HYMENOPTEROUS PARASITES OF *IPS* spp. BARK BEETLES (COLEOPTERA:SCOLYTIDAE) IN VIRGINIA

by

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Dissertation submitted to the Graduate Faculty of the
Virginia Polytechnic Institute
in candidacy for the degree of

DOCTOR OF PHILOSOPHY

in

Entomology

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June 1968

Blacksburg, Virginia

TOP 5-2-78

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ACKNOWLEDGEMENTS

I wish to extend my gratitude to Dr. H. M. Kulman under whom the project was initiated, Dr. R. L. Pienkowski who served as advisor during most of the study, and Dr. H. J. Heikkenen who served during the final stages. All three provided assistance and showed interest throughout the study.

The author is also indebted to Dr. S. E. Neff, Dr. J. M. Grayson, Dr. E. C. Turner, Dr. H. A. I. Madgwick, and Dr. J. L. Bishop who served on my graduate committee and provided advice and constructive criticism during the study and preparation of the manuscript.

My appreciation is extended to Dr. O. Peck for identification of reared parasites and his providing a key to the Chalcidoidea. Appreciation is extended to Dr. C. F. W. Muesebeck for identification of Braconidae and Dr. N. M. Downie for identification of Coleoptera.

Appreciation is extended to Mrs. Josephine Proco and Miss Sarah Duncan for typing this dissertation, and to Mr. B. L. Guthrie and Mr. I. J. Stout for their assistance in the laboratory.

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I. INTRODUCTION

The pine engraver beetles (Ips spp.:Coleoptera:Scolytidae) may be serious pests depending on certain prerequisite conditions. In their secondary or "normal" role they breed in slash and damaged, dying, and dead trees. The broods emerging from these sources normally attack similar material. When such material is scarce due to cessation of cutting operations in mid-season or when conditions are especially favorable for brood development, an excess of beetles is often produced which, due to the lack of more suitable material, attack healthy trees. Repeated attacks cause these trees to succumb and die. When normally healthy trees are weakened by fire, flood, defoliation, drought, stagnation, etc., then they become more acceptable host material for successful engraver attacks. When the production of a very large number of beetles in "normal" breeding material coincides with physiological stress in "healthy" trees, then population explosions can occur. When large numbers of beetles and low host vigor do not coincide, spot kills commonly occur. According to Thatcher (32), spot kills, although not conspicuous, add up to large volumes of timber loss each year.

The spot kills are usually scattered small groups which usually makes salvage unfeasible. Control of Ips spp. is difficult due to their sporadic occurrence, difficulty in recognizing an attack early, and the high cost of chemical control. In view of such difficulties foresters will generally have to rely on some form of natural control augmented by silvicultural practices.

Insect parasites are natural control agents that could possibly have their effectiveness increased by proper stand management. Before parasites can be evaluated as control agents, however, their role as parasites of Ips must be validated and much of their life history must be learned.

This study was undertaken from March 1965 to June 1968 with the following objectives:

1. To determine the species of insect parasites attacking Ips spp. by individual rearing directly from the host.
2. To learn the habits of the parasites.
3. To determine the effect of various natural factors and some artificial conditions on parasite populations.
4. To evaluate, if possible, the parasites as control agents.

II. LITERATURE REVIEW

There have been few previous studies on parasites of Ips spp. in the southeastern United States. The various authors who have listed parasites generally have included few details on life histories or data which could lead to some evaluation of the potential of parasites as control agents. The life histories of most of the parasites confirmed in this study have not been described for species of Ips found in southeastern United States. Therefore, they are largely an unknown quantity in Ips population dynamics, especially at endemic levels. In a recent review of parasites of Scolytidae, Bushing (5) lists 95 references to 22 species of parasites of Ips spp. bark beetles which normally occur in southeastern United States. Thatcher (32), lists 23 references to the parasites of the three species normally infesting southern pines. The number of publications may be misleading, however, since most are merely references to other publications. Publications on actual confirmations of parasites are rare. Many "confirmations" of parasitism are based only on close associations of the parasites with the bark beetles. In many cases the original authors point this out but are quoted as making confirmations in references to their work. For instance Clemens (8) states: "It is impossible to remove larvae and pupae from a log and keep them for the purpose of rearing parasites from them. The best that can be done is to place the logs in cages . . ., catch all insects that emerge, and judge which are likely to be parasites." However, some subsequent articles cite

Clemens as confirming parasitism (5,6,25,26,34). The most common method of "confirmation" appears to have been rearing from pupae found in Ips galleries.

The following are the references to parasites of southern Ips spp. including the parasites found in this study, with notes by this author indicating if and how confirmations were made, or that they were merely references to other works.

Ips avulsus (Eichhoff)

Braconidae	
Dendrosotor sulcatus Muesebeck	5(**), 24(****), 25(**), 32(**), Berisford 1968(*).
Coeloides pissodis (Ashmead)	Berisford 1968(*) (n.r.).
Heterospilus sp.	Berisford 1968(*) (n.r.).
Eurytomidae	
Eurytoma conica Provancher	Berisford 1968(-) (n.r.).
Pteromalidae	
Heydenia unica Cook and Davis	3(?), 5(**), 25(**), 26(**), Berisford 1968(*).
Rhopalicus pulchripennis Crawford	Berisford 1968(-) (n.r.).
Tomicobia tibialis Ashmead	Berisford 1968(-) (n.r.).
Torymidae	
Roptrocerus xylophagorum Ratzeburg	Berisford 1968(-) (n.r.).

Ips calligraphus (Germar)

Braconidae

Coeloides brunneri Viereck	5(**), 6(**), 32(**). Chamberlin (6) erroneously referred to Bedard (4) who reported C. brunneri on the Douglas-fir beetle, Dendroctonus pseudotsugae. Bushing (5) and Thatcher (32) referred only to Chamberlin.
Coeloides pissodis (Ashmead)	3(?), 5(**), Berisford 1968(*).

Pteromalidae

Tomicobia tibialis Ashmead	3(?), 5(**), 6(**), 16(**), 20(+), 25(**), 26(**), 28(+), 32(**).

Torymidae

Roptrocerus eccoptogastri (Ratzeburg)	2(a description of species reared by A. D. Hopkins), 5(**), 6(**), 18(a catalog apparently referring to his own work), 20(+), 25(**), 26(**), 32(**).

Liodontomerus sp.	5(**), 32(**). Formerly Lochites sp. reported by Hopkins (18) and later identified as Roptrocerus eccoptogastri (Ratz.).

Ips grandicollis (Eichhoff)

Braconidae

Coeloides pissodis (Ashmead)	3(?), 5(**), Berisford 1968(*).
Dendrosotor sulcatus Muesebeck	Berisford 1968(*) (n.r.).
Heterospilus sp.	Berisford 1968(*) (n.r.).
Spathius canadensis Ashmead	5(**), 6(**), 12(**), 13(**), 18(a catalog apparently referring to his own work), 19(****), 20(***), 22(**), 23(**), 32(**).
Spathius pallidis Ashmead	1(a description of specimens reared by A. D. Hopkins), 5(**), 6(**), 9(**), 13(**), 18(a catalog apparently referring to his own work), 19(**), 23(**), 25(**), 29(***), 32(**), Berisford 1968(*).

Eurytomidae	
Eurytoma conica Provancher	Berisford 1968(*) (n.r.)
Eurytoma sp.	Berisford 1968(-) (n.r.)
Pteromalidae	
Cecidostiba dendroctoni Ashmead	5(**), 6(**), 20(***), 25(**), 26(**), 32(**).
Heydenia unica Cook and Davis	Berisford 1968(*) (n.r.)
Rhopalicus pulchripennis Crawford	Berisford 1968(*) (n.r.)
Tomicobia tibialis Ashmead	5(**), 6(**), 16(**), 20(+), 25(**), 26(**), 28(+), 32(**), Berisford 1968(*).
Torymidae	
Roptrocerus eccoptogastri (Ratzeburg)	2(a description of species reared by A. D. Hopkins), 3(?), 5(**), 6(**), 18(a catalog apparently referring to his own work), 20(+), 25(**), 26(**), 32(**).
Roptrocerus xylophagorum Ratzeburg	Berisford 1968(*) (n.r.)
Liodontomerus sp.	5(**), 32(**). Formerly Lochites sp. reported by Hopkins (18) and later identified as Roptrocerus eccoptogastri (Ratz.).

Ips pini (Say)

Braconidae

Bracon sp.	5(**), 8(?), 34(**).
Coeloides pissodis (Ashmead)	Berisford 1968(-) (n.r.).
Coeloides sp.	5(**), 33(***).
Dendrosotor sulcatus Muesebeck	Berisford 1968(-) (n.r.).
Heterospilus sp.	Berisford 1968(*) (n.r.).
Spathius pallidis Ashmead	Berisford 1968(*) (n.r.).
Spathius sp.	5(**), 6(**), 8(?), 34(**).

Eurytomidae

Eurytoma conica Provancher	Berisford 1968(*) (n.r.).
Eurytoma sp.	Berisford 1968(*) (n.r.)

Pteromalidae

?Amblymerus sp.	Berisford 1968(*) (n.r.)
Cecidostiba polygraphi Ashmead	Berisford 1968(*) (n.r.)
Heydenia unica Cook and Davis	Berisford 1968(-) (n.r.)
Rhopalicus pulchripennis (Crawford)	5(**), 26(**), 28(***), 33(***), Berisford 1968(*).
Rhopalicus tutela (Walker)	5(**), 26(**), 33(***), Berisford 1968(*).
Tomicobia tibialis Ashmead	5(**), 6(**), 16(**), 20(+), 25(**), 26(**), 28(+), Berisford 1968(*).

Torymidae

Roptrocerus eccoptogastri (Ratzeburg)	2(a description of specimens reared by A. D. Hopkins), 5(**), 6(**), 8(?), 18(a catalog apparently referring to his own work), 20(+), 25(**), 26(**), 33(adults collected from *Ips* galleries), 34(**).
Roptrocerus xylophagorum (Ratzeburg)	5(**), 15(?), 26(**), 34(**), Berisford 1968(*).

Ips spp.

Braconidae

Chelonus sp.	Berisford 1968(-) (n.r.).
Coeloides brunneri Viereck	5(**), 30(from Bushing(5)).
Dendrosotor sulcatus Muesebeck	5(**), 24(****), 25(**).
Doryctes sp.	Berisford 1968(-) (n.r.).
Phanerotoma sp.	Berisford 1968(-) (n.r.).
Spathius canadensis Ashmead	5(**), 6(**), 9(**), 17(***), 22(**), 27(**).

Eurytomidae

Eurytoma tomici Ashmead	5(**), 26(**), 31(**).
Eurytoma sp.	5(**), 30(from Bushing (5)).

Pteromalidae	
Cecidostiba burkei Crawford	5(**), 30(from Bushing(5)).
Heydenia unica Cook and Davis	Berisford 1968(*) (n.r.).
Rhopalicus pulchripennis (Crawford)	5(**), 10(from Bushing(5)).
Tomicobia tibialis Ashmead	5(**), 14(Bushing(5) erroneously refers to Furniss (14) who did not list any Ips parasites), 21(+), 26(**).
Torymidae	
Roptrocerus eccoptogastri (Ratzeburg)	5(**), 30(from Bushing (5)).

(*) Confirmed as Ips parasite by this author (Berisford 1968)

(**) Only a reference to other works

(***) Reared from pupae found in Ips galleries

(****) Method of confirmation not reported

(+) Confirmed by rearing directly from host

(?) Not confirmed as a parasite, only as an associate

(-) Found as an associate by this author (Berisford 1968)

(n.r.) New record; not previously reported as a parasite of Ips sp.

III. METHODS AND MATERIALS

A. Study Area

The study was conducted in Brunswick and Carroll counties which lie in the piedmont and mountains respectively. The study period was from March 1965 to June 1968.

B. Mass Rearings

In order to collect large numbers of parasites and their hosts, a modification of the garbage can rearing technique of Clark and Osgood (7) was used. Fibre drums 14 inches in diameter and 27 inches high were used. Holes were cut at the base of each drum to accomodate a glass jar which provided a light source and allowed easy collection of the emerging arthropods. A cardboard ramp was placed in each drum to facilitate movement of arthropods into the jars. Ventilation was provided by blowers attached to central air ducts with openings for each drum to which was attached a length of plastic tubing extending to the drum. Each drum was provided with an air outlet and both the inlet and outlet tubes were covered with fine mesh plastic screening to prevent escape of the arthropods.

Infested log bolts were placed in the drums and emerging arthropods collected from the glass jars. Arthropods were counted and preserved in alcohol for future identification. Ips beetles were counted, a sample retained and sent to specialists for verification of the species and the remainder discarded. After emergence stopped,

the bolts were removed from the drums and bark thickness and circumference at each end were recorded. All arthropods remaining in the drums were handled in the previously described manner.

During the summer of 1965, Ips infested material was brought into the laboratory and placed in the rearing drums. A number of parasites of Ips beetles were collected from slash and standing trees.

C. Individual Rearings

Experiments showed that best success in confirming Ips parasites by rearing directly from the host resulted from peeling the bark from infested material and placing each larva or pupa in a number four gelatin capsule. Individuals which were obviously parasitized, i.e. had parasite larvae attached or appeared abnormal in any way were placed inside a larger number 000 gelatin capsule in addition to the number four capsule. A note was placed in the capsule explaining the condition and location of the larva or pupa when found. A total of 19,546 larvae and 7,378 pupae were handled in this manner during the study. After encapsulation the larvae and pupae were placed in a chamber maintained at 27° C. Although there was considerable mortality of both hosts and parasites resulting from mechanical injury during removal, dessication, and starvation, there was sufficient survival to confirm parasitism and provide adequate series for identification.

In the spring of 1966, investigations were begun to determine which parasites were present, the overall rate of parasitism of Ips spp., and the relative numbers of parasites in relation to the following:

(1) Species of Ips - The species encountered in this study were Ips avulsus (Eichhoff), I. calligraphus (Germar), I. grandicollis (Eichhoff), and I. pini (Say).

(2) Species of host tree - Infested material was examined from loblolly pine, Pinus taeda L.; white pine, Pinus strobus L. (1967 only); and Virginia pine, Pinus virginiana Mill. (1967 only).

(3) Level in tree - All data were taken separately for each six foot section of trees. Each section was cut into four 18 inch bolts. Alternate bolts were peeled for individual rearings and placed in rearing drums, respectively.

(4) Standing vs felled trees - Infested standing loblolly pines were collected whenever possible and compared with felled trees.

(5) Bark thickness - Bark thickness of each bolt placed in rearing drums was measured with a bark gauge at each end and in the center and averaged. The relationship to rate of parasitism was examined by linear regression.

(6) Number of emerging adult Ips - The average number of adult Ips from rearing drums per square inch of bark surface was determined and also examined by a regression analysis.

(7) Age of Ips infestation - Initial infestations of Ips beetles were created at four locations by felling pairs of trees which became naturally infested. The infestations at the sites were maintained by removing only one member of each pair of trees for study and leaving the other to maintain the populations of Ips beetles and

their parasites. As each generation of Ips matured, another pair of trees was felled to provide fresh material for attack.

(8) Location of parasites in Ips galleries - In order to determine parasite habits, during 1967 all encapsulated Ips larvae and pupae which were obviously parasitized were labeled indicating the location as Ips nuptial chamber, egg gallery, larval gallery, or pupal chamber. All pupated parasites were recorded as being free, or pupated in the larval or pupal remains of Ips. Ips larvae or pupae with parasite larvae attached were so designated.

(9) Time of year - The date was recorded for all material collected. Also the generation of Ips was noted in the continuous infestation described in item seven.

IV. RESULTS

The findings from the study are described in the following paragraphs according to the outline in the methods and materials (Section III).

Species of Ips and Host Trees. The species of Ips encountered in this study were Ips avulsus(Eichhoff), Ips grandicollis (Eichhoff), Ips calligraphus (Germar), and Ips pini (Say). The different species of Ips were usually associated with a specific type of host material. Felled loblolly pine yielded only Ips grandicollis in significant numbers; occasionally, a few Ips avulsus were recovered, but they never comprised more than two percent of the total. Thus the felled loblolly pines were considered to contain pure infestations of Ips grandicollis. Only three standing loblolly pines were collected; two of these were infested with Ips avulsus and one with Ips calligraphus. The three standing white pines collected were infested with Ips pini. Virginia pine slash was infested with Ips grandicollis but no parasites were recovered. The numbers and species of parasites recovered from the different tree hosts are shown in Table I.

The rates of parasitism and parasite species for each Ips species could not be directly compared due to the different types of host material and the different physiographic provinces from which material was collected. The loblolly pines were collected in Brunswick County, Virginia, which lies in the lower Piedmont. The

eastern white pine was collected in Carroll County, Virginia, which lies in the mountains. The rate of parasitism for Ips in different host material for 1967 is shown in Figures 1-7. The 1966 data was not graphed, but is shown in Appendix Tables I-XII. Some parasites were typically associated with either loblolly pine or white pine, but it could not be determined if this was due to the Ips species involved, the tree host, or the physiographic province in which they were found.

Level Within Host Tree. The species and numbers of parasites recovered from different tree levels are shown in Appendix Tables XXX-XXXXV. The rates of parasitism for 1967 are shown in Figures 1-7. Several of the parasites appeared to be confined to the upper levels of trees in loblolly pine, but two of the most abundant parasites, Tomicobia tibialis and Roptrocerus xylophagorum, were common at all levels.

Standing vs Felled Trees. This comparison could not be made statistically due to the large amount of variation in rates of parasitism. The sample for the standing loblolly pine consisted of only three trees. The different species of Ips infesting the host material probably made comparisons of the species recovered invalid, but data in Table I indicate that the parasite complexes are similar. The rates of parasitism may be seen by comparing Figure 6 with Figures 1-5.

Bark Thickness. The effect of bark thickness on rate of parasitism was examined by a regression analysis. Regressions were calculated using the data from the felled loblolly pine consisting of 162 observations. Bark thickness was the independent variable and the dependent variable was percent parasitism (transformed to the arc sine). A regression calculated using total percent parasitism at each six foot level, (calculated from numbers of emerging adults), showed no correlation with bark thickness, giving a coefficient of determination (r^2), of 0.0454. A regression using only those species known to oviposit through the bark also produced no correlation with an r^2 value of only 0.0865. In spite of this lack of correlation, Eurytoma conica, Heydenia unica, Rhopalicus pulchripennis, Rhopalicus tutela, Dendrosotor sulcatus, Spathius pallidis, Coeloides pissodis, and Heterospilus were usually found in the upper bole of loblolly pine.

Number of Emerging Ips Adults. In order to determine if heavy Ips populations attracted proportionately more parasites than light infestations, a regression was calculated for felled loblolly pines using the average number of adult Ips emerging per square inch of bark surface at each six-foot level and percent parasitism (transformed to the arc sine). The analysis showed no correlation (r^2=0.1277) between Ips density and the rate of parasitism as calculated from numbers of emerging adults.

Age of Ips Infestation. Of the four plots established in 1966 using felled loblolly pines to maintain Ips infestations, only one maintained a continuous infestation during 1966 and 1967. This small sample indicated there was no appreciable change in total parasitism (Figure 8), and no change in species or relative abundance except as influenced by the numbers of Ips infesting the trees (Figures 9 and 10). The Chalcidoid parasites were nearly absent at low Ips population levels.

Seasonal Abundance and Parasite Habits. The location of parasite larvae and pupae in Ips galleries was recorded during the individual rearings in gelatin capsules to gain some information on the habits of the parasites. This data is summarized in Tables II and III. Habits of the four most common parasites in felled loblolly and standing white pine are compared in Figures 11-14. The numbers of parasites recovered for different collection dates are shown in Figures 15-18 in an attempt to determine seasonal abundance. The data are expressed as a percentage of the total number of parasites to compensate for varying Ips populations. Each of the Ips parasites confirmed in this study are discussed in the following pages.

Eurytoma conica Provancher (Hymenoptera:Eurytomidae)

Hosts: Phloeosinus dentatus (Say), Hypothenemus dissimilis (Zimmerman), (Bushing 5). Ips avulsus (?), Ips grandicollis, Ips pini, Pityogenes hopkensii (Swain) (?)*.

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* A number of Pityogenes hopkensii were reared from white pine.

Eurytoma conica larvae were found attached to both an Ips larva and pupa (Tables II and III), but also was found disassociated from Ips as both larvae and pupae, indicating that they may detach from the host before pupating or possibly attack more than one host. The pupae were usually found in Ips pupal chambers, indicating that they attack late instar larvae or pupae after the pupal chamber is nearly complete. The remains of an Ips larva was never found near the pupated parasite. E. conica, with one exception, was found only in the upper bole of loblolly pines. Oviposition was not observed but probably occurs through the bark since only the relatively thin-barked white pine had parasitism throughout the tree. E. conica was rare in loblolly pine but was fairly common in white pine (Table I), and probably contributed significantly to the parasite complex. It was present in low numbers in felled loblolly pine at each sample date except June 10 and July 10 at one location, and responded weakly to changes in host density (Figure 9).

Eurytoma sp. (Hymenoptera:Eurytomidae)

Hosts: Ips calligraphus

One Eurytoma sp. was confirmed on an Ips grandicollis larva in felled loblolly pine (Table II).

Heydenia unica Cook and Davis (Hymenoptera:Pteromalidae)

Hosts: Dendroctonus frontalis Zimmerman, Dendroctonus obesus (Mannerheim), Dendroctonus simplex LeConte, Ips avulsus (Eichhoff), Orthotomicus latidens (LeConte), Phloeosinus dentatus (Say), Phloeosinus sequoiae Hopkins, Phloeosinus taxodii Blackman, Pityogenes knechteli Swaine, Pityophthorus burkei Blackman, Polygraphus poligraphus Linnaeus, Scolytus rugulosus (Ratzeburg), Pissodes strobi (Peck) (Bushing, 5), Ips grandicollis.

Heydenia unica was fairly common in loblolly pine, but almost absent in white pine (Table I). It appeared to be confined to the upper levels of the bole, indicating that it probably oviposits through the bark. H. unica was confirmed as a parasite in 1966 but the habit data showed it found only as free larvae or pupa in Ips pupal chambers (Tables II and III). It was present at each sample date in 1966 except September 14, and was absent in April and May collections in 1967 but present in all later collections, (Figures 11-14). The data from the continuous generations (Figure 9) show that H. unica appeared to respond weakly to changes in host density, showing a decline in numbers after an initial rise, while host numbers continued to rise.

Roptrocerus xylophagorum Ratz. (Hymenoptera:Torymidae)

Hosts: Ips confusus (LeConte), Ips pini (Say), Orthotomicus caelatus (Eichhoff), Phloeosinus dentatus (Say), Polygraphus poligraphus

Linnaeus, Scolytus guadrispinosus Say, Scolytus rugulosus (Ratzeburg), (Bushing 5). Ips avulsus (?), I. calligraphus, I. grandicollis.

R. xylophagorum was the most common parasite recovered from loblolly pine infested with I. grandicollis. Reid (28) reported that adults were found moving over Ips infested lodgepole pine slash and ovipositing from late June to early August in Alberta, Canada. I found it present in every sample with peak numbers occurring in mid-July (Figures 11 and 13). Reid (28) stated that some may overwinter as pupae or larvae, but most appear to overwinter as adults. He also found adults within Ips galleries and observed one female in an egg gallery, ovipositing through an egg-niche plug into the larval gallery. I frequently observed R. xylophagorum females entering Ips galleries but did not observe oviposition. The larvae of R. xylophagorum appear to attack late instar Ips larvae and often detach from their host before pupation as they were frequently found pupated within Ips pupal chambers and frequently found divorced from any Ips larvae or larval remains (Figures 15-18). In one instance, two R. xylophagorum appear to attack late instar Ips larvae and often detach from their host before pupation as they were frequently found pupated within Ips pupal chambers and frequently found divorced from any Ips larvae or larval remains (Figures 15-18). In one instance, two R. xylophagorum adults were reared from the same host. It was also the most common parasite reared from Ips pupae (Table IV), but it is not known if it

were attached to a larva which pupated or had sought out the pupa and attacked it. R. xylophagorum was abundant in all levels of trees, apparently not influenced by bark thickness. R. xylophagorum appeared to be potentially the most effective parasite studied because it responds quickly to changes in host density (Figure 9), is not limited by bark thickness, attacks both larvae and pupae, possibly attacks more than one host since it is frequently found alone in Ips galleries and is apparently mobile enough to seek out hosts in all parts of Ips galleries.

Rhopalicus pulchripennis Crawford (Hymenoptera:Pteromalidae)

Hosts: Conophthorus lambertianae Hopkins, Dendroctonus monticolae Hopkins, Dendroctonus sp., Ips pini, Ips sp., Orthotomicus sp., Pityogenes sp., Polygraphus poligraphus Linnaeus, Polygraphus sp., Scolytidae, Scolytus piceae (Swaine), Scolytus sp., Culindrocopturus eatoni Buchanan, Cylindrocopturus furnissi Buchanan, Cylindrocopturus sp., Pissodes sp., Pissodes strobi Peck, Coeloides dendroctoni Cushman, (Bushing 5), Ips avulsus (?), Ips grandicollis.

I observed R. pulchripennis ovipositing through the bark on white pine. R. pulchripennis was common in both white pine and loblolly pine (Table I). It was present at each collection in 1966, (Figure 11), but was absent from several collections for 1967 (Figure 13), and showed no definite seasonal abundance. R. pulchripennis did not show any

marked response to changes in host density and did not appear to conform to the seasonal activity of Roptrocerus xylophagorum as reported by Reid (28). Taylor (31) reported that R. pulchripennis most commonly emerged in June on the white pine weevil and that they might have a second generation on the weevil in one season.

Rhopalicus tutela (Walker) (Hymenoptera:Pteromalidae)

Hosts: Dendroctonus piceaperda Hopkins, Ips pini (Say), Scolytidae, Pissodes strobi (Peck). (Bushing 5). Ips grandicollis.

Rhopalicus tutela was one of the two most abundant parasites recovered from white pine, was nearly absent from felled loblolly and completely absent from standing loblolly pine (Table I). Adults were observed ovipositing through the bark of Ips infested white pine but it was not determined if eggs were laid directly on Ips larvae. No seasonal data was obtained for R. tutela since there were only two collection dates for white pine and it was abundant on both dates and in all levels (Appendix Tables XXXXII-XXXXIII). Forty seven percent of R. tutela larvae were found attached to Ips larvae, and the remaining larvae were free, either in Ips larval galleries on pupal chambers (Figure 17). A few pupae, (8%), were found with the remains of their hosts, but the majority were free in Ips pupal chambers (Figure 18). These data indicate that the parasite normally leaves its larval host before pupating and possibly attacks one host then seeks out another to complete its development, because it is doubtful that an Ips

larva with the parasite attached could complete its larval development and excavate a pupal chamber before succumbing.

Dendrosotor sulcatus Muesebeck (Hymenoptera:Braconidae)

Hosts: Dendroctonus frontalis Zimmerman, Ips avulsus (Eichhoff), Ips sp. (Bushing 5). Ips grandicollis, Ips pini (?).

In this study D. sulcatus was one of the four most abundant parasites recovered from felled loblolly pine. Only one specimen was reared from white pine, however. It was generally confined to the upper levels of the bole, and was present in every sample taken but was most abundant in May, August, and September (Figs. 12 and 14). D. sulcatus appeared to be sensitive to changes in host density (Fig. 10). D. sulcatus larvae do not spend all their time attached to a single host larva as they are often found free in Ips larval galleries and pupal chambers (Fig. 15). The pupae, however, are almost always found associated with the remains of host larvae (Fig. 16), suggesting that they may attack more than one host. D. sulcatus was also recovered from Ips pupae (Table IV), but is probably not an important pupal parasite.

Spathius pallidis Ashmead (Hymenoptera:Braconidae)

Hosts: Dendroctonus frontalis Zimmerman, Ips grandicollis (Eichhoff), Chrysobothris femorata (Olivier), (Bushing 5) Ips pini.

Spathius pallidis was reared from felled loblolly and white pine but was absent in standing loblolly (Table I). S. pallidis usually found only in the upper bole of loblolly pine. Only twelve specimens

were reared from white pine but some of these were from the lower bole. Of the S. pallidis larvae reared in gelatin capsules during 1967, 94% were attached to Ips larvae and the remaining 6% were found free in Ips pupal chambers (Fig. 15). These were probably larvae which were preparing to pupate since a large proportion of the pupae were found associated with Ips larval remains and some found in pupal chambers free from Ips remains (Fig. 16). S. pallidis was always present except in July 1967, with peak numbers recovered in late August 1966 and Mid-April 1967. It generally made up a small proportion of the parasite complex. S. pallidis did not appear to respond to host population changes (Fig. 10).

Coeloides pissodis (Ashmead) (Hymenoptera:Braconidae)

Hosts: Dendroctonus frontalis Zimmerman, Ips calligraphus (Germar), Ips grandicollis (Eichhoff), Pissodes nemorensis Germar, Pissodes strobi (Peck), (Bushing 5), Ips avulsus.

No biological information for Coeloides pissodis on Ips was found; however Taylor (31) reported one generation per year on the white pine weevil with emergence peaks occurring in mid-June to mid-July and late July to August in Massachusetts. Taylor also reported that some overwinter in cocoons and emerge the following spring. I reared C. pissodis from each of seven continuous generations of Ips grandicollis in loblolly pine during 1966-1967. The highest recovery occurred during June and July in 1966, and in the overwintering generation collected in March, 1967 (Figures 12 and 14). However, it was

present only in very low numbers in 1967. C. pissodis larvae attack Ips larvae and remain attached until they complete development, usually before the Ips larvae excavates a pupal chamber (Figure 16). Pupation usually occurs within the remains of the host.

Oviposition occurs through the bark, thus C. pissodis is limited mostly to the upper bole, although limited oviposition sites might occur in furrows in the bark of the lower bole. I did not recover C. pissodis from the lower 12 feet of any loblolly pines. C. pissodis was not found to parasitize Ips pupae. The searching and oviposition habits of the female were observed to be very similar to that of C. brunneri as reported by Ryan and Rudinsky (29).

Tomicobia tibialis (Hymenoptera:Pteromalidae)

Hosts: Dendroctonus pseudotsugae Hopkins, Ips calligraphus (Germar), Ips confusus (LeConte), Ips grandicollis (Eichhoff), Ips oregonis (Eichhoff), Ips perroti Swaine, Ips pini (Say), Ips sp., Orthotomicus caelatus (Eichhoff), Pityophthorus puberulus LeConte, Pityophthorus pulchellus Eichhoff, Scolytidae adults (Bushing 5), Ips avulsus (?).

Reid, (28), reported some habits of T. tibialis on Ips pini and Ips perroti as follows: "During the spring flight of Ips, a small hymenopteran, ... T. tibialis, was observed following an Ips adult moving over the back prior to making its entry hole. The parasite periodically attacked the bark beetle and with great speed and rapid movement of its ovipositor attempted to deposit eggs either on or within the beetle. In the fall, many of the dead Ips adults found in

main galleries, the parents of the brood, contained Tomicobia pupae, each occupying the entire abdominal and thoracic cavities. The pupa overwintered in the host, emerging as an adult in the spring by cutting a round hole through the elytral declivity or posterior ventral portion of the abdomen." Hopkins (21) reported the same habits. I reared T. tibialis from all types of host material infested with Ips and recovered one fully developed pupa from 117 dead I. pini adults removed from the egg galleries. Although adults of T. tibialis were collected from the trunks of Ips infested white pine, oviposition on Ips adults was not observed. T. tibialis appears to be rather ineffective as an Ips population regulator since the beetles are apparently able to construct egg galleries and lay eggs. The effect on egg gallery length, number of eggs, etc. is unknown, however. It was not present in two white pines collected June 27, 1967, but was common in one collected on August 7. It was found throughout the season in loblolly pines (Appendix Tables XXX-XXXXV).

Heterospilus sp. Haliday (Hymenoptera:Braconidae)

Hosts: Ips avulsus, I. grandicollis, I. pini

This species was one of the four most abundant parasites reared from white pine (Table I), but was absent or present only in low numbers in felled loblolly pines. Heterospilus larvae were commonly found attached to Ips larvae and occasionally to pupae but many were also found free (Fig. 17). The parasite pupae,however, were usually found pupated near the remains of the host larvae (Fig. 18).

Heterospilus was abundant throughout the boles of the two white pine trees collected June 27, but was absent in one collected August 7 (Appendix Tables XXXXII-XXXXIII), indicating that it may not be available as an Ips control agent for part of the season.

Cecidostiba polygraphi Ashmead (Hymenoptera:Pteromalidae)

Hosts: Polygraphus poligraphus Linnaeus (Bushing 5), Ips pini.

Cecidostiba polygraphi was the most abundant parasite reared from white pine and was absent from all loblolly pine sampled (Table I). It was present on both sample dates in large numbers. It was reared as both a larval and pupal parasite but was most common on larvae (Fig. 17). C. polygraphi pupae were usually found free from larval or pupal Ips remains and were most often found in Ips larval galleries, indicating that they may attack early instar larvae, (Fig. 18). This species was also observed to oviposit through the bark. It appears to be capable of exerting strong influence on Ips populations as it was present in large numbers at the initiation of the Ips infestation. This single species contributed nearly one-third of the individuals in the white pine parasite complex.

?Ambylmerus sp. (Hymenoptera:Pteromalidae).

A few males were identified by Dr. Oswald Peck as ?Ambylmerus but he stated that females were needed for positive identification. A key to the nearctic Chalcidoidea parasitizing Ips spp. provided by Dr. Peck was used and several obviously different parasites were keyed out as ?Ambylmerus. These later proved to be at least three families

of Proctotrupoidea but have not yet been identified to species. Two of the male specimens originally identified as ?Amblymerus were found attached to Ips larvae and one found as a free pupa in an Ips pupal chamber (Table II). No preference for a particular area of the bole was shown by these insects.

Parasitism of Ips Pupae

The species of parasites confirmed as Ips pupal parasites are shown in Table IV. The rate of confirmed pupal parasitism was very low (Table V). Parasitism at this low rate is probably insignificant but the large numbers of parasite pupae found in Ips pupal chambers suggests the possibility that the parasite larva may have so completely destroyed the Ips pupa that no trace could be found since the Ips pupa does not have any heavily sclerotized parts such as the larval head capsule which normally remains after the larva is consumed by the parasite.

TABLES

Table I. Numbers of Ips parasites reared from Ips infested bolts - 1966-1967.

Species of Parasites	Felled Loblolly Pine		Standing Loblolly Pine		Standing White Pine	
	Mass Reared	Individually Reared	Mass Reared	Individually Reared	Mass Reared	Individually Reared
Eurytoma conica	16	6	8	4	41	14
Eurytoma sp.	0	1	0	0	0	0
Heydenia unica	62	43	28	23	4	1
Roptrocerus xylophagorum	1005	325	64	70	318	139
Tomicobia tibialis*	153	0	5	0	33	2
?Amblymerus sp.**	96	3	27	0	3	0
Rhopalicus pulchripennis	90	33	9	8	42	4
Rhopalicus tutela	5	1	0	0	650	114
Dendrosotor sulcatus	168	318	8	43	1	0
Spathius pallidis	51	89	0	0	2	10
Coeloides pissodis	135	106	13	15	4	0
Heterospilus sp.	29	15	31	27	147	96
Cecidostiba polygraphi	0	0	0	0	655	477

* Parasite of adult Ips

** Thought to be three families of Proctotrupoidea in addition to several males identified by Dr. Oswald Peck as ?Amblymerus

Table II. Location and Habits of Individually Reared Ips spp. Parasites from Felled Loblolly Pine.

Location and Habit	Eurytoma conica	Eurytoma sp.	Heydenia unica	?Amblymerus sp.	Roptrocerus xylophagorum	Dendrosotor sulcatus	Spathius pallidis	Coeloides pissodis	Hetero-spilus sp.
Attached to Ips larva				2	14	2	16	11	
Attached to Ips pupa					1				
Free larva in Ips larval gallery					22	1		2	
Free larva in Ips pupal chamber	3		12		30	2	1		
Pupated in Ips larval remains					6	83	3	12	4
Free pupa in Ips egg gallery					2				
Free pupal in Ips larval gallery	1				41	1			
Free pupa in Ips pupal chamber	3	1	2	1	123	4	1	1	
Free adult in Ips pupal chamber					8	1			
Total	7	1	14	3	247	94	21	26	4

Table III. Location and Habits of Individually Reared Parasites from White Pine.

Location and Habit	Eurytoma conica	Heydenia unica	Roptrocerus xylophagorum	Rhopalicus pulchripennis	Rhopalicus tutela	Cecidostiba polygraphi	Spathius pallidis	Heterospilus sp.
Attached to Ips larva	1		10		7	42		18
Attached to Ips pupa	1		8			5		1
Free larva in Ips larval gallery			15		5	63	1	15
Free larva in Ips pupal chamber			50	1	3	48		8
Pupated in Ips larval remains			36		5	5	4	36
Free pupa in Ips egg gallery						2		
Free pupa in Ips larval gallery			4		14	101		4
Free pupa in Ips pupal chamber	7	1	7	2	42	80	5	7
Free adults in Ips pupal chamber	5		6	1	42	132		6
Total	14	1	94	4	118	478	10	94

Table IV. Species and Number of Confirmed as Parasites of Ips spp. pupae.

Species of Parasites	Loblolly Pine	White Pine
Roptrocerus xylophagorum	10	8
Dendrosotor sulcatus	2	0
Eurytoma conica	0	1
Heterospilus sp.	0	1
Cecidostiba polygraphi	0	5

Table V. Percent parasitism of Ips pupae.

Felled Loblolly Pine									
	Generations							Tree Number	Percent Parasitism
Plot Number	1	2	3	4	5	6	7		
1	0.63	0.00	----	----	0.00	0.00	----	1	0.12
2	1.58	0.00	0.00	----	0.00	0.00	----	2	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	----	3	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00		

FIGURES

Figure 1. Percent parasitism of Ips, based on observed parasitism or parasitism indicated by parasite location (solid lines) and percent parasitism calculated from numbers of emerging adults (broken lines) in two felled loblolly pines.*

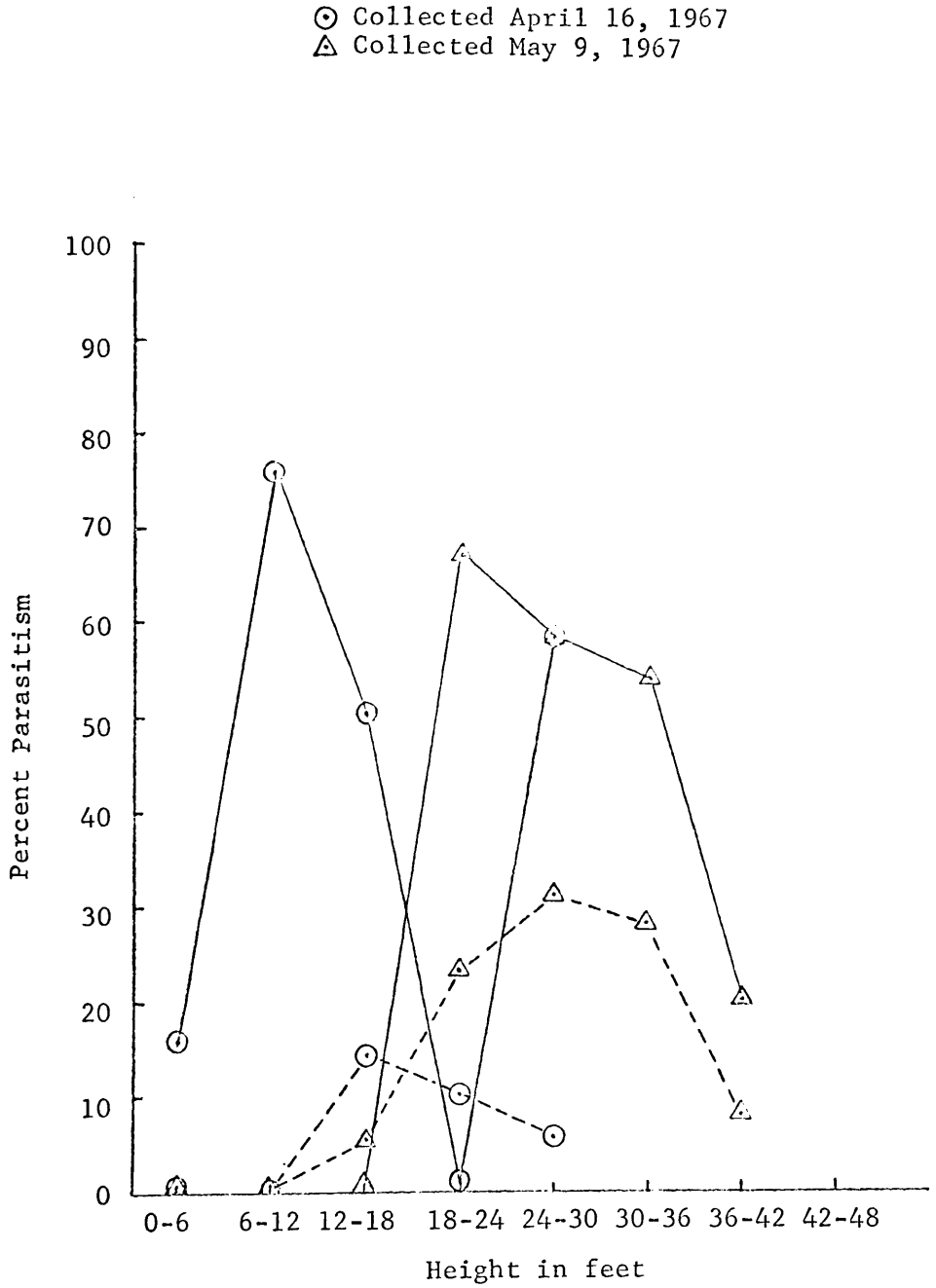


Figure 2. Percent parasitism of Ips, based on observed parasitism or parasitism indicated by parasite location (solid lines) and percent parasitism calculated from numbers of emerging adults (broken lines) in three felled loblolly pines. Collected June 10, 1967.

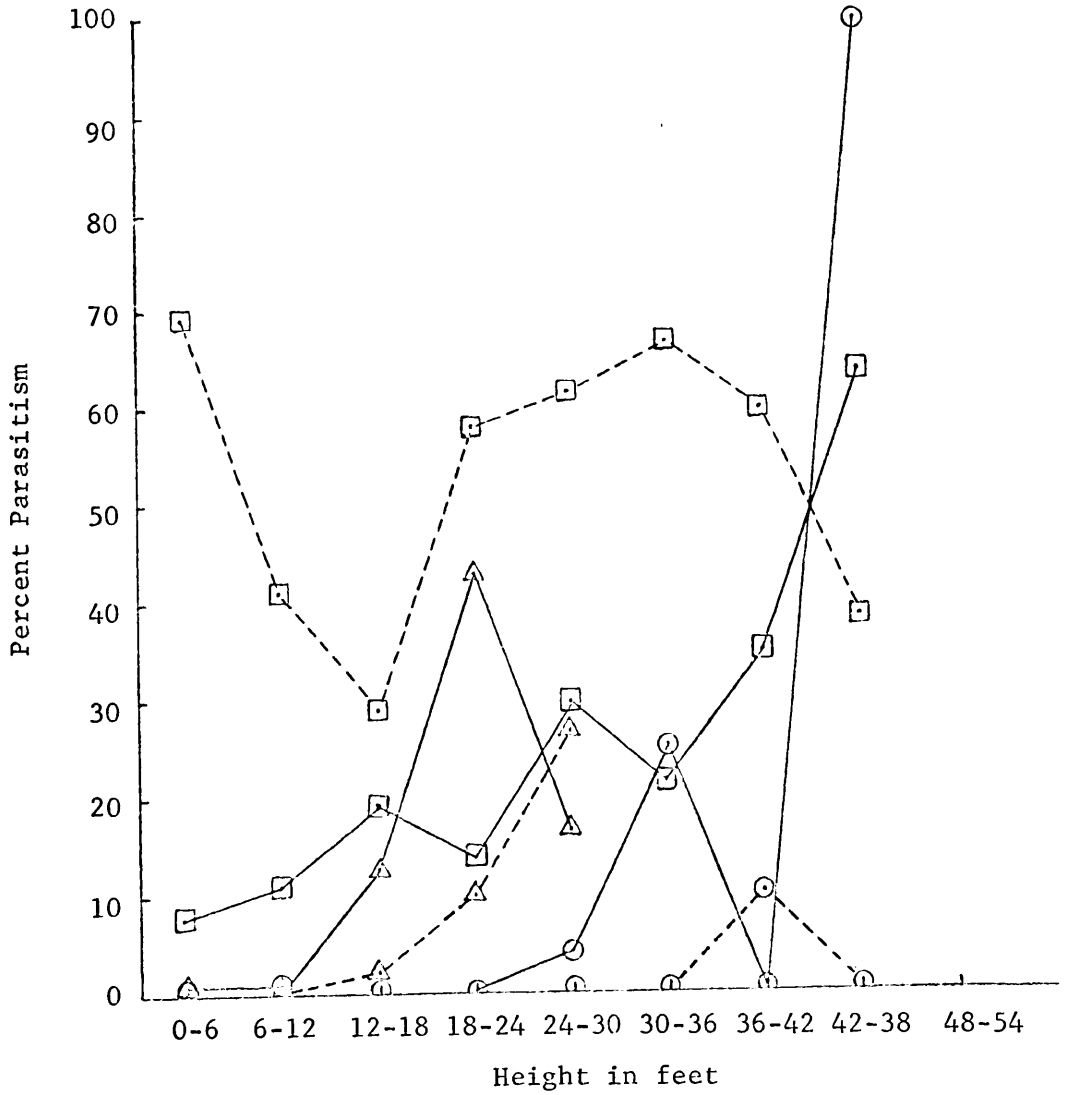


Figure 3. Percent parasitism of Ips, based on observed parasitism or parasitism indicated by parasite location (solid lines) and percent parasitism calculated from numbers of emerging adults (broken lines) in two felled loblolly pines*.

⊙ Collected July 10, 1967
⊡ Collected July 20, 1967

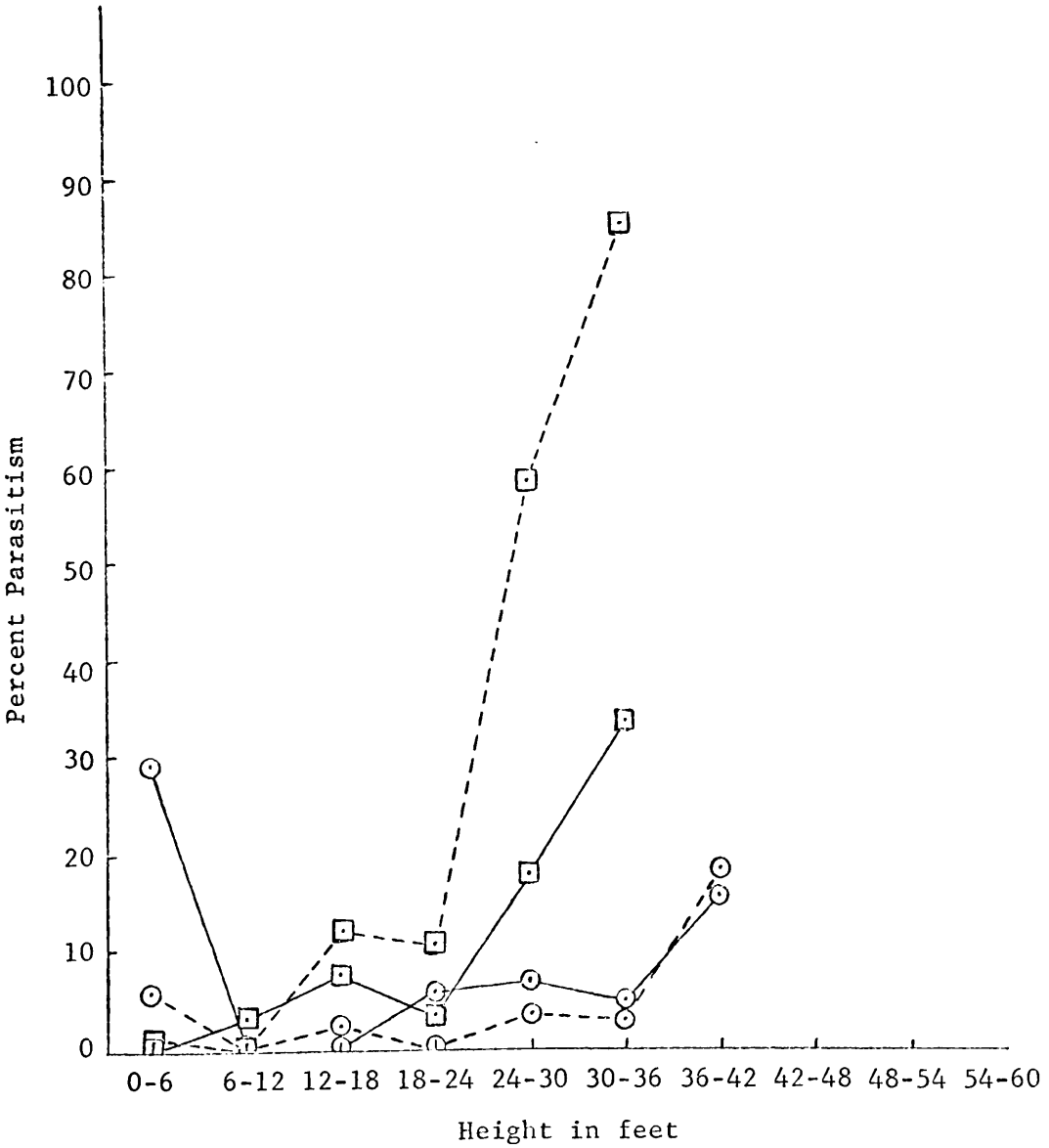


Figure 4. Percent parasitism of Ips based on observed parasitism or parasitism indicated by parasite location (solid lines) and percent parasitism calculated from numbers of emerging adults (broken lines) in two felled loblolly pines*.

* Collected August 7, 1967

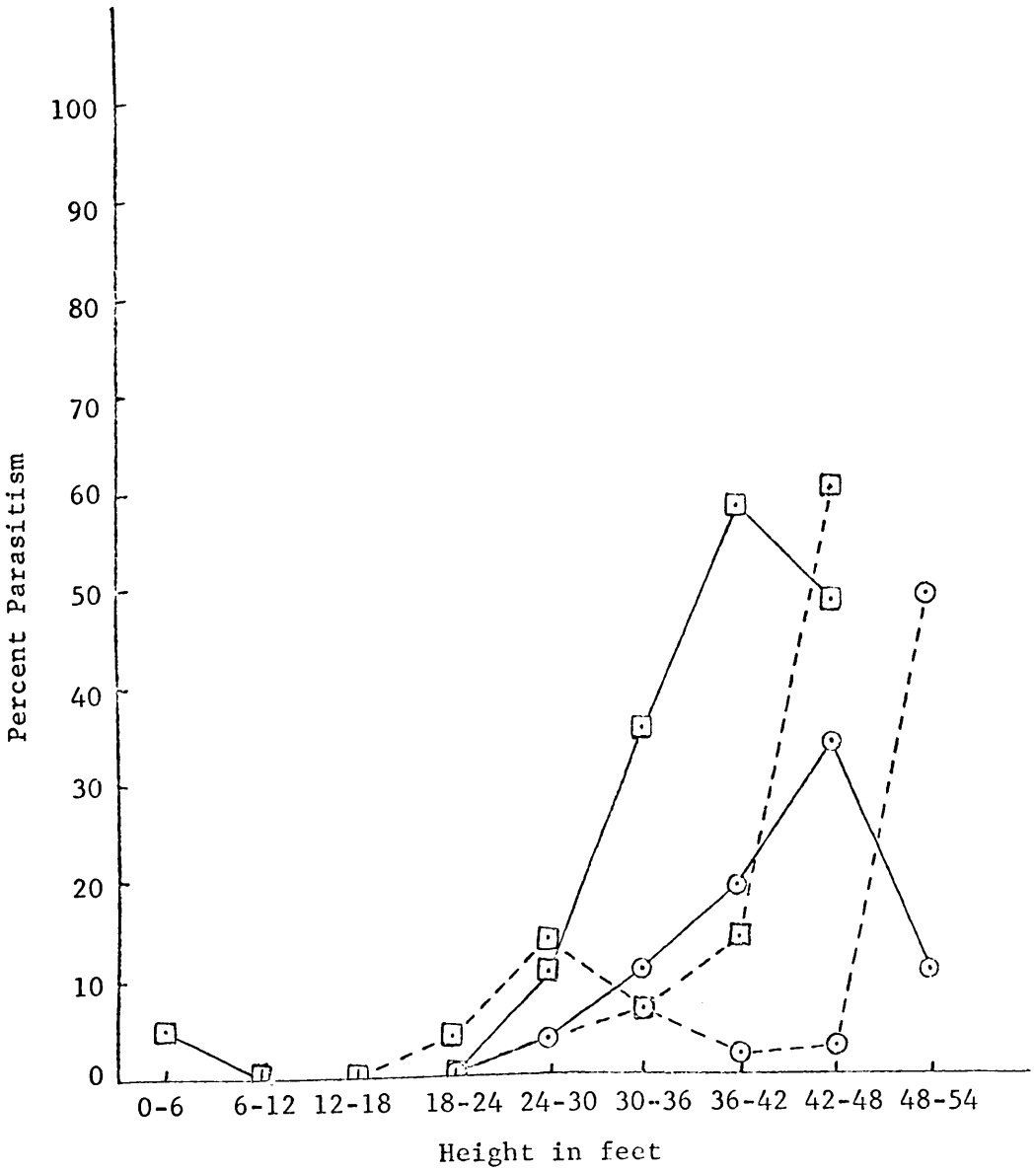


Figure 5. Percent parasitism of Ips based on observed parasitism, or parasitism indicated by parasite location (solid lines) and percent parasitism calculated from numbers of emerging adults (broken lines) in two felled loblolly pines*.

*Collected August 21, 1967

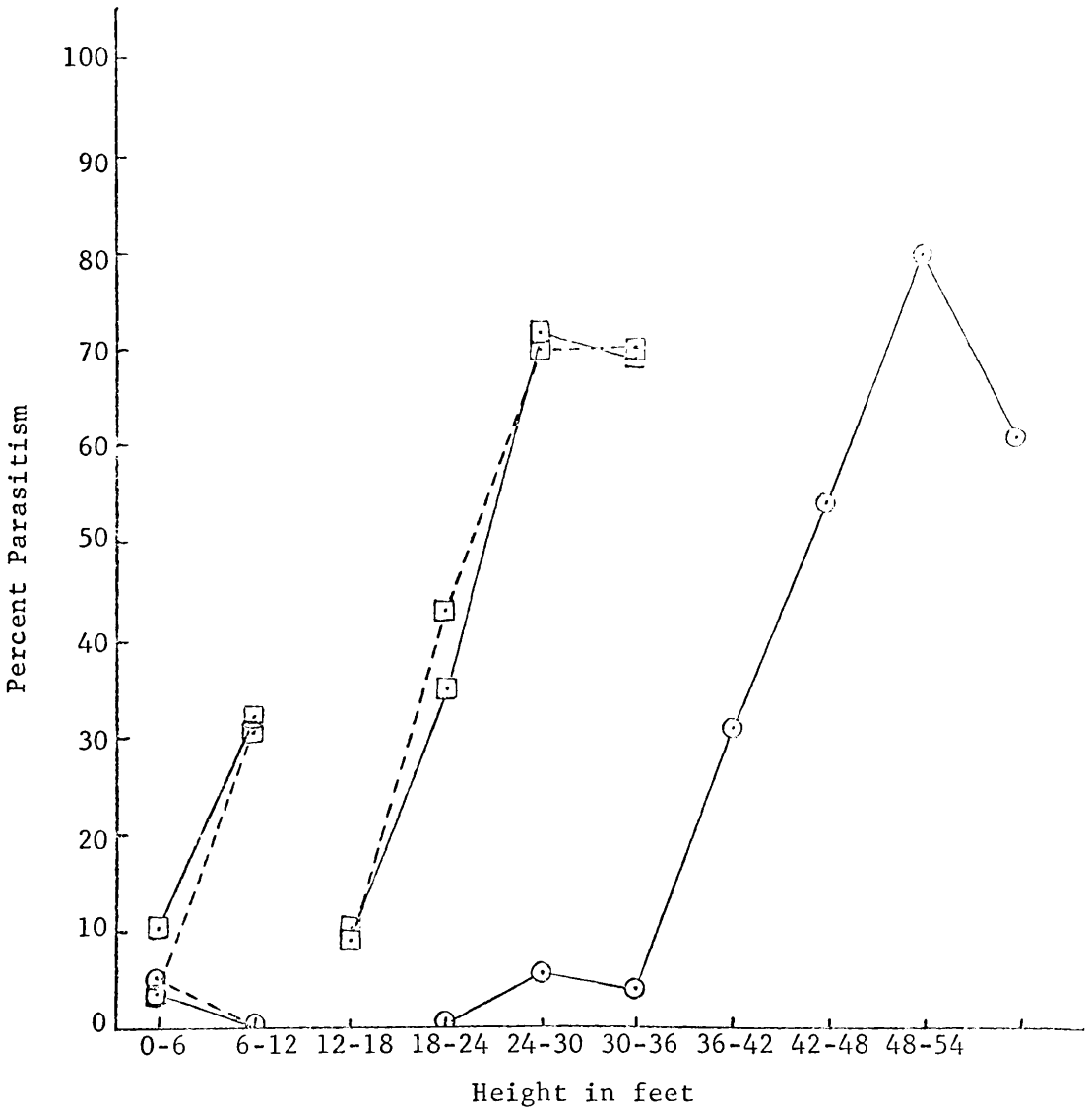


Figure 6. Percent parasitism of Ips infesting standing loblolly pines*. (Percentages calculated from numbers of emerging adults).

_____ Infested with Ips avulsus
- - - - Infested with Ips calligraphus
* Collected August 17, 1966

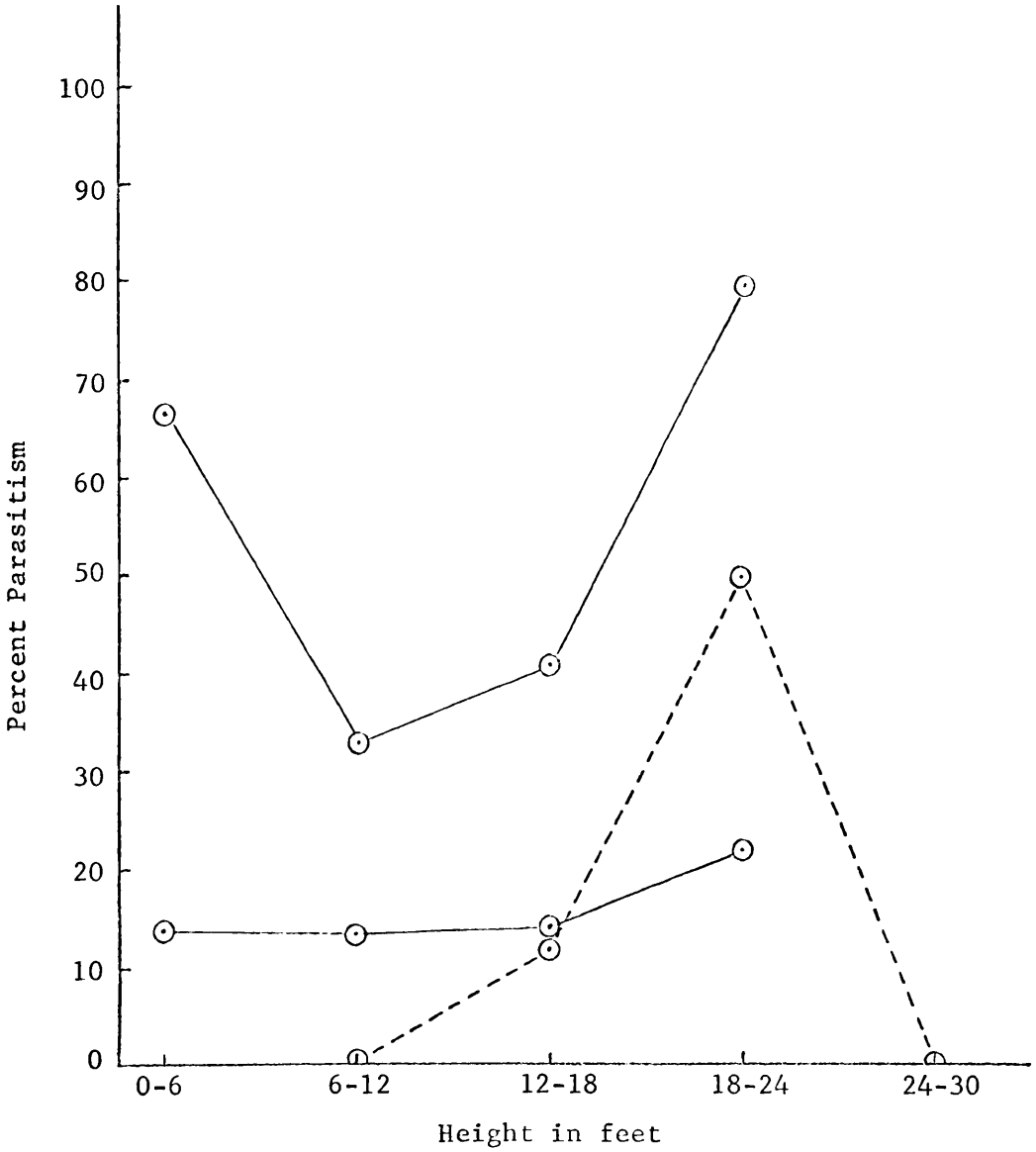


Figure 7. Percentages of Ips based on observed parasitism or parasitism indicated by parasite location (solid lines) and percent parasitism calculated from numbers of emerging adults (broken lines) in three standing white pines*

⊙ Collected June 27, 1967
⊡ Collected June 27, 1967
△ Collected August 14, 1967
No larvae or pupae dissected out of next two levels.

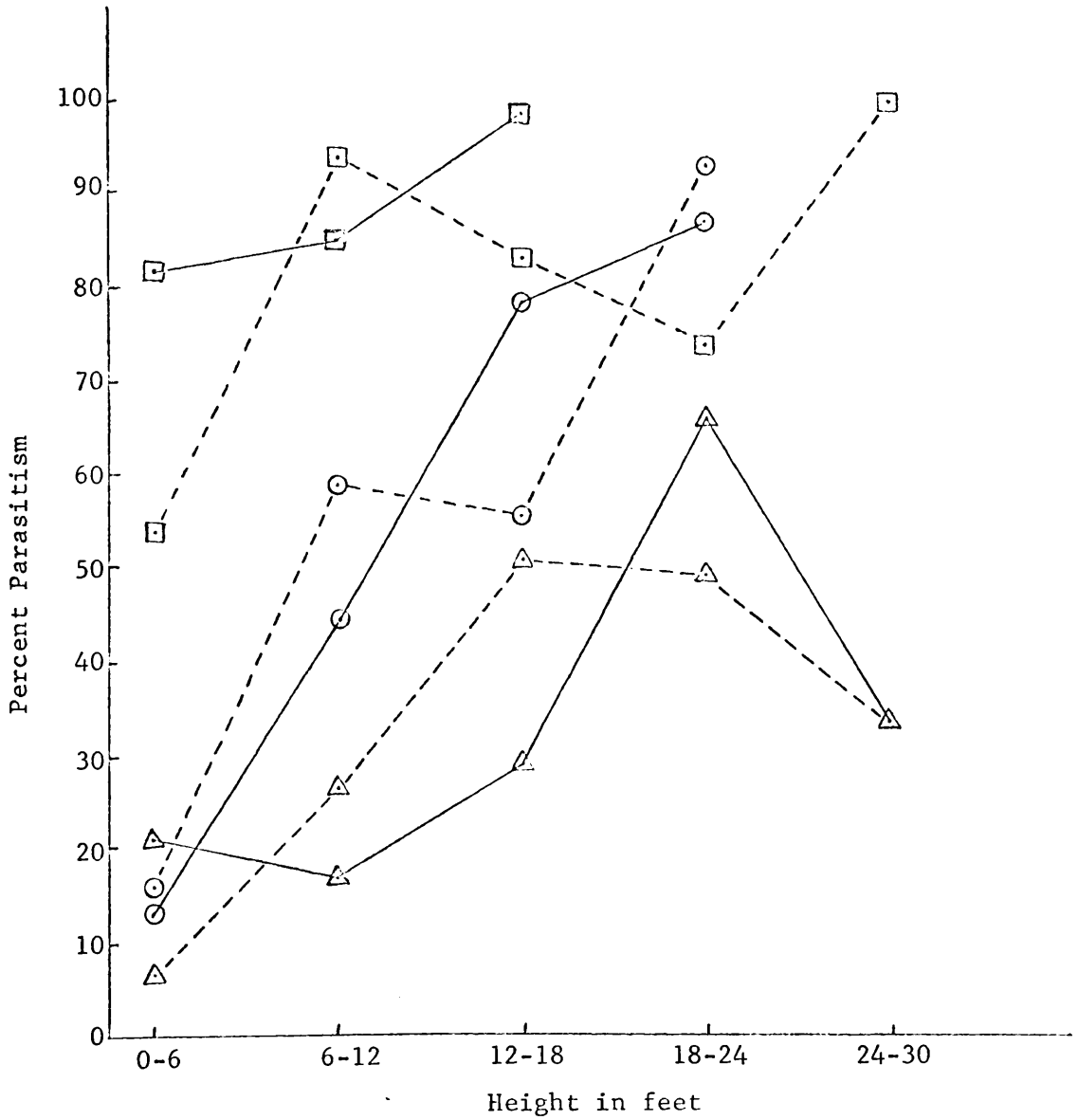
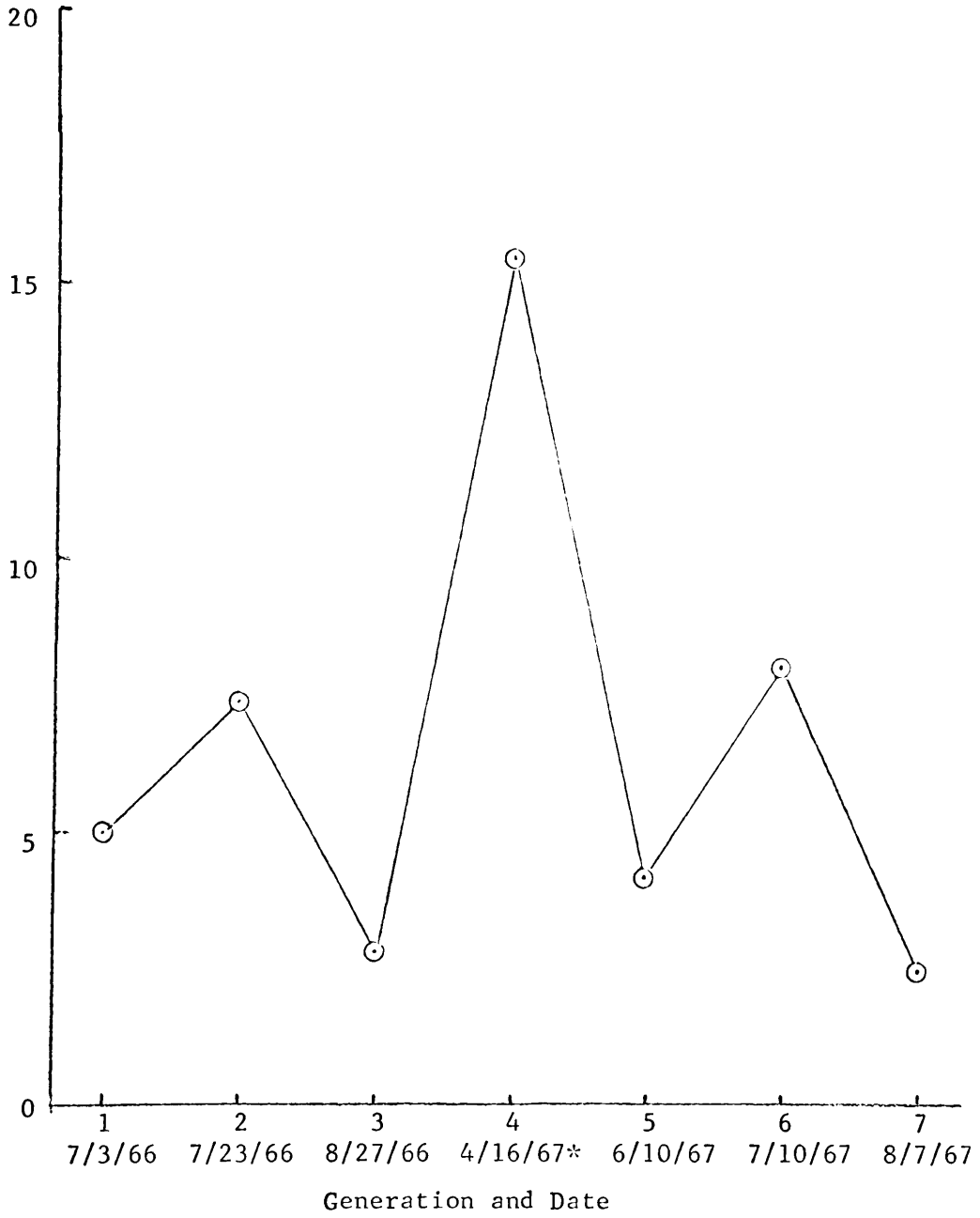


Figure 8. Total percent parasitism for seven continuous Ips generations at one location on felled loblolly pine. (Percentages calculated from numbers of emerging adults).



* Overwinter generation 1966-1967

Figure 9. Numbers of Chalcidoid parasites recovered from felled loblolly pines at one location for seven consecutive Ips generations and corresponding Ips population density.

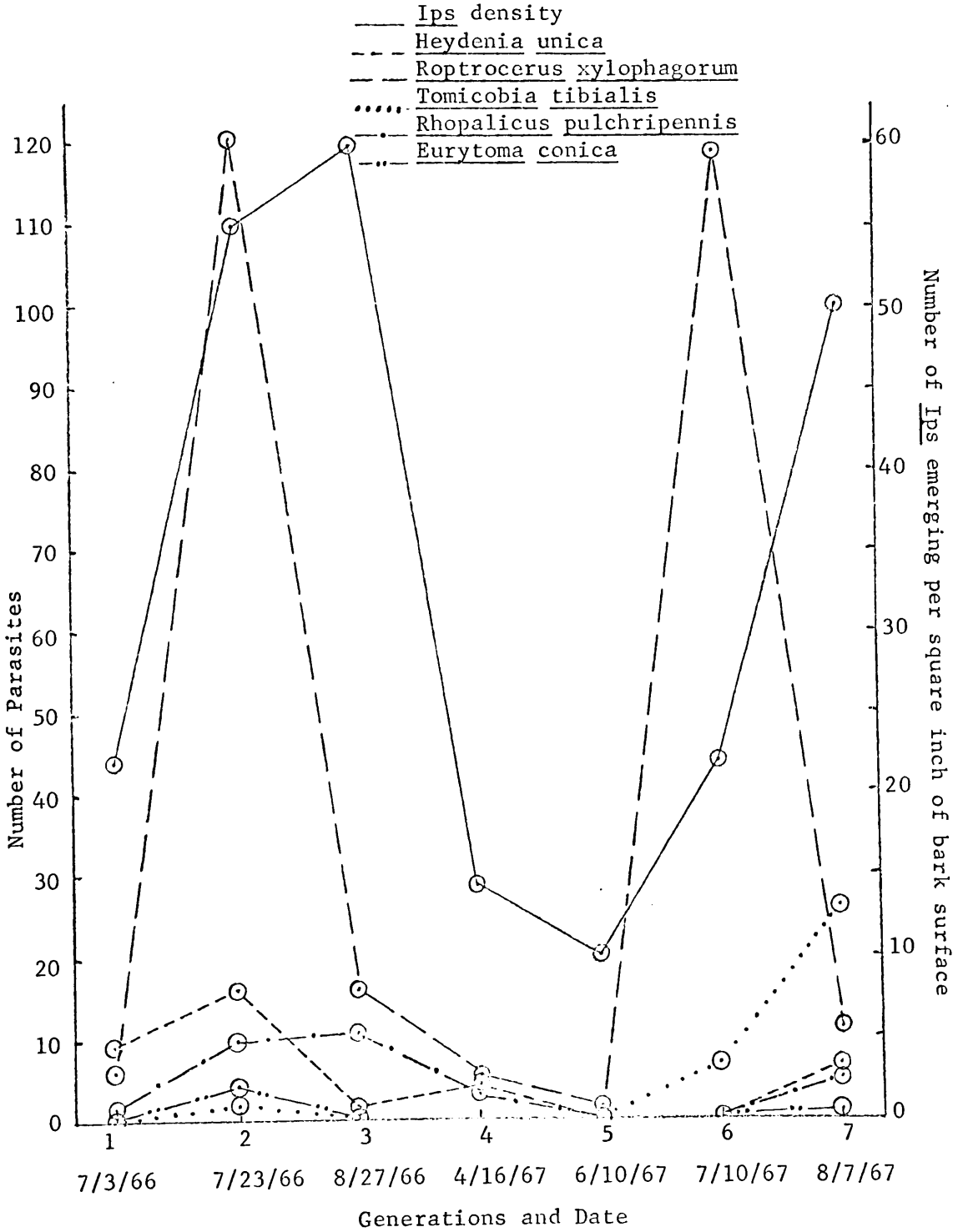


Figure 10. Numbers of Braconid parasites recovered from felled loblolly pines at one location for seven consecutive Ips generations and corresponding Ips population density.

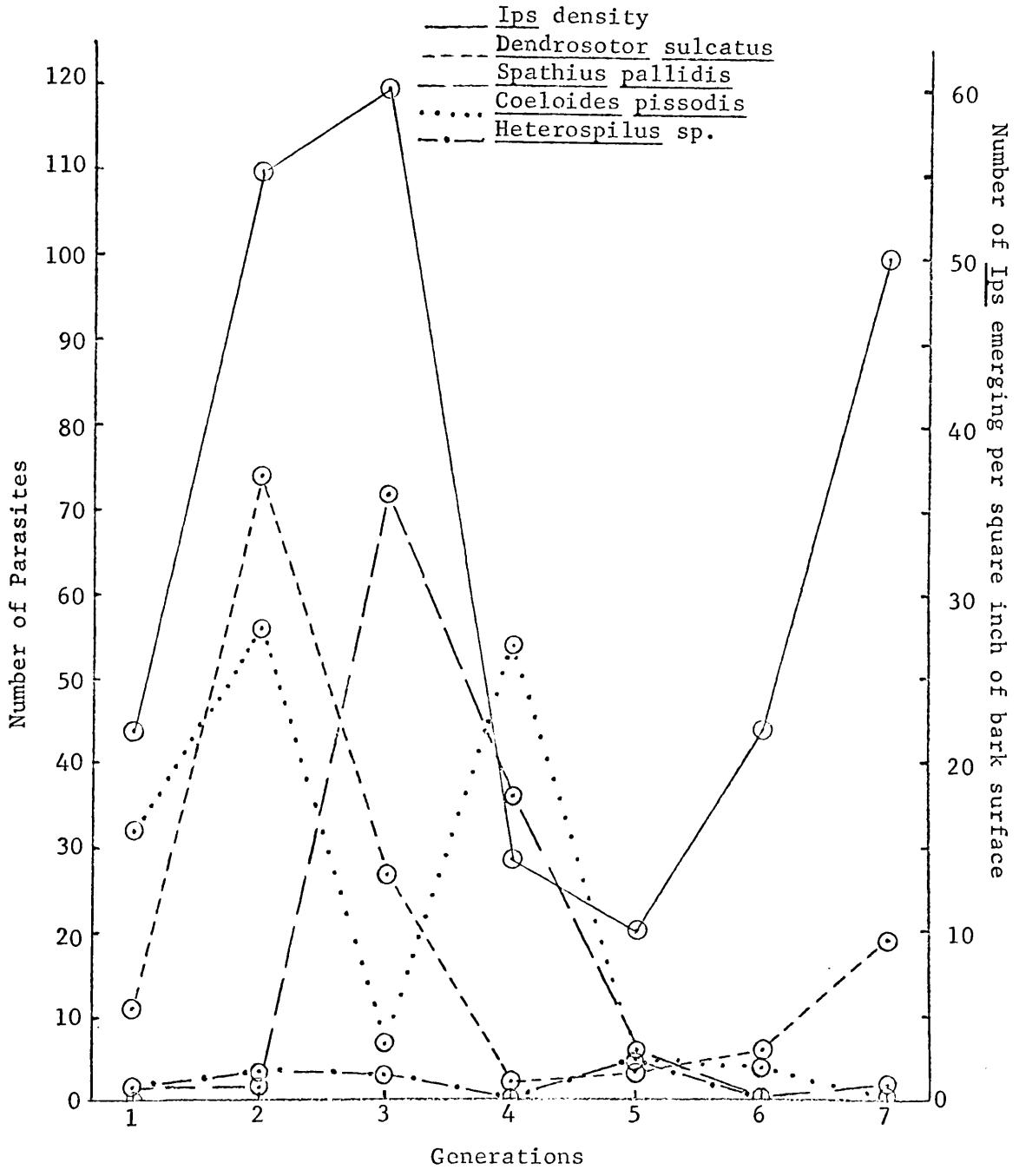


Figure 11. Seasonal abundance of Chalcidoid Ips parasites in felled loblolly pines for 1966. (Each species expressed as a percentage of the total parasites recovered).

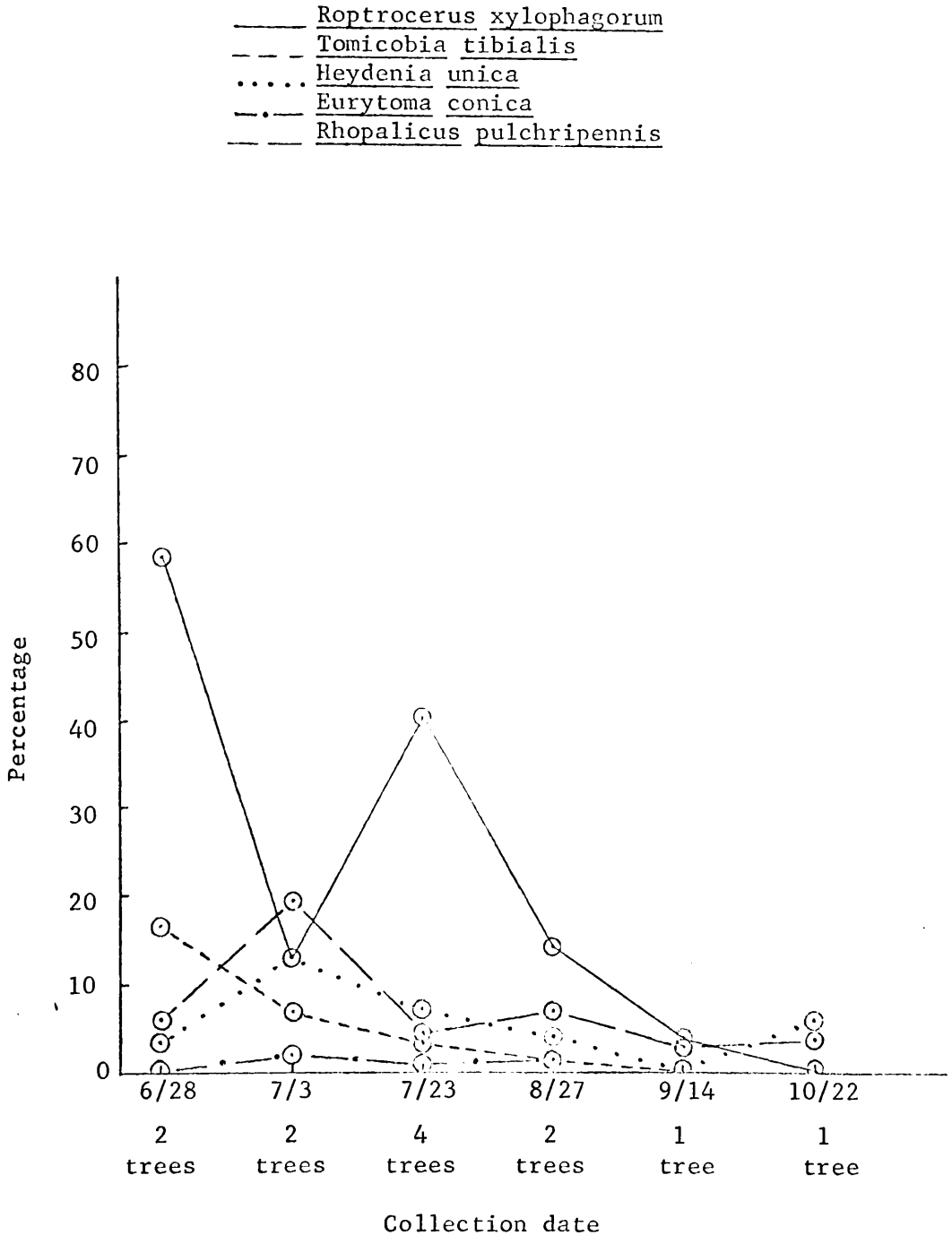


Figure 12. Seasonal abundance of Braconid Ips parasites in felled loblolly pines for 1966. (Each species expressed as a percentage of the total parasites recovered).

_____ Dendrosotor sulcatus
_ _ _ _ Spathius pallidis
. . . . . Coeloides pissodis
—.— Heterospilus sp.

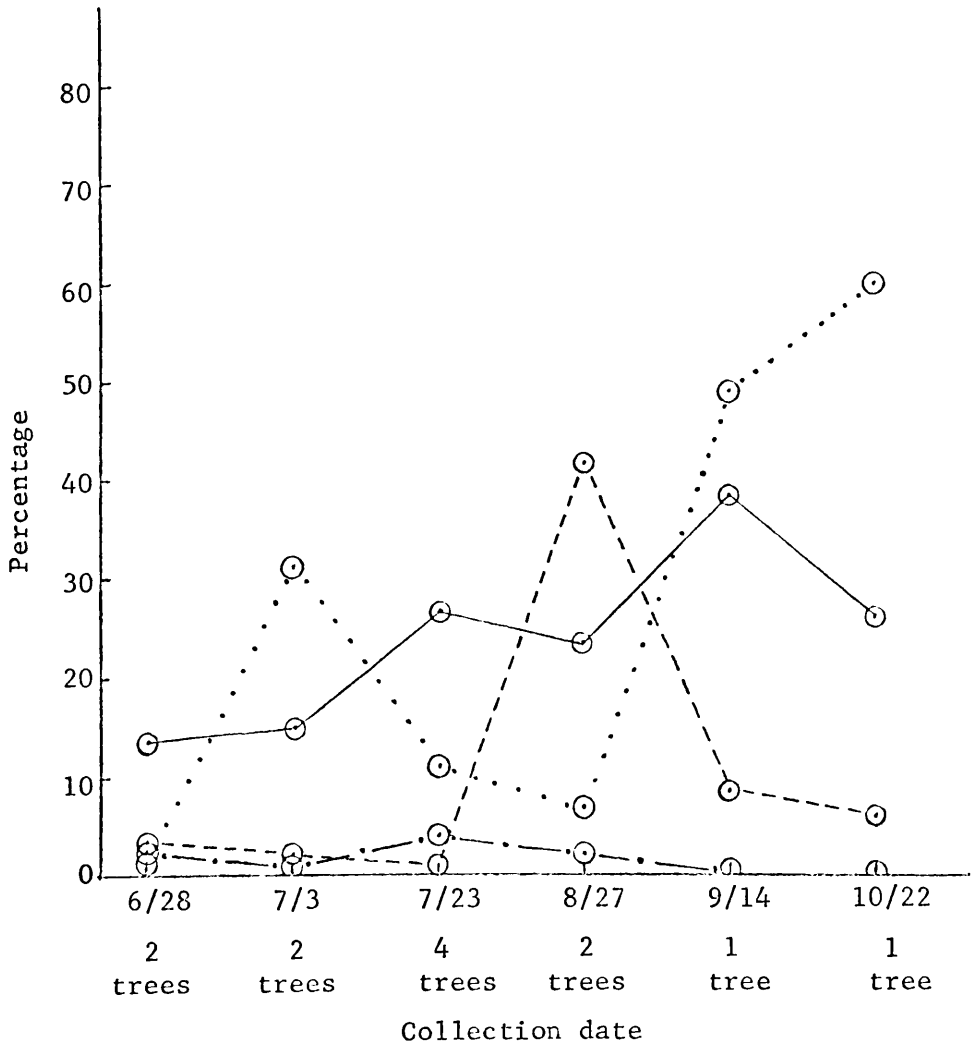


Figure 13. Seasonal abundance of Chalcidoid Ips parasites in felled loblolly pines for 1967. (Each species expressed as a percentage of the total parasites recovered).

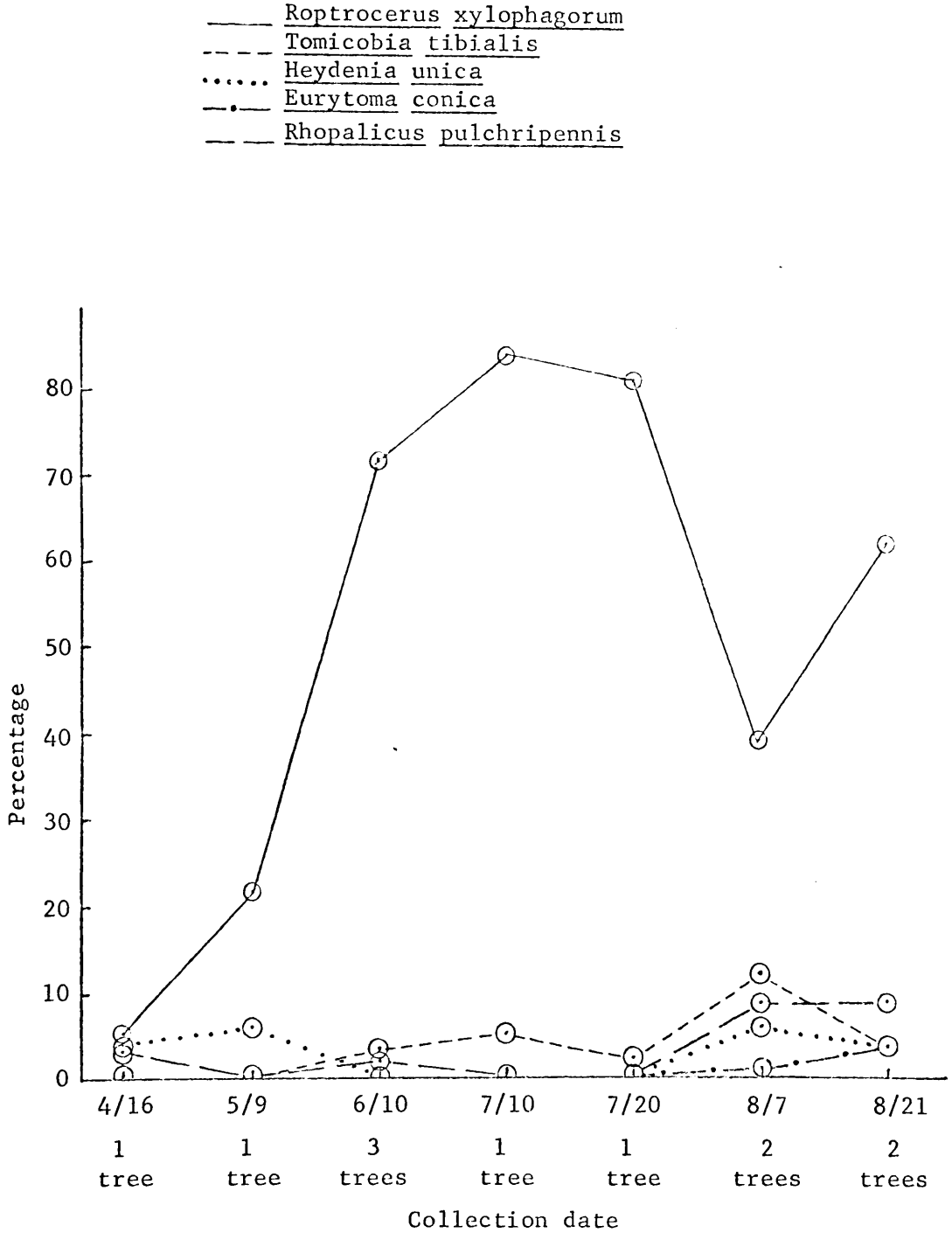


Figure 14. Seasonal abundance of Braconid Ips parasites in felled loblolly pines for 1967. (Each species expressed as a percentage of the total parasites recovered).

_____ Dendrosotor sulcatus
__ __ Spathius pallidis
_ _ _ _ Coeloides pissodis
. . . . . Heterospilus sp.

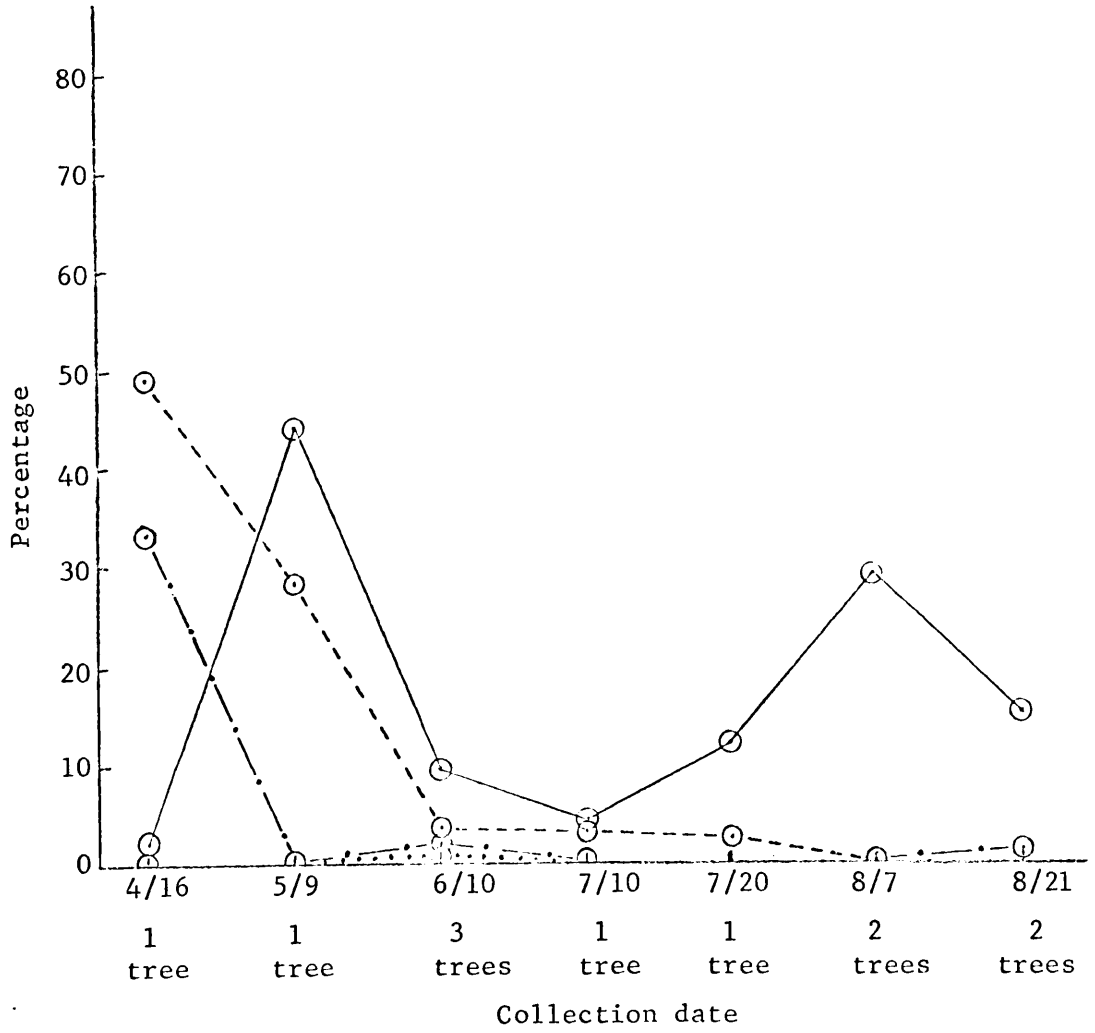


Figure 15. Percentages of larvae of the four most common parasites individually reared from felled loblolly pine found in different locations in Ips galleries.

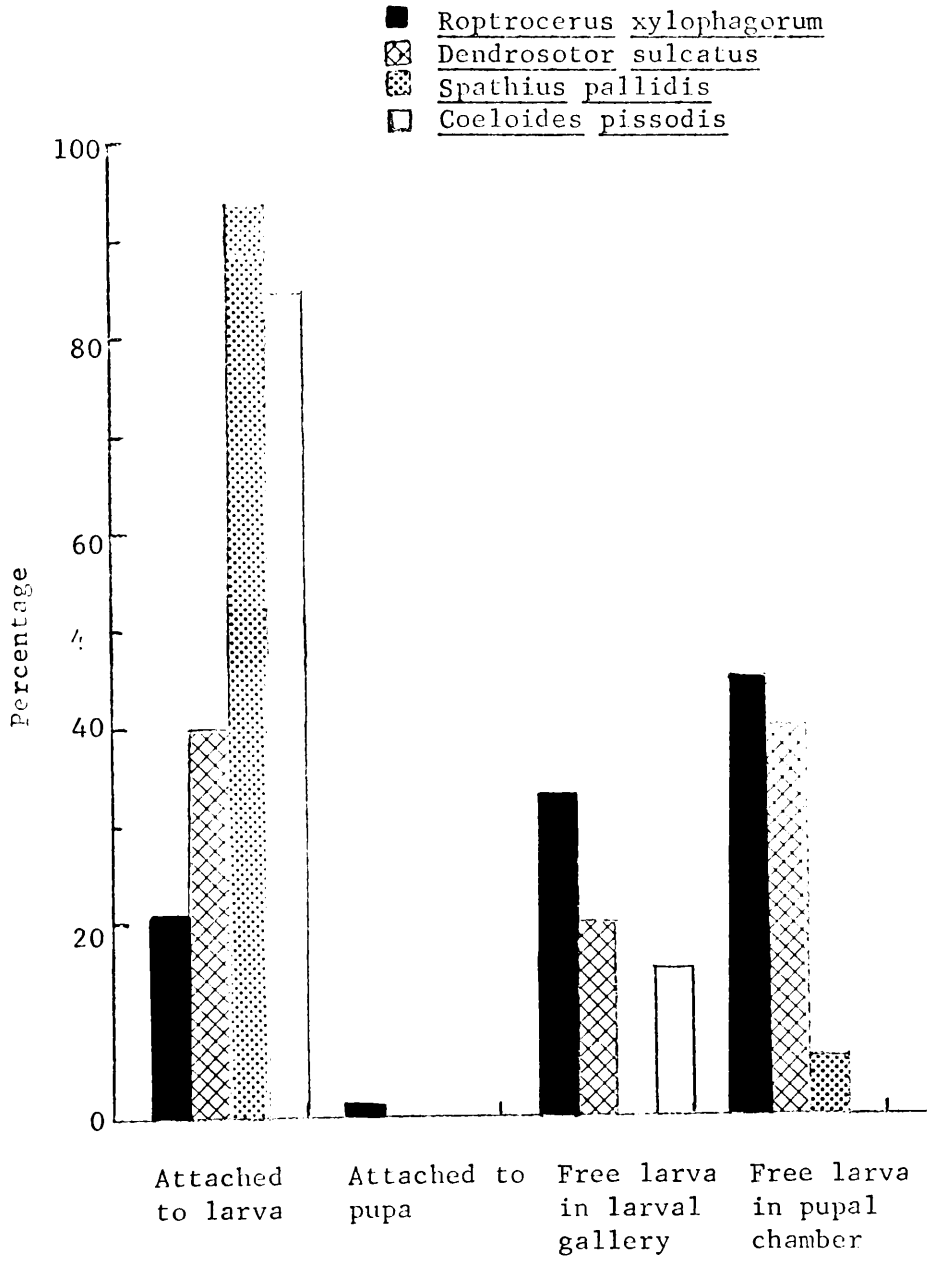


Figure 16. Percentages of larvae of the four most common parasites individually reared from white pine found in different locations in Ips galleries.

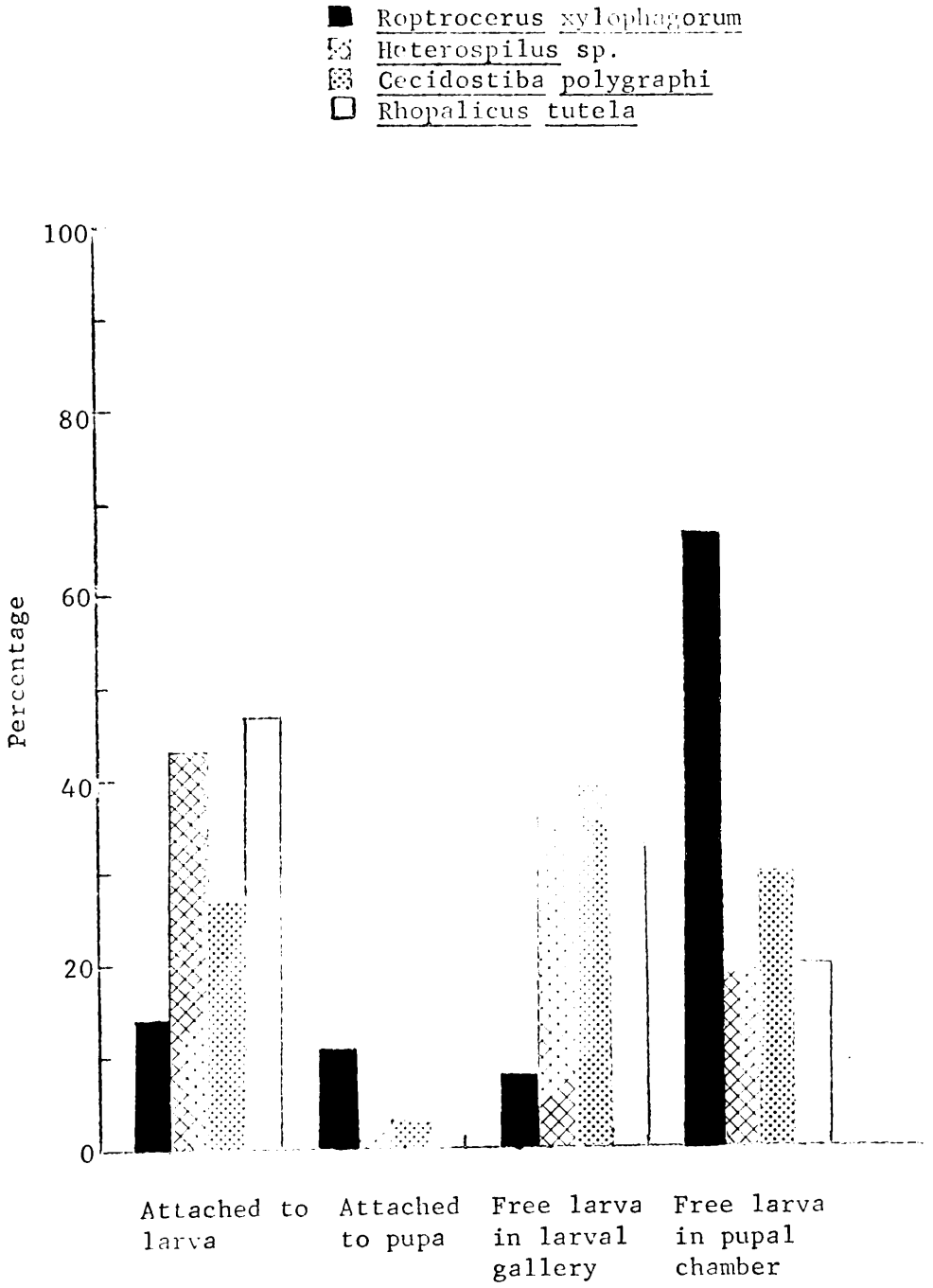


Figure 17. Percentages of pupae of the four most common parasites individually reared from felled loblolly pine found in different locations in Ips galleries.

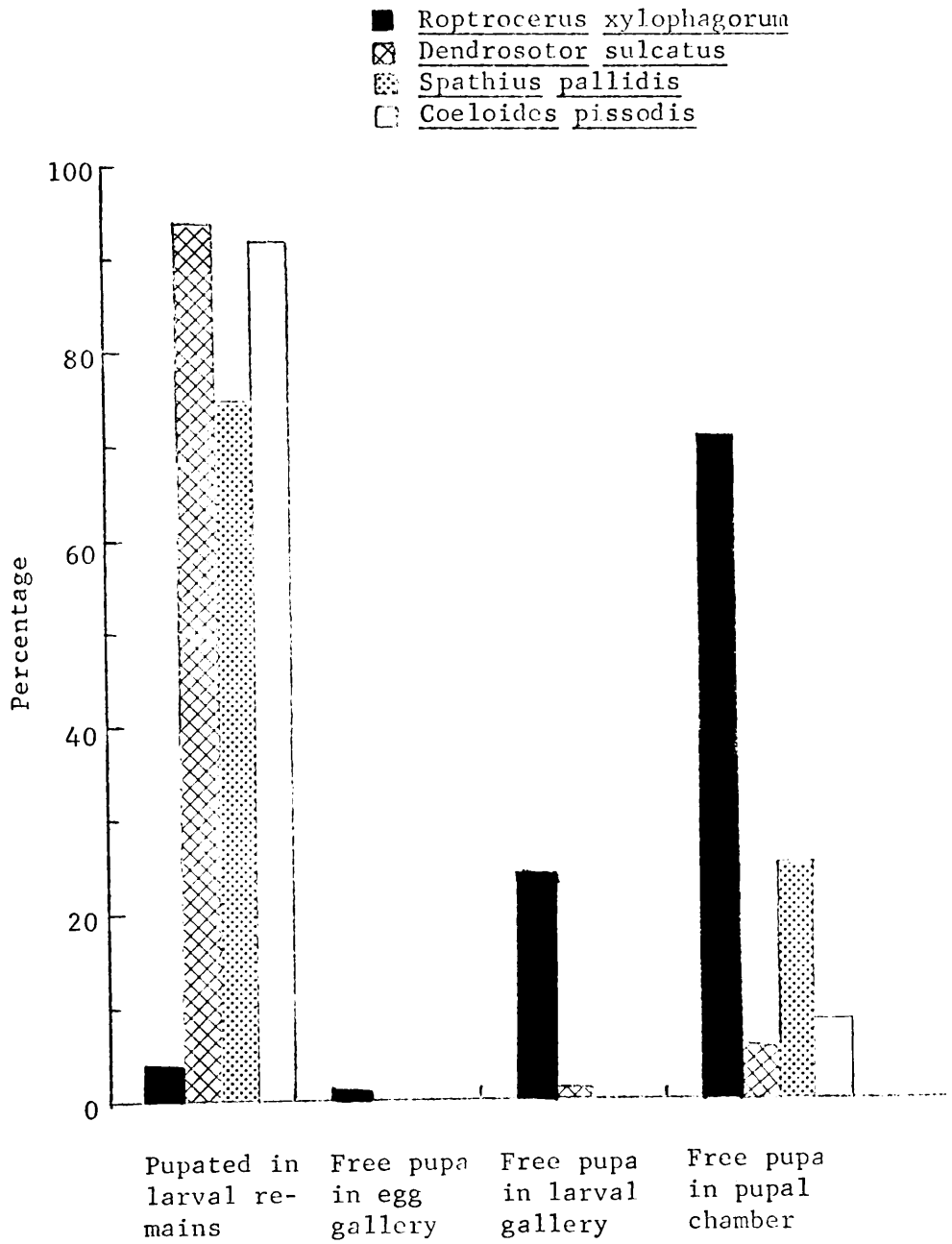
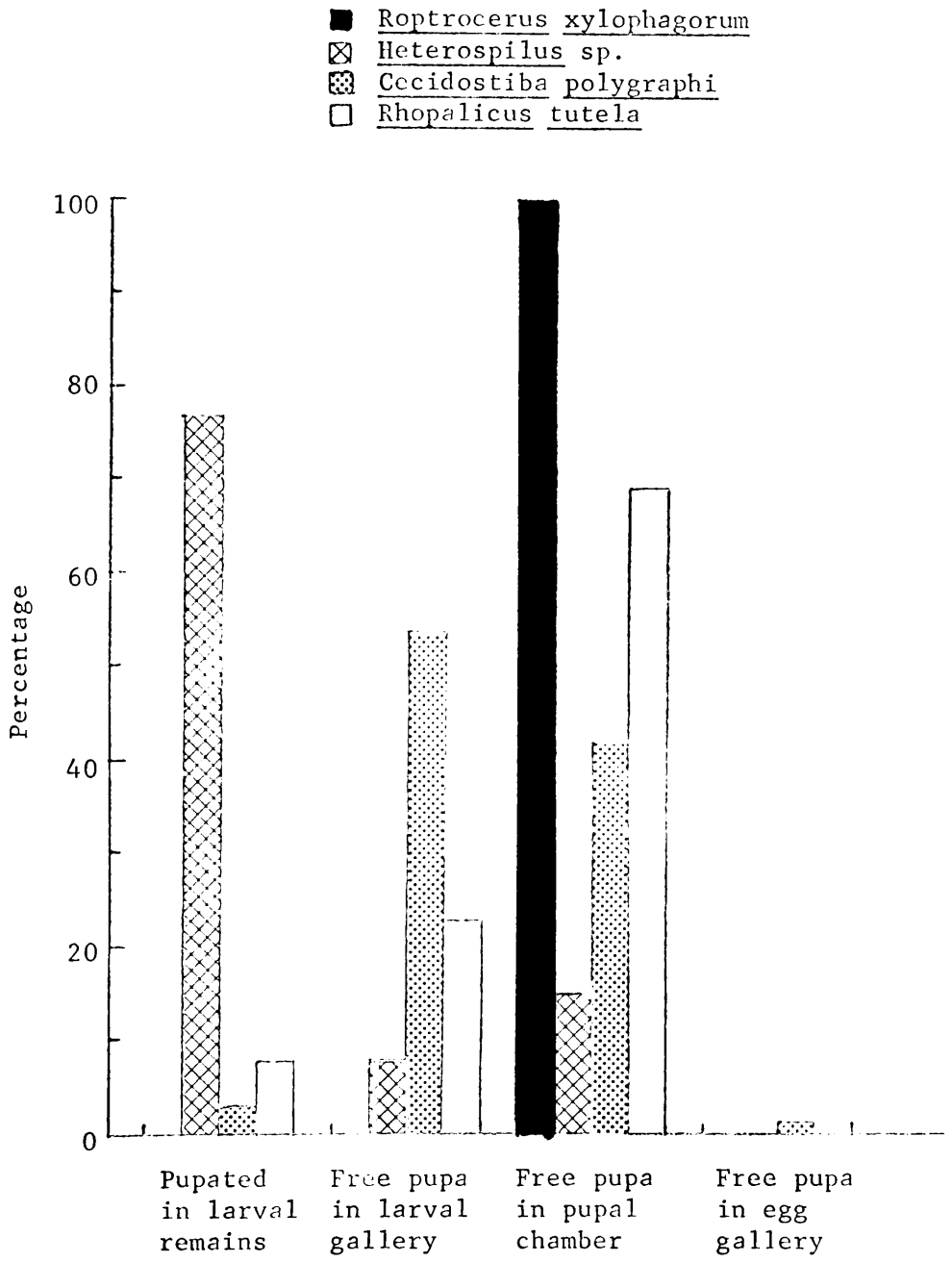


Figure 18. Percentage of pupae of the four most common parasites individually reared from white pine found in different locations in Ips galleries.



V. DISCUSSION AND CONCLUSIONS

During the course of the study, 26 new host records for parasites of the southern Ips were determined. This indicates that the complex of parasites is large but also points out the nearly complete lack of study of parasites of Ips spp. bark beetles.

The parasites may be strongly oriented to a particular tree species and their association with a particular Ips species may or may not be incidental. Although Ips are probably capable of attacking all types of host material, the parasites present in large numbers on one tree host may be absent or rare on another, thus the importance of each parasite must be evaluated separately for each insect host and each tree host. DeLeon (11) reported that a parasite of the mountain pine beetle, Coeloides dendroctoni Cushman, parasitized the beetles attacking three species of pines but did not parasitize the same host in one other species of pine.

The data show that some parasites appear to be confined to upper levels of loblolly pine trees. These parasites oviposit through the bark and are probably restricted by bark thickness since they were found over the entire bole of the thin-barked white pine. However, the overall rate of parasitism was generally higher in the upper levels of all species of trees (Figures 1-7). The attempts to correlate parasitism with bark thickness probably failed due to the highly erratic rates of beetle attack at different levels, and large numbers of samples with no parasitism at all levels. Although no measurements

of ovipositor lengths were made, the bark thickness on the lower bole of loblolly pines was obviously sufficient to preclude oviposition by those species ovipositing through the bark. Some workers think that parasites locate hosts by the vibrations produced by the larvae feeding beneath the bark. Ryan and Rudinsky (29), induced Coeloides brunneri Viereck oviposition by scratching on the bark with a pin. Chamberlin (6), reported that some sort of olfactory attraction is involved, and Wood, et. al. (35) found predators attracted to compounds in Ips confusus sex pheromones. Bushing (5), speculated that host specificity may result from the movement of setae of certain lengths and diameters against gallery walls producing specific tonal qualities. Thick corky bark could act as "insulation" and make it difficult for female parasites to locate potential hosts in the lower bole, but it should have little effect if the attraction is olfactory since Ips infested trees have numerous holes in the bark which should permit any odors to escape.

The physiographic province in which the host tree is located may effect parasites since the different vegetation supports a different insect complex which could serve as alternate hosts. For instance both Coeloides pissodis and Rhopalicus tutela are common parasites of the white pine weevil which is virtually absent in the piedmont of Virginia. Both of these parasites were recovered from Ips in the piedmont, however. It is not known if climate was a factor in determining the parasite complexes, but many of the parasites have been found in very diverse climates in the United States.

Although the effect of the density of Ips attack on the parasites appeared to be neglible, the results cannot be regarded as conclusive since the sample was small and percent parasitism was calculated from numbers of emerging adults during the mass rearings.

The effect of a small continuous infestation of Ips maintained through seven generations during two growing seasons was also negligible, but this probably cannot be compared with an infestation of epidemic proportions maintaining itself through several generations. The reaction of parasites to epidemic populations is virtually unknown on Ips spp. in the southeastern United States.

The parasites in general failed to show marked periods of abundance; this may be due to the multivoltine host being present throughout the season. One notable exception was Roptrocerus xylophagorum which although present at all sample dates, appeared in very high numbers in July. However, the rate of Ips infestation was generally higher during this period also and it responded quickly to changes in host density (Fig. 9). Also, Tomicobia tibialis and Heterospilus sp. on white pine were abundant on one collection date and absent on the other, suggesting definite seasonal activity in the mountains.

The rates of parasitism calculated from numbers of emerging adults probably does not provide a truly accurate measure of the effect of parasites on the beetles because once the trees are removed to the laboratory, they are no longer available to parasites, thus early instar Ips larvae or even eggs may finally emerge as adults, producing a distorted picture of parasitism. Also I believe that the

drying that occurs in the rearing cans may be more detrimental to parasites than to Ips beetles. Finally, percentages calculated from numbers of emerging adults assume that only one host is successfully attacked by each parasite; these studies suggest the possibility that more than one host may be attacked. In some cases considerable discrepancy was observed between parasitism calculated from numbers of emerging adults and observed parasitism on Ips larvae and pupae dissected out of infested logs (Figs. 1-7). The observed parasitism is probably more accurate since it is the confirmed rate of parasitism at the time of collection and it is not complicated by late-developing Ips broods. However, some of the differences are due to sampling different bolts. Although they are adjacent, both parasitism and Ips density vary greatly at different tree levels. Also the observed data do not take into account any parasite eggs which may not have hatched at the time of dissection and some very small parasite larvae may have been overlooked if they failed to develop into adults in the gelatin capsules. I believe that the above factors are at least in part responsible for the erratic results often obtained by workers in determining parasitism of bark beetles.

This study has succeeded in determining the parasites associated with Ips in Virginia and provided some information on habits and seasonal abundance. Future studies are needed to determine the life histories and habits of the parasites and their specific habitat

requirements must be known if their effect is to be enhanced by silvicultural practices. The parasites must be studied both at endemic and epidemic Ips population levels if their true roles in the host-parasite complex are to be evaluated. Laboratory studies will be necessary to determine longevity, fecundity, mating and oviposition behavior, and the mechanism by which the parasites locate their hosts. The interactions among Ips. parasites, predators, scavengers, and other associates will eventually need to be determined before any single group can be effectively manipulated to provide a higher degree of bark beetle control.

VI. SUMMARY

Ips spp. bark beetles do not attack and kill large areas of timber, thus their damage usually results in complete timber loss because salvage of small groups of trees is usually not feasible. Due to their sporadic nature, only silvicultural or integrated control seems likely.

A study was undertaken in the summer of 1965 to determine the insect parasites of *Ips* spp. beetles in Virginia and to learn about their habits. The work was expected to provide a base for further studies which ultimately would suggest silvicultural practices to increase the effectiveness of parasites on *Ips* populations. Mass rearings of arthropods from log bolts infested with *Ips* were made to determine relative abundance of parasites and hosts. Individual rearings were made to confirm parasitism and gain some knowledge of parasite habits. Twelve species of parasites were confirmed on *Ips* and two more were found as associates and were suspected of being *Ips* parasites.

Data collected on habits indicated that some parasites may be capable of attacking more than one host. Some parasites showed definite seasonal abundance while most did not. The effect of continuous *Ips* infestation for two years, bark thickness, density of *Ips* populations, and species of host tree on parasite abundance and relative numbers was investigated. Assumptions were made as to their effect on the rate of parasitism based on the data collected.

The study has accomplished its primary objective of defining the parasite complex on Ips spp. infesting loblolly pine in the Virginia Piedmont and has gathered some information on habits. Also several parasites along with some of their habits were determined for Ips pini infesting white pine in the mountains of Virginia.

The preliminary work in this study will provide a basis for future investigations which will be necessary before control through silvicultural practices to enhance the regulating effect of parasites can be effective. A detailed knowledge of the arthropod complex in Ips attacked trees also will be necessary for effective integrated control.

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APPENDIX

Table I. Data collected on felled loblolly pine from mass rearings. Plot I, first generation 1966. (Collected June 28, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per square inch	Ave. Bark Thickness (inches)
0-6	114	0	0	931.16	.12	.75
6-12	316	0	0	809.64	.39	.31
12-18	130	9	6.47	769.90	.17	.23
18-24	143	5	3.38	705.24	.20	.23
24-30	116	7	5.69	704.20	.16	.23
30-36	70	15	17.65	602.82	.12	.21
36-42	70	12	14.63	519.73	.13	.22
42-48	186	70	27.34	336.14	.55	.17
48-54	236	22	8.53	539.31*	.44	.09
Total	1381	140	9.20	5918.14	.23	.27

*Includes limbs

Table II. Data collected on felled loblolly pine from mass rearings. Plot II, first generation, 1966. (Collected June 28, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	63	1	1.56	683.38	.09	.67
6-12	94	4	4.08	582.66	.16	.36
12-18	44	8	15.38	535.90	.08	.22
18-24	148	8	5.13	511.59	.29	.18
24-30	36	17	32.07	442.62	.08	.17
30-36	113	6	5.08	384.30	.29	.17
36-42	238	45	15.90	636.23	.37	.07
Total	763	89	10.45	3776.68	.20	.26

Table III. Data collected on felled loblolly pine from mass rearings. Plot III, first generation 1966 (Collected July 3, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips per Square Inch	Ave. Bark Thickness (inches)
0-6	155	0	0	778.23	.20	.30
6-12	124	0	0	724.76	.17	.21
12-18	134	0	0	664.60	.20	.21
18-24	164	1	0.74	644.76	.25	.22
24-30	200	15	6.98	560.52	.36	.18
30-36	76	23	23.23	530.16	.14	.17
36-42	87	8	8.42	350.46	.25	.14
Total	940	47	5.00	4253.49	.22	.20

Table IV. Data collected on felled loblolly pine from mass rearings. Plot IV, first generation 1966 (Collected July 3, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	559	4	0.71	702.00	0.80	0.25
6-12	462	3	0.64	648.00	.71	.18
12-18	386	4	1.02	601.22	.64	.12
18-24	377	0	0	545.40	.69	.11
24-30	512	3	0.58	510.84	1.00	.09
30-36	444	0	0	459.00	.97	.08
36-42	371	0	0	419.04	.88	.07
42-48	451	0	0	357.48	1.26	.07
48-54	337	7	2.03	308.52	1.09	.07
54-60	343	18	4.99	220.32	1.56	.06
Total	4242	39	0.91	4771.82	0.89	.11

Table V. Data collected on felled loblolly pine from mass rearings. Plot I, second generation 1966. (Collected July 23, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	117	0	0	599.07	0.20	0.46
6-12	159	0	0	501.12	.32	.18
12-18	210	0	0	439.56	.48	.15
18-24	167	0	0	390.96	.43	.12
24-30	64	6	8.57	348.84	.18	.12
30-36	134	4	2.90	315.36	.42	.09
36-42	60	6	9.09	228.90	.26	.08
42-48	65	1	1.52	113.40	.57	.06
Total	976	17	1.71	2937.21	.33	.16

Table VI. Data collected on felled loblolly pine from mass rearings. Plot II, second generation 1966. (Collected July 23, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness
0-6	65	26	28.57	286.29	0.11	0.59
6-12	262	0	0	518.40	.50	.44
12-18	78	2	2.50	469.80	.17	.42
18-24	67	25	27.17	409.20	.16	.32
24-30	48	53	52.48	316.34	.15	.23
30-36	37	59	61.46	210.84	.18	.09
Total	557	165	22.85	2210.87	.25	.35

Table VII. Data collected on felled loblolly pine from mass rearings. Plot III, second generation 1966. (Colleged July 23, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness
0-6	431	0	0	773.07	0.56	0.42
6-12	334	0	0	722.52	.46	.33
12-18	454	0	0	686.88	.66	.32
18-24	465	15	3.12	631.63	.74	.27
24-30	194	35	15.28	485.01	.40	.19
30-36	123	56	31.28	346.68	.35	.19
36-42	135	65	48.15	199.76	.68	.13
Total	2136	171	7.41	3845.55	.55	.31

Table VIII. Data collected on felled loblolly pine from mass rearings. Plot IV, second generation 1966. (Collected July 23, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness
0-6	118	11	8.53	826.92	0.14	0.66
6-12	111	0	0	681.29	.16	.52
12-18	241	0	0	635.77	.38	.46
18-24	223	0	0	619.92	.36	.42
24-30	158	10	5.95	570.24	.28	.43
30-36	99	5	4.81	539.70	.18	.42
36-42	90	14	13.46	441.72	.20	.28
42-48	24	22	47.83	395.28	.06	.20
48-54	21	33	61.11	301.17	.07	.17
54-60	14	18	56.25	170.54	.08	.08
Total	1099	113	9.32	5182.55	.21	.36

Table IX. Data collected on felled loblolly pine from mass rearings. Plot II, third generation 1966. (Collected September 14, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness
0-6	120	2	1.64	523.80	0.23	0.41
6-12	97	1	1.02	475.20	.20	.31
12-18	87	0	0	435.24	.20	.20
18-24	103	0	0	404.10	.25	.16
24-30	96	5	4.95	359.54	.27	.16
30-36	113	7	5.83	251.58	.44	.12
Total	616	15	2.38	2449.46	.25	.23

Table X. Data collected on felled loblolly pine from mass rearings. Plot III, third generation 1966. (Collected August 27, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness
0-6	118	0	0	577.64	0.20	0.40
6-12	185	0	0	528.12	.35	.34
12-18	244	0	0	490.32	.50	.24
18-24	272	0	0	437.40	.62	.22
24-30	322	5	1.53	361.70	.89	.18
30-36	409	12	2.85	297.00	1.38	.16
36-42	170	30	15.00	173.74	.98	.11
Total	1720	47	2.66	2865.92	.60	.24

Table XI. Data collected on felled loblolly pine from mass rearings. Plot IV, third generation 1966. (Collected August 27, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness
0-6	107	1	0.92	749.52	0.14	0.68
6-12	216	0	0.00	679.32	.32	.45
12-18	241	1	0.41	614.34	.39	.35
18-24	145	1	0.68	537.84	.27	.30
24-30	348	1	0.29	454.68	.76	.27
30-36	182	10	5.21	355.23	.51	.21
36-42	129	12	8.51	205.20	.63	.13
Total	1368	26	1.86	3596.11	.38	.34

Table XII. Data collected on felled loblolly pine from mass rearings. Plot IV, fourth generation 1966. (Collected October 22, 1966).

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips (per square inch)	Ave. Bark Thickness
0-6	36	0	0	567.95	0.06	0.70
6-12	47	0	0	469.80	.10	.35
12-18	103	0	0	439.56	.23	.31
18-24	74	0	0	405.00	.18	.28
24-30	62	0	0	340.20	.18	.21
30-36	102	0	0	219.11	.46	.14
Total	424	0	0	2441.62	.17	.33

Table XIII. Data collected on felled loblolly pine from mass rearings. Plot I, first generation 1967 (Collected June 10, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	0	5	100	670.68	0	0.50
6-12	0	23	100	574.56	0	.28
12-18	0	5	100	523.80	0	.21
18-24	0	2	100	480.60	0	.14
24-30	19	0	0	442.80	0.04	.13
30-36	32	0	0	412.56	.08	.12
36-42	25	3	10.71	358.56	.07	.09
42-48	0	0	--	210.60	0	.07
Total	76	38	33.33	3674.16	.02	.20

Table XIV. Data collected on felled loblolly pine from mass rearings. Plot II, first generation 1967 (Collected June 10, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	14	32	69.56	707.40	0.02	0.40
6-12	23	16	41.03	537.84	.04	.10
12-18	51	21	29.17	495.72	.10	.09
18-24	26	36	58.06	438.48	.06	.08
24-30	22	36	62.07	423.36	.05	.07
30-36	14	37	72.55	378.00	.04	.07
36-42	23	43	65.15	330.48	.07	.06
42-48	118	74	38.54	273.24	.43	.06
Total	291	295	50.34	3584.52	.08	.12

Table XV. Data collected on felled loblolly pine from mass rearings. Plot III, first generation 1967 (Collected April 16, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	6	0	0	657.72	0.01	0.49
6-12	40	0	0	554.04	.07	.26
12-18	119	8	6.30	502.20	.24	.20
18-24	79	24	23.30	466.56	.17	.18
24-30	42	20	32.26	405.00	.10	.17
30-36	53	21	28.38	333.72	.16	.14
36-42	113	10	8.13	222.48	.51	.09
Total	452	83	15.51	3141.72	.14	.22

Table XVI. Data collected on felled loblolly pine from mass rearings. Plot IV, first generation 1967 (Collected May 9, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	22	0	0	681.48	0.03	0.69
6-12	29	0	0	557.28	.05	.51
12-18	30	5	14.28	454.68	.06	.32
18-24	17	2	10.53	378.00	.04	.24
24-30	30	2	6.25	294.84	.10	.23
Total	128	9	6.57	2366.28	.05	.40

Table XVII. Data collected on felled loblolly pine from mass rearings. Plot I, second generation 1967 (Collected August 21, 1967)

Height (feet)	No. *Ips* Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. *Ips* Per Square Inch	Ave. Bark Thickness (inches)
0-6	54	3	5.26	838.08	0.06	0.37
6-12	28	0	0	692.28	.04	.22
12-18	63	0	0	651.24	.10	.15
18-24	55	0	0	617.76	.09	.08
24-30	70	0	0	574.56	.12	.06
30-36	23	0	0	548.64	.04	.06
36-42	10	0	0	491.40	.02	.08
42-48	54	0	0	430.92	.12	.06
48-54	19	0	0	361.80	.05	.06
54-60	3	0	0	227.88	.01	.04
Total	379	3	0.78	5434.56	.07	.12

Table XVIII. Data collected on felled loblolly pine from mass rearings. Plot II, second generation 1967 (Collected August 7, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	425	0	0	752.76	0.56	0.58
6-12	24	0	0	691.20	.03	.38
12-18	226	0	0	638.28	.35	.26
18-24	96	4	4.00	568.08	.17	.18
24-30	55	9	14.06	523.80	.10	.14
30-36	108	9	7.69	465.48	.23	.10
36-42	82	14	14.58	373.68	.22	.09
42-48	30	45	60.00	272.16	.11	.07
Total	1046	81	7.19	4285.44	.24	.22

Table XIX. Data collected on felled loblolly pine from mass rearings. Plot III, second generation 1967 (Collected June 10, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (Inches)
0-6	27	0	0	537.84	0.05	0.63
6-12	64	0	0	446.04	.14	.42
12-18	55	1	1.78	383.40	.14	.23
18-24	47	5	9.62	327.24	.14	.15
24-30	8	3	27.27	275.40	.03	.20
Total	201	9	4.28	1969.92	.10	.33

Table XX. Data collected on felled loblolly pine from mass rearings. Plot IV, second generation 1967 (Collected July 20, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	262	2	0.76	712.80	0.37	0.50
6-12	74	0	0	584.28	.13	.29
12-18	30	4	11.76	505.44	.06	.23
18-24	17	2	10.53	441.72	.04	.17
24-30	18	26	59.09	357.48	.05	.12
30-36	7	43	86.00	279.72	.02	.12
Total	408	77	15.88	2881.44	.11	.24

Table XXI. Data collected on felled loblolly pine from mass rearings. Plot III, third generation 1967 (Collected July 10, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	50	3	5.66	808.92	0.06	0.39
6-12	6	0	0	695.52	.01	.19
12-18	80	2	2.44	635.40	.12	.19
18-24	142	0	0	611.28	.23	.20
24-30	179	7	3.76	640.36	.28	.11
30-36	226	6	2.59	501.12	.45	.11
36-42	273	64	18.99	405.00	.67	.09
Total	956	82	7.90	4297.60	.22	.18

Table XXII. Data collected on felled loblolly pine from mass rearings. Plot IV, third generation 1967 (Collected August 21, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	164	5	2.96	690.12	0.24	0.45
6-12	72	33	31.43	582.12	.12	.22
12-18	52	6	10.34	507.60	.10	.19
18-24	33	25	43.10	412.56	.08	.18
24-30	33	79	70.54	305.64	.11	.12
30-36	15	36	70.59	153.36	.10	.07
Total	369	184	31.72	2651.40	.14	.20

Table XXIII. Data collected on felled loblolly pine from mass rearings. Plot III, fourth generation 1967 (Collected August 7, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	655	0	0	830.52	0.79	0.33
6-12	436	0	0	711.72	.61	.16
12-18	459	0	0	668.52	.69	.18
18-24	278	1	0.36	627.48	.44	.15
24-30	181	8	4.23	560.52	.32	.11
30-36	122	9	6.87	509.76	.24	.10
36-42	138	2	1.43	419.04	.33	.10
42-48	76	2	2.56	339.12	.22	.08
48-54	41	39	48.75	140.40	.29	.06
Total	2386	61	2.49	4807.08	.50	.14

Table XXIV. Data collected on standing loblolly pine from mass rearings. Tree number I. (Collected August 17, 1966)

Height (feet)	No. *Ips* Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. *Ips* Per Square Inch	Ave. Bark Thickness (inches)
0-6	2	4	66.67	498.82	0.004	0.63
6-12	41	20	32.78	422.28	.10	.43
12-18	32	22	40.74	305.56	.10	.33
18-24	13	52	80.00	160.75	.08	.13
Total	88	98	52.60	1387.41	.06	.38

Table XXV. Data collected on standing loblolly pine from mass rearings. Tree number II. (Collected August 17, 1966)

Height (feet)	No. *Ips* Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. *Ips* Per Square Inch	Ave. Bark Thickness (inches)
0-6	125	18	12.59	678.46	0.18	0.85
6-12	111	17	13.28	559.13	.20	.48
12-18	139	23	14.20	372.39	.37	.32
18-24	107	31	22.46	226.75	.47	.19
Total	482	89	15.60	1836.73	.26	.46

Table XXVI. Data collected on standing loblolly pine from mass rearings. Tree number III. (Collected August 17, 1966)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	28	0	0	876.31	0.03	0.91
6-12	61	0	0	716.04	.08	.74
12-18	23	3	11.54	603.38	.04	.52
18-24	2	2	50.00	498.03	.004	.44
24-30	1	0	0	326.98	.003	.37
Total	115	5	4.17	3020.74	.04	.60

Table XXVII. Data collected on standing white pine from mass rearings. Tree number I (Collected June 27, 1967)

Height (feet)	No. *Ips* Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. *Ips* Per Square Inch	Ave. Bark Thickness (inches)
0-6	958	186	16.26	555.12	1.73	0.09
6-12	132	188	58.75	440.64	.30	.05
12-18	144	180	55.56	333.72	.43	.05
18-24	3	43	93.48	179.28	.02	.04
Total	1237	597	32.55	1508.76	.82	.06

Table XXVIII. Data collected on standing white pine from mass rearings. Tree number II (Collected June 27, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	61	72	54.14	561.60	0.11	0.09
6-12	4	75	94.94	465.48	.01	.05
12-18	8	40	83.33	396.36	.02	.04
18-24	7	20	74.07	289.08	.02	.04
24-30	0	7	100.00	154.44	0	.03
Total	80	214	72.79	1866.96	.04	.05

Table XXIX. Data collected on standing white pine from mass rearings. Tree number III (Collected August 7, 1967)

Height (feet)	No. Ips Emerging	No. Parasites Emerging	Percent Parasitism	Bolt Surface Area (square inches)	No. Ips Per Square Inch	Ave. Bark Thickness (inches)
0-6	657	53	7.47	887.76	0.74	0.23
6-12	1391	504	26.60	685.80	2.03	.10
12-18	329	342	50.97	532.44	.62	.06
18-24	147	142	49.13	360.72	.41	.05
24-30	97	49	33.56	240.84	.40	.05
Total	2621	1090	29.37	2707.56	.97	.10

Table XXX. Numbers of Ips spp. parasites belonging to the Chalcidoidea, reared from felled loblolly pines. Ips generation number one, 1966. (mass reared-individually reared)

Collection Date	Plot Number	Height (feet)	Species of Parasites: Eurytoma conica	Eurytoma sp.	Heydenia unica	Roptrocerus xylophagorum	Tomicobia* tibialis	Rhopalicus pulchripennis	Rhopalicus tutela	?Amblymerus sp.	Total
6/28/66	I	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	2-0	7-0	0-0	0-0	0-0	9-0
		18-24	0-0	0-0	0-0	1-0	4-0	0-0	0-0	0-0	5-0
		24-30	0-0	0-0	0-0	3-1	4-0	0-0	0-0	0-0	7-1
		30-36	0-0	0-0	0-0	6-0	9-0	0-0	0-0	0-0	15-0
		36-42	0-0	0-0	0-0	9-0	3-0	0-0	0-0	0-0	12-0
		42-48	0-0	0-0	1-0	65-6	1-0	0-0	0-0	0-0	67-6
		48-54	0-0	0-0	2-0	14-14	3-0	0-0	0-0	0-0	19-14
		Total	0-0	0-0	3-0	100-21	31-0	0-0	0-0	0-0	134-21
6/28/66	II	0-6	0-0	0-0	0-0	1-2	0-0	0-0	0-0	0-0	1-2
		6-12	0-0	0-0	0-0	4-2	0-0	0-0	0-0	0-0	4-2
		12-18	0-0	0-0	0-1	4-3	2-0	0-0	0-0	1-0	7-4
		18-24	0-0	0-0	0-1	2-2	5-0	0-0	0-0	0-0	7-3
		24-30	0-0	0-0	1-1	10-3	4-0	0-0	0-0	0-0	15-4
		30-36	0-0	0-0	0-1	5-14	1-0	0-0	0-0	0-0	6-15
		36-42	0-0	0-0	0-2	17-11	17-0	7-3	0-0	0-0	41-16
		Total	0-0	0-0	1-6	43-37	29-0	7-3	0-0	1-0	81-46
7/3/66	III	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	1-0	1-0	1-0	0-0	0-0	0-0	3-0
		30-36	0-0	0-0	3-1	1-0	0-0	0-0	0-0	0-0	4-1
		36-42	0-0	0-0	0-4	5-0	0-0	0-0	0-0	0-0	5-4
		Total	0-0	0-0	4-5	7-0	1-0	0-0	0-0	0-0	12-5
7/3/66	IV	0-6	0-0	0-0	0-0	0-0	4-0	0-0	0-0	0-0	4-0
		6-12	0-0	0-0	0-0	0-0	0-0	2-0	0-0	0-0	2-0
		12-18	1-0	0-0	0-0	0-0	1-0	2-0	0-0	0-0	4-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-1	0-0	0-0	1-0	0-0	2-0	0-0	4-1
		30-36	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		36-42	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		42-48	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		48-54	0-0	0-0	4-0	0-0	0-0	1-0	0-0	0-0	5-0
		54-60	1-0	0-0	0-0	0-0	0-0	14-0	0-0	0-0	15-0
		Total	2-0	0-1	4-0	0-0	6-0	19-0	2-0	0-0	34-1
	Grand Total		2-0	0-1	12-11	150-58	67-0	26-3	2-0	1-0	261-73

* Parasite of adult Ips only.

Table XXXI. Numbers of *Ips* spp. parasites belonging to the Braconidae, reared from felled loblolly pine. *Ips* generation number one, 1966. (mass reared-individually reared)

Collection Date	Plot Number	Height (feet)	Species of Parasites (mass reared-individually reared)				
			Dendrosotor sulcatus	*Spathius pallipis*	*Coeloides pissodis*	*Heterospilus* sp.	Total
6/28/66	I	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-2	0-0	0-0	0-0	0-2
		24-30	0-0	0-0	0-0	0-0	0-0
		30-36	0-0	0-0	0-0	0-0	0-0
		36-42	0-1	0-0	0-0	0-0	0-1
		42-48	3-0	0-0	0-0	0-0	3-0
		48-54	0-8	2-2	0-0	1-0	3-10
		Total	3-11	2-2	0-0	1-0	6-13
6/28/66	II	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	1-0	1-0
		18-24	0-2	0-0	1-1	0-0	1-3
		24-30	2-3	0-0	0-0	0-0	2-3
		30-36	0-15	0-1	0-0	0-0	0-16
		36-42	1-0	0-5	2-0	1-4	4-18
		Total	3-29	0-6	3-1	2-4	8-40
7/3/66	III	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	1-0	0-0	0-0	0-0	1-0
		24-30	1-0	0-0	11-0	0-0	12-0
		30-36	5-2	1-0	13-0	0-0	19-2
		36-42	0-2	0-0	3-5	0-0	3-7
		Total	7-4	1-0	27-5	0-0	35-9
7/3/66	IV	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	1-0	0-0	0-0	1-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	0-0
		30-36	0-0	0-0	0-0	0-0	0-0
		36-42	0-1	0-0	0-0	0-0	0-1
		42-48	0-0	0-0	0-0	0-0	0-0
		48-54	2-0	0-0	0-0	0-0	2-0
		54-60	2-1	0-0	0-0	1-0	3-1
		Total	4-2	1-0	0-0	1-0	6-2
		Grand Total	17-46	4-8	30-6	4-4	55-64

Table XXXII. Numbers of *Ips* spp. parasites belonging to the Chalcidoidea reared from felled loblolly pines. *Ips* generation number two, 1966. (mass reared-individually reared).

Collection Date	Plot Number	Height (feet)	Species of Parasites: *Eurytoma conica*	*Eurytoma* sp.	*Heydenia unica*	*Roptrocerus xylophagorum*	*Tomicobia tibialis*	*Rhopalicus pulchripennis*	*Rhopalicus tutela*	?*Amblymerus* sp.	Total
7/23/66	I	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	1-0	0-0	0-0	0-0	3-0	4-0
		30-36	0-0	0-0	0-0	0-0	2-0	0-0	0-0	2-0	4-0
		36-42	0-0	0-0	0-0	3-0	3-0	0-0	0-0	0-0	6-0
		42-48	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		Total	0-0	0-0	0-0	4-0	5-0	0-0	0-0	5-0	14-0
7/23/66	II	0-6	0-0	0-0	1-0	23-0	2-0	0-0	0-0	0-0	26-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	1-0	0-0	0-0	0-0	0-0	0-0	1-0
		18-24	0-0	0-0	4-0	17-0	1-0	0-0	0-0	0-0	22-0
		24-30	0-0	0-0	4-1	36-0	1-0	0-0	0-0	0-0	41-1
		30-36	3-0	0-0	8-1	11-1	2-0	8-0	2-0	0-0	34-2
		Total	3-0	0-0	18-2	87-1	6-0	8-0	2-0	0-0	124-3
7/23/66	III	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	1-0	12-0	1-0	1-0	0-0	0-0	15-0
		24-30	0-0	0-0	1-2	31-1	0-0	1-0	0-0	0-0	33-3
		30-36	3-0	0-0	0-0	31-2	0-0	0-0	0-0	0-0	34-8
		36-42	1-0	0-0	4-2	37-7	1-0	8-0	0-0	1-0	52-9
		Total	4-0	0-0	6-10	111-10	2-0	10-0	0-0	1-0	134-20
7/23/66	IV	0-6	0-0	0-0	0-0	8-0	0-0	0-0	0-0	0-0	8-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	1-0	0-0	0-0	9-0	10-0
		30-36	0-0	0-0	1-0	1-0	0-0	0-0	0-0	3-0	5-0
		36-42	0-0	0-0	1-0	11-1	1-0	0-0	0-0	0-0	13-1
		42-48	0-0	0-0	0-1	15-0	0-0	1-0	0-0	0-0	16-1
		48-54	0-0	0-0	3-1	16-0	3-0	4-0	0-0	0-0	26-1
		54-60	1-0	0-0	1-0	0-0	1-0	7-0	0-0	0-0	10-0
		Total	1-0	0-0	6-2	51-1	6-0	12-0	0-0	12-0	88-3
		Grand Total	8-0	0-0	30-14	253-12	19-0	30-0	2-0	18-0	360-26

Table XXXIII. Numbers of Ips spp. parasites belonging to the Braconidae reared from felled loblolly pines. Ips generation number two, 1966. (mass reared-individually reared).

Collection Date	Plot Number	Height(feet)	Species of Parasites				
			Dendrosotor sulcatus	Spathius pallidis	Coeloides pissodis	Heterospilus	Total
7/23/66	I	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	1-2	1-0	0-0	0-0	2-2
		30-36	0-1	0-0	0-0	0-0	0-1
		36-42	0-0	0-0	0-0	0-0	0-0
		42-48	0-0	0-0	0-0	1-0	1-0
		Total	1-3	1-0	0-0	1-0	3-3
7/23/66	II	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	1-6	0-0	0-0	0-0	1-6
		18-24	3-9	0-0	0-2	0-0	3-11
		24-30	9-3	0-0	3-1	0-0	12-4
		30-36	13-8	0-0	5-1	7-2	25-11
		Total	26-26	0-0	8-4	7-2	41-32
7/23/66	III	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-6	0-0	0-5	0-0	0-11
		24-30	1-16	0-0	1-1	0-0	2-17
		30-36	0-24	1-0	22-13	0-0	23-37
		36-42	6-21	0-0	4-10	3-0	13-31
		Total	7-67	1-0	27-29	3-0	38-96
7/23/66	IV	0-6	3-0	0-0	0-0	0-0	3-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	0-0
		30-36	0-4	0-0	0-0	0-0	0-4
		36-42	1-8	0-0	0-0	0-0	1-8
		42-48	3-6	0-0	2-0	1-0	6-6
		48-54	1-11	0-0	3-0	3-1	7-12
		54-60	2-8	0-0	0-1	6-1	8-10
		Total	10-37	0-0	5-1	10-2	25-40
		Grand Total	44-133	2-0	40-34	21-4	107-171

Table XXXIV. Numbers of Ips spp. parasites belonging to the Chalcidoidea reared from felled loblolly pines. Ips generation number three, 1966 (plots II, III, IV). Generation number four, 1966 (plot IV). (mass reared-individually reared).

Collection Date	Plot Number	Height (feet)	Eurytoma conica	Eurytoma sp.	Heydenia unica	Roptrocerus xylophagorum	Tomicobia tibialis	Rhopalicus pulchripennis	Rhopalicus tutela	?Amblymerus sp.	Total
9/14/66	II	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		30-36	0-0	0-0	0-0	0-1	0-0	1-0	0-0	0-0	1-1
		Total	0-0	0-0	0-0	0-1	0-0	1-0	0-0	0-0	1-1
8/27/66	III	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	1-1	0-0	0-0	0-0	1-0	2-1
		30-36	0-0	0-0	1-0	8-0	0-0	0-0	0-0	0-0	9-0
		36-42	0-0	0-0	0-0	4-2	0-0	10-1	0-0	0-0	14-3
		Total	0-0	0-0	1-0	13-3	0-0	10-1	0-0	1-0	25-4
8/27/66	IV	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	1-0	0-0	0-0	0-0	1-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		30-36	0-0	0-0	0-0	7-1	0-0	0-0	0-0	0-0	7-1
		36-42	1-0	0-0	3-2	1-0	0-0	0-1	0-0	0-0	7-3
		Total	1-0	0-0	3-2	8-1	1-0	0-1	0-0	0-0	15-4
10/22/66	IV*	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-1	0-0	0-0	0-0	0-0	0-0	0-1
		24-30	0-0	0-0	0-1	0-0	0-0	0-1	0-0	0-0	0-2
		30-36	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		Total	0-0	0-0	0-2	0-0	0-0	0-1	0-0	0-0	0-3
		Grand Total	1-0	0-0	6-4	21-5	1-0	11-3	0-0	1-0	41-12

* Fourth generation

Table XXXV. Numbers of Ips spp. parasites belonging to the Braconidae reared from felled loblolly pines. Ips generation number three, 1966 (plots II, III, IV). Ips generation number four, 1966 (plot IV). (mass reared-individually reared).

Collection Date	Plot Number	Height (feet)	Species of Parasites				
			Dendrosotor sulcatus	Spathius pallidis	Coeloides pissodis	Heterospilus sp.	Total
9/14/66	II	0-6	0-0	0-0	2-0	0-0	2-0
		6-12	0-0	0-0	1-0	0-0	1-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	2-1	0-0	3-0	0-0	5-1
		30-36	6-5	0-3	0-12	0-0	6-20
		Total	8-6	0-3	6-12	0-0	14-21
8/27/66	III	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-1	0-0	0-0	0-0	0-1
		18-24	0-0	0-0	0-1	0-0	0-1
		24-30	1-3	1-0	1-1	0-0	3-4
		30-36	0-1	3-9	0-4	0-0	3-14
		36-42	3-18	13-46	0-0	0-3	16-67
		Total	4-23	17-55	1-6	0-3	22-87
8/27/66	IV	0-6	0-0	1-0	0-0	0-0	1-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	1-0	0-0	1-0
		24-30	0-0	0-0	1-0	0-0	1-0
		30-36	1-3	0-0	2-0	0-0	3-3
		36-42	4-6	1-0	0-1	0-0	5-7
		Total	5-9	2-0	4-1	0-0	11-10
10/22/66	IV*	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-1	0-2	0-0	0-0	0-3
		18-24	0-4	0-0	0-4	0-0	0-8
		24-30	0-1	0-0	0-16	0-0	0-17
		30-36	0-3	0-0	0-1	0-0	0-4
		Total	0-9	0-2	0-21	0-0	0-32
		Grand Total	17-47	19-60	11-40	0-3	47-150

*Fourth generation

Table XXXVI. Numbers of Ips spp. parasites belonging to the Chalcidoidea reared from felled loblolly pines. Ips generation number one, 1967. (mass reared-individually reared).

Collection Date	Plot Number	Height (feet)	Species of Parasites: Eurytoma conica	Eurytoma sp.	Heydenia unica	Roptrocerus xylophagorum	Tomicobia tibialis	Rhopalicus pulchripennis	Rhopalicus tutela	?Amblymerus sp.	Total
6/10/67	I	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	5-0	5-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	23-0	23-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	5-0	5-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		30-36	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		36-42	0-0	0-0	0-0	0-0	1-0	0-0	0-0	0-0	1-0
		Total	0-0	0-0	0-0	0-0	1-0	0-0	0-0	33-0	34-0
6/10/67	II	0-6	0-0	0-0	0-0	27-9	4-0	0-0	0-0	1-0	32-9
		6-12	0-0	0-0	0-0	13-10	1-0	0-0	0-0	1-0	15-10
		12-18	0-0	0-0	0-0	18-3	2-0	0-0	0-0	1-0	21-3
		18-24	0-0	0-0	0-1	35-6	0-0	0-0	0-0	0-0	35-7
		24-30	0-0	0-0	0-0	30-8	0-0	0-1	0-1	0-0	30-10
		30-36	0-0	0-0	0-0	33-6	1-0	0-1	0-0	0-0	34-7
		36-42	0-0	0-0	0-0	38-5	1-0	0-0	0-0	0-0	39-5
		42-48	0-0	0-0	0-0	63-30	2-0	1-4	0-0	0-0	66-34
		Total	0-0	0-0	0-1	257-77	11-0	1-6	0-1	3-0	272-85
4/16/67	III*	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	2-0	0-0	2-0	0-0	0-0	4-0
		18-24	0-0	0-0	4-0	0-0	0-0	1-0	0-0	0-0	5-0
		24-30	0-0	0-0	0-0	0-0	0-0	0-0	0-0	1-0	1-0
		30-36	0-0	0-0	0-0	2-0	0-0	0-0	0-0	3-0	5-0
		36-42	0-0	0-0	0-0	1-0	0-0	0-0	0-0	1-0	2-0
		Total	0-0	0-0	4-0	5-0	0-0	3-0	0-0	5-0	17-0
5/9/67	IV	0-6	0-0	0-0	0-0	0-2	0-0	0-0	0-0	0-0	0-2
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	1-0	0-0	0-0	0-0	0-0	1-0
		24-30	0-0	0-0	1-0	1-0	0-0	0-0	0-0	0-0	2-0
		Total	0-0	0-0	1-0	2-2	0-0	0-0	0-0	0-0	3-2
		Grand Total	0-0	0-0	5-1	264-79	12-0	4-6	0-1	41-0	326-87

* Overwinter generation 1966-1967.

Table XXXVII. Numbers of Ips spp. parasites belonging to the Braconidae reared from felled loblolly pines. Ips generation number one, 1967. (mass reared-individually reared).

Collection Date	Plot Number	Height (feet)	Species of Parasites				
			Dendrosotor sulcatus	Spathius pallidis	Coeloides pissodis	Heterospilus sp.	Total
6/10/67	I	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	1-0	1-0
		24-30	0-0	0-0	0-0	0-0	0-0
		30-36	0-8	0-0	0-1	0-0	0-9
		36-42	0-0	1-0	0-0	0-0	1-0
		42-48	0-0	0-0	0-0	0-0	0-0
		Total	0-8	1-0	0-1	1-0	2-9
6/10/67	II	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	1-0	0-0	0-0	0-0	1-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-5	0-0	1-2	0-0	1-7
		24-30	2-2	0-0	3-1	1-0	6-3
		30-36	3-2	0-0	0-0	0-0	3-2
		36-42	2-6	0-0	0-0	2-0	4-6
		42-48	8-2	0-0	0-0	0-2	8-4
		Total	16-17	0-0	4-3	3-2	23-22
4/16/67	III*	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	1-0	0-0	3-0	0-0	4-0
		18-24	0-0	3-4	16-2	0-0	19-6
		24-30	0-0	7-4	12-3	0-0	19-7
		30-36	0-0	7-7	9-5	0-0	16-12
		36-42	1-0	3-1	4-0	0-0	8-1
		Total	2-0	20-16	44-10	0-0	66-26
5/9/67	IV	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-1	0-0	0-0	0-0	0-1
		12-18	2-0	0-0	3-1	0-0	5-1
		18-24	0-0	0-0	1-0	0-0	1-0
		24-30	0-5	0-0	0-0	0-0	0-5
		Total	2-6	0-0	4-1	0-0	6-7
		Grand Total	20-31	21-16	52-15	4-2	97-64

* Overwinter generation

Table XXXVIII. Numbers of *Ips* spp. parasites belonging to the Chalcidoidea reared from felled loblolly pines. *Ips* generation number two, 1967. (mass reared-individually reared)

Collection Date	Plot Number	Height (feet)	Species of Parasites								
			Eurytoma conica	*Eurytoma* sp.	*Heydenia unica*	*Roptrocerus xylophagorum*	*Tomicobia tibialis*	*Rhopalicus pulchripennis*	*Rhopalicus tutela*	?*Amblymerus* sp.	Total
8/21/67	I	0-6	0-0	0-0	0-0	0-1	0-0	0-0	0-0	3-0	3-1
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		30-36	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		36-42	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		42-48	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		48-54	0-0	0-0	0-0	0-1	0-0	0-2	0-0	0-0	0-3
		54-60	0-1	0-0	0-1	0-2	0-0	0-6	0-0	0-0	0-10
		Total	0-1	0-0	0-1	0-4	0-0	0-8	0-0	3-0	3-14
8/7/67	II	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	2-0	1-0	0-0	0-0	0-0	3-0
		24-30	0-0	0-0	0-0	4-1	4-0	0-1	0-0	1-0	9-2
		30-36	0-0	0-0	0-1	5-12	1-0	0-0	0-0	0-0	6-12
		36-42	0-0	0-0	2-2	12-19	0-0	0-0	0-0	0-0	14-21
		42-48	0-0	0-0	0-1	15-7	4-0	5-6	0-0	0-0	24-14
		Total	0-0	0-0	2-4	38-39	10-0	5-7	0-0	1-0	56-50
6/10/67	III	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-1	0-0	0-0	0-1
		24-30	0-0	0-0	0-0	1-0	0-0	0-0	0-0	0-0	1-0
		Total	0-0	0-0	0-0	1-0	0-0	0-1	0-0	0-0	1-1
7/20/67	IV	0-6	0-0	0-0	0-0	0-0	1-0	0-0	0-0	1-0	2-0
		6-12	0-0	0-0	0-0	0-1	0-0	0-0	0-0	0-0	0-1
		12-18	0-0	0-0	0-0	4-2	0-0	0-0	0-0	0-0	4-2
		18-24	0-0	0-0	0-0	0-0	1-0	0-0	1-0	0-0	2-0
		24-30	0-0	0-0	0-0	24-9	1-0	0-0	0-0	0-0	25-9
		30-36	0-0	0-0	0-0	42-21	0-0	0-0	0-0	0-0	42-21
		Total	0-0	0-0	0-0	70-33	3-0	0-0	1-0	1-0	75-33
	Grand Total		0-1	0-0	2-5	109-76	13-0	5-16	1-0	5-0	135-98

Table XXXIX. Numbers of Ips spp. parasites belonging to the Braconidae reared from felled loblolly pines, [illegible] 1967. (mass reared-individually reared).

Collection Date	Plot Number	Height (feet)	Species of Parasites				
			Dendrosotor sulcatus	Spathius pallidis	Coeloides pissodis	Heterospilus sp.	Total
8/21/67	I	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	0-0
		30-36	0-0	0-0	0-0	0-0	0-0
		36-42	0-0	0-0	0-0	0-0	0-0
		42-48	0-2	0-0	0-0	0-0	0-2
		48-54	0-0	0-0	0-0	0-0	0-9
		54-60	0-2	0-0	0-0	0-0	0-2
		Total	0-13	0-0	0-0	0-0	0-13
8/7/67	II	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	1-0	0-0	0-0	0-0	1-0
		24-30	0-2	0-0	0-0	0-0	0-2
		30-36	2-0	0-0	1-0	0-0	3-0
		36-42	0-12	0-0	0-0	0-0	0-12
		42-48	21-8	0-0	0-0	0-0	21-8
		Total	24-22	0-0	1-0	0-0	25-22
6/10/67	III	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	1-0	0-0	0-0	0-0	1-0
		18-24	0-0	4-2	1-4	0-0	5-6
		24-30	2-0	0-0	0-0	0-0	2-0
		Total	3-0	4-2	1-4	0-0	8-6
7/20/67	IV	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-2	0-0	0-2
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	1-4	0-0	0-0	0-0	1-4
		30-36	1-9	0-0	0-0	0-2	1-11
		Total	2-13	0-0	0-2	0-2	2-17
	Grand Total		29-48	4-2	2-6	0-2	35-58

Table XXXX. Numbers of Ips spp. parasites belonging to the Chalcidoidea reared from felled loblolly pines. Generation number three, 1967 (plots III and IV). Generation number four, 1967 (plot III). (mass reared-individually reared)

Collection Date	Plot Number	Height (feet)	Species of Parasites: Eurytoma conica	Eurytoma sp.	Heydenia unica	Roptrocerus xylophagorum	Tomicobia tibialis	Rhopalicus puichripennis	Rhopalicus tutela	?Amblymerus sp.	Total
7/10/67	III*	0-6	0-0	0-0	0-0	0-0	1-0	0-0	0-0	2-0	3-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	1-0	0-0	0-0	0-0	1-0	2-0
		18-24	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	2-13	5-0	0-0	0-0	0-0	7-13
		30-36	0-0	0-0	0-0	3-11	1-0	0-0	0-0	0-1	4-12
		36-42	0-0	0-0	0-0	64-25	0-0	0-0	0-0	0-1	64-26
		Total	0-0	0-0	0-0	70-49	7-0	0-0	0-0	3-2	80-51
8/21/67	IV*	0-6	0-0	0-0	1-0	2-0	0-0	0-0	0-0	2-0	5-0
		6-12	0-0	0-0	0-0	28-5	1-0	0-0	0-0	1-0	30-5
		12-18	0-0	0-0	0-0	5-3	1-0	0-0	0-0	0-0	6-3
		18-24	0-0	0-0	1-0	21-12	0-0	0-0	0-0	1-0	23-12
		24-30	0-0	0-0	3-2	64-21	1-0	0-0	0-0	3-0	71-23
		30-36	4-5	0-0	1-0	8-4	5-0	9-5	0-0	0-1	27-15
		Total	4-5	0-0	6-2	128-45	8-0	9-5	0-0	7-1	162-58
8/7/67	III**	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	1-0	0-0	0-0	0-0	0-0	0-0	1-0
		24-30	0-0	0-0	0-0	1-0	5-0	0-0	0-0	0-0	6-0
		30-36	0-0	0-0	0-0	1-0	1-0	1-0	0-0	0-0	3-0
		36-42	0-0	0-0	0-1	0-0	2-0	0-0	0-0	0-0	2-1
		42-48	0-0	0-0	0-5	2-1	0-0	0-0	0-0	0-0	2-6
		48-52	1-0	0-0	0-0	6-0	18-0	4-0	0-0	0-0	29-0
		Total	1-0	0-0	1-6	10-1	26-0	5-0	0-0	0-0	43-7
	Grand Total		5-5	0-0	7-8	208-95	41-0	14-5	0-0	10-3	285-116

* Ips generation number three

** Ips generation number four

Table XXXXI. Numbers of Ips spp. parasites belonging to the Braconidae reared from felled loblolly pines. Ips generation number three, 1967 (plots III and IV). Generation number four, 1967 (plot IV). (mass reared-individually reared).

Collection Date	Plot Number	Height (feet)	Species of Parasites				
			Dendrosotor sulcatus	Spathius pallidis	Coeloides pissodis	Heterospilus sp.	Total
7/10/67	III*	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	0-1	0-0	0-4	0-0	0-5
		30-36	2-1	0-0	0-0	0-0	2-1
		36-42	0-2	0-0	0-0	0-0	0-2
		Total	2-4	0-0	0-4	0-0	2-8
8/21/67	IV*	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	3-0	0-0	0-0	0-0	3-0
		12-18	0-1	0-0	0-0	0-0	0-1
		18-24	2-1	0-0	0-0	0-0	2-1
		24-30	8-6	0-2	0-1	0-0	8-9
		30-36	8-0	1-0	0-0	0-0	9-0
		Total	21-8	1-2	0-1	0-0	22-11
8/7/67	III**	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	2-0	0-0	0-0	0-0	2-0
		30-36	6-0	0-0	0-0	0-0	6-0
		36-42	0-0	0-0	0-0	0-0	0-0
		42-48	0-1	0-1	0-0	0-0	0-2
		48-54	10-0	0-0	0-0	0-0	10-0
		Total	18-1	0-1	0-0	0-0	18-2
	Grand Total		41-13	1-3	0-5	0-0	42-21

* Ips generation number three
** Ips generation number four

Table XXXXII. Numbers of Ips spp. parasites belonging to the Chalcidoidea reared from three standing white pines at one location. (mass reared-individually reared)

Collection Date	Tree Number	Height (feet)	Species of Parasites: Eurytoma conica	Heydenia unica	Roptrocerus xylophagorum	Tomicobia tibialis	Cecidostiba polygraphi	Rhopalicus pulchripennis	Rhopalicus tutela	?Amblymerus sp.	Total
6/27/67	I	0-6	7-5	0-0	0-1	0-0	42-44	11-2	100-45	0-0	160-97
		6-12	2-0	0-0	0-0	0-0	149-74	0-0	13-8	0-0	164-82
		12-18	1-0	0-0	0-1	0-0	132-112	3-1	5-9	0-0	141-123
		18-24	2-0	0-0	4-0	0-0	19-0	0-0	5-0	0-0	30-0
		Total	12-5	0-0	4-2	0-0	342-230	14-3	123-62	0-0	495-392
6/27/67	II	0-6	3-3	0-0	14-4	0-0	39-159	0-0	2-4	0-0	58-170
		6-12	4-1	0-0	0-0	0-0	27-34	0-0	1-1	0-0	32-36
		12-18	1-1	0-1	6-1	0-0	4-2	0-0	0-0	0-0	11-5
		18-24	0-0	3-0	2-0	0-0	0-0	0-0	0-0	1-0	6-0
		24-30	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		Total	8-5	3-1	22-5	0-0	70-195	0-0	3-5	1-0	107-211
8/7/67	III	0-6	0-0	0-0	14-6	21-1	2-0	0-0	14-0	1-0	52-7
		6-12	4-1	0-0	162-69	4-1	74-4	0-0	259-20	1-0	504-95
		12-18	8-1	1-0	68-38	5-0	83-16	1-0	176-26	0-0	342-81
		18-24	2-1	0-0	34-19	2-0	18-30	15-0	71-1	0-0	142-51
		24-30	7-1	0-0	0-0	1-0	27-2	12-1	2-0	0-0	49-4
		Total	21-4	1-0	278-132	33-2	204-52	28-1	522-47	2-0	1089-238
		Grand Total	41-14	4-1	304-139	33-2	616-477	42-4	648-114	3-0	1691-751

Table XXXXIII. Numbers of *Ips* spp. parasites belonging to the Braconidae reared from three standing white pines. (mass reared-individually reared)

Collection Date	Tree Number	Height (feet)	Species of Parasites				
			Dendrosotor sulcatus	*Spathius pallidis*	*Coeloides pissodis*	*Heterospilus* sp.	Total
6/27/67	I	0-6	0-0	1-8	3-0	21-21	25-29
		6-12	0-0	1-0	1-0	22-25	24-25
		12-18	0-0	0-0	0-0	39-32	39-32
		18-24	0-0	0-0	0-0	13-5	13-5
		Total	0-0	2-8	4-0	95-83	101-91
6/27/67	II	0-6	0-0	0-2	0-0	17-9	17-11
		6-12	0-0	0-0	0-0	8-1	8-1
		12-18	0-0	0-0	0-0	9-3	9-3
		18-24	0-0	0-0	0-0	1-0	1-0
		24-30	0-0	0-0	0-0	0-0	0-0
		Total	0-0	0-2	0-0	35-13	35-15
8/7/67	III	0-6	1-0	0-0	0-0	0-0	1-0
		6-12	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	0-0	0-0
		24-30	0-0	0-0	0-0	0-0	0-0
		Total	1-0	0-0	0-0	0-0	1-0
		Grand Total	1-0	2-10	4-0	130-96	137-106

Table XXXIV. Numbers of Ips spp. parasites belonging to the Chalcidoidea reared from three standing loblolly pines. (mass reared-individually reared)

Collection Date	Tree Number	Height (feet)	Species of Parasites: Eurytoma conica	Heydenia unica	Rhopalicus pulchripennis	?Amblymerus sp.	Total
8/17/66	I*	0-6	0-0	0-0	3-8	0-0	0-0	1-0	4-8
		6-12	0-0	0-0	19-9	0-0	0-0	19-9
		12-18	0-0	1-2	15-12	1-0	1-4	0-0	18-18
		18-24	6-2	14-17	12-8	0-0	3-3	0-0	35-30
		Total	6-2	15-19	49-37	1-0	4-7	1-0	76-65
8/17/66	II*	0-6	0-0	0-0	1-0	0-0	0-0	17-0	18-0
		6-12	0-0	8-0	0-11	2-0	0-0	7-0	17-11
		12-18	0-0	1-1	13-20	1-0	2-0	1-0	18-21
		18-24	2-2	5-3	0-0	0-0	3-1	1-0	11-6
		24-30	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		30-36	0-0	0-0	0-2	0-0	0-0	0-0	0-2
		Total	2-2	14-4	14-33	3-0	5-1	25-0	64-40
8/17/66	III**	0-6	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		12-18	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		18-24	0-0	0-0	0-0	1-0	0-0	0-0	1-0
		24-30	0-0	0-0	0-0	0-0	0-0	0-0	0-0
		Total	0-0	0-0	0-0	1-0	0-0	0-0	1-0
	Grand Total		8-4	29-23	63-70	5-0	9-8	27-0	141-105

* Infested with Ips avulsus

** Infested with Ips calligraphus

Table XXXXV. Numbers of Ips spp. parasites belonging to the Braconidae reared from three standing loblolly pines. (mass reared-individually reared).

Collection Date	Tree Number	Height (feet)	Species of Parasites				
			Dendrosotor sulcatus	Spathius pallidis	Coeloides pissodis	Heterospilus sp.	Total
8/17/66	I*	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	1-2	0-0	0-0	0-0	1-2
		12-18	2-20	0-0	2-1	0-0	4-21
		18-24	3-6	0-0	0-0	14-27	17-33
		Total	6-28	0-0	2-1	14-27	22-56
8/17/66	II*	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-1	0-0	0-0	0-0	0-1
		12-18	1-12	0-0	3-5	1-0	5-17
		18-24	1-0	0-0	3-0	16-0	20-0
		24-30	0-0	0-0	0-0	0-0	0-0
		30-36	0-1	0-0	0-1	0-0	0-2
		Total	2-14	0-0	6-6	17-0	25-20
8/17/66	III**	0-6	0-0	0-0	0-0	0-0	0-0
		6-12	0-0	0-0	0-1	0-0	0-1
		12-18	0-0	0-0	3-7	0-0	3-7
		18-24	0-0	0-0	2-0	0-0	2-0
		24-30	0-0	0-0	0-0	0-0	0-0
		Total	0-0	0-0	5-8	0-0	5-8
		Grand Total	8-42	0-0	13-15	31-27	52-84

* Infested with Ips avulsus.

** Infested with Ips calligraphus.

Table XXXXVI. Results of linear regression analysis of total percent parasitism of *Ips* (transformed to the arc sine) vs bark thickness.

Source	d.f.	SS	MS	F	r^2
Due to Regression	1	2750.6149	2750.6149	7.6184**	0.0454
Residuals	160	57767.2057	361.0450		
Total	161	60517.8206			

**Significant at the one percent level

Table XXXXVII. Results of linear regression analysis of percent parasitism of Ips (transformed to the arc sine) parasites ovipositing through bark vs bark thickness.

Source	d.f.	SS	MS	F	r^2
Due to Regression	1	2065.7892	2065.7892	15.1522**	0.0865
Residuals	160	21813.6564	136.3353		
Total	161	23879.4456			

**Significant at the one percent level

Table XXXXVIII. Results of linear regression analysis of total percent parasitism of Ips (transformed to the arc sine) vs density of emerging Ips adults (expressed as beetles per square inch of bark surface).

Source	d.f.	SS	MS	F	r^2
Due to Regression	1	7732.4254	7732.4254	23.4380**	0.1277
Residuals	160	52785.3952	329.9087		
Total	161	60517.8206			

**Significant at the one percent level

IX. VITA

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HYMENOPTEROUS PARASITES OF *IPS* SPP. BARK BEETLES (COLEOPTERA:SCOLYTIDAE) IN VIRGINIA

by

Charles Wayne Berisford

ABSTRACT

The genus *Ips* DeGeer (Coleoptera:Scolytidae) cause considerable mortality of pines each year in the United States. Since these pests are difficult to detect early and chemical control is generally too expensive, parasites may provide a feasible method of control. Little is known about parasites of *Ips*, however.

This study was designed to identify the Hymenopterous parasites attacking *Ips* spp. in Virginia, to learn their habits and life histories, and to evaluate their potential as control agents.

The study was carried out from 1965 to 1967 in Brunswick and Carroll Counties, in Virginia, which lie in the Piedmont and Ridge and Valley physiographic provinces, respectively.

The four species of *Ips* studied were *Ips avulsus* (Eichhoff), *Ips calligraphus* (Germar), *Ips grandicollis* (Eichhoff), and *Ips pini* (Say). The tree hosts were loblolly pine, *Pinus taeda* L., Virginia pine, *Pinus virginiana* Mill., and white pine, *Pinus strobus* L.

Parasites were mass-reared from log bolts infested with *Ips* spp. in specially constructed rearing drums. Confirmations of parasitism were made by removing *Ips* larvae and pupae from infested logs and

rearing parasites from them in gelatin capsules. The rate of parasitism of Ips and the relative abundance of Ips parasites were studied in relation to species of Ips, species of host tree, level in tree, standing vs felled trees, bark thickness, density of Ips in tree host, age of Ips infestation, location of parasites in Ips galleries, and time of year.

Thirteen species of Ips parasites were confirmed and 32 new host records were established on the different Ips species. The parasite complex in loblolly pine was different from white pine but it could not be determined if this was due to tree host, Ips host, or physiographic province. Several parasites were found only in the upper bole of host trees, suggesting that they may be limited by bark thickness. The parasite complexes were similar in standing and felled loblolly pines. No relationship between bark thickness and rate of parasitism was found and the rate of parasitism appeared to be independent of the density of Ips emerging from logs. An Ips infestation maintained for seven continuous generations over a two year period did not show any appreciable change in relative numbers of parasites or rate of parasitism.

Data collected on seasonal abundance and habits showed some parasites to be abundant only for short periods but some others were abundant at all times. One parasite, Roptrocerus xylophagorum Ratz. was abundant on all collection dates. It responded quickly to changes in host density and was found throughout the bole of infested trees. Most of the parasites appeared to attack Ips larvae. The rate of

confirmed pupal parasitism was neglible but may be higher than actually observed due to the complete destruction of the Ips pupa by the parasite.

This study pointed up the lack of basic knowledge of Southern Ips parasites and their life histories, defined the hymenopterous parasite complex of Ips in Virginia, added 32 new host records for Ips parasites, gathered information on their life histories and examined their potential as control agents for Ips spp.