Value of Nymphal Morphology in Determining Identity of Pregenital and Genital Segments in Adult Corimelaena incognita (Hemiptera: Heteroptera: Thyreocoridae)

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ABSTRACT There has been disagreement concerning the number and identity of the abdominal segments involved in the development of the genitalia and, therefore, pregenitalia of the Hemiptera. Although these studies have been conducted during the past two centuries, they have involved only adults. Here we present the results of our study of the nymphs of Corimelaena incognita (McAtee and Malloch) in which we trace the development of the abdomen through the five instars into the adult and determine the number of segments involved in genitalic development. The total number of spiracles (seven) and location of each spiracle (i.e., below or within the lateral carina) were important in this determination. We conclude that the genitalia begin with segment 9 in the male (pygophore) and segment 8 (gonocoxae 1) in the female.

KEY WORDS Corimelaena incognita, Thyreocoridae, morphology, spiracle, segmentation

The morphology of the pregenital and genital abdominal segments of the Hemiptera has received much attention during the past two centuries and has involved studies of basic morphology and terminology and discussions of the specific segments involved in development of particular structures. Baker (1931) listed several of the earlier papers in chronological sequence in his study of the male genitalia of the Canadian species of Pentatomidae. He noted the publication by Sharp (1890) was particularly valuable to his study as were some later papers (e.g., Crampton 1922, Singh-Pruthi 1925, Muir 1926) that would have been useful to him for comparative purposes but were published subsequent to the writing of his paper, which he had “first written some years ago.” These and more recent papers (e.g., McDonald 1966, Sweet 1981) have dealt primarily with adults. Because of the importance and thoroughness of Baker’s 1931 study, we have chosen his paper as the starting point for the literature review in our study of the value of the nymphs in determining the number and identity of the abdominal segments involved in development of the adult pregenitalia and genitalia.

Baker (1931) listed several conclusions about the development of the male pregenitalia and genitalia in the Pentatomidae. These included, among several others, the following: 1) abdominal segment 8 always is present but reduced in size, partially or completely retracted into the segments anterior to it, and lacks appendages; 2) segment 9 becomes the pygophore; and 3) segment 10 (proctiger) is much reduced in size and exists as a small flaplike structure within the pygophore. Related to this, Sweet (1981, p. 43) stated that in the Hemiptera, the pregenital abdomen consists of segments 1–8 and 1–7 in males and females, respectively. More specifically, Schuh and Slater (1995, p. 49) stated that the pregenital abdomen consists of terga 1–8 and sterna 2–8 in males and terga 1–7 and sterna 2–7 in females. Primitively, there are eight pairs of abdominal spiracles on segments 1–8, pair 1 located dorsally or absent, pairs 2–8 located ventrally (Sweet 1981, Schuh and Slater 1995).

As a side note, McAtee and Malloch (1933, p. 198), in their classic taxonomic treatment of the Thyreocoridae (considered as subfamily Thyreoecorinae by McAtee and Malloch), noted that they had not seen Baker’s 1931 paper before the writing of their work. They stated that they had counted the abdominal segments from the “base of the abdomen according to the evidence of the spiracles” (i.e., visible?). Therefore, the number of pairs of spiracles was five (e.g., δ, fig. 259; θ, figs. 105 and 106), located on segments 2–6. But, they noted that Baker (1931) had “evidently assigned numbers to the abdominal segments after assuming that certain ones were involved in the formation of the genitalia. Our sixth is his seventh segment.” Therefore, McAtee and Malloch’s segments 2–6 become 3–7. This suggests that McAtee and Malloch (1933) did not realize that there was an additional pair on segment 2 hidden beneath the metapleuron. But, strangely, they mentioned in their discussion of the “Characters of the Subfamily” (p. 194) that the...
spiracles of abdominal segment 2 are in a membranous anterior strip of the sternite and refer to Fig. 7. In Fig. 7, counting posteriorly, McAtee and Malloch’s sixth segment actually is the seventh. So, they apparently were aware of the correct number of segments involved (seven rather than six) but did not correct the discrepancy between their introductory statement (p. 194) and the descriptions of the various species.

Figs. 1–2. Nymphal stages of *C. incognita*. (1) First instar, dorsal view. (2) First instar, ventral view. SP(1,2,3,7); TB, trichobothrium (dorsal view modified from Bundy and McPherson 2009).

Figs. 3–4. Nymphal stages of *C. incognita*. (3) Third instar, dorsal view. (4) Third instar, ventral view. SP(1,2,3,7); TB, trichobothria (dorsal view modified from Bundy and McPherson 2009).
There has been little consideration of the importance of nymphal morphology in understanding the number of segments involved in the development of the adult pregenital and genital segments and, as far as we are aware, none concerning the Pentatomoidea. Puchkov (1958) noted that in the Lygaeidae, “The externally visible spiracles are situated on abdominal segments II–VII. Their disposition is constant throughout the larval phase of each species, but they are very small and can only be discerned with ease under a 20X lens in stage III–V larvae which have a pale colored abdomen.”

Figs. 5–6. Nymphal stages of *C. incognita*. (5) Fifth instar, male, dorsal view. (6) Fifth instar, male, ventral view. SP(1,2 3,7), spiracle (1,2,3,7); TB, trichobothria (dorsal view modified from Bundy and McPherson 2009).

Figs. 7–8. Nymphal stages of *C. incognita*. (7) Fifth instar, female, dorsal view. (8) Fifth instar, female, ventral view. SP(1,2 3,7), spiracle (1,2,3,7); TB, trichobothria (dorsal view modified from Bundy and McPherson 2009).
Recently, we coauthored a paper on the biology of *Corimelaena incognita* (McAtee and Malloch) in which we included descriptions of the immature stages (Bundy and McPherson 2009). Not mentioned in our study is that the males and females can be sexed in the fifth instar, typical of many pentatomoids and, thus, serve as a link between the nymphs and adult males and females. *C. incognita* is a member of the Thyreocoridae that as adults (as stated earlier) have the first pair of spiracles of abdominal segment 2 hidden (or almost hidden) in a membranous anterior strip beneath the metapleuron (McAtee and Malloch 1933). Thus, the total number of spiracles in the adult is six pairs, which are located on segments 2–7. In addition, this species belongs in the subgenus *Parapora* McAtee and Malloch in which the adults have the spiracles of segments 3–6 (i.e., 4–7) in the lateral carina (McAtee and Malloch 1933, see key, p. 359), the remaining two pairs (segments 2–3) below the carina (Figs. 9–12, current study). However, in our study (2009), we reported seven pairs of abdominal spiracles in the nymphs, two pairs below and five pairs in the lateral carina. Those of abdominal segment one were not present. So, what is the fate of the seventh pair? Is it suppressed in the adult or was it overlooked by McAtee and Malloch (1933)?

In this article, we trace the fate of the seven pairs of spiracles throughout nymphal development into the adult. We also present our findings on sexual differences in the morphology between the male and female fifth instars and adults. Finally, we used these results to determine the number of abdominal segments involved in the pregenital and genital areas of the males and females.

**Materials and Methods**

Specimens in this study were from field samples and laboratory cultures collected during our earlier study (Bundy and McPherson 2009). All samples had been preserved in 80% ethanol (EtOH). Drawings were made on a lightbox from digital photographs taken...
through a dissecting microscope. Scanning electron micrographs were used as an aid to determine the presence or absence of spiracles in adult bugs. Each specimen was mounted on a carbon adhesive tab, sputter-coated with gold, and examined with a scanning electron microscope (S3400N II, Hitachi High Technologies, Pleasanton, CA) at an accelerating voltage of 10 kV.

Results and Discussion

As reported by Bundy and McPherson (2009), there are nine lateral plates in all instars of *C. incognita*, extending dorsally and ventrally from the lateral edge of the abdomen. Lateral plate 1 consists of two sclerites that are separated dorsally and fused ventrally in the first instar (Figs. 1 and 2) and completely fused dorsally and ventrally in the second-fifth instars (Figs. 3–8); lateral plates 2–8 consist of a single sclerite. Lateral plate 9 is discussed below. Each of the nine plates belongs to an individual segment.

Also important in determining the fate of the abdominal spiracles during development is the presence and number of medial plates dorsally and ventrally. Dorsally, there are eight medial plates; plates 1 and 2 are paired and plate 8 is fused with the adjacent laterals (i.e., lateral plate 9) (Figs. 1 and 3, 5, 7). Ventrally, there are seven medial plates (five or six in the first instar), plates 1–3 (1–2 in the first instar) are small, paired; plates 4–7 (3–6 in the first instar) are larger and not paired; plate seven (plate six in the first instar) also is fused with the adjacent laterals (i.e., lateral plate 9) and, thus, with the corresponding dorsal plates, forms an annulus around the anus (Figs. 2 and 4, 6, 8).
As noted above (Bundy and McPherson 2009), there are seven pairs of abdominal spiracles in the nymphs, all of which are visible in the five instars and located in the lateral plates; lateral plates 1 and 9 lack spiracles. Spiracles 1 and 2 (plates 2–3) are below the lateral carina, one mesad of 2, and spiracles 3–7 (plates 4–8) are within the lateral carina (Figs. 2 and 4, 6, 8). Therefore, the total number of segments is nine (nine terga, nine sterna). In addition, there is a single trichobothrium posteromesad of each spiracle on segments 3–7 in the first instar (Fig. 2) and an additional trichobothrium in the second to fifth instar (Figs. 4 and 6, 8). Finally, there is an increasing association of abdominal segment 1 (indicated by the first lateral sclerite) with the metathorax until it is completely fused with the thorax dorsally (Figs. 1 and 3, 5, 7) and incompletely fused ventrally (Figs. 2 and 4, 6, 8) in the fifth instar. The first pair of spiracles (segment 2) is overlapped by the metaleuron in the adult (Fig. 12).

The male and female fifth instars can be distinguished by differences in the abdomen posteroventrally (Figs. 6 and 8). In the male (Fig. 6), the terminal medial plates are relatively unchanged from earlier instars (Figs. 2, 4). In the female, ventromedial plate six has split into two sclerites (Fig. 8). In both sexes, the abdomen terminates with two concentric annuli apparently formed from segments 9–10 and the associated dorsolateral, lateral, and ventromedial plates. It is possible that segment 11 is represented by membrane but not readily apparent.

In the adult male, the last visible pair of spiracles is the sixth pair and located on segment 7 (Fig. 9). If the pygophore represents segment 9 and the proctiger segment 10, as suggested by Baker (1931) for pentatomids, then segment 8 is hidden or reduced or was overlooked by McAtee and Malloch (1933). We found that, in fact, segment 8 is present as a collarlike structure (Fig. 14) as noted by Baker (1931) for pentatomids. In addition, we found what appears to be a reduced pair of spiracles representing the seventh pair on this segment. If true, then segment nine becomes the pygophore and 10, the proctiger. We did not detect any evidence of segment 11.

In the adult female (Fig. 10), the last visible pair of spiracles is the seventh pair and located on segment 7 (Fig. 9). If the pygophore represents segment 9 and the proctiger segment 10, as suggested by Baker (1931) for pentatomids, then segment 8 is hidden or reduced or was overlooked by McAtee and Malloch (1933). We found that, in fact, segment 8 is present as a collarlike structure (Fig. 14) as noted by Baker (1931) for pentatomids. In addition, we found what appears to be a reduced pair of spiracles representing the seventh pair on this segment. If true, then segment nine becomes the pygophore and 10, the proctiger. We did not detect any evidence of segment 11.

In the adult female (Fig. 10), the last visible pair of spiracles is the seventh, is either greatly reduced or absent. Based on the locations of the spiracles and associated trichobothria, the seventh pair should be present on paratergites 8 (=hypopleurites of Sweet 1996), dorsal to gonocoxae 1 (McDonald 1966). However, we were unable to find them, even with the aid of an electron microscope (Fig. 13). McDonald (1966) illustrated the female genitalia of Corimelaena pulicaria (Germar) (fig. 506, p. 148) and did not show a spiracle on parategite 8.

We originally selected C. incognita for this study because of the position of the abdominal spiracles in its subgenus, Parapora (those of segment 2–3 below, 4–7 within the lateral carina), which provided another landmark for tracking development of the segments.
through the five instars into the adult. The disadvantage is the small size of these bugs (e.g., adult, 3–4 mm).

To lessen the impact of small body size, we also examined the adult male and female pregenitalia and genitalia of the stink bug Acrosternum (Chinavia) hilare (Say), which is a much larger insect (~13–19 mm). We found a more obvious pair of spiracles (Fig. 16) on the collar (segment 8) (Figs. 15 and 16) surrounding the pygophore and a reduced pair on paratergites 8 of the female (Figs. 17 and 18). McDonald (1966) illustrated the female genitalia of Acrosternum pennsylvanicum (DeGeer) (Fig. 467, p. 142) and showed a spiracle on paratergite 8.

Based on the evidence we have presented from our study of the nymphs of C. incognita (supplemented with information from A. hilare), we conclude that the genitalia of this species begin with segment 9 in the male (pygophore) and segment 8 (gonocoxae 1) in the female, thus supporting the broader statements of Baker (1931), Sweet (1981), and Schuh and Slater (1995) concerning the origins of the pregenitalia and genitalia of the Hemiptera.

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