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NOTES ON FOREST INSECTS.

I. ON TWO BARK-BEETLES ATTACKING THE TRUNKS OF WHITE PINE TREES.

By M. W. Blackman, Ph.D.,
Professor of Forest Entomology, New York State College of Forestry, Syracuse, N. Y.

So little is known of the life history and habits of some of our common forest insects that even more or less casual or fragmentary observations are often of value and should be recorded in order to make them available for other workers. During the past few years the writer has accumulated a considerable amount of such data either in the way of more or less disconnected field observations, or in the course of work upon larger problems undertaken either individually or as joint problems with advanced student working in the laboratory. In the present paper are presented data upon several insects affecting the white pine, *Pinus strobus*. Part of the observations, especially the experimental data on *Hylurgops pinifex* Fitch and some of the field observations on *Ips longidens* Sw., were made by a former graduate student, Capt. A. J. MacNab, to whom we wish to make due acknowledgments.

Ips longidens Swaine.

Ips longidens was described by Swaine in 1911[1] (p. 214), but no later mention of it has been found in the literature except that by the same author (1918, p. 114).[2] The only host tree recorded is "Eastern Hemlock" and the distribution is given as New York State and Nova Scotia. Although not included by Blatchley and Leng (1916) among the Scolytidæ of northeastern North America, there can be no doubt as to the validity of the species. Indeed,

[1] Canadian Ent., Vol. XLIII, pp. 213–223.
[2] Dominion Canada, Dept. Agri., Ent. Br., Bull. 14, p. 114.

it is a rather common insect in central New York and is readily distinguished from its relatives not only by its structure but by its habits as well. Although Swaine (*loc. cit.*) mentions only hemlock (*Tsuga canadensis* Engelm) as the host tree, the writer has never been able to find it in this tree, but has observed hundreds of brood-burrows and thousands of specimens in all stages in the inner bark of white pine. This is especially unusual when we know that the type locality of this species is central New York (Ithaca) and our observations were made in the same general region of the state.

Ips longidens in central New York may work either as a primary or a secondary enemy of the white pine. It is found most commonly in the lower and middle regions of the trunks of trees in the pole stage—*i. e.*, from 4 to 8 inches in diameter. In larger trees, where it sometimes occurs, its brood-burrows are constructed in the middle and upper trunk regions and occasionally in the tops and branches. It is thus evident that the factor which determines the choice of location for breeding is the character of the bark. It prefers bark upon the older sapling or pole stage of white pine, the surface of which is roughened but which is still less than one fourth of an inch in thickness, although in a few instances the brood has been found successfully established in bark of a thickness as great as one half of an inch. On the other hand, the beetles have been induced to breed in captivity in limbs on which the bark is less than one eighth of an inch thick and the surface of which is smooth except near the origin of smaller limbs.

The brood of *Ips longidens* was found nearly exclusively in white pines of from 4 to 8 inches D. B. H. which were either dying or had been more or less weakened by overshading. The tops of these trees were small and ragged, the bark was thin, and the foliage scanty. Usually at the time when the beetles enter the trees the foliage has begun to turn yellow, but in some cases there are no indications that the tree is actually dying, but only of a weakened or suppressed condition. There can be no doubt that in many cases these bark beetles are the actual cause of the death of trees which would otherwise survive for may years. *Ips longidens* will also breed in felled pines in the pole stage and in the tops of larger trees.

The brood-burrows are always started in the new host tree by

the males[1] which leave their old host several days earlier than the females of the same age. Their methods of working have been observed by the writer under a binocular microscope, and correspond very closely with those employed by *Pityogenes hopkinsi* Swaine, which have been recorded in detail elsewhere (Blackman, 1915,[2] pp. 16–32). When the brood-burrow is made in the trunk, as it is in the great majority of cases, the entrance gallery, which is cylindrical and of a diameter just large enough to accommodate the insect making it, extends through the bark diagonally upward at an angle of about 45 degrees. On reaching the surface of the wood the male excavates an irregular shaped nuptical chamber which lies partly in the bark and partly in the sapwood.

The burrow is now ready for the females of which there are usually several for each male. Each of these immediately after her entrance begins to excavate a separate egg-gallery. In the majority of instances these galleries run in a direction perpendicular to the grain of the wood (Plate IV, fig. 2), although occasionally some females follow a course parallel to the grain. There are from one to five egg-galleries to each engraving. The following tables present, in summary, various data derived from a careful study of the engravings of *Ips longidens*.

Number of Egg-galleries, Based on a Study of 118 Engravings.

Brood-burrows having one egg-gallery	10
" " " two "	54
" " " three "	37
" " " four "	15
" " " five "	2
Average number of egg-galleries in a brood-burrow	2.53

Length of Egg-galleries, Based on the Study of 50 Engravings.

	Average length.	No. of galleries studied.
Uniramous burrow	25.37	8
Biramous "	19.42	54
Triramous "	17.5	24
Quadriramous "	16.9	28
Average length all types	18.8	114

[1] Cf. Blackman, 1915 Tech. Pub. No. 2, N. Y. State Coll. Forestry, pp. 15, 16. Blackman & Stage, 1918 Tech. Pub. No. 10, N. Y. State Coll. Forestry, p. 46.

[2] *Loc. cit.*

The relation between fecundity and the proportion of sexes in the various types of burrows is shown by the following tables of data:

Number of Egg-niches in the Egg-galleries, Based on a Study of 40 Engravings.

	Average no. of egg-niches.	No. of engravings studied.
Uniramous engraving	23	6
Biramous "	41.04	23
Triramous "	48.9	11
Average number to engraving	40.5	40
Egg-gallery of uniramous engraving	23	6
" " " biramous "	20.5	46
" " " triramous "	16.3	33
Average number, all types	19.05	85

From the above it is evident that each female under monogamic conditions produces more eggs than under conditions of bigamy or polygamy; but just as with *Polygraphus rufipennis* Kirby and *Eccoptogaster piceæ* Swaine (Blackman and Stage, *loc. cit.*, pp. 45, 53), the greatest individual reproductive efficiency exists when the burrow is occupied by one male and two females.

The larval burrows at the start are at nearly right angles to the egg-gallery (Plate IV, fig. 2) and are entirely in the inner bark. As they proceed farther, however, they groove the sapwood deeper and deeper and show a tendency to become winding in their course. These larval mines end in oval pupal chambers excavated nearly entirely from the sapwood. The new generation of adults continue feeding in the old host for weeks or sometimes even months before reaching sexual maturity. If young adults, fully mature so far as coloration and general appearance are concerned, are removed from their larval host tree and confined with new pieces of pine they will usually not breed until they have fed on the inner bark for a week or more.

On March 20, 1915, a number of young adults, removed from their hibernating quarters, were confined with several suitable pieces of white pine. Within two days all but a few, which had died, had entered the cut ends of the material, all of them making

simple cylindrical feeding burrows with no indication of a nuptial chamber. On April 1, all of the beetles were still in their feeding burrows, but by April 20, all but two or three had emerged and males and females were in newly established brood-burrows. On June 4, pupæ and callow adults of the new generation were obtained from these burrows. It is thus seen that, under laboratory conditions, callow adults of the new generation may be obtained from mature beetles in about 50 days, but these are not sexually mature until they have fed on the inner bark and sapwood for several weeks or a month. It is apparent that in central New York it is possible under field conditions for *Ips longidens* to complete two generations in an average year and in an especially long, warm season to increase this to two and one-half generations. Observations extending over a period of six years, however, convince the writer that ordinarily a single generation is the rule, although a partial second brood is by no means uncommon. There is thus a decided mixing of generations and new brood-burrows may be started at any time from May 15 (over-wintered adults) to September 15. Both adults and larvæ have been taken in the field on various dates including every month except December. The larvæ are as successful in withstanding winter conditions as are the young fully colored adults, and much more successful than are the callow beetles and pupæ.

The over-wintered adults leave their old hosts considerably later than do some other bark beetles. An instance of this was observed in the field by the writer in the spring of 1915. On April 24 of that year, the first individual of *Pityogenes hopkinsi* a male, was observed to have emerged and started its nuptial chamber in a new host near at hand. Within a week nearly all of the over-wintered males and many of the females had left this old host. On the other hand the over-wintered adults of *Ips longidens*, which occurred in the trunk of the same tree, did not leave their old host in any numbers until the middle and latter part of May.

Ips longidens has been found associated in the same tree with a considerable number of other bark and wood boring forms. Those most commonly associated include *Ips pini* Say, *Pityogenes hopkinsi* Swaine, *Crypturgus atomus* Lec., *Graphisurus fasciatus* DeG., and *Monohammus scutellatus* Say. These occur very commonly in the same regions in which *Ips longidens* prefers to breed. Other

forms, which have been found to be associated but not so commonly, include *Dendroctonus valens* Hopk., *Orthotomicus* (*Ips*) *cœlatus* Eich., *Dryocœtes americanus* Hopk., *Hylurgops pinifex* Fitch, *Gnathotrichus materiarius* Fitch, *Cossonus corticola* Say, *Monohammus confusor* Kirby, *M. titillator* Fabr., *Rhagium lineatum* Oliv., and *Pytho americanus* Kirby, occurring principally in the lower trunk region of the pine tree; while *Pityophthorus granulatus* Swaine, *Chrysobothris femorata* Fabr., *C. dentipes* Germ., *Pogonocherus mixtus* Say, are occasionally associated in the tops and limbs.

Two beetles known to be predaceous were found rather commonly associated with *Ips longidens*. These are *Phyllobœnus dislocatus* Say and *Hypophlœus tenuis* Lec. One parasitic Hymenopteron, *Cœlopisthus* sp. was taken alive from a pupal chamber and there can be little doubt that it is parasite on this bark beetle.

Hylurgops pinifex Fitch.

Hylurgops pinifex differs markedly in habit from the preceding in that it is a monogamic form. It attacks white pines by preference although Hopkins[1] 1899, p. 449, records it from other species of pine as well, and Swaine[2] 1918, p. 81, lists the hosts as "Pines, Spruce and Eastern Larch." Its burrows are constructed in the lower part of standing pines and especially in the stumps of recently cut trees. The burrows have never been found by the writer at a greater height than seven feet from the ground and are more commonly in the lowermost three feet of the base of large thick-barked trees. This region is often heavily infested and the brood very frequently extend their burrows through the bark of the main roots to a distance of 6 or 8 inches under ground. The factor which determines the choice of the bases of trees is not entirely the character of the bark in the region attacked but is apparently the clumsy flight of the adult beetles, for in a number of cases felled trees have been found infested at a distance of 30 feet from their bases in regions where the bark was relatively thin, and in the laboratory the beetles have been induced to breed in similar material.

The brood-burrows of Hylurgops are radically different from those of *Ips longidens* or other polygamous forms, the most striking

[1] West Virginia Agr. Exp. Sta., Bull. 56.
[2] *Loc. cit.*

differences being correlated with the difference in breeding habits. Hylurgops appears to be strictly monogamic. Typically the brood-burrow consists of a simple, nearly straight longitudinal chamber extending either downward or upward from the entrance

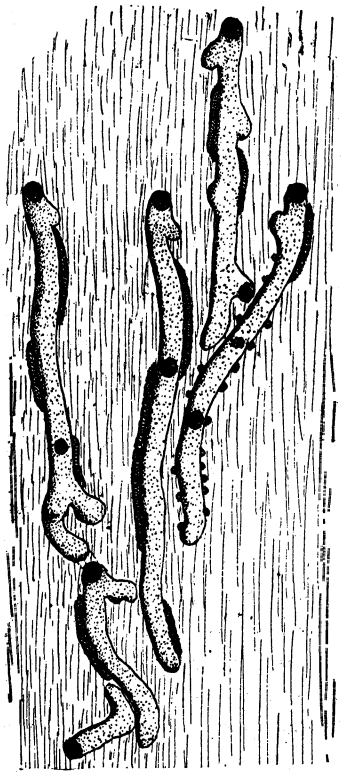


Figure 1. Burrows of *Hylurgops pinifex* in bark of white pine. Note the arrangement of the egg, either in niches or in grooves along the sides of the egg-gallery. Three-fourths natural size.

gallery (Fig. 1). Usually, just inside of the entrance there is a short branch or alcove, seldom greater in depth than the length of the beetle, which is used as a turning niche and also as a nuptial recess (Fig. 1; Plate 4, fig. 3). At or near the other end of the fully completed egg-gallery there is likely to be a somewhat similar recess which, however, instead of lying parallel to the surface of the wood extends outward part way through the bark. It doubt-

less is used by the female for reversing her position in the burrow. The remainder of the egg-gallery is a simple cylindrical mine which extends longitudinally, typically nearly straight, but frequently more or less curved. Its diameter is just great enough to allow convenient passage of the beetle. In length these egg-galleries vary from 50 to 85 mm. with an average of about 70 mm.

A number of instances have been observed where the same entrance gallery has been used in common by two or more pairs of beetles. That these are not cases of true polygamy is evidenced by the fact that each egg gallery arising from the common entrance has its own nuptial recess, and also by the fact that in all instances where the beetles were still present, the two sexes in these multiple burrows occurred in equal numbers.

The eggs are laid by the females either in niches or in longitudinal grooves along one or both sides of the egg-galleries, more typically in grooves. Most of the females appear to use the grooves entirely, a considerable number use both niches and grooves and none have been observed to use the niches exclusively. In the side grooves, the eggs are deposited in considerable numbers, often forming a layer several tiers wide, but when niches are used only from two to six are placed in one recess. In all cases the eggs are securely packed and the niche or groove closed with a layer of sawdust so that the opening of the gallery is of nearly uniform bore and the beetles may pass through it without endangering the eggs. No attempt has been made to count the eggs or larvæ of a single pair, but the number must be considerable as often the combined length of all of the egg-grooves of the two sides is equal to or greater than the length of the egg-gallery. In fact, the brood of Hylurgops is so numerous and their appetite so voracious, that it is very difficult to obtain brood-burrows fit for study unless the bark is stripped off before the larvæ have fed many days. Otherwise the feeding galleries of the larger larvæ and the young adults are carried back and forth over the egg-galleries until these become entirely unrecognizable.

The ability of the larvæ to live under adverse conditions is well illustrated by the following observations: On June 18, 1915, near Cranberry Lake, N. Y., several stumps of large white pine trees felled during the preceding winter were found to be heavily infested with *Hylurgops pinifex*, *Dendroctonus valens* Hopk., *Ips pini* Say,

and *Orthotomicus* (*Ips*) *cœlatus* Eich. These stumps were still green and sappy and pitch exuded from all of the burrows, while those of D. *valens* had the characteristic pitch tubes. The burrows of Hylurgops were in all stages from those recently started to completed burrows containing recently hatched larvæ. In no case had these extended their burrows more than two centimeters, and in most instances eggs or larvæ just hatched occupied the egg-grooves in the sides of the galleries. The pieces of bark on being removed contained such good specimens of the early brood-burrows that a considerable number of them were taken to camp, wrapped in old newspapers, and shipped to the laboratory, no effort being made either to remove the brood or to preserve it from injury although specimens were taken. The boxes containing these bark specimens were not unpacked until September 2, when the writer was surprised to find large numbers of adults of the new generation burrowing into the bark or feeding upon its inner surface which was by then quite dry. These undoubtedly had developed from the young larvæ and eggs present on June 18. That the eggs then present had later hatched was readily established by an examination of the egg-grooves.

On October 20, 1916, numerous young adults found in their parent burrows, were brought into the laboratory and 46 of these placed in a celluloid box securely fastened to the rough bark of a section of the trunk of a recently cut, dying pine. Most of the beetles wandered about for the next few days in their enclosure, seeking a means of escape, some of them stridulating frequently. These latter were males. However, before the following morning several females had started burrows through the bark and within two days were observed to be casting out white chips, showing that they had begun to groove the sapwood. By October 25, all of the beetles except four had disappeared beneath the bark, many of them utilizing the entrance holes made by the first workers. One month later (November 25) a piece of bark near one of the entrance holes was carefully removed and eggs and young larvæ were found in considerable numbers. Some of the larvæ had burrowed for a distance of 35 mm. through the inner bark and were probably less than two weeks old. The eggs examined were oval in shape, slightly less than 1 mm. in their longest diameter, and contained well formed larvæ which hatched two days later.

The burrows made by the larvæ at first extend at right angles to the egg-gallery but soon become quite tortuous. They are rather extraordinary for their length frequently being from 25 to 30 cm. long and toward the last having a diameter of 4.5 to 5 mm. Before pupating, the full grown larvæ constructs a pupation chamber, which is often a more definite structure than is commonly made by scolytids. Ordinarily, pupation of those small beetles occurs in a simple cavity hollowed out of the bark or the wood. But in many cases *Hylurgops* builds a more elaborate structure somewhat similar to the hibernaculum of *Rhagium lineatum* and like this, consisting not only of an excavation in both bark and sapwood, but in addition surrounded by a wall made up of bits of wood, bark and excrement held together by a substance which acts as a glue (Plate IV, Fig. 4). The resemblance to the pupation chamber of *Rhagium* is still further heightened by the presence of a short passage-way made by the larva nearly through the outer bark. These pupal chambers are about 5 x 8 mm. in diameter. In several cases the larvæ had bored into the sapwood and made their pupal chambers entirely in the wood, sometimes penetrating the wood to a depth of nearly 5 mm. The entrance was plugged before pupation occurs and exit was had through a separate hole. Both of these sorts of pupation cavities should probably be considered as adaptations which serve to protect the tender pupæ from the larger larvæ and the young adults, which appear to have a very voracious appetite, and which extend their tunnels back and forth through the inner bark, often passing over and destroying egg-galleries and larval burrows alike.

Several full grown larvæ were taken from their pupation chamber and placed in Stender dishes in slightly moistened sawdust where they were kept under observation during all of the changes which ensued until they became fully colored adults. Briefly, the observations made are summarized below. The time required for the transforming of the larva to the pupa is about four and one-half hours. During most of this time the larva squirmed and wriggled and contorted its body nearly continuously with brief rests after each more violent effort. The effect here was, doubtless, the loosening up of the larval skin, and after about three hours of such efforts the skin appeared to be quite loose and something of the pupal form could be seen beneath it. Finally the larval skin split

lengthwise along the back of the thorax and head as far as the base of the mandibles, and through this opening the head and thorax of the pupa was pushed. It then required only a few minutes for the pupa to free itself of the old larval skin except where it was continuous with the lining of the alimentary canal at the anus. At this point the larval skin often adheres very firmly and sometimes is not dislodged for several days.

The newly transformed pupa is colorless except for a faint tinge of brown at the points of the dorsal spines of the abdomen. During the succeeding seven days various parts of the body acquired pigment in about the following order:—the mandibles, the eyes, bases of maxillæ and labrium, joints of femur and tibia, coxæ, tarsi, base of antennæ, scutellar region. At the end of a week the pupæ are ready to transform. The mandibles are motile, the body form is more like that of the adult and the elytra are no longer folded around the body with their tips ventral as at first, but now are dorso-lateral in position.

The first indication of the moulting of the pupa is a loosening of the pupal skin in the head region. Later the skin here splits and is soon slipped down over the pronotum whereupon the mandibles are used to tear it and release the prothoracic legs. The rest of the process is rapid as the legs are now brought into play and the body soon freed of the loosened covering. In one instance where transformation was observed, the entire process of moulting required eleven minutes.

The newly emerged adult is by no means as helpless as is the case with many Scolytids, and seems to require a considerably shorter time in attaining its adult color. Adults 36 hours old are brown-ochre in tint with wing covers opaque and in less than a week are dark brown, nearly black in color. There is normally but one generation of *Hylurgops pinifex* per year in central New York but if the young adults which ordinarily feed in their larval hosts from late summer until the following June are removed from their feeding burrows, they will readily enter a new host and start new brood-burrows.

As Hylurgops usually occurs only in the lowermost trunk regions, the forms commonly associated with it are of limited numbers. Perhaps the most common is *Orthotomicus* (*Ips*) *cœlatus* Eich., which in central New York is nearly invariably found in the

same stumps as Hylurgops. Other beetles frequently associated are *Dendroctonus valens* Hopk., *Dryocœtes americanus* Hopk., *Ips pini* Say, *Ips calligraphus* Germ., *Cossonus corticola* Say, *Monohammus confusor* Kirby, *M. titillator* Fabr., *Rhagium lineatum* Oliv., *Pytho americanus* Kirby, and occasionally *Gaphisurus fasciatus* DeG., and *Ips longidens* Swaine. Associates occurring in the feeding burrows of the young adults include *Glischrochilus sanguinolentus* Oliv., and several other unidentified nitulids and staphylinids.

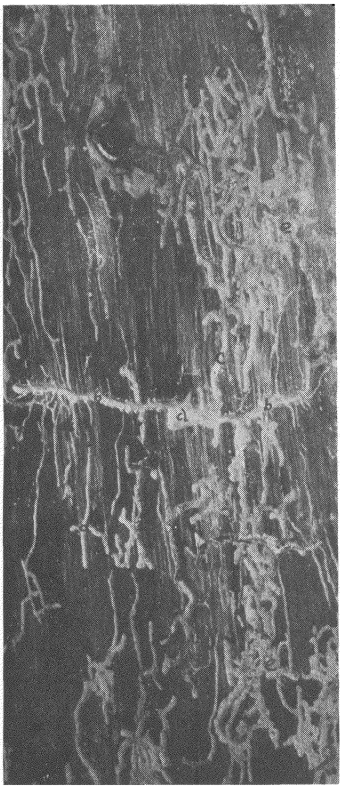
Explanation of Plate IV.

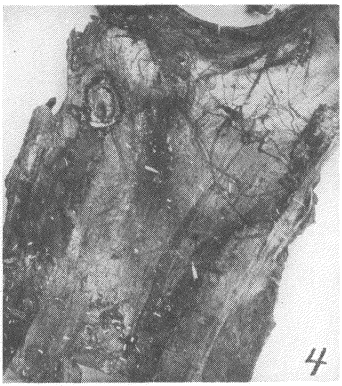
Fig. 1. View of the inner bark of white pine showing the brood-burrows of *Ips longidens*. In the egg-gallery shown below, the plugs of white frass by which the eggs are retained in their egg-niches are still plainly visible although the eggs have hatched long since. About three-fourths natural size.

Fig. 2. Engraving made by *Ips longidens* on the surface of the wood of white pine. The nuptial chamber (a), two transverse, (b) and one longitudinal (c) egg-galleries with their egg-niches, larval burrows (d) and the feeding burrows (e) of the young adults are shown. About two-thirds natural size.

Fig. 3. Brood-burrow of *Hylurgops pinifex* in the inner bark of white pine. Note the entrance gallery (a), the nuptial recess (b), the egg-gallery (c) with the egg-groove along the right side, the turning niche (d) and the burrows of the young larvæ (e). About one-half natural size.

Fig. 4. Fragment of the bark of white pine showing the pupal chamber of *Hylurgops pinifex*. About three-fifths natural size.





BLACKMAN—BARK-BEETLES.