberia tripunctata</i> Swed.	1	1							
<i>Oberia bimaculata</i> Oliv.		2							
<i>Clythanthus ruricola</i> Oliv.			1	1	4		2		
<i>Orsodachna atra</i> Ahrens.			1						
<i>Gallerucella decora</i> Say.			1	1					
<i>Nolonta puncticollis</i> Say.				1					
<i>Trihabda virgata</i> Lec.							2		
<i>Diabrotica 12-punctata</i> Oliv.							1		
<i>Diachus auratus</i> Fabr.								1	
<i>Anthrenus castaneae</i> Melsh.			1				2	2	
<i>Dolopius lateralis</i> Fsch.		1					1		
<i>Asaphes decoloratus</i> Say.							1		
<i>Agrilus ruficollis</i> Fabr.		1							
<i>Podabrus tomentosus</i> Say.	1								
<i>Podabrus regulosus</i> Lec.		1							
<i>Pyropyga decipiens</i> Harr.						1			
<i>Chaulignathus pennsylvanicus</i> DeC.							1	4	7
<i>Ditemnus</i> sp.								1	
<i>Trichodes nuttalli</i> Kirby.			2					1	
<i>Trichius affinus</i> Gory.		9	4	5	1		2	1	1
<i>Macroductylus subspinosus</i> Fabr.				1					
<i>Isonira similis</i> Blatch.	1								
<i>Arthromacra aenea</i> Say.		1					1		
<i>Anaspis rufa</i> Say.		2	11	9	+	+	16	+	
<i>Mordellistena morula</i> Lec.		1							
<i>Mordellistena biplagiata</i> Helm.			2	3	2	1	1		
<i>Mordellistena ambusta</i> Lec.							2		
<i>Mordella marginata</i> Melsh.			3	2	1	3	2	1	1
<i>Epicauta pennsylvanica</i> DeC.									1
<i>Odontocorynus scutellum-album</i> Say.			1	3	2		4	2	

Leptura mutabilis Newn. As will be seen from the table, this species was at its maximum in 1917 during the first half of July. All but two specimens were taken from wild black-

berry blossoms. Of these two, one was from a spiræa blossom, while the other was taken June 22 from the surface of a beech log felled three years before. Of the twelve specimens taken in 1917, eleven of which were from flowers, eight are of the testaceous variety known as variety *luridipennis*. *L. mutabilis* has been bred from a small branch of a dying alder obtained near Syracuse, and Mr. Carl Wright, a student in the college, has taken a specimen of the testaceous form from the wood of hemlock at Cranberry Lake, N. Y. Apparently it has a variety of hosts.

Leptura pubera Say. The seasonal distribution of this species nearly coincides with that of *L. mutabilis*, but extends slightly later. Specimens were numerous upon blackberry blossoms until the appearance of the spiræa blooms, when they showed a very marked preference for the latter. During the first three weeks in July this species was decidedly the most common lepturid. In 1914 several specimens were taken from daisy heads.

Leptura sphericollis Say. But three specimens of this species were taken in 1917, two from wild blackberry in the first week in July and one from mountain azalea on June 20. These all are of the typical form with the black prothorax. Three specimens were also taken in July, 1914, of which two are of the typical coloration and one has the red prothorax characteristic of the variety *ruficollis*.

Pachyta monticola Rand. But one specimen of this lepturid was taken during the last season and it was obtained from a blackberry blossom on July 3. The only other specimen taken by the author from this same general region was from the bark of recently felled balsam tree, July 8, 1914. No breeding data is available, but it is believed the specimen captured on balsam was preparing to oviposit. Wickham (1897, p. 171) records the adult from the blossoms of wild rose.

Leptura lineola Say. This species, which in the region studied is never one of the most abundant lepturids, has a seasonal distribution extending over July, the maximum

number in 1917 having been taken during the third week. One specimen was also taken in July, 1914, and two on August 1, 1915. It has reached its maximum numbers about the time the wild spiræa begins to bloom.

Leptura vittata Oliv. This very abundant species begins to appear in some numbers before the wild spiræa blossoms, but does not reach its maximum until these flowers are nearly at their best. In both 1915 and 1917 they had practically disappeared by the middle of August. Copulating pairs were seen July 17 and 27 (numerous) and August 17. The specimens show a considerable range of variation in the coloration of the elytra but this variation is within much narrower limits than in *L. mutabilis* *L. vagans*, etc. *L. vittata* has been bred from dead larch wood but doubtless breeds in spruce and balsam in the Elka Park region as little or no larch is present there.

Leptura nana Newm. Only two specimens of this small species have been taken from Elka Park. Of these, the one taken July 20, 1917, is entirely black, while the other specimen taken July 23, 1914, is of the variety *hamatites* characterized by the red prothorax. Nothing is known regarding its breeding habits.

Leptura proxima Say is perhaps the most abundant lepturid in the Elka Park region, its only rival in this respect being *Typocerus velutinus*. In all, some 60 specimens were taken in 1917, all but one of which were on the blossoms of spiræa. This single exception was on elderberry blossoms (*Sambucus canadensis* L.), but apparently had merely alighted there as it was not feeding. The seasonal occurrence of this species may be said to correspond nearly exactly with that of the wild spiræa blossoms. It begins to appear with the first blossoms of the spiræa, is at its maximum during the greatest abundance of these, and decreases in numbers with the waning of the flowers. The data from other years agrees entirely in this respect. Copulating pairs were common throughout the last week in July and the first three weeks in August. Wickham (1897, p. 192) reports

this species as having been bred from maple. No additional data is at hand.

Leptura vagans Oliv., while never as numerous as several other species, has about the same seasonal distribution as *L. proxima*. Six specimens were taken in 1917 — three of the typical variety having black elytra with a reddish brown marginal stripe and three having the elytra entirely testaceous. In 1915 eight specimens showing about the same seasonal distribution were taken — two on August 1 and six on August 15. Of these, three are of the testaceous variety and five are typical. The larvæ have been reported (Wickham, 1897, p. 192) as boring in yellow birch and hickory and it is likely that the former of these two trees acts as host in the Elka Park region.

Strangalia luteicornis Fabr. Only three of these were taken in the region studied — not a sufficient number for me to venture any statement regarding the period of greatest abundance. Nothing is known regarding its larval host.

Leptura rubrica Say begins to appear in numbers during the second week of the blooming season of spiræa and continues in considerable numbers for nearly a month. In 1914 thirteen specimens were taken on July 23 and this species was doubtless at its maximum at that time, this being entirely in accord with the data on other forms which show that the season of 1914 was about two weeks earlier in its advancement than in 1915 and 1917. My field notes record copulating couples as common on July 27 and August 3. *L. rubrica* has been bred from hickory at Syracuse.

Leptura plebeja Rand. Only one specimen has been taken by me in the Elka Park region and this gives no basis for a conclusion regarding seasonal distribution. However, from the fact that I have specimens from Cranberry Lake taken on July 12 and September 16 it is believed this species may occur at any time in late summer. It is apparently not very common in either of the regions mentioned. An adult of this species has been obtained from spruce wood in the Cranberry Lake region of the Adirondacks.

Typocerus velutinus Oliv. is one of the extremely common and numerous forms upon spiræa blossoms. It begins to appear soon after these flowers and occurs in maximum numbers when they are at their best. In general its seasonal distribution is similar to that of *L. proxima*, but appears to be about one week later both in its beginning and its decline. The data for the various years check very closely when judged in terms of the advancement of the season or of the condition of the blossoms upon which the adults depend for food. Copulating pairs were observed on July 27, August 3 (common) 9 and 17 respectively. *T. velutinus* shows a very considerable degree of variation in its color pattern. The light bands are nearly obsolete in some cases while in others they are so enlarged as to show a tendency to fuse more or less. Several adults have been bred from much decayed hickory at Syracuse and it is likely that it breeds in decayed wood of a variety of species of trees.

Leptura cordifera Oliv. has the same seasonal distribution as *T. velutinus* but in the region studied is not so extremely common as this other lepturid. There is much variation here as regards relative amount of black and yellow on the elytra. It has been bred from chestnut (Lugger, 1884, p. 204).

Leptura canadensis Oliv. The seasonal distribution of this form is interesting from the fact that it appears later in the summer than any of the other lepturids taken on wild spiræa. Another interesting fact is that up until August 13, but a single specimen had been seen and yet in this week seventeen specimens were taken — it being the most numerous lepturid at that time and remaining so for the rest of the season. Of the 30 specimens taken in 1917, six are of the variety *erythroptera* and the rest, which are of the more typical coloration show considerable variation in the amount of red upon the elytra. There is considerable disproportion in the number of males and females taken from the flowers, for of the thirty specimens twenty-four are males. Of the red-winged variety three were males and three females.

One sexual difference in this species is that in the male the antennæ are strongly serrate and are entirely or nearly entirely black while in the female they are quite feebly serrate and according to Leng (1890, p. 189) joints 4-11 are annulate with yellow. As a matter of fact, the antennæ in both sexes are subject to considerable variation as regards color. The following data on the variation in the antennæ of the males of *Leptura canadensis* is based on a study of fifty-two antennæ from thirty-one individuals, some of the specimens having lost on antennæ:

Antennæ entirely black.....	33	from 19 individuals.
Antennæ with joint 8 with more or less yellow at base	18	from 11 individuals.
Antennæ with joint 6 with more or less yellow at base	1	from 1 individual.
Antennæ with joints 6 and 8 more or less yellow at base	1	from 1 individual.

Except in one case, the two antennæ on the same individual were similar.

The variation in the female antennæ is more striking. The thirteen females studied agree in having joints 1, 2 and 3 and 11 entirely black and joints 5, 6 and 8 with more or less yellow. The following tabulated data on variation in the antennæ of the female of *Leptura canadensis* is based on a study of twenty-two antennæ from thirteen individuals.

With joints 4-10 all more or less yellow...	7	from 4 individuals.
With joint 4 entirely black	3	from 2 individuals.
With joint 7 entirely black	11	from 7 individuals.
With joint 9 entirely black	14	from 8 individuals.
With joint 10 entirely black	4	from 3 individuals.
With joints 7, 9 and 10 entirely black.....	3	from 2 individuals.
With joints 7 and 9 entirely black.....	10	from 6 individuals.
With joints 8 entirely or nearly entirely yellow low	19	from 11 individuals.
With joints 6 entirely or nearly entirely yellow low	14	from 9 individuals.
With joints 6 and 8 entirely or nearly entirely yellow	13	from 9 individuals.

It will be seen from the above that in the specimens from the Elka Park region taken in 1915 and 1917 there is a tendency toward joints 4, 7, 9 and 10 to be entirely black, and

this is especially noticeable in joints 7 and 9. There is a still more decided tendency for joints 6 and 8 to become entirely yellow, this condition being especially true as regards joint 8.

Dr. Felt (1906, p. 670) reports this lepturid as breeding in spruce and hemlock and the author has taken it from spruce.

Other Lepturids. In addition to the Lepturids listed above, all of which were collected in 1917, there are a number of other species taken other years which should be mentioned.

Acmeops directa Newm. Four specimens of this lepturid were taken from the flowers of wild spiræa and other blossoms during the third week in July, 1914. Considerable variation in color is noticeable in these specimens.

Bellamira scalaris Say. But one specimen of this striking insect has been taken by me in the vicinity of Elka Park and this was obtained from spiræa bloom during the third week in July, 1914. This insect habitually breeds in yellow birch (Packard, 1890, p. 486). Large numbers of the larvæ, pupæ and newly transformed adults were found in a birch log in the region of Cranberry Lake, N. Y., in July, 1917, by Prof. C. J. Drake of this Department.

Leptura subhamata Rand. Two males of this species were collected July 23, 1914, from wild spiræa near Elka Park. Wickham (1897, p. 192) reports it as having been taken in a beech log.

Leptura subargentata Kirby. Seven specimens of this species were taken in July, 1914, four from flowers (probably spiræa, but notes do not specify) and three taken on the wing and upon felled balsam near the top of Twin Mountain.

Leptura circumdata Oliv. Four specimens of this species were obtained from spiræa blossoms July 23, 1914. Prof. C. J. Drake reports having cut an adult of this species from a spruce log near Cranberry Lake in July, 1917.

Leptura biforis Newn. One specimen of this beetle was taken July 23, 1914, from spiræa bloom. Nothing is known regarding its breeding habits.

Leptura vibex Newn. A single example of this species was taken July 10, 1914, from leaves about half way up Spruce Top Mountain. It is not known that this species ever visits wild spiræa but from the great uniformity in habits shown by the adults of this genus it seems probable.

Leptura aurata Horn. Two specimens were taken from spiræa July 23, 1914. Nothing further is known regarding its habits.

Only a few species of Coleoptera other than the lepturids already treated were taken in sufficient numbers for any conclusions to be drawn regarding their seasonal distribution. A few of these are briefly mentioned below.

Oberea tripunctata Swed. and *Oberea bimaculata* Oliv. may be mentioned together. Two specimens of each were taken during the first two weeks of July, 1917, from blossoms of wild blackberry in the stems of which they are said to breed.

Clytanthus ruricola Oliv. This cerambycid occurs at its maximum numbers in late July and early August at the height of the wild spiræa season. While it frequents these flowers by preference it is also occasionally seen on the flowers of the daisy, golden-rod and others. A number of specimens of this form have been bred from hickory at Syracuse but no hickory occurs in the Elka Park region and it must depend upon some other wood. In one case a specimen was observed which was apparently preparing to oviposit in beach and it is probable this serves as a larval host.

Chaulignathus pennsylvanicus DeG. is well known to be a late season form. It appears about the middle of August and does not occur in great numbers until the spiræa blossoms are decidedly on the wane and the golden rods are at their maximum. For that reason much larger numbers are to be seen on golden rod than upon spiræa, Yet in spite of this it will be seen from the table that the specimens actually

taken from spiræa were continually on the increase up to September 1, although the numbers of these blossoms were rapidly decreasing.

Trichius affinus Gory. Although this beetle occurs in some numbers throughout the entire summer, it is more numerous in July. It is found in the early season most frequently on the blossoms of raspberry, blackberry and daisy but with the appearance of the spiræa bloom it shows a decided preference for this.

Five species of *Mordellidæ* were taken from the blossoms studied and three were very common. The most common form is *Anaspis rufa* Say, which is present in considerable numbers from the third week in July until the close of the season. No effort was made to collect these consistently after the third week in July and on several of the weeks the specimens were so numerous that they were not saved. The general assertion, however, may be safely made that the seasonal distribution is timed to that of the spiræa blooming period. *Mordellistena biplagiata* Helm. seems to reach its maximum before the spiræa bloom is at its best and no specimens were taken after August 17. *Mordella marginata* Melsh. has about the same seasonal distribution as *Anaspis rufa*.

Odontocorynus scutellum-album Say. This small curculionid was taken on no other flower than that of wild spiræa where it appeared to be feeding upon pollen. Its occurrence coincides very closely with that of this blossom. A pair in copulation was observed July 25, 1917.

It is probable that most of the remaining beetles which are included in the table, but are not mentioned in the notes, are more or less casual or accidental visitors and are not on the flowers in search of food. Probable exceptions to this statement are furnished by *Anthrenus castaneæ* Melsh. and *Epicauta pennsylvanica* DeG., both of which are probably pollen eaters.

The preceding table of hymenopterous visitors to the blossoms of wild spiræa perhaps needs little explanation or comment. It should, however, be remembered that these insects represent forms having rather diverse habits and modes of life. Thus the objects gained by the insects in visiting the flowers varies considerably. Some of them doubtless obtain only honey; others — a more numerous class, including the various bees and social wasps — seek both honey and pollen; others, perhaps, are in search of pollen only; while still others are in search of their prey. A few should be classed as casual visitors only — having alighted upon the blossoms by accident.

The number of specimens of most of the species listed in the table is not sufficiently great to warrant any deductions regarding seasonal distribution. Some few species, however, occurred in sufficient numbers to make a tentative conclusion desirable. Some of these are briefly discussed below.

Allantus dubius Nort. This saw-fly begins to frequent the flowers of spiræa in considerable numbers during the first week of the blossoming season. Indeed they seem to be at their maximum at this time and in succeeding weeks are gradually on the decrease. It is not known upon what this insect fed before the appearance of the spiræa, as there were none taken from wild blackberry or other blossoms. Nothing was found regarding the breeding habits.

Allantus basilaris Say begins to appear upon the spiræa during the fourth week of July, reaches its maximum at the middle of August and no specimens were taken after August 25. This species is not quite so numerous as the sister species, only eighteen specimens being taken, and of these only three are males.

Vespula (Vespa) diabolica De Saussure, one of the commonest of the colonial wasps, may be taken as a good example of insects of this genus and general mode of life. This insect is a frequent visitor to wild spiræa in search both of honey and pollen. It, however, does not visit the blossoms of this plant to the exclusion of other flowers, but during the height of the blooming season seems to prefer these flowers to all

others. Later when *Solidago graminifolia* is in full bloom and is very abundant these blossoms are sought by the yellow jackets in great numbers. Even at this time, however, a proportional number apparently visit the few spiræa blossoms remaining. Regarding the seasonal distribution of the yellow jacket and of other species of the same genus, as would be expected of a colonial form, there is a rather gradual numerical increase during early and midsummer and a very rapid increase later in the season. This rapid increase in 1917 commenced during the first week in August and by the middle of this month this species was so common that specimens were no longer retained. However, it was apparent that they were rapidly increasing in numbers up to the time observation ceased, September 2, at which time individuals of the various species of *Vespula* far outnumbered all other flower visitors combined.

Bremus (Bombus) terricola Kirby. This bumble-bee, which apparently is the most common one frequenting spiræa blossoms in the Elka Park region, may be used as an example of the genus. Its seasonal distribution as shown by its relative abundance upon spiræa is similar to that of the yellow jacket although it is never quite so numerous. This is to be expected from the similarity in habit between these forms both of which are colonial forms and visit the blossoms in search of honey and pollen.

The data regarding most of the remaining Hymenoptera is not complete enough to warrant important conclusions. In the case of such forms as the various species of *Psammochares*, *Odynerus*, *Eumenes*, *Solenius* and *Cerceris*, the visits of which to spiræa blossoms are probably as likely to be in search of prey as for obtaining honey or pollen, we would not expect much uniformity of occurrence. Therefore a curve showing the numbers occurring at stated periods on one particular species of flower would not be so likely to represent the true seasonal distribution of the species because prey could likely be obtained from many other sources.

The ants listed above, the species of which were kindly determined by Mr. M. R. Smith of the Bureau of Ento-

mology represent only specimens collected accidentally except those taken in the last week in August. It might be said, however, that ants are constant visitors to the blossoms of spiræa and blackberry throughout the entire season. They are perhaps the most consistently numerous insect visitors as they are to be found working among the blossoms in almost every kind of weather except during heavy rain storms and even then some are stranded there. It is likely that their primary object is to obtain nectar but it is by no means improbable that they eat pollen as well.

NUMBER OF SPECIMENS OF HEMIPTERA TAKEN EACH WEEK, JULY 1-SEPTEMBER 1, 1917.

Species	July 1-7	July 8-14	July 15-21	July 22-28	July 29-Aug. 4	Aug. 5-11	Aug. 12-18	Aug. 19-25	Aug. 26-Sept. 1
<i>Euschistus euschistoides</i> Voll.	2								
<i>Euschistus tristigmus</i> Say.						1*			
<i>Euschistus variolarius</i> P. B.					-1	1a-	1n-		
<i>Acrosternum hilaris</i> Say.						1n-			
<i>Meadorus lateralis</i> Say.								1	
<i>Alydus eruinus</i> Say.					-1-				
<i>Corizus crassicornis</i> Linn.								2a-1n	1n
<i>Phlegyas abbreviatus</i> Uhl.							1		
<i>Sinea diadema</i> Fabr.						1n		2a	
<i>Neurocolpus nubilus</i> Say.					1				
<i>Adelphocoris rapidus</i> Say.				1	2	1	2	4	3
<i>Lygus vanduzeei</i> Knight.	1		1	1				1	
<i>Lygus pratensis</i> Linn.						4			
<i>Lygus</i> sp. a.		2							
<i>Lygus</i> sp. b.								1	
<i>Lopidia instabile</i>						2	5	3	1
<i>Plagiognathus</i> sp.			2	7	1		4	1	1
<i>Aphrophora quadrinotata</i> Say.							1		
<i>Graphocephala teliformis</i> Walk.					1		1		

* The letter "a" signifies adult, the letter "n" signifies nymph.

Probably little comment is necessary regarding the *Hemiptera* listed above. It is likely that most of these should be looked upon as casual visitors, and not as forms which visit the flowers to obtain some portion or product of these for use as food. Where such a casual or accidental relation exists, it is apparent that quantitative data of the insect on the flower would not be likely to furnish a reliable foundation upon which to base conclusions regarding its sea-

sonal abundance. It is possible that a few of these bugs actually were obtaining food from the flowers, and if it should prove that the spiræa is the favorite source of food, the data for such forms should lend itself to the formation of a reliable curve showing seasonal distribution. In the case of *Lopidia instabile*, one of the most consistent hemipterous visitors to spiræa blossoms, the curve is at least not unbelievable.

I am indebted to Prof. C. J. Drake, my colleague, in the department for his kindness in identifying the Hemiptera, listed in the table.

NUMBER OF SPECIMENS OF DIPTERA TAKEN EACH
WEEK, JULY 1-SEPTEMBER 1, 1917.

Species	July 1-7	July 8-14	July 15-21	July 22-28	July 29- Aug. 4	Aug. 5-11	Aug. 12-18	Aug. 19-25	Aug. 26- Sept. 1
<i>Asilus orphne</i> Wk	1	1							
<i>Criorhina analis</i> Macq.		1							
<i>Chilosia similis</i> Shannon		1							
<i>Tephritis albiceps</i> Lw.			1						
<i>Hammerschmidtia ferruginea</i> Fallen				1					
<i>Chrysogaster nigripes</i> Lw.				1					
<i>Pangonia tranquilla</i> O. S.						8	2		
<i>Ceraturgus cruciatus</i> Say						1			
<i>Peleteria robusta</i> Wd.						1			
<i>Hemyda aurata</i> Dew.						1			
<i>Chrysogaster pulchella</i> Will.						1			
<i>Criorhina intersistens</i> Wk.						1			
<i>Spilomyia fusca</i> Lw.						1	2	3	
<i>Syritta pipiens</i> L.							1		
<i>Eristalis tenax</i> L.							2		1
<i>Tabanus trispilus</i> Wd.							1		
<i>Gymnosoma fuliginosa</i> Dew.							1		
<i>Eristalis bastardi</i> Macq.								1	1
<i>Anthrax alternata</i> Say									1
<i>Eurosta coma</i> Wd.									2

Of the *Diptera* listed in the accompanying table only a few should probably be classified as other than casual visitors to the blossoms of spiræa. It seems certain that some at least of the *Syrphidæ* obtain nectar from these flowers, and if these insects were present in any considerable numbers, they should furnish reliable data regarding the season of greatest abundance. However, the numbers in all cases were so lim-

ited as to make it unwise to deduce more than rather general conclusions. Thus we can say that *Pangonia tranquilla* is most abundant in the Elka Park region when the blossoms of wild spiræa are at their maximum, which in 1917 was during the first half of August. Similarly we may say that *Spilomyia fusca* begins to appear at about the same time but does not reach its maximum numbers until the spiræa blossoms are decidedly on the wane. This species then, does not appear until *Vespula marginata* and other similar black and white hornets of which it is a mimic, are becoming quite numerous, and does not reach its maximum numbers until these hornets are the most abundant flower visitors. The very striking resemblance of the fly and hornet can but be admitted by anyone who has collected both from the same flowers.

I am under obligations to Prof. A. S. Hine of Ohio State University for his kindness in identifying the flies in the above table.

In addition to the various *Coleoptera*, *Hymenoptera*, *Hemiptera* and *Diptera* which are listed in the accompanying table a considerable number of insects belonging to other orders were observed on spiræa blooms. Doubtless the majority of these were casual visitors which would be no more likely to be found on blossoms than on any other structure occurring in the same location. This is certainly true of several species of dragon flies, grasshoppers, katydids, caddisflies, etc. In addition to these, several moths and a number of butterflies were seen upon spiræa blossoms, but no effort was made to obtain quantitative data of any of these. The following butterflies were observed upon the blossoms of spiræa: *Papilio turnus* Linn, *P. polyxenes* Fabr., *Feniseca tarquinius* Fabr., *Basilarchia arthemis* Drury, *B. astyanax* Fabr., *B. archippis* Cram., *Grapta progne* Cram., *Argynnis cybele* Fabr., and *Erynnis* sp. The moths taken are fewer in number of species and include *Hæmorrhagia diffinis* Boisd., *Lycomorpha pholus* Drury, *Ctenucha virginica* Charp., *Synanthedon bassiformis* Walk., *S. acerni* Clem., and *Oxyptilis* sp. These moths apparently were on the

flowers in search of food as some of them when taken were observed to have their probosces uncoiled and searching about among the flowers for the nectaries.

In arriving at conclusions regarding seasonal distribution and seasonal succession of insects from data such as here presented, it is wise to scrutinize such data with the greatest of care. It has already been shown that the collections were made as nearly as possible at intervals of seven days. But it was considered to be more important that the climatic conditions — temperature, moisture, light and wind — should be as nearly uniform as possible, than that the interval should be exactly one week. Of course, some variation of these conditions were inevitable and unavoidable but the collection days were as uniform as possible and the results are believed to be entirely trustworthy in this respect.

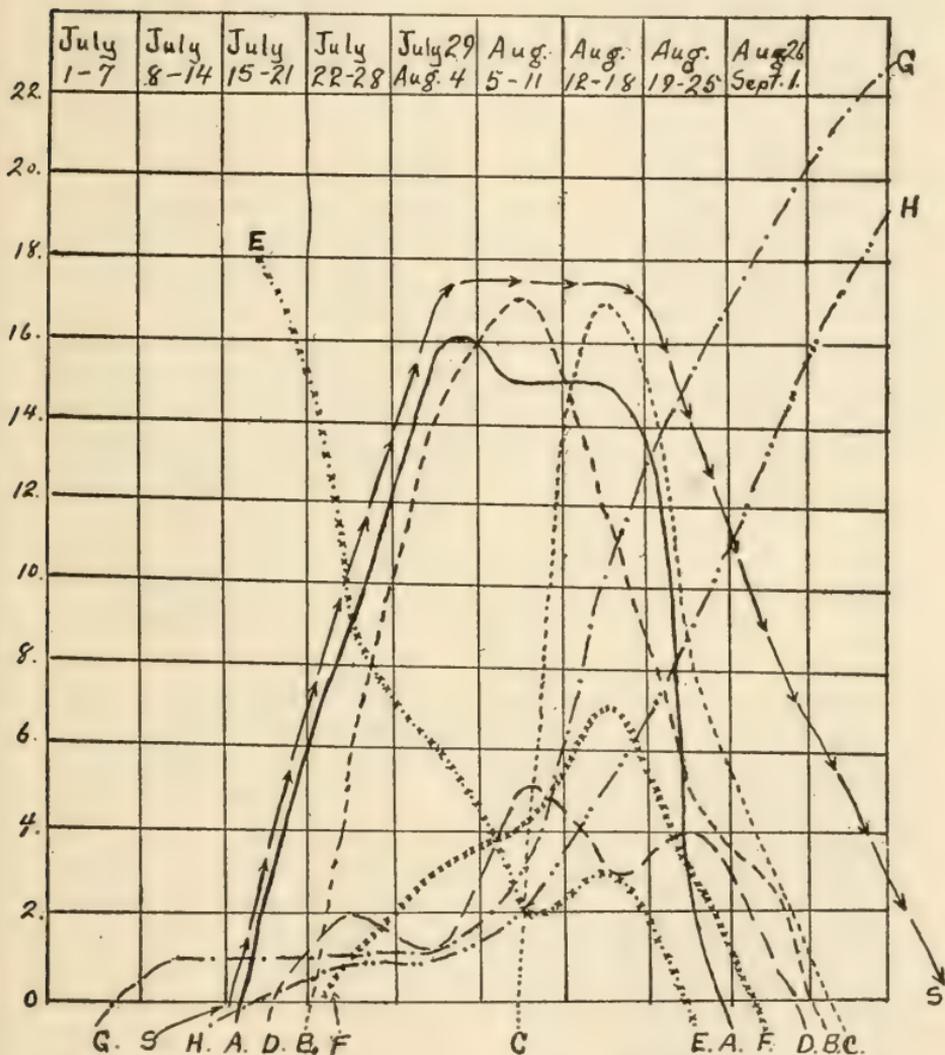
The validity of conclusions from such data is also dependent upon the uniformity with which each species of insect seeks the blossoms from which the collections are made. Thus in the case of some of the insects from spiræa blossoms, it is believed that the number taken on any date represents a fairly definite per cent of those actually in the adult condition at that time. In other cases it is believed that the numbers taken have not even an approximately definite relation to the numbers actually out. The object of the insect's visit to the blossom has much to do with the reliability of the data for the purpose mentioned. Thus, if the insect is in search of honey or of pollen or of both of these, and if observations have shown that the blossoms in question are the favorite source of this material, the data should be reliable. If the insect visitor is in search of insect prey, the data is not so valid unless it is established that the predaceous or parasitic form is in search of some particular species which is usually to be found only on the flower in question. If the insect is an accidental or casual visitor which has happened to alight upon the flower the data is valueless, as the number taken from flowers would bear no fixed relation to the actual numbers at the time.

It would seem then, that in the case of an insect feeding upon pollen or honey, or both, which has shown a preference for that derived from the spiræa blossom, a curve showing its numerical abundance upon this flower at fixed intervals, should represent its seasonal distribution. The accuracy of this curve would depend upon the factors already mentioned. The larger the number of insects taken at each period and the larger per cent collected of those actually out, the more reliable will be the curve. It is apparent that when the number of specimens of a consistent visitor to spiræa is great enough, quantitative data furnishes material for the construction of a reliable curve showing seasonal numerical distribution.

A number of curves from such data are shown in the accompanying figure. It will be seen that typically they fall into two general classes dependent upon the habits and mode of life of the insect. In cases of species which live as individuals (*i. e.*, not in colonies), the curve typically shows an even rise, which may be either gradual — such as *Allantus basilaris* — or sudden — such as *Leptura canadensis* — until a maximum is reached. This maximum may be held for several weeks followed by regular decline, as in *Leptura proxima*, or a more or less gradual drop may follow the maximum immediately, as in the curves of *Typocerus velutinus* and *Leptura cordifera*. The irregularity in the curve of *Leptura cordifera* is due to the small number of specimens of this species taken as it is apparent that in a small number, a variation of one or two individuals causes a relatively great irregularity in the curve.

The curve showing the seasonal distribution of colonial insects such as the yellow-jackets, hornets and bumble-bees, is of quite a different character as will be seen by studying G and H of the accompanying figure. Here the insects (fertile females) appear in small numbers with the beginning of the flowers in early summer. These little more than hold their own until the season has advanced to such a degree that the spiræa blossoms have about reached their maximum, when with the appearance of an ever-increasing number of workers,

CURVES SHOWING THE SEASONAL DISTRIBUTION OF CERTAIN INSECTS TYPICAL OF THOSE VISITING THE BLOSSOMS OF WILD SPIRÆA.



A — *Leptura proxima*
 B — *Typocerus velutinus*
 C — *Leptura canadensis*
 D — *Leptura cordifera*

E — *Allantus dubius*
 F — *Allantus basilaris*
 G — *Vespa (Vespa) diabólica*
 H — *Bremus (Bombus) terricola*

S — Blossoms of *Spiraea latifolia*.

the curve showing numerical abundance soars upward and continues rising until the onset of cold weather. It is not known exactly what would be the course of the curve following the first heavy frost, but there would doubtless be a very rapid drop as the wasps and bees sought hibernation quarters.

One interesting observation regarding the seasonal distribution of several of the lepturids especially, is apparent both in the table and in the curve. This is the fact that all of the late summer lepturids showed a rapid decrease in numbers after August 17, 1917. At this date the spiræa blossoms were only just beginning to wane and several of the lepturids as *Leptura proxima* and *L. canadensis* were still at their maximum and *L. cordifera* and *Typocerus velutinus* were but little below their highest numbers. Yet by the following week *L. proxima* had nearly disappeared and there was a very striking decrease in all of the lepturids. This rapid drop in numbers then occurred in 1917 before any frost and was out of all proportion to the decrease in spiræa blossoms. A careful search was made upon the blossoms of other plants, and while the various *Vespidæ* and *Bombidæ* and beetles such as *Chaulignathus pennsylvanicus* were present there in ever-increasing numbers no specimen of lepturids were found. It apparently is a case where insects cease feeding on the approach of cold weather but a considerable time before killing frosts occur. In the cases of insects which hibernate either as adults or as immature forms such cessation of feeding before the fall frosts might be spoken of as an adaptive response, as it seems to be generally understood that insects are better able to hibernate at low temperature when the digestive processes have ceased some time and the alimentary canal has been entirely emptied of food and waste materials. The species in question, however, doubtless never hibernates in the adult condition, and it is believed that the response to the cool nights which herald the approaching frosts results in cessation of feeding and more prompt ovipositing on the part of the adults already out. It is likely also that the cool nights react upon the

larvæ and pupæ which are about ready to transform, in such a manner as to postpone the completion of their life cycle until the following summer. This latter is in line with numerous observations of the author which show that the duration of the life history of many species of boring insects is subject to considerable variation, due often to apparently only small differences in the environmental conditions.

My thanks are due to several men for the assistance they have given by identifying specimens. I wish to thank Dr. Harry P. Brown of the Department of Dendrology of this college, for identifying the several plants mentioned; Prof. C. J. Drake, my colleague in the Department of Entomology of this college for naming the Hemiptera; Prof. J. S. Hine of the Department of Zoology and Entomology, Ohio State University, for naming the flies, and Mr. M. R. Smith of the Bureau of Entomology, U. S. Department of Agriculture, Baton Rouge, La., for identifying the ants.

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EXPLANATION OF PLATES.

All photographs were made by the senior author.

Plate 1.

FIG. 1. View of the inner bark of American larch, showing the burrows of *Dendroctonus simplex*. The wider passages are the egg-galleries made by the adults, while the shorter burrows at right angles to them are the larval mines. Note the arrangement of the larval mines in alternate groups of from three to six on opposite sides of the egg-gallery. This is best shown in connection with the egg-gallery at the right-hand side of the picture. About four-fifths natural size.

PLATE I.

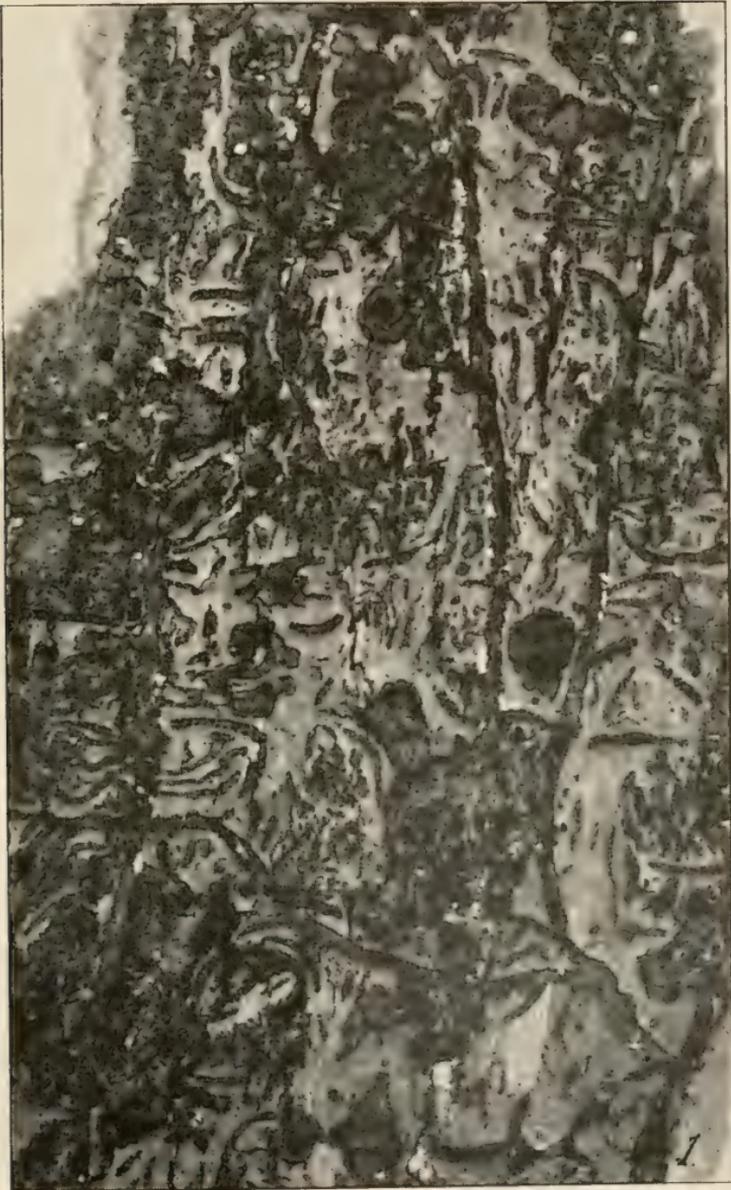


Plate II.

FIG. 2. Top of American larch with the outer bark removed, showing the burrows of *Polygraphus rufipennis*. Note the engravings with one, two and four egg-galleries. It will be seen that the egg-galleries are typically and nearly invariably transverse, while the larval mines are longitudinal. Reduced to seven-tenths natural size.

FIG. 3. Burrows of *P. rufipennis* in the inner bark of the trunk of the American larch. Note the direction of the egg-galleries and the variation in the number of these in the different engravings. The bark even on the trunk of larch is relatively thin, and therefore the nuptial chamber is here at the juncture of inner bark and sapwood. Slightly less than one-half natural size.

FIG. 4. Burrows of *P. rufipennis* in the inner bark of red spruce. The bark here is thicker than in larch and the nuptial chambers of the burrows are therefore in the outer part of the inner bark and not visible. Reduced to about three-fourths natural size.

FIG. 5. Section of the trunk of larch from which the greater part of the outer bark has been removed by woodpeckers, exposing numerous burrows of *P. rufipennis* and one burrow of *Monohammus scutellatus*. These birds have acted as a partial check upon the borers, as a large per cent of the latter had been eaten by them; yet in spite of their work the number of borers which remained alive was considerably larger than the number originally entering the bark. Thus, while woodpeckers render efficient assistance in keeping down the numbers of boring insects, they cannot be depended upon to restore the balance of nature unless aided by artificial or by other natural factors. Reduced to about two-fifths natural size.

PLATE II.



Plate III.

FIG. 6. Another section of trunk of larch tree showing the work of woodpeckers in removing the outer bark in order to feed upon the borers therein. In this case the work has not been quite so thorough as in Fig. 5. Reduced to about two-fifths natural size.

FIG. 7. General view of the engravings of *Eccoptogaster piceæ* upon the surface of the wood of larch tops, showing the general appearance of larch wood one year after it has been attacked. This section of the tree contained nearly a pure culture of *E. piceæ*, but one engraving of *P. rufipennis* may be seen near the lower left-hand corner of the photograph. Note the different types of burrows. Reduced to slightly less than two-fifths natural size.

FIG. 8. Engraving of *E. piceæ* in larch, showing the burrow with two egg-galleries, which is the most common type. Note that there is a much larger number of egg niches in the upper egg-gallery, although in this case the two are about the same length. Typically the upper egg-gallery, which is the first one begun, is both longer and contains more egg niches. The larval mines at first are nearly parallel to each other and at nearly right angles to the egg-gallery, but later they become very tortuous. The wider, deeper, more tortuous burrows (as those in the upper left-hand region of the picture), which appear whiter on account of their grooving the sapwood so deeply, are made by the young adults, which feed in the old host for a time before emerging. About four-fifths natural size.

FIG. 9. Engraving of *E. piceæ* with three egg-galleries. About four-fifths natural size.

PLATE III.



Plate IV.

FIG. 10. Burrow of *Eccoptogaster piceæ* in larch, having only one egg-gallery. The length of this one is remarkable even for uniramous burrows, as is also the number of egg-niches. Slightly more than three-fourths natural size.

FIG. 11. View of the inner bark of larch, showing the burrows of *Crypturgus pusillus* arising from the engravings of *P. rufipennis*. This shows the usual confused appearance after the larvæ have developed and destroyed the egg-galleries. The flocculent white material is due to fungi. Reduced to about four-fifths natural size.

FIG. 12. Engraving of *Crypturgus pusillus* in the inner bark of red spruce. In this case twenty-two egg-galleries arise from the nuptial chamber of an abandoned burrow of *P. rufipennis* and several more from the egg-gallery. The egg-galleries here are not so much destroyed by the larvæ as usual because most of these have burrowed at another level, in the outer part of the inner bark. About three-fourths natural size.

FIG. 13. Engraving of *C. pusillus* in inner bark of larch. Here also the egg-galleries originate from the nuptial chamber of *P. rufipennis*. About four-fifths natural size.

PLATE IV.

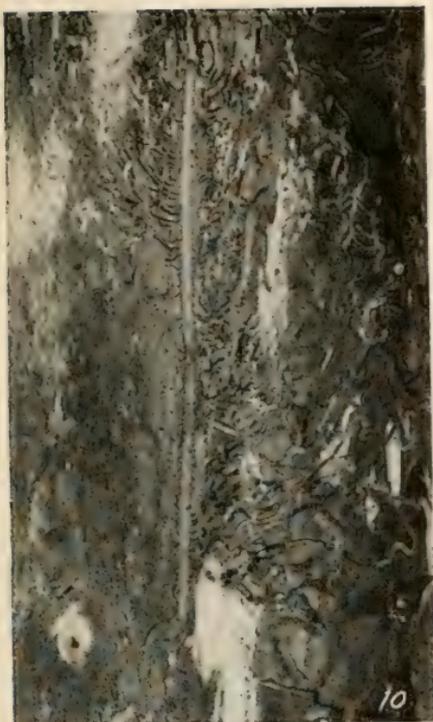


Plate V.

FIG. 14. Segment of the trunk of larch with bark removed, showing the burrows of *Polygraphus rufipennis* and *Phymatodes dimidiatus*. The wider grooves in the wood, many of which end in oval openings leading down into pupation chambers, are made by *P. dimidiatus*. About two-thirds natural size.

PLATE V.



Plate VI.

FIG. 15. Burrows of *Phymatodes dimidiatus* in trunk of larch. Near the center can be seen the complete larval burrow, the entrance to the pupation chamber and the exit hole. The entire burrow is relatively short, as would be expected of a one-year form. Reduced to about two-thirds natural size.

FIG. 16. Burrow made by the larva of *Monohammus scutellatus* in white pine. All of the larval work cannot be seen, but characteristic points are shown. Note that the part of the burrow adjacent to the chamber in the wood used for retiring, hibernation and pupation has been kept free of frass, while much of the rest is packed full of the characteristic "sawdust" like detritus. Note also the oval opening leading to the pupation chamber (below) and the nearly exactly circular exit opening (above). Reduced to slightly less than one-half natural size.

FIG. 17. Thin-barked limb of white pine showing where the adults of *M. scutellatus* have fed upon the thin smooth bark. At various places in the smoother areas of the bark can be seen the work of the mandibles of the beetles. The females oviposit in such areas and the several small white spots in these areas indicate "ventilation openings" through which the newly hatched larvæ have extruded the white frass. These "ventilation openings" of the very young larvæ are the openings made by the ovipositor of the female, which have been enlarged and utilized by the newly hatched larva. Reduced to about one-half natural size.

FIG. 18. Portion of the trunk of a small larch sapling, showing the burrow of *Leptostylus sex-guttatus*. The entire burrow, including larval mine, entrance to pupation chamber and exit hole, is shown. This being a two-year form, the burrow is relatively quite long. Slightly more than one-half natural size.

PLATE VI.



Plate VII.

FIG. 19. Burrow of *Neoclytus longipes* in limb of larch. This cerambycid is a two-year form and the larval burrow here is narrow, deep and extraordinarily long. After grooving the sapwood just beneath the bark for most of its life, the larva bores through the sapwood for some distance before pupating. Thus the exit hole may be on the opposite side of the limb from the point of entrance to the chamber in the wood. Slightly more than one-half natural size.

FIG. 20. Another burrow of *N. longipes* in a larch limb. This burrow is perhaps more typical from the fact that the larva tunneled the wood for a distance of $10\frac{1}{2}$ cm. before it pupated. Reduced to slightly less than one-half natural size.

FIG. 21. Burrows of *Pogonocherus mixtus* in larch. The burrow is here rather short but quite wide for so small a form. Entrance to and exit from the pupal chamber is through the same opening. This is not so common among cerambycids as it is with the buprestids. About one-half natural size.

FIG. 22. Burrow of *Anthaxia quercata* in limb of larch. The burrow made by this small flat-headed borer during its first year is shallow and rather narrow, but during the second year the larva is likely to excavate a broad area rather than continue it as a linear mine. The adult emerges from the pupal chamber through the same opening by which the larva entered. About five-eighths natural size.

PLATE VII.



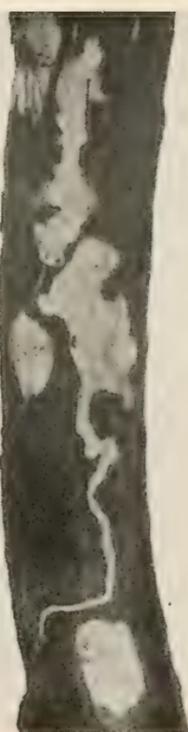
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Plate VIII.

FIGS. 23, 24. Burrows of *Chrysobothris blanchardi* in larch limb. The larval mine during the first year is likely to be linear and is usually not very tortuous while that made during the second year is very tortuous. The adult in emerging from the pupal chamber uses the entrance burrow made by the larva. The two burrows shown in Fig. 24 are quite typical. Fig. 23 reduced to about one-half natural size. Fig. 24 reduced to about two-fifths natural size.

FIG. 25. Burrow of *C. blanchardi* in larch from which the frass has not been removed. Note that this material forms alternate bands of light and dark. This is produced by the habit of the larva in excavating from the bark and from the sapwood alternately. This material is arranged to form curved striæ by the abdomen of the flat-headed larva, which is habitually bent to form a loop and pressed against the frass in order that the borer may obtain leverage in rasping off the fibres. Reduced to about two-fifths natural size.

FIG. 26. Burrow of *Chrysobothris sex-signata* in small larch sapling. The burrow here is relatively shallower and wider than those made by the foregoing buprestids. That made during the second year is especially wide. The larval entrance to the pupal chamber is used by the adult in emerging. Reduced to about five-ninths natural size.

PLATE VIII.



Plate IX.

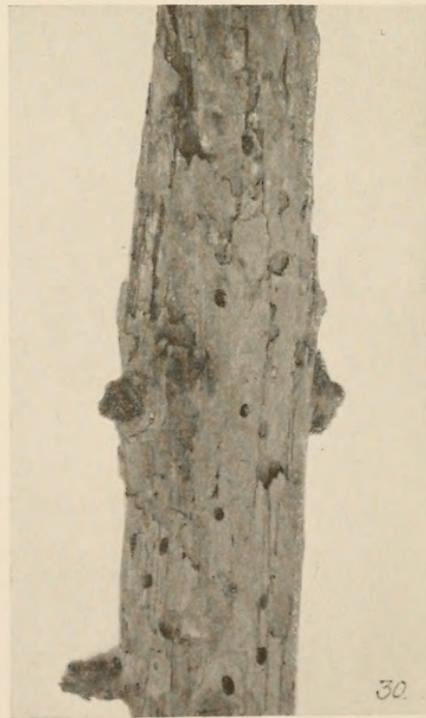
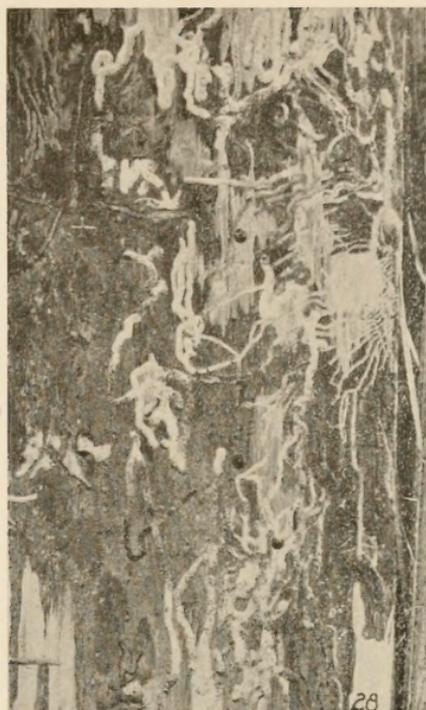
FIG. 27. Burrows of *Chrysobothris dentipes* in white pine. The greater part of the larval burrow of this species is in the sapwood immediately under the bark. When nearly full grown the larva tunnels into the wood and often bores through this for a distance of several inches before pupating. In emerging the adult makes an opening of its own which is often at some distance from the point at which the larva entered the wood. Reduced to slightly less than three-fifths natural size.

FIG. 28. Section of the trunk of larch showing the burrows of *Polygraphus rufipennis* (upper left) and of *Eccoptogaster piceæ* (right) and the exit holes of *Urocera albicornis*. Reduced to about two-thirds natural size.

FIG. 29. View of a segment of the trunk of Tree V. The exposed decaying wood was killed a number of years ago, probably by peeling. At that time it had been tunneled by the larvæ of *Serropalpus barbatus* and perhaps other forms, and decay had for this reason been more rapid. A specimen of *Adelocera brevicornis* was taken from this wood in the field, and *Tenebrio tenebriodes* and *Dryophthorus americanus* were bred from it in the breeding cages. The more recently killed wood at the sides shows the engravings of *P. rufipennis*. Reduced to one-third natural size.

FIG. 30. Portion of the heart wood from Tree V, showing the larval burrows made by *Serropalpus barbatus* many years before. The burrows of *Dryophthorus americanus* may be seen at various places. This insect bores in the soft "spring wood," leaving the harder "summer wood" nearly intact. Reduced to about two-thirds natural size.

PLATE IX.



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