

Tiphiidae and Mutillidae, for instance, the posterior margin of the second abdominal segment is slightly constricted. In Vespidae and Formicidae, the second segment is strongly constricted posteriorly and differentiated as a petiole. Within Formicidae, an additional constriction is developed between the third and fourth abdominal segments. The skeletomuscular study of the additional petiolar structures is of interest not only for the implications for functional morphology, but also for better understanding of true phylogenetic relationships among Formicidae, Vespidae and Scoliidae. Nevertheless, relatively few studies have dealt with the skeletomusculature of these body parts in the aculeates.

Furthermore, the skeletomuscular study of the additional petiole can also shed new light on phylogeny among the formicids, because the abdominal characters present a major puzzle to formicid systematists (cf., HÖLLDOBLER & WILSON, 1990). The ponerine tribe Amblyoponini is widely acknowledged as a "primitive" formicid group, since the group has the second abdominal segment attached broadly to the third segment, like tiphiids. In contrast, Sphecomyrminae, the oldest fossil ant subfamily, has the second segment attached narrowly to the third segment. A major question in formicid phylogeny is whether the abdominal structure of Amblyoponini represents an evolutionary reversion of Sphecomyrminae, or whether Amblyoponini (and possibly the remainder of Ponerinae) is an independent clade of formicids predating Sphecomyrminae (i.e., the family Formicidae may be diphyletic).

The present study examined the skeletomusculature of the anterior abdominal segments in Aculeata to discuss the problem of relationships among Formicidae, Vespidae and Scoliidae, and the problems presented by the abdominal characters concerning the relationships among formicids.

Materials and Methods

Only female specimens were examined. In social groups, such as Formicidae and Vespidae, worker specimens were used.

To observe the musculature, specimens were dissected in 70% ethanol and dehydrated in an ethanol series ranging 70% to 99%, and then treated with hexamethyl disilazane for 10 min to prevent muscle shrinkage. Cuticular structures were examined by digesting cellular materials with 10% KOH for 8 hr. The preparations were observed with scanning electron microscope with gold coating. The taxa examined are listed in Table 1.

Different terms have been used for the part of the abdominal sclerites, so that many discrepancies have been occurred, in particular for the anterior part of the sclerites (cf., SNODGRASS, 1935, 1942; SHORT, 1959; TAYLOR, 1978; BOLTON, 1990). In this paper, I call the anterior part "pretergum" and "presternum" instead of "acrosclerites" of BROWN (1975), because the area in