Spruce beetle (Coleoptera: Scolytidae) parasitoids: cephalic morphology of larvae and a key to species (Hymenoptera: Braconidae, Pteromalidae)

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Abstract—Cast exuviae from final-instar larvae of four species of hymenopterous parasitoids of *Dendroctonus rufipennis* (Kirby, 1837) were examined for diagnostic characters. The head capsules of *Bracon tenuis* Muesebeck and Walkley, 1951, *Coeloides rufovariegatus* (Provancher, 1880), *Roptrocerus xylophagorum* (Ratzeburg, 1844), and *Dinotiscus dendroctoni* (Ashmead, 1894) each displayed unique combinations of characters allowing discrimination among species. Head capsules are illustrated, and a key to species is presented.

Résumé—Nous avons examiné les exuvies des larves de dernier stade de quatre espèces d'hyménoptères parasitoïdes de *Dendroctonus rufipennis* (Kirby, 1837) à la recherche de caractères diagnostiques. Les capsules céphaliques de *Bracon tenuis* Muesebeck et Walkley, 1951, de *Coeloides rufovariegatus* (Provancher, 1880), de *Roptrocerus xylophagorum* (Ratzeburg, 1844) et de *Dinotiscus dendroctoni* (Ashmead, 1894) portent toutes des combinaisons uniques de caractères qui permettent l'identification des espèces. Nous présentons des illustrations des capsules céphaliques et un clé d'identification des espèces.

[Traduit par la Rédaction]

Parasitic Hymenoptera are poorly known taxonomically, and many species are undescribed (LaSalle and Gauld 1992). Reasonably up-to-date keys to families of parasitic Hymenoptera are available (*e.g.*, Goulet and Huber 1993). For some superfamilies, recent keys to genera exist for some regions (*e.g.*, Gibson *et al.* 1997; Wharton *et al.* 1997), but keys to species exist for relatively few genera in Canada. Existing keys are for adults only. The situation is far worse for larvae. Very few larvae have been described, and keys to species are rare (Finlayson 1960; Čapek 1970). The importance of parasitoids in natural regulation of host populations is widely acknowledged, but the paucity of taxonomic tools to identify parasitoid larvae poses significant challenges for studies of parasitoid biology.

The parasitoid assemblage of a single host species usually consists of at least a few species that co-occur in time and space. To obtain positive identification, parasitoids must be reared to the adult stage (*e.g.*, Wesley 2002, using an agar-based medium). The success rate is sometimes low, rendering identification of rare parasitoid species problematic. Thus, it is advantageous to be able to discriminate accurately among immature stages of different species collected in the field. Keys to species of larvae associated with specific hosts are valuable tools that can aid in elucidation of parasitoid behavior and assessment of impacts on the host

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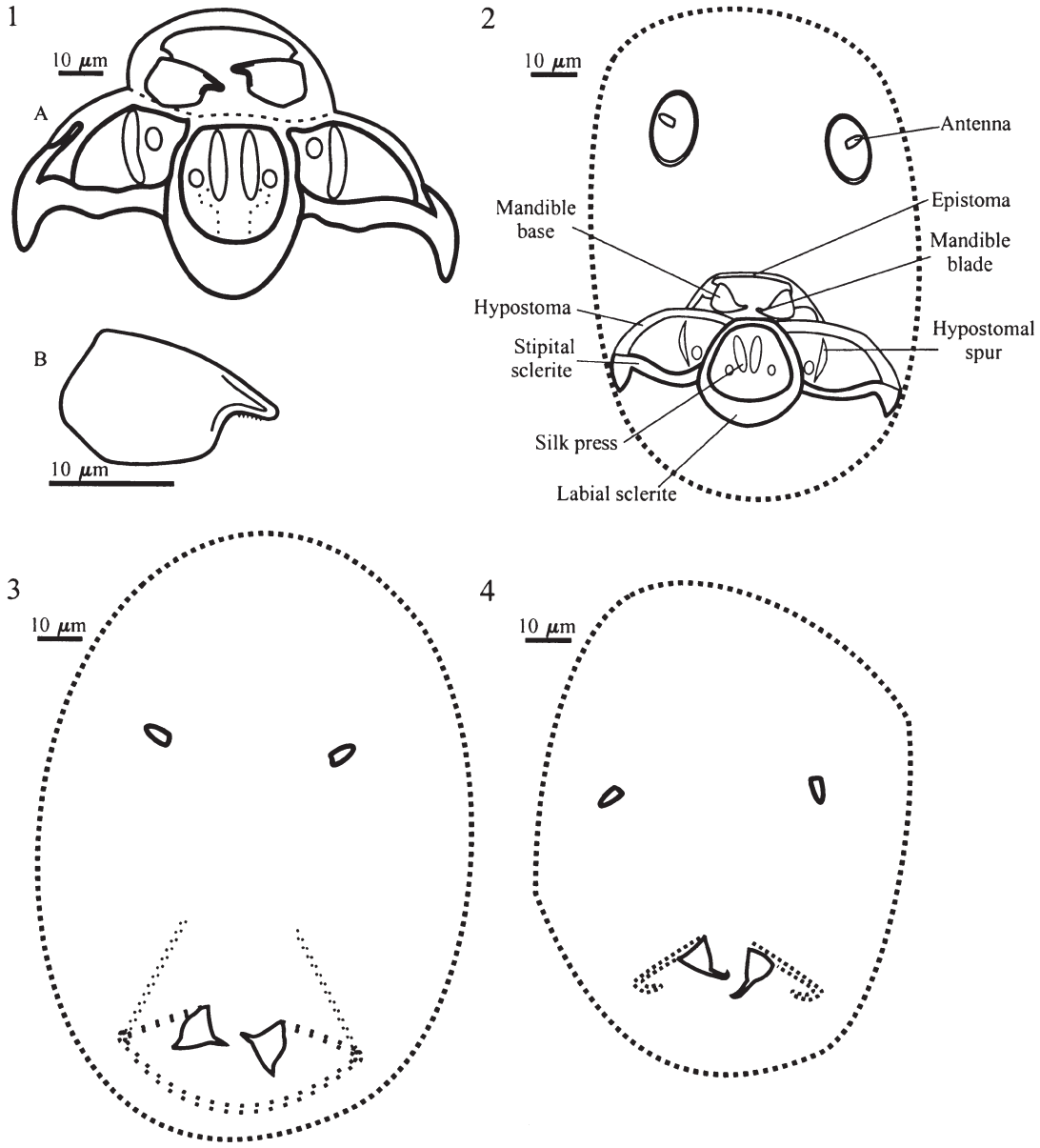
Figs. 1–4. Cephalic structures of parasitoid larvae of *Dendroctonus rufipennis* in anterior view. 1, *Coeloides rufovariegatus*; 2, *Bracon tenuis*; 3, *Roptrocerus xylophagorum*; 4, *Dinotiscus dendroctoni*.



population. Most of the sclerotized structures of hymenopterous larvae are concentrated in the cephalic region and, consequently, this area is a good source of useful taxonomic characters. Through rearing of larvae and association of cast exuviae of final-instar larvae with adults, we have been able to determine the cephalic structures of four species of parasitoids associated with the spruce beetle, *Dendroctonus rufipennis* (Kirby, 1837) (Coleoptera: Scolytidae), in northwestern Alberta and to construct a key to species.

Coccoons from which reared and identified parasitoid adults emerged were examined, and exuviae of the final-instar larvae were removed. Methods for extracting exuviae, and for clearing and examining larvae, were modified from Finlayson (1960). Exuviae were removed from their cocoons and rehydrated in water for 4–8 h. Rehydrated exuviae were placed in warm

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(40–50 °C) 10% KOH solution for 1–3 h to digest unsclerotized tissue and clear cephalic structures for microscopic examination. Cocoons and exuviae were examined for distinguishing characteristics for each larval parasitoid species. Cleared exuviae were placed in glycerin on a well slide and examined with a stereomicroscope. Exuviae associated with reared adults were stored in genitalia vials on the pinned adult specimens and deposited as vouchers in the Northern Forestry Centre Insect Museum, Canadian Forest Service, Edmonton, Alberta.

Photographs of head capsules were taken with a Pixera digital camera attached to a Leica MZ 7.5 microscope. Multiple photographs of each species, from several angles, were combined and then converted into composite line drawings to illustrate differences among species. Terms used follow Čapek (1970) and Finlayson (1960).

Four hymenopterous parasitoids were successfully reared from *D. rufipennis* collected in northern Alberta (Wesley 2002): two braconid species, *Bracon tenuis* Muesebeck and Walkley, 1951 and *Coeloides rufovariegatus* (Provancher, 1880), and two pteromalid species, *Roptrocerus xylophagorum* (Ratzeburg, 1844) and *Dinotiscus dendroctoni* (Ashmead, 1894). Diagnostic characters were few. Cocoons were white, oval, similar to those of many other solitary parasitoids, and, aside from a slight size difference between the braconids and the pteromalids, indistinguishable among the species. Estimation of the size and shape of larvae was problematic given that exuviae were originally recovered in a flattened and distorted shape in the bottom of the cocoon, embedded in the meconium. The integument of exuviae was smooth and featureless. However, cephalic structures were found that are unique and diagnostic for all four species.

Larvae of the braconid species have well-developed cephalic sclerotization, with distinctly pigmented and sclerotized epistoma, hypostoma, and stipital and labial sclerites and a heavily sclerotized mandible (Figs. 1, 2). *Coeloides rufovariegatus* larvae possess an elongate-oval labial sclerite (height approximately 1.3 times the width between the stipital sclerites), hypostomal spurs that touch the stipital sclerite and the hypostoma, an easily visible silk press, and a mandibular blade containing a primary apical tooth and a subapical "comb" of minute teeth (Figs. 1A, 1B). *Bracon tenuis* larvae possess an approximately isodiametric labial sclerite (height about the same as the width between the stipital sclerites), hypostomal spurs that do not touch the stipital sclerite or the hypostoma, and a mandibular blade with one apical tooth (Fig. 2).

Larvae of the pteromalid species have poorly developed cephalic sclerotization: the hypostoma and stipital sclerite are poorly pigmented and sclerotized, and the epistoma and labial sclerite are lacking (Figs. 3, 4). *Roptrocerus xylophagorum* larvae possess lightly sclerotized mandibles, and the blade is shorter than the length of the mandible base and is straight at the tip (Fig. 3). *Dinotiscus dendroctoni* larvae also possess lightly sclerotized mandibles, but the blade is nearly as long as the mandible base and is hooked at the tip (Fig. 4).

Larvae of parasitoids of the spruce beetle in Alberta may be distinguished using the following key:

1. Head capsule with sclerotized and pigmented epistoma, hypostoma, stipital sclerite, and labial sclerite (Figs. 1, 2) (Braconidae) 2
1′. Head capsule lacking epistoma and labial sclerite, other sclerites effaced (Figs. 3, 4) (Pteromalidae) . . . 3
2(1). Hypostomal spurs touching stipital sclerite and hypostoma, labial sclerite height approximately 1.3 times width between stipital sclerites (Fig. 1A), mandibular blade heavily sclerotized with a row of minute teeth (Fig. 1B), antennae indistinct . . . . . *C. rufovariegatus* (Provancher)
2′. Hypostomal spurs not touching stipital sclerite or hypostoma, labial sclerite approximately isodiametric, mandibular blade with single apical tooth, antennae lightly sclerotized but distinct (Fig. 2) . . . . . *B. tenuis* Muesebeck and Walkley
3(1). Mandible blade approximately 0.5 times as long as mandible base and with a straight tip (Fig. 3) . . . . . *R. xylophagorum* (Ratzeburg)
3′. Mandible blade at least 0.75 times as long as mandible base and with a hooked tip (Fig. 4) . . . . . *D. dendroctoni* (Ashmead)

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