THE INSECT PARASITES OF THE EUROPEAN PINE SHOOT MOTH, RHYACERIONA BUOLIANA (SCHIFFERMÜLLER) (LEPIDOPTERA: TORTRICIDAE) IN WISCONSIN WITH KEYS TO THE ADULTS AND MATURE LARVAL REMAINS

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The European pine shoot moth, *Rhyacionia buoliana* (Schiffermüller), was introduced accidentally into North America. It was first discovered damaging pines at Great Neck, New York in 1913, but it was not definitely identified until 1914 (Busck, 1914). Transportation of infested nursery stock resulted in the rapid spread of the shoot moth, and by 1951 it was present throughout the Northeast, southward to Virginia, and westward to Wisconsin and Illinois. The shoot moth was first reported in the Pacific Northwestern United States in Washington in 1959 (U.S.D.A., Pacific N.W., 1960). By 1961, infested ornamental pines had been discovered in several cities in Washington and Oregon, and in northern California (U.S.D.A., Pacific N.W., 1962; U.S.D.A., Pacific S.W., 1962).

The preferred hosts of the shoot moth are the hard pines. In North America the most commonly attacked species are *Pinus resinosa* Ait., *P. sylvestris* L., and *P. mugho* Turra. Although the shoot moth does not usually kill trees, larval feeding in buds and elongating shoots inhibits their growth and deforms them so that they are unsuitable for future harvest.

*R. buoliana* has been present in Wisconsin since 1951. In 1958, four counties reported infestations, and by 1959, pine plantations in 27 southern and eastern counties had infestations (Wis. Conserv. Dept., 1953, 1959; Benjamin *et al*, 1959). In 1960, a project was undertaken to investigate the bionomics of the shoot moth in Wisconsin, and to determine the structure of its parasite and predator complex. The information was compiled from field collections and laboratory studies of material collected during the summers of 1961–1963 from five forest plantations in the Point Beach State Forest, Two Rivers, Wisconsin.

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This paper deals with the known parasites of *R. buoliana* in Wisconsin. Keys for the separation of the parasites based on the remains left in the bud after the parasite has emerged; and for the separation of the parasite adults are given. Descriptions of the final-instar cephalic structures, and spiracles of Hymenoptera, puparia and buccopharyngeal armature of Diptera, and notes on the biology of the parasites are also included.

**METHODS**

The material upon which the keys are based consisted of adult parasites, and host and parasite remains from buds that could be positively associated with the parasites emerging from them. The adults were identified by the staff of the Insect Identification and Parasite Introduction Branch of the U. S. Department of Agriculture at Beltsville, Maryland.

Material used in the preparation of the key to parasite remains included host larval and pupal remains; empty egg chorions (in a few instances), cast larval and pupal skins, and cocoons of the hymenopterous parasites; and puparia with the included buccopharyngeal armature of the dipterous parasite. Cast larval skins of the hymenopterous parasites were removed from the buds, softened in 10 percent potassium hydroxide for 30 minutes to several hours, and washed in distilled water. Skins could be dyed lightly by first running them up to 70 percent alcohol, and then immersing them in a solution of iodine crystals dissolved in 70 percent alcohol; the skins were then mounted on microscope slides in non-resinous mounting medium (Turtox CMC-10) or in Hoyer's medium.

Illustrations of parasite remains were made with the aid of a projecting prism for gross characters and outlines, and an Ernst Leitz binocular compound microscope fitted with an ocular grid for fine details. The terminology used for the parts of the cephalic structures and spiracles of the final-instar larvae of Hymenoptera, and, in part, the buccopharyngeal armature of the Diptera is the same as that compiled from various authors by Finlayson (1960). Zuska (1963) was referred to for the terminology used in describing the puparium of the Diptera.

Drawings of the parts of adult parasites were made from pinned specimens with the aid of a Bausch & Lomb binocular dissecting microscope fitted with an ocular grid. Illustrations of wing venation were made with the aid of a prism projector, from wings mounted on microscope slides in non-resinous mounting medium.
PARASITES OBTAINED

The following parasites, including two species of Diptera and 18 of Hymenoptera have been reared from R. buoliana in Wisconsin:

DIPTERA

Chloropidae: Oscinella conicola (Greene).
Tachinidae: Erynna tortricis (Coq.)

HYMENOPTERA

Braconidae: Apanteles sp., Bracon n. sp., Bracon gelechiæ Ashmead.
Ichneumonidae: Exeristes comstockii (Cresson), Scambus tecumseh Viereck, Scambus sp., Itoplectis conquistor (Say), I. ? evetiae Viereck, Coccygomimus annulipes (Brullé), Gambrus sp., Porizonini, Atrometus sp.
Eulophidae: Elachertus pini Gahan, Hyssopus thymus Girault.
Eupelmidae: Eupelmus cyaniceps Ashmead, Macronecta vesicularis (Retzius).
Pteromalidae: Habrocytus thyridopterigis Howard.
Eurytomidae: Eurytoma pini Bugbee.

Two keys have been prepared for the separation of the above species. The first is designed to aid in separating the parasites on the basis of the host and parasite remains left in the bud after the parasite has emerged. Twelve species of parasites, one dipteran and eleven hymenopterons, are included in the key to parasite remains. The remaining seven species have not been included because insufficient material was available. The second key is for the identification of the adults of the parasites of R. buoliana.

KEY TO THE PARASITES OF R. BUOLIANA BASED ON PARASITE REMAINSa

1. Internal solitary parasites emerging from fully developed pupae; parasite remains inside host pupal skin ------- 2
   External solitary or gregarious parasites or hyperparasites of larvae or pupae; parasite remains in host gallery ---------------------------------- 5

2. (1) Parasite remains a dipterous puparium (Figs. 1–4). ---
   ---------------------------------- Erynna tortricis (Coq.)
   Parasite remains consisting of the shed larval skin of final-instar hymenopterous larva -------------- 3

---aFinal-instar larval skins of Hymenoptera, or dipterous puparia and buccopharyngeal armature.
3. (2) Hypostomal arms present (Fig. 18); atrium of spiracle nearly the same width as the stalk (Fig. 35)  

Hypostomal arms lacking (Figs. 15, 16); atrium of spiracle not as above; atrium large, leading into a narrower stalk (Fig. 34), or directly into a closing apparatus by a small opening (Fig. 33)  

--- Atrometus sp.  

4. (3) Atrium of spiracle about three times as wide as the stalk; stalk ends in a well-developed closing apparatus (Fig. 34)  

--- Itopletis ? evetriae Vier.  

Atrium of spiracle without a stalk; connected directly to a well-developed closing apparatus through a small opening (Fig. 33)  

--- Cocccygomimus annulipes (Brellé)  

5. (1) Cephalic structures reduced, only mandibles, or mandibles and clypeus, developed (Figs. 19, 21, 24)  

Cephalic structures well-developed, not limited to the above  

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6. (5) Cephalic structures consisting of mandibles and a heavily sclerotized clypeus armed with denticles (Fig. 21)  

--- Macroneura vesicularis (Retz.)  

Cephalic structures apparently consisting only of mandibles  

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7. (6) Atrium with chambers tapering gradually, ending at a distinct closing apparatus (Fig. 38)  

--- Habrocytus thyroidopterigis How.  

Atrium with chambers tapering sharply, ending in a long, thin, finely-annulated stalk; very small closing apparatus present (Fig. 36)  

--- Hyssopus thymus Gir.  

8. (5) Mandibles armed with a single large denticle posteriorly (Fig. 27); cephalic structures limited to little more than pleurostomata bearing the superior and inferior mandibul-ary processes  

--- Eurytoma pini Bugbee  

Mandibles armed with two rows of fine teeth, or several thin leaf-like teeth; cephalic structures consisting of epistoma, pleurostomata, hypostomata, and labial sclerite  

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9. (8) Mandibles armed with several thin leaf-like teeth in addition to the heavily sclerotized primary mandibular blade (Figs. 8, 11)  

--- Exeristes comstockii (Cress.)  

Scambus (Scambus) tecumseh Vier. and Scambus (S.) spp.  

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10. (9) Row of leaf-like teeth limited posteriorly by the posterior angle of the mandible which is drawn out into a tooth
(Fig. 8); spiracle with a distinct closing apparatus (Fig. 30) \textbf{Bracon} n. sp. Row of leaf-like teeth not limited posteriorly by a tooth, posterior angle smoothly rounded (Fig. 11); spiracle without closing apparatus (Fig. 31) \textbf{Bracon} gelechiae Ashm.

KEY TO THE ADULTS OF THE PARASITES OF \textit{R. BUOLIANA}\footnote{Apanteles sp. and Oscinella conicola (Gr.) are included as questionable parasites of \textit{R. buoliana}.}

1. Wings extremely abbreviated, apparently absent; reduced to tiny opaque, nearly acute pads whose apical portion is bent erect \textbf{Macroneura vesicularis} (Retz.) Wings well-developed \hfill 2

2. (1) One pair of wings; \textbf{Diptera} \hfill 3

Two pairs of wings; \textbf{Hymenoptera} \hfill 4

3. (2) Thorax with a complete transverse suture; body with many bristles; insect much like a small (5 mm.) housefly in appearance \textbf{Erynnia tortricis} (Coq.) Thorax without a transverse suture; body covered with fine setae, only a few bristles; tiny (1 mm.), black shining flies \textbf{Oscinella conicola} (Gr.) \hfill 5

4. (2) Wing venation reduced (Figs. 40–43); antennae geniculate \hfill 9

Wing venation well-developed (Figs. 44–46); antennae filiform \hfill 5

5. (4) Abdomen compressed, shining black; head and thorax coarsely punctate; venation as in Fig. 40 \textbf{Eurytoma pini} Bugbee

Abdomen not compressed, more or less flattened \hfill 6

6. (5) Stigma in forewing furcate (Fig. 43); tarsi 4-segmented; black minute insects \hfill 7

Stigma in forewing not furcate (Figs. 41, 42); tarsi 5-segmented; bright metallic green or blue insects \hfill 8

7. (6) Stigma in forewing strongly furcate (Fig. 43); pro- and mesothoracic femora and tibiae nearly entirely fuscus \textbf{Hyssopus thymus} Gir. Stigma in forewing not so strongly furcate as in Fig. 43; pro- and mesothoracic femora and tibiae nearly white \textbf{Elachertus pini} Gal.

8. (6) Mesoscutellum (sc12) acute anteriorly, axillae (ax) nearly touching medially (Fig. 51); marginal vein more than four times as long as stigmal vein (sv) plus stigma (st) (Fig. 42) \textbf{Eupelmus cyaniceps} Ashm.
Mesoscutellum truncate anteriorly, axillae widely separated (Fig. 52); marginal vein only slightly longer than the stigmal vein plus stigma (Fig. 41) ——— Habrocytus thyridopterigis How.

9. (4) Forewing with a single recurrent vein (rv) (Figs. 44, 45) ——— 10
Forewing with two recurrent veins (Fig. 46) ——— 12

10. (9) Forewing with both 2nd marginal (2nd M) and 2nd submarginal (2nd SM) cells present (Fig. 45) ——— 11
Forewing with neither 2nd marginal nor 2nd submarginal cells present (Fig. 44) ——— Apanteles sp.

11. (10) Mesopleuron, and at least anterior half of mesonotum glabrous and shining black; abdomen mostly yellowbrown, sometimes with darker shading caudally; tergum of petiole and anterior medial portion of segment II black ——— Bracon n. sp. Mesopleuron and mesonotum not glabrous and shining, rather dull black, clothed in short grey hairs; abdomen entirely fuscous above; inner margin of eyes each marked with two yellowish semi-circles ——— Bracon gelechiæ Ashm.

12. (9) Major axis of the petiole (ab₁) and that of the rest of the abdomen forming a distinct angle (Figs. 53, 54); petiole distinctly elongate ——— 13
Major axis of the petiole and that of the rest of the abdomen more nearly parallel (Fig. 55); petiole not distinctly elongate ——— 15

13. (12) Abdomen extremely compressed; petiole (ab₁) and the second abdominal segment (ab₂) about six times as long as their greatest diameter (Fig. 53); head and thorax patterned with yellow ——— Atrometes sp.
Abdomen not markedly compressed; petiole and second abdominal segment as in Fig. 54 ——— 14

14. (13) Propodeum divided into several areas set off by propodeal carinae; abdominal segments mostly dark, terga of segments II and III each with fusco-testaceous areas laterally, sometimes joined medially ——— Porizonini: Unknown species 1
Propodeum not divided into areas by propodeal carinae; abdominal segments I, II, III, and the anterior portion of segment IV ferruginous ——— Gambrus sp.

15. (12) Hind tibia dark at extreme base, i.e. tibia with apical and basal bands and a median pale band ——— 16
Hind tibia pale at extreme base, i.e. tibia with or without bands, but pale at base, or with apical and subbasal dark bands and median basal bands ——— 18
16. (15) Inner margin of eye weakly concave above antennal socket (Fig. 50); tarsal segments 1, 2, and 3 without distinct bands basally. *Coccygominimus annulipes* (Brullé)

Inner margin of eye rather strongly concave at antennal socket (Fig. 49); tarsal segments 1, 2, and 3 with distinct white bands basally.  

17. (16) Abdominal terga with white or cream-colored posterior margins. *Itoplectis conquistor* (Say)

Abdominal terga entirely dark. *Itoplectis ? evetriae* Vier.

18. (15) Nervellus (nv) intersected by the discoidella (dsc) at or below the middle (Fig. 48)

Nervellus intersected by the discoidella near or above the middle (Fig. 47). *Exeristes comstockii* (Cress.)

19. (18) Median pale band on hind femur incomplete ventrally.

*Scambus* (Scambus) tecumseh Vier.

Median pale band on hind femur complete ventrally.

*Scambus* (Scambus) sp.

**NOTES ON PARASITE BIOLOGY AND DESCRIPTIONS**

**DIPTERA**

**Chloropidae**

*Oscinella conicola* (Greene)

This tiny chloropid was recorded from *R. buolinana*-infested buds by Watson and Arthur (1959), who stated that it had previously been known to feed in red pine cones, and considered it as having a questionable role as a shoot moth parasite. Torgersen and Coppel (1962) reared two *O. conicola* from a shoot moth-infested bud and listed it as a parasite. No shoot moth emerged, and the bud was not dissected to ascertain the status of the association. According to Kulman (personal communication to H. C. Coppel), in West Virginia, *O. conicola* is very abundant in infested tips, but there appears to be no adverse effect upon the shoot moth. As members of this family may be parasitic or predacious as well as phytophagous (Borror and DeLong, 1960; Imms, 1960), it seems that the role of this insect is still not adequately clarified.

**Tachinidae**

*Erynnia tortricis* (Coq.)

Figs. 1–6

Four shoot moth pupae, collected in 1963, were parasitized by *E. tortricis*. Two pupae, from which the flies had already emerged, were collected on July 12. Two adults emerged on July 14 from host pupae collected on June 26 and 28.
E. tortricis is an internal parasite emerging from the pupa of R. buoliana. A puparium is formed within the host pupal skin, and two stigmatophores borne on a single variably shaped trunk protrude through the host pupal skin where the wing pads, legs, and antennae terminate (Fig. 1). Zuska (1963) stated that the stigmatophores are formed as late as during the pupation of the larva. This might account for the variable shape of the stigmatophore trunk since it may be exerted through the hard host pupal skin while still soft and pliable; hardening taking place as the exerted portion dries. Exit from the puparium is through an opening made by fractures along the horizontal and vertical sutures to form a dorsal and ventral flap. The host pupal skin is forced open along a line between head and prothorax, down one or both sides along the sutures separating the wings from the legs and mouthparts. The resulting flap may or may not remain attached to the host pupal skin.

Puparium (Figs. 2, 3) 4.61 to 5.12 mm. long, not including the stigmatophores; 2.05 to 2.56 mm. in diameter at widest point. Spiracular plate (Fig. 4) perforated by four to six orificia arranged in a roughly radial pattern. Number of orificia often variable between stigmatophores on a single individual; five orificia probably normal. Distance from anus to posterior spiracles (as defined by Zuska, 1963) slightly less than one one-third largest diameter of puparium. Buccopharyngeal armature (Figs. 5, 6) 0.39 to 0.45 mm. long; attached to inside of ventral flap at site of secondary mouth opening. Mandibular hooks moderately heavy, curving slightly anteroventrally; two or three teeth along ventral margin; in dorsal view (Fig. 6) each hook bears a denticle on either side. Lightly sclerotized salivary gland plate present. Articulation between mandibular hooks and intermediate sclerite difficult to distinguish even after lengthy clearing; no articulation present between intermediate and basal sclerites. Basal sclerite divided into two dorsal wings that become progressively less sclerotized posteriorly; distinctly veined posteriorly. Ventral wings fused medially to form lightly sclerotized flap.

**Hymenoptera**

Braconidae

Microgasterinae

Apanteles sp.

Fig. 44

A single specimen of Apanteles sp. was collected in the insectary on July 24, 1963. The specimen had escaped from a bag of R. buoliana-infested buds that had been collected the previous day. This species is included as a questionable parasite of R. buoliana.
Figure 1. Pupal skin of Rhyacionia buoliana (Schiff.) with the puparium of Erynnia tortricis (Coq.) in situ.
Braconinae

Bracon n. sp.

Figs. 7–9, 30

According to C. F. W. Muesebeck (personal communication) this species is apparently undescribed. The parasite develops externally on the shoot moth larva, one, two, or three to a host. Eight individuals were recovered from six host larvae. These emerged from July 1 to July 16. The collections of buds from which these parasites emerged were made from June 18 to June 24, 1963. In one instance, a single host larva supported three braconids of this species and six H. thyridopterigis, all of which emerged successfully. The pteromalids emerged nearly two weeks after the braconids.

Cocoon tan; a regular ellipse approximately 2 mm. by 5 mm.; exit hole cut at one end of cocoon about 1.25 mm. in diameter. Cocoon constructed near host remains; tied down by spreading mat of silk strands. Meconium, pupal skin, and mature larval skin are found in cocoon. Exit from host gallery through gallery entrance kept open by host larva before death.

Cephalic structure (Fig. 7) characterized by fusion of epistoma, pleurostomata, and hypostomata to form a vaulting arch over the mandibles, stipital sclerites, and labial sclerite. Superior mandibular processes well-developed; inferior processes simple, each accompanied by a lacinal sclerite. Primary mandibular blade followed by several thin, leaf-like teeth posteriorly; these leaf-like teeth limited posteriorly by the posterior angle of mandible which is drawn out into a heavily sclerotized tooth (Fig. 8). Stipital sclerites form nearly a straight line with one another; encounter dorsal arms of labial sclerite at a point immediately below a line drawn through the labial palpi. Labial sclerite open dorsally; thickened along ventral margin; dorsal arms narrower than ventral margin, widened slightly at their ends where they enclose a silk press that is nearly as wide as long. Maxillary and labial palpi bear two sensoria each. Antennae about twice as long as basal diameter; antennal sockets not apparent. Larval skin densely covered with tiny spines (Fig. 9) and scattered setae 0.03 mm. long. Spiracle (Fig. 30) consists of a large atrium on a thick, nearly parallel-sided stalk that is clearly annulated; stalk ends at a distinct closing apparatus. Atrium sculptured on its inner walls by two sub-parallel rings made up of continuous lines of minute warts.
Braconinae

Bracon gelechiæ Ashmead

Figs. 10, 11, 31, 45

*B. gelechiæ* was originally described as a parasite of gelechiids on oak (Muesebeck *et al.*, 1951). It has since been recorded from *R. frustrana*, as *Microbracon gelechiæ*, by Cushman (1927), and from *R. buoliana* by Schaffner (1959) in the Northeast, and by Watson and Arthur (1959) in Ontario. Miller and Neiswander (1955) in Ohio, listed *B. gelechiæ* as a species of unverified status in connection with parasite rearings from bud collections containing *R. buoliana*.

Nine specimens of *B. gelechiæ* developed on five shoot moth larvae. This species is a gregarious external parasite of the larva; from one to four parasites develop on a single host individual. The emergence period lasted from July 3 to July 17. Collections from which these individuals emerged were made from June 15 to July 3, 1963.

According to Cushman (1927) *M. gelechiæ* develops as a solitary or gregarious external parasite on large larvae of *R. frustrana*. He stated that the pupal period is spent in a dense brown cocoon. In the material collected at Two Rivers, the cocoon of this parasite was very light, nearly white. The roughly elliptical cocoon is not closely associated with the host remains, and may be found as distant from the host remains as the entrance to the gallery. The cocoon is about 1.1 mm. by 4.1 mm.; exit from the cocoon is through a hole about 0.8 mm. in diameter cut at one end. Meconium, pupal skin, and the final-instar larval skin may be found in the cocoon, but they are often missing.

The cephalic structures of this species (Fig. 10) were prepared from a single damaged specimen, consequently the juxtaposition of its parts is not accurate. The general aspect of *B. gelechiæ* is the same as the *Bracon* species above. In particular, this species differs from the former in the following respects; The cephalic structures are smaller overall; the dorsal arms of the labial sclerite are narrow as compared with the width of the ventral portion; the silk press is longer than wide; the mandibles bear several thin leaf-like teeth, however, they are not limited posteriorly by a tooth, but rather the posterior angle of the mandible is smoothly rounded (Fig. 11); the antennae are slightly less than twice their basal diameters in length. The larval skin, like that of *B. n. sp.*, is covered with minute spines and a few scattered setae. Spiracle (Fig. 31) with a large atrium atop a scarcely tapering, distinctly annulated stalk ending in a short non-annulated, parallel-sided section;
there is no closing apparatus. Inner wall of atrium bears two rings of fine wavy lines around its lower half; these lines not composed of a series of warts as in the previous *Bracon* species.

**Figures 2–6.** Puparium and buccopharyngeal armature of *Erynnia tortricis* (Coq.): 2, puparium, posterior view; 3, puparium, lateral view; 4, stigmaphore plate, dorsal view; 5, final-instar buccopharyngeal armature, lateral view; 6, final-instar buccopharyngeal armature, dorsal view. **7–11.** Cephalic structures and spines of final-instar hymenopterous larval skins: 7–9, *Bracon* n. sp.; 7, cephalic structure, anterior view; 8, distal portion of right mandible, ventral view; 9, portion of skin showing spines; 10–11, *Bracon gelechiae* Ashm.; 10, cephalic structure, anterior view; 11, distal portion of right mandible, ventral view.
Ichneumonidae

Ephialtinae: Pimplini

Exeristes comstockii (Cresson)

Figs. 12–14, 32, 47, 55

Exeristes comstockii is a common parasite of lepidopterous larvae that feed inside the growing shoots or in the cones of pines (Townes and Townes, 1960). E. comstockii was recorded as a parasite of R. buoliana in Connecticut (Friend, 1935), Massachusetts, Rhode Island, New York, and New Jersey (Schaffner, 1959), Michigan (Miller, 1959), Ohio (Miller, 1953), West Virginia (Harman and Kulman, 1962), Wisconsin (Torgersen and Coppel, 1962), British Columbia (Mathers and Olds, 1940), and Ontario (Watson and Arthur, 1959). Among the other species that are often found in plantations infested with R. buoliana, and whose damage is sometimes attributed to the shoot moth, the following are known hosts of E. comstockii: R. rigidiana (Ferm.), R. frustrana (Comst.), Dioryctria zimmermani (Grote), Petrova comstockiana (Ferm.), and occasionally Pissodes strobi (Peck) (Townes and Townes, 1960).

The biology of E. comstockii was studied by Cushman (1927), Miller (1953), and by Arthur (1963), who also illustrated the immature cephalic structures and spiracles. E. comstockii is a solitary external parasite on the shoot moth larva. There are two generations per year. The summer generation develops and overwinters on a host other than R. buoliana, but it is not known what species serves as the overwintering host at Two Rivers. In Ontario, the adults of the spring generation emerge between June 9 and 27 (Arthur, 1963). Miller (1953), in Ohio, recorded adult emergence from June 6 through July 15. Laboratory emergence at Two Rivers extended from July 2 through July 29. The average peak laboratory emergence date for three years' observations was July 14. The sex ratio is slightly less than 2:1 in favor of females.

From the earliest and latest host collection dates, and the earliest and latest emergence dates from 1961 to 1963, it was calculated that the development time for E. comstockii from egg to adult is from 22 to 26 days. Males are produced on the average, in 23 days; females in 26 days. These averages correspond exactly to those of Arthur (1963).

The parasite larva constructs a cocoon of loosely spun white silk. The cocoon is variable in shape depending upon its position in the gallery, and is commonly closely associated with the host remains.

Cephalic structure (Fig. 13) well-developed; epistoma complete, with two setae and one sensorium on either side; labial sclerite
encloses labrum with several pairs of setae and at least two pairs of sensoria; suspensorial sclerite present medially behind mandibles. Superior mandibulary processes long, directed ventrad; inferior processes simple, each accompanied by a lacinial sclerite. Mandibles with long, slightly curved blades with two rows of fine hair-like teeth (Figs. 12, 13). Hypostomal arms extend laterad; hypostomal spurs long and narrow; stipital sclerites progressively less sclerotized laterally, most heavily sclerotized medially where they meet hypostomal spurs and labial sclerite. Labial sclerite nearly closed dorsally; ventral portion more than twice the width of the dorsal arms, and irregularly dentate along ventral margin; opening of silk press evident medially where dorsal arms bend inward. Maxillary and labial palpi with two sensoria each. Antennae long, approximately three times as long as average diameter. Vertex with four large pigmented areas, the median areas largest, lateral areas narrower and each accompanied by a much smaller area posteriorly (Fig. 14). Larval skin with fine warty appearance, and scattered setae. Atrium of spiracle (Fig. 32) bears closely spaced annulations and numerous projections on the inside upper one-half of chamber; chamber tapers to a stout stalk with parallel, finely-crenulate sides, enclosing a well-defined closing apparatus. The final-instar spiracle differs from that illustrated by Arthur (compare Arthur, 1963, p. 1086, Fig. 4). The material illustrated in this work had a greater number of annulations, and a stouter general aspect, with a more pronounced taper.

Scambus (Scambus) tecumseh Viereck, and Scambus spp.

Ichneumonids in this genus have been reared from shoot moth material rather commonly, but not in large numbers. Raizenne (1952) listed rearings from shoot moth collections made from 1938 to 1948 in Ontario. Also in Ontario, Watson and Arthur (1959) recorded a complex of Scambus species, S. hispae and S. tecumseh, as active parasites of the shoot moth. S. hispae was reared as a parasite of R. buoliana in the Northeast by Schaffner (1959). Miller and Neiswander (1955) listed S. hispae as an unverified parasite of R. buoliana in Ohio.

Collections made at Two Rivers, from 1961 to 1963, yielded five specimens in the genus Scambus. Three females, identified as S. (S.) tecumseh emerged during July of 1963. Emergence dates for these were July 3, 16, and 25, from hosts collected on June 18, 25, and 28, respectively. Two undetermined specimens of Scambus emerged on June 7, 1961 and July 1, 1963, from shoot moth-infested buds collected on May 13, 1961 and June 22, 1963. All the Scambus species reared at Two Rivers were solitary, external, larval parasites. Incompletely formed pupae were also found asso-
ciated with the parasite remains. *S. (S.) tecumseh* was sometimes a victim of the cleptoparasitic habit of *Eurytoma pini*.

The final-instar cephalic structures and spiracles of the *Scambus* species and *E. comstockii* are so similar that it was not possible to separate the two adequately. It is suggested that Arthur (1963) be consulted for separation of *E. comstockii* and the *Scambus* complex, since too little *Scambus* material was reared at Two Rivers to make valid comparisons.

**Ephialtinae**: Ephialtini

*Itoplectis conquisitor* (Say)

This ichneumonid is an extremely common parasite of lepidopterous pupae and prepupae, especially those exposed or weakly protected. Over 80 species of lepidoptera have been recorded as hosts for *I. conquisitor* (Musebeck *et al*, 1951; Arthur, 1963). Townes and Townes (1960) stated that it may act as a secondary by parasitizing ichneumonids and braconids within their cocoons. It has been reared as a parasite of *R. buoliana* nearly everywhere this host occurs in North America. Finlayson (1962) illustrated the final-instar cephalic structure and spiracle. Arthur (1963) illustrated the first four larval instar cephalic structures and spiracles, and described the biology of the species. Other notes on the biology of *I. conquisitor*, as a parasite of a Coleophora species, were discussed by Doner (1986).

*I. conquisitor* was not recovered from the shoot moth at Two Rivers, but Wilkinson (1957) reared it from pupae of *R. buoliana* collected in Milwaukee County, Wisconsin. Individuals of *I. conquisitor*, including females apparently searching for hosts, were collected in flight in the plantations at Two Rivers. Field captures, during 1961 and 1962, were made from June 29 to October 8. Most of the individuals were caught in the early half of July of both years. In 1962, the peak flight activity was about ten days earlier.

Nests of *Archips cerastorana* (Fitch) were numerous on *Prunus* spp. growing adjacent to some of the plantations. Several nests were collected and placed in rearing cages on July 17, 1962. Five individuals of *I. conquisitor* emerged between July 18 and 23.

**Itoplectis ? evetriae**

Figs. 16, 17, 34

Three individuals, two males and a female, emerged from shoot moth pupae in the summer of 1963. The emergence dates were July 12 and 13 for material collected on June 21; the female emerged on July 20, from a pupa collected on June 30. These specimens were tentatively identified, by L. M. Walkley, as possibly a
new species near \textit{evetriae}, but more specimens are needed to establish whether the separating characters are stable.

This species is a solitary, internal parasite emerging from the pupa of \textit{R. buoliana}. No cocoon is present, and the host is empty except at the end of the abdomen where the parasite remains are found closely associated with the sclerotized portions of the host.
genital apparatus. Exit from the host pupa by the adult parasite is through a hole cut in the anterior end of the pupal skin. The exit hole has a jagged margin, and occurs on the pupa at about the middle of the scutellum. The adult parasite escapes from the host gallery by cutting a hole through the silk plug made by the host larva prior to pupation.

Cephalic structure of mature larva (Fig. 16) heavily sclerotized; epistoma, pleurostomata, and hypostomal spurs fused to form a ring broken ventrally by the labial sclerite. Superior mandibular processes simple, articulate about one-quarter of the way down the articulating surface of each mandible; inferior processes indented to receive the large, blunt mandibular condyles. Hypostomal arms absent, two small projections present opposite the inferior mandibular processes where the hypostomal arm would ordinarily arise. Hypostomal spurs long and narrow; stiplital sclerites reduced. Labial sclerite broadly U-shaped, rectangular; ventral margin greatly widened; dorsal arms widely separated at their apices. Spiny hypopharyngeal region present, bounded laterally by dorsal arms of labial sclerite, and ventrally by pre-labial sclerite. No silk press evident. Mandibles (Fig. 17) heavy, without teeth, but each with a blunt protuberance posteriorly near base of primary blade. Maxillary palpi each with one large sensorium, and about three smaller ones; labial palpi each with two large sensoria, and about five smaller ones. Epistoma with three sensoria on each side. Antennae reduced to buttons. Vertex with two elongate pigmented areas that are more heavily sclerotized than the remainder of the vertex. Larval skin finely textured, with very short, hardly noticeable setae. Atrium of spiracle (Fig. 34) nearly round; numerous irregularly shaped protuberances scattered over its inner wall. Atrium borne on short annulated stalk about one-third its diameter; stalk with about eight rings; terminates at a distinct closing apparatus about twice as wide as the stalk.

*Coccogomimus annulipes* (Brullé)

Figs. 15, 33, 50

The rearing of *C. annulipes* from *R. buoliana* is a new host record (Torgersen and Coppel, 1962). It had previously been recorded from other Olethreutinae, including *Carpocapsa pomonella* (L), *Grapholitha molesta* Busck, *Gretchenia bolliana* (Sling.), and *Laspeyresia nigricana* Steph. (Townes and Townes, 1960).

*C. annulipes* is a solitary internal parasite that emerges from the pupa of *R. buoliana*. A single female emerged on August 8 from an infested bud collected on July 24. The specimen emerged from a shoot moth pupa containing the remains of a fully formed
moth. The thorax of the pupal case was split mid-dorsally, indicating that either the host had already begun to emerge when it was finally killed by the parasite, or the activity of the parasite in attempting to escape, caused the pupal case to rupture. Exit of the parasite adult is made by cutting through the posterior few segments of the pupal case, leaving a jagged margin.

Cephalic structure of final-instar (Fig. 15) heavily sclerotized; epistoma, pleurostomata, and hypostomal spurs form a ring broken ventrally by the labial sclerite. Superior mandibular processes stout, articulate about one-quarter of the way down the articulating surface of each mandible; inferior processes simple, heavily-bodied, with apical depression in which mandibular condyle articulates. Hypostomal arms absent, lightly sclerotized projections present opposite inferior mandibular processes where hypostomal arms ordinarily arise. Hypostomal spurs stout; reduced stipital sclerites distinct, heavily sclerotized medially, but less so laterally. Labial sclerite nearly elliptical, as opposed to that of *I. ? evetriae* which approximates a rectangle; widened ventral portion forms nearly a semi-circle; dorsal arms widen markedly apically; nearly meet medially; an indistinct silk press lies between apices of dorsal arms. Hypopharyngeal region bears long teeth. Mandibles heavily-bodied; without teeth, but each bears a protuberance at the base of the blade. Maxillary palpi each with at least two sensoria; labial palpi each with one large sensorium and four small sensoria. Labral sclerite absent, but labral area bears several small setae on either side. Antennae reduced to buttons, each with three sensoria; large sclerotized antennal socket surrounds each antenna. Vertex with two elongate pigmented areas. Atrium of spiracle (Fig. 33) nearly round; its inner wall without protuberances or patterning. Atrium not borne on a stalk; connected directly to a well-developed, deeply fluted closing apparatus.

**Gelinae: Mesostenini**

*Gambrus* sp.

Fig. 54

Two individuals, one male and one female, of this species emerged on July 21, 1961. The buds from which they emerged were collected on July 18. Each specimen developed on a single host.

**Ophioninae: Porizonini (=Campoplegini)**

Unknown species 1

This tribe commonly parasitizes lepidopterous larvae (Muesebeck *et al.*, 1951). Schaffner (1959) listed the rearing of several
campoplegine larvae collected in conjunction with studies of the parasites attacking *R. buoliana* in the Northeastern United States.

A single specimen of an unidentified species in this tribe was reared from shoot moth material collected at Two Rivers in 1961. A male emerged on August 18 from a shoot moth-infested bud collected on July 13.
Anomalini

Atrometus sp.

Figs. 18, 35, 53

The only Atrometus species that has been reared from the shoot moth is A. clavipes, recorded by Wolff and Krause (1922) in Europe, and by Watson and Arthur (1959) in Ontario. Besides R. buoliana, several other tortricids have been recorded as hosts of A. clavipes. These are: Grapholitha molesta Busck, Spilonota ocellana (D. and S.), Acleris variana (Fern.) (Muesebeck et al., 1951), and Ancyliis comptana Froh. (Watson and Arthur, 1959). The individual reared at Two Rivers was identified as Atrometus species near clavipes (Davis) and paediscae (Ashm.). One specimen emerged on July 17 from shoot moth-infested material collected on June 20, 1963. The specimen was a solitary, internal pupal parasite.

The adult parasite emerges from the pupa through a hole cut in the anterior end; the exit hole has a jagged margin around the pupa at about the anterior one-third of the scutellum dorsally, and across the middle of the labial palps ventrally. No cocoon is formed; the larval skin is found at the end of the pupa opposite the exit hole.

Cephalic structure of the final-instar larva (Fig. 18) characterized by a wide epistoma fused on either side with the pleurostoma and hypostomal arms; pleurostoma and hypostomal arms greatly widened, and extend laterally. Superior mandibulary processes stout, articulate in depressions at the dorsal end of the articulating surface of each mandible; inferior processes articulate with stout mandibular condyles. Mandibles heavily-bodied. Hypopharyngeal region with a cobblestone texture. Hypostomal spurs absent; stipital sclerites curve downward from hypostomal arms to meet the labial sclerite, and then curve upward to the hypopharyngeal region. Labial sclerite open, widened ventrally; dorsal arms widened slightly apically where they bend medially. U-shaped mouth of silk press evident between dorsal arms. Labial and maxillary palpi each have one large sensillum, one narrow crescent-shaped sensillum, and two or three small radiating sensoria, respectively. Epistoma with a single sensillum on each side; labral area with two palp-like organs each with four sensoria. Antennae were not located. Larval skin smooth, without setae, but has a few patches of very short stout spines. The condition of the single larval skin did not allow determination of the position of these spines on the larva. Atrium of spiracle (Fig. 35) small, opens directly into closing apparatus that is about equal in diameter to atrium.
Eulophidae
Elachertinae
Elachertus pini Gahan

Three specimens of *Elachertus pini* were reared from shoot moth material collected in April and May of 1959 by H. C. Coppel, officials of the Wisconsin Conservation Department and the Plant Industry Division of the Wisconsin Department of Agriculture (Torgersen and Coppel, 1962). This was a new parasite record for *R. buoliana*. Previously this parasite had been collected only from a *Dioryctria* species and from *R. frustrana* (Peck, 1963).

*Hyssopus thymus* Girault

Figs. 19, 20, 36, 43

*H. thymus* is a very common parasite of *R. buoliana* especially in the Midwestern and Eastern United States, and has also been reared from shoot moth material in Ontario. Friend (1935), Friend and Hicock (1936), and Friend *et al* (1938) recorded it as the most common parasite of the shoot moth in Connecticut. Rearings from shoot moth material collected throughout the Northeast (Schaffner, 1959), showed a preponderance of this species, both in the number of collections yielding the parasite, and in the number of individuals reared. The number of individuals recorded by Schaffner probably represents many fewer hosts because this is a gregarious species, but is not so designated in his paper. However, the figures indicate the tremendous activity of *H. thymus* as a parasite of the shoot moth. At Natrium, West Virginia, *H. thymus* is the most commonly reared parasite of *R. buoliana* (Harman and Kulman, 1962).

The biology of *H. thymus* was studied by Miller (1953), Coppel *et al.* (1955), and Watson and Arthur (1959). This tiny eulophid is a gregarious, external parasite of the shoot moth larva; two generations, and a partial third generation are produced per year. Adults emerge in the spring after overwintering as pupae in the gallery of the dead host. The summer generation of *H. thymus* at Two Rivers emerges between June 18 and August 7. Peak emergence takes place during mid- and late July. From 95 parasitized hosts in 1963, 1,100 *H. thymus* emerged. The range in the number of individuals emerging per host larva was 1 to 86, with an average of 11.5. In 1961, when only 11 hosts were involved, the average was 6.2 parasites per host, with a range from 1 to 18. Longevity studies conducted at Two Rivers showed that adults can survive for an average of 47 days, range for five individuals was 46 to 49 days, if they have a source of food and water.

*H. thymus* emerged successfully from the same hosts with *Eurytoma pini*, *Habrocytus thyridopterigis*, and *Macroneura vesicularis*. When *H. thymus* develops successfully on a single host with *M. vesicularis*, it is probably due to the failure of the secondary to destroy all of the developing eulophids.

Dissections of buds from which *H. thymus* have emerged reveal the empty pupal skins. These skins are dark brown and fragment either at the time of emergence of the adults, or are broken by their movements following emergence. The final-instar larval skin is attached to the abdomen of the pupal skin or adheres to the gallery wall. The pupal skins are closely associated with the host remains. No cocoon is constructed by the parasite.

Cephalic structure of final-instar larva (Fig. 19) apparently limited to mandibles. Mandible (Fig. 20) with straight blade bearing a row of hair-like teeth. Antennae extremely flattened, much wider than long. Two pairs of sensoria, probably rudimentary palpi, present near the bases of mandibles. Due to shifting and flattening of mounted skins, the above characters may have variable positions. Larval skin smooth, and without setae. Atrium of spiracle (Fig. 36) large, funnel-shaped, and many chambered, ending in a long stalk with a small closing apparatus at the end.
Eupelmidae
Eupelmus cyaniceps Ashmead
Fig. 51

Eupelmus cyaniceps was recorded as a parasite of R. buoliana by Raizenne (1952). Only one specimen of E. cyaniceps was reared from shoot moth material collected at Two Rivers (Torgersen and Coppel, 1962). An adult female emerged on August 5, 1961 from a bud collection made on July 25. The host remains consisted of a partly devoured larva of R. buoliana accompanied by the larval remains of a final-instar E. comstockii. Therefore, it can be surmised that E. cyaniceps can be a secondary parasite of R. buoliana through E. comstockii. No cocoon is constructed. The fractured shed pupal skin of E. cyaniceps was recovered, but the final-instar larval skin was not found, either attached to the pupal skin, or loose in the gallery.

Macroneura vesicularis (Retzius)
Figs. 21, 22, 37

Macroneura (=Eupelmella) vesicularis is a solitary, external, primary or secondary parasite on a great variety of insects (Peck, 1963). Watson and Arthur (1959) recorded this species as a parasite of R. buoliana in Ontario. Only three other species of tortricids are known, or suspected hosts of M. vesicularis (Peck, 1963).

Notes on the biology, and illustrations of the immature stages of M. vesicularis, as a predator of Microletron fusceipennis Zett. in the cocoons of Neodriprion sertifer Geoffr. in Europe, were prepared by Morris (1938). Phillips and Poos (1927) described and illustrated the egg and larval instars as Eupelmimus saltator (Lind.), and Doner (1936), in Wisconsin, discussed its biology as a parasite of Coleophora pruniella Clem. Finlayson (1960) illustrated the final-instar cephalic structure of M. vesicularis. This species is thelytokous, and is easily distinguished from the other parasites of the shoot moth by the apparent lack of wings in the adult. The female paralyzes her host before ovipositing, and sometimes feeds at the puncture (Doner, 1936). The egg is similar to that of Eurytoma pini, with projections at either end. The two differ in that the eggs of M. vesicularis lack spines. According to Doner (1936), after a 36 hour incubation period, M. vesicularis takes 20 days to develop to the adult on C. pruniella, and emergence occurs from July 13 to 21. At Two Rivers, development takes no fewer than 30 days, and in some cases as many as 43 days; emergence is from July 19 to August 18, with the peak occurring between July 24 and August 2. A single field capture of an adult
was made on June 25, 1962, fully a month ahead of laboratory emergence of this species. The lengthy developmental and emergence period is probably due to the cool springs and summers experienced at Two Rivers.

Laboratory dissections of buds from which *M. vesicularis* had emerged indicated that *E. comstockii* and *H. thymus* served as hosts for this secondary parasite. *E. comstockii* was more often the primary involved, possibly indicating *M. vesicularis* prefers the larger host. In a single case of multiple parasitism, both *M. vesicularis* and 20 *H. thymus* developed and emerged successfully on a single host. This case probably indicates a situation wherein the secondary simply overlooked some of its tiny competitors, or the secondary had not reached the voracious final-instar until after the *H. thymus* had pupated and emerged.

No cocoon is constructed by the parasite larva. The shed pupal skin is honey-colored, fragmented, and may or may not be closely associated with the host remains. Exit from the bud is made through a hole cut in the silk plug which was made by the host larva prior to death. The exit hole is about 0.75 to 1.00 mm. in diameter.

Cephalic structure of final-instar larva (Fig. 21) consists of mandibles and a heavily sclerotized clypeus with denticles along its ventral margin; labrum bears four pairs of papillae. Figure 21 shows a portion of the pleurostoma, also part of the inferior mandibular strut. Curved blade of mandibles without teeth. Inferior mandibular condyles stout, articulate in groove of inferior mandibular strut. Mandibular strut was called hypopharyngeal bracon by Phillips (1927). Lightly sclerotized silk press present; apparently consisting of two closely appressed tubes with fine spiral thickenings in its walls (Figs. 21, 22). Maxillary and labial palpi bear three sensoria each. Antennae slightly less than twice their basal diameter in length. Larval skin smooth, characteristically covered with scattered long setae, and a few short setae at the posterior end of the skin. Atrium of spiracle (Fig. 37) narrowly funnel-shaped, numerous chambers decreasing in size to the closing apparatus which is followed by a long annulated stalk.

Pteromalidae

Pteromalinae: Pteromalini

*Habrocytus thryidopterigis* Howard
Figs. 23–26, 38, 41, 52

*R. buoliana* was recorded as a host of *H. thryidopterigis* by Raizenne (1952) in Ontario, by Schaffner (1959) in the North-
east, and as a questionable recovery from the shoot moth by Miller and Neiswander (1955) in Ohio. This species is a gregarious primary or secondary parasite of the shoot moth at Two Rivers. From 24 host larvae, 68 parasite individuals emerged; an average of 2.83 parasites per host (range 1 to 8). For three seasons, 1961 through 1963, the emergence period was from July 1 to August 15. The peak emergence period was in early August in 1961, and in mid-July in 1962 and 1963. Adults were captured in the field as early as June 9, weeks before this species emerged from laboratory collections.

When *H. thyridopterigis* acted as a primary, it was associated with the larva of the shoot moth. *E. comstockii* was the most common primary parasite hyperparasitized by *H. thyridopterigis*. Re-
 mains of *Eurytoma pini* and *H. thymus* were also recovered, indicating that these also served as hosts. This parasite emerged successfully with *H. thymus*, *Eurytoma pini*, and *Bracon* n. sp. from the same host individuals.

The larva constructs a silken cocoon which may or may not be closely associated with the host remains. The shed pupal skin is lightly golden brown fragmented, and sometimes found outside the cocoon. Mature larval skin does not always adhere to the shed pupal skin and may be loose in the host gallery. Egg elliptical (Fig. 23), more rounded at one end, and evenly patterned with tiny spines and papillae except for the pointed end where the chorion is smooth. Papillae are about equal in diameter to the bases of the spines.

Cephalic structure of final-instar larva (Fig. 24) apparently limited to mandibles, which, on the shed skin, project straight forward. Close examination reveals the presence of fragments of what are probably the superior mandibular processes attached to the superior mandibular condyle of each mandible (Fig. 25). In Figure 26, the superior mandibular process is omitted. Mandibles with slightly curved blades bearing a row of hair-like teeth. Palpi present near the bases of the mandibles; their position may vary with the disposition of the parts in handling the skin. Antennae tapered, slightly longer than basal width. Larval skin not distinctively textured; light in color, and with few setae. Atrium of spiracle (Fig. 38) with about seven gradually tapering chambers ending at a well-defined closing apparatus. Apical chamber of atrium patterned with very fine wavy lines.

**Eurytomidae**

*Eurytoma pini* Bugbee

Figs. 27–29, 39, 40

In much of the literature on the parasites of *R. buoliana*, *Eurytoma pini* has been listed as *E. tylodermatis* Ashm. (Friend and Hicock, 1933, 1936; Miller, 1953; Miller and Neiswander, 1955), or *E. appendigaster* (Swed.) (Sheppard, 1933). Bugbee (1958) believed that this species probably occurs wherever pines and its preferred host, *R. frustrana*, are present. It has been recorded as an active parasite of *R. buoliana* in Connecticut (Friend and Hicock, 1933, 1936), Ohio (Miller, 1953), West Virginia (Harman and Kulman, 1962), Wisconsin (Torgersen and Coppel, 1962), and Ontario (Arthur, 1961).

Arthur (1961) described the cleptoparasitic habits of *E. pini*, and illustrated the immature stages. He observed adults emerging from early June to late June, and Miller (1953), in Ohio, recorded
emergence from June 21 to July 21. At Two Rivers, the earliest of 44 adults reared from parasitized *R. buoliana* during three years, emerged on July 5, the latest on August 11. Peak emergence occurred between July 18 and 21. The sex ratio is about 2:1 in favor of females; Miller (1953) observed a 3:1 sex ratio. *E. pini* was collected in flight in the field on June 18, about two weeks before emergence began in the laboratory. Unfed adults lived for about six days (range 3 to 12). A single male, fed on honey water, survived for 38 days.

The period required for development from egg to adult, calculated from earliest and latest collection and emergence dates, is approximately 28 days (range 21 to 34). Studies by Miller (1953) showed that, exclusive of the egg and larval feeding period, it takes an average of 18 days for development from the prepupal stage to emergence of the adult.

At Two Rivers, a single adult emerged from each host. Most authors have considered this species to be a solitary parasite, however, Arthur (1961) observed up to three adults emerging from a single host. *E. pini* usually develops on shoot moth larvae, but it is not uncommon to find that it has developed on a pupa; a situation also observed by Miller (1953). Dissections of buds from which *E. pini* had emerged revealed that this parasite had succeeded at the expense of the larva of *Scambus tecumseh* or, more commonly, the larva or pupa of *E. comstockii*. Remains of both *E. pini* and *E. comstockii* were found in buds from which *H. thryridopterigis* developed and emerged successfully. In addition, there was a single case wherein both *E. pini* and nine *H. thymus* emerged from one host larva; and one case in which *E. pini* and *H. thryridopterigis* successfully emerged, having developed either on, or at the expense of *E. comstockii*. From these observations it is possible to claim both secondary and multiple parasitic behavior for *E. pini*.

No cocoon is constructed for pupation. The parasite remains are closely associated with the host remains. The pupa is dark honey-brown, fragmented, and usually has the mature larval skin adhering to it. The adult escapes from the host gallery either by cutting through the silk or resin mass, or directly through a thin portion in the host gallery wall. The exit hole is 1.0 to 1.2 mm. in diameter.

Egg elliptical (Fig. 29); slightly more pointed at one end. Blunt end with a sharp barb-like process with a roughened surface; pointed end with a long, smooth, thin-walled closed tube that is slightly swollen at its tip. Chorion armed with numerous spines. The presence of these eggs in a great many of the galleries of *R.*
FIGURES 40–55. Wings, heads, thoraces, and petioles of adult Hymenoptera:
40, Eurytoma pini Bugbee, forewing; 41, Habrocytus thyridopterigis Howard, forewing; 42, Eupelmus cyaniceps Ashm., forewing; 43, Hyssopus thymus Gir., forewing; 44, Apanteles sp., forewing; 45, Bracon gelechiae Ashm. forewing; 46, Itoplectis ? evetriae Vier. forewing; 47, Exeristes comstockii (Cress.), hind wing; 48, Scambus tecumseh Vier., hind wing; 49, Itoplectis ? evetriae Vier., head, anterior view; 50, Coecygonimus annulipes (Brullé), head, anterior view; 51, Eupelmus cyaniceps Ashm., thorax, dorsal view; 52, Habrocytus thyridopterigis Howard, thorax, dorsal view; 53, Atrometus sp., petiole, lateral view; 54, Gambrus sp., petiole, lateral view; 55, Exeristes comstockii (Cress.), petiole, lateral view. ab, first abdominal segment; ab₂, second abdominal segment; ax, axilla; cx₃, metathoracic coxa; dsc, discoidella; mv, marginal vein; nv, nervellus; prp, propodeum; rv, recurrent vein, scl₃ mesoscutellum; st, stigma; sv, stigmatic vein; 2nd M, second marginal cell; 2nd SM, second submarginal cell.
buoliana successfully parasitized by other parasite species attests to the great activity of E. pini as a cleptoparasite.

Cephalic structure of final-instar larva (Fig. 27) consists of mandibles and two broadly U-shaped sclerites bearing the mandibular articulations. Head capsule split medially (dotted lines) down through cephalic structure dividing mouth frame into two parts joined only by the cuticle of the venter of the head. Epistoma absent; pleurostomata bear large superior mandibular processes; hypostomal arms reduced to narrow strips extending ventrad. Hypopharyngeal bracon (Phillips, 1927) bears the inferior mandibular articulations. Mandible (Fig. 27) with a large curved blade bearing a large denticle posteriorly. In anterior view (Fig. 28) mandible shows a distinctive curve to the superior mandibular condyle; this hooks behind the mandibular process on the pleurostoma. "Vestigial maxillary palps" (Phillips, 1927) and three sensoria are present on either side below, or apparently on, the hypopharyngeal bracon depending upon the disposition of the skin. Antenna about twice as long as its diameter; antennal sclerites surrounded by more heavily sclerotized areas than the remainder of the head capsule; a single sensorium is present near each antennal socket. Larval skin smooth; head capsule and skin bear scattered long and short setae 0.07 to 0.15 mm. long; some shorter setae are present around the cephalic structure. Atrium of spiracle (Fig. 39) funnel-shaped with numerous annulations; apical ring of atrium patterned with fine wavy lines. There is a well-defined closing apparatus composed of three distinct spindle-shaped valves.

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SUMMARY

Twenty species of parasites of Rhyacionia buoliana (Schiffermüller) have been reared in Wisconsin. Two keys have been prepared to separate the parasites. The first is designed to aid in
identifying the parasites on the basis of the host remains left in the bud after the parasite has emerged. Twelve species of parasites, one Diptera and eleven Hymenoptera, are included in the key to parasite remains. The second is for the identification of the adults of the parasites of *R. buoliana* in Wisconsin. Brief notes on the biology of each species, and descriptions of the final-instar cephalic structures are also given.

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