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DESCRIPTION OF THE IMMATURE STAGES OF *METHONA CONFUSA CONFUSA* BUTLER, 1873 AND *METHONA CURVIFASCIA* WEYMER, 1883 (NYMPHALIDAE, ITHOMIINAE) FROM EASTERN ECUADOR

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ABSTRACT. Here we describe the complete life history for *Methona confusa confusa* Butler, 1873 and *Methona curvifascia* Weymer, 1883 from eastern Ecuador. Each stage from egg to pupa is described and illustrated. Descriptions of first instar chaetotaxy and instar durations are also reported. Both species were found feeding on *Brunfelsia grandiflora schultesii* Plowman. Mature *M. confusa* larvae have 12 transverse bands that are all yellow in color, including one on segment A9 as observed for *M. megisto* and *M. themisto*. In contrast, *M. curvifascia* lacks a transverse band on segment A9, having 11 transverse bands in total that are white in middle segments and orange in anterior and posterior segments. The pupa of *M. confusa* and *M. curvifascia* differs in the arrangement of spots on the thorax dorsum.

Additional key words: *Brunfelsia grandiflora*, chaetotaxy, egg clustering, Solanaceae.

Butterflies in the genus *Methona* Doubleday, 1847 (Ithomiinae) are large, warningly colored butterflies illustrated in the original descriptions of both Batesian (*M. confusa*) and Müllerian (*M. megisto*) mimicry (Bates 1862; Müller 1879). Despite being involved in the conception of a theory that has generated a massive publication record, *Methona* biology is relatively poorly understood. The genus *Methona* is distributed across much of South America east of the Andes reaching its southern limit in southern Brazil, extreme northern Argentina and Uruguay (Forbes 1943; Mielke & Brown 1979; G. Lamas pers. comm.). In addition, Lamas (2004) indicates that two new subspecies of *M. confusa* are present in Panama.

Host records have been published for four of the seven recognized species and *Methona* are apparently monophagous on the Solanaceae genus *Brunfelsia* (Brown 1987; Drummond 1976, 1986; Drummond & Brown 1987). However, only three species have any published information on immature stage morphology (Brown 1987; Brown & Freitas 1994; Drummond 1976; Motta 2003; Willmott & Freitas 2006), and a complete description of the immature stages has not been published for any species in the genus. Here we report on the immature stages of two species of *Methona* from the upper Amazon basin in eastern Ecuador, *Methona confusa confusa* Butler, 1873 and *M. curvifascia* Weymer, 1883. Both of these species are residents of the Amazon basin, however *M. confusa* is distributed more broadly, occurring throughout the whole basin (and including the populations in Panama mentioned above), and *M. curvifascia* is restricted to western Amazonia (G. Lamas pers. comm.). We describe all early stages, report instar durations and provide detailed description of first instar chaetotaxy and briefly discuss differences in larval color pattern in the genus.

MATERIALS AND METHODS

Observations were made from January to February 2007 in Provincia Sucumbios, Ecuador, in the forests surrounding Garzacocha (00°29.87'S, 76°22.45'W) and Challuacocha (00°26.29'S, 76°16.81'W). Early stages were reared in plastic cups and plastic bags under ambient conditions (22–30° C, 70–100% relative humidity) in a wood building with screen windows. Larvae were moved daily to a shaded environment under a nearby building to maintain ambient conditions. Observations were recorded daily and head capsules and pupal exuviae were collected. Larval specimens were boiled and subsequently stored and studied in 70% ethanol. Vouchers are deposited in the Essig Museum of Entomology at UC Berkeley. Descriptions other than first instar chaetotaxy are based on several individuals from a single clutch of eggs for *M. confusa*, and more than 10 individuals for *M. curvifascia*. First instar chaetotaxy follows nomenclature of Motta (2003), and Hinton (1946), Kitching (1984) and Peterson (1962) were also consulted. The number of specimens for which first instar chaetotaxy was examined is listed in Appendix 1. Host plant vouchers are deposited in the University and Jepson Herbaria at UC Berkeley (voucher number RIH-1424, UC accession #

UC1933451) and Herbario Nacional de Ecuador (voucher number RH01-117).

RESULTS

Methona confusa confusa Butler, 1873

Hostplant. *Brunfelsia grandiflora schultesii* Plowman (Solanaceae), known locally as chiricaspi. The group of *M. confusa* eggs was found on an individual plant that also hosted eggs of *M. curvifascia*.

Oviposition. Not observed. Eggs occur in large clusters on the underside of fresh but mature sized leaves. One cluster of 46 unhatched eggs (at 1.5 m) and a cluster of 18 hatched eggs were found. Plants with eggs were ~2m tall and located in shaded areas at gap edges.

Egg. Figure 1A. Duration: Unknown. Eggs hatched four days after found in the field. Egg is white, adorned with 9–11 horizontal and 19–22 vertical ridges making many small rounded cells. Mean egg height = 1.23 mm (s.d. = 0.04, n = 3). Mean egg width = 0.98 mm (s.d. 0.03, n = 3). Mean axes ratio (height/width) = 1.26 (s.d. = 0.01, n = 3).

1st instar. Figure 1B & C. Duration: 3 to 7 days. Mean head capsule width = 0.77 mm (s.d. = 0.02, n = 10). Head capsule and thoracic legs are black. Proleg shields are large and black. Anal plate is present and shiny black. Body is covered with short pale setae. Body is widest near the head and tapering posteriorly. Body is dark olive green with paler olive transverse bands. Body has pale transverse bands with slightly raised ridges within, ridge on A1 & A2 most pronounced. Larvae eat channels into the leaf from the margin consuming all layers of the leaf.

See Appendix 1 for description of first instar chaetotaxy. An additional lateral body seta (Figure 2) was observed on the meso- and metathorax of the two larvae studied compared with the ithomiines studied by Motta (2003), including *Methona themisto*. This seta is assigned to the lateral group in descriptions (Appendix 1) because this keeps other setae consistent with adjacent segments and the lateral group has a third seta in some moth families (Hinton 1946). Thus, the top seta is inferred to be L1 with the middle L2 and most ventral L3 (Fig. 2). Descriptions of characters involving setae L1 and L2 on these segments should be treated with caution, as homology of L1 and L2 may not have been correctly inferred.

2nd instar. Figure 1D. Duration: 4 to 6 days. Mean head capsule width = 1.18 mm (s.d. = 0.04, n = 10). Like the previous instar with the following observations: body is brown and transverse bands are dirty white with tints of yellow. Segments T1-A9 have a transverse band making 12 bands total. The transverse band on segments A3-A6 leans slightly to the posterior. The transverse pale band is located in the posterior of each segment except T1, which is pale anteriorly and almost entirely pale. Transverse ridges are more pronounced this instar.

3rd instar. Figure 1E. Duration: 3 to 4 days. Mean head capsule width = 1.69 mm (s.d. = 0.04, n = 5). Like previous instar with the following observations: body a rich dark brown and transverse bands dirty white first day turning yellow subsequently. Rest on underside of leaf, sometimes with body straight, sometimes curled in a "J" (Fig. 1H).

4th instar. Figure 1F. Duration: 4 to 7 days. Mean head capsule width = 2.50 mm (s.d. = 0.07, n = 5). Like previous instar with the following observations: transverse bands are yellow and slanting slightly toward the posterior. Transverse bands on A3–6 extend farthest ventrally and are not as pointed at their terminus. Transverse band on A9 is smaller than others, extending the shortest distance ventrally. Laterally, rounded protuberances form a fleshy shelf. Transverse ridges run across this shelf ending below it. The transverse ridges are generally located in the anterior of the transverse yellow band on each segment. Spiracle on T1 is located at posterior margin of yellow band, all other spiracles are anterior of yellow band. Body is covered in short pale pubescence.

5th instar. Figure 1G & H. Duration: 8 to 12 days. Mean head capsule width = 3.39 mm (s.d. = 0.20, n = 4). Like previous instar with the following changes and observations: body dark brown, appearing black in some individuals, with yellow transverse bands. Area of yellow transverse band posterior to ridge fades to whitish on segments A3–6. Yellow bands fade slightly laterally. The day before pupating the yellow fades in all bands.

Pupa. Figure 1I, J & K. Duration: 12 days. Pupa is pendant and bent near abdomen tip but not at abdomen-thorax junction. Pupa colored yellow with distinct black marks. Dorsally with two rows of thin black marks that are thinnest near head. Last segment before cremaster has these dorsal marks merged into wide line. Cremaster is black. Spiracles are outlined in thick black marks. Wing pad has costal margin marked with black. Wing pad posterior margin along thorax marked with black that breaks up into dots near spiracles. Center of wing pad has broken black lines. Ventrally is an inverted black mushroom-shaped spot anterior of cremaster that surrounds a pair of black tubercles. Ventrally at edge of wing pad two black marks merge together. Ocular caps marked with black that starts near eye and extends ventrally as a thick line. Ventrally central black marks over legs and black marks near base of antennae. Thorax slightly keeled with three black marks: anterior spot elongate and thickest toward head, middle one elongate and forked, and posterior one an elongate spot that is widest in the middle (Fig. 1J). The extent of dark markings is variable with some individuals with heavier dark markings (Fig. 1J).

Eyes darken one to two days before eclosing. The day before eclosing black and gold appear in wing pad, then wing pad turns black, followed by abdomen. Pupa has unpleasant odor, as does freshly eclosed adult.

Methona curvifascia Weymer, 1883

Hostplant. *Brunfelsia grandiflora schultesii* Plowman (Solanaceae).

Oviposition. A female was observed ovipositing on a relatively small host from 11:30–12:30. The plant was 1.25–1.5 m tall and located in tall secondary growth with bright light but shaded by a thin canopy of leaves. The female flew to host leaves, tapped the upper surface of the leaf, and then would land on these leaves, occasionally opening her wings and antennating the leaf. She did this repeatedly for 40 minutes. She then landed on a leaf at 0.5 m and hung at its edge, curled her abdomen under and laid a single egg on the underside of the leaf. She was obscured from view after laying this egg but remained close to the site where she laid for ~ 3 min. She then flew to a nearby bird dropping and fed from it. Three eggs were found where she laid the one observed, so she may have laid all three in a few minutes although only the one was observed. Two other eggs were found on this plant along with a freshly hatched first instar. Egg placement with respect to the leaf border appeared somewhat variable and not confined to the leaf border, with eggs sometimes being closer to the leaf midvein than leaf border. Leaves chosen for oviposition varied from small younger growth (3–5 cm in length) to fresh nearly full-sized leaves (8–10 cm). Other plants hosting eggs/larvae were ~2 m tall and found in shaded areas at the edge of primary forest gaps.

Egg. Figure 3A. Duration: 6 days (n = 1). Mean egg height = 2.05 mm (s.d = 0.10, n = 3). Mean egg width = 1.30 mm (s.d. = 0.05, n = 3). Mean axes ratio (height/width) = 1.58 (s.d. = 0.07, n = 3). Egg is white, widest two-thirds the distance from base but only slightly wider there. Egg adorned with 14–17 horizontal and 26–30 vertical ridges. The horizontal and vertical ridges make rounded cells that merge near the apex. Head capsule is visible at egg apex one day before hatching.

1st instar. Figure 3B. Duration: 3 days (n = 2) to 4 days (n = 2). Mean head capsule width = 0.90 mm (s.d. = 0.03, n = 2). When first hatched body is dark grey with paler grey transverse bands in anterior of T1 and posterior of segments T2–A8 making 11 pale bands in total. Within each pale band is a raised transverse ridge that crosses the dorsum. Body covered in short pale setae. Head capsule black and thoracic legs are black. Proleg shields large and black. Black sclerotized anal plate present. Second day and beyond, body dark brown with white to dirty white transverse bands (Fig. 3B). Transverse bands widest dorsally, more narrow laterally. Transverse band on T1

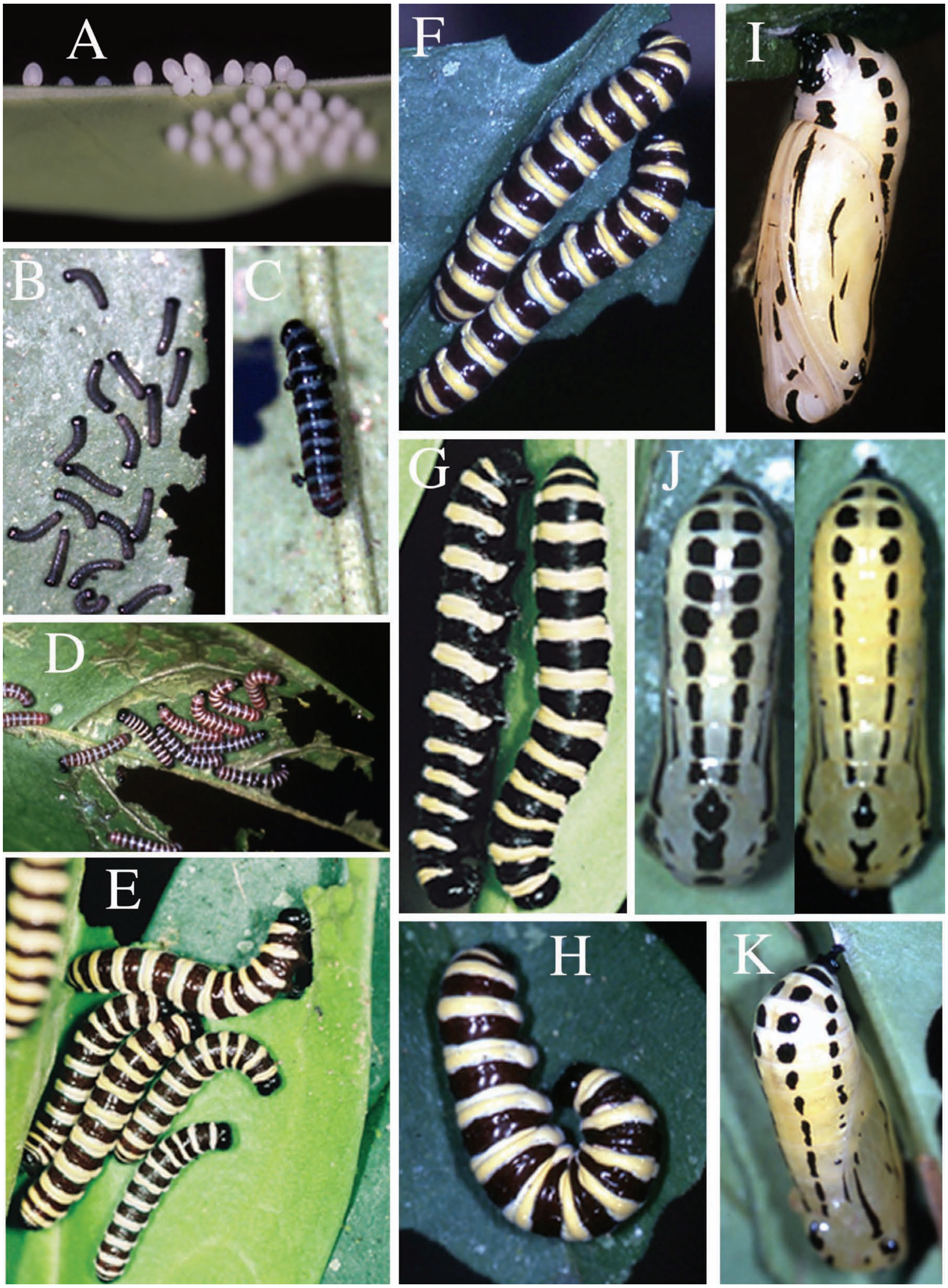

FIG. 1. *Methona confusa* immature stages. A. Egg clutch. B. First instar, first day with very pale bands, feeding from leaf margin. C. First instar > 1 d old with pale bands. D. Second instars, midmolt first instars and feeding damage. E. Third instar. F. Fourth instar. G. Fifth instar. H. Fifth instar in resting position. I. Ventro-lateral view of pupa. J. Dorsal view of two pupae showing range of variation in black markings. K. Dorso-lateral view of pupa illustrating detail near cremaster.

wider than other segments dorsally. Larvae eat little, to more than three quarters egg when first hatched. Larvae feed at leaf margin making channels into side of leaf (Fig. 3C & D). See Appendix 1 for description of first instar chaetotaxy.

2nd instar. Figure 3C. Duration: 3 days (n = 2) to 4 days (n = 1). Mean head capsule width = 1.33 mm (s.d. = 0.03, n = 4). Like previous instar with the following observations: First day, white transverse band of T1 and T2 now with yellow tints. Second day and beyond, transverse band on T1 is yellow and white transverse band on T2 and A8 with yellow tints. Raised ridges more pronounced this instar, with T1 less pronounced than other segments. On segments A3–6 the transverse white band bends forward laterally and ends just above the proleg. Spiracles dark. Spiracle on T1 surrounded by yellow in posterior of transverse band. Spiracles in other segments located at anterior margin of bands.

3rd instar. Figure 3D. Duration: 3 days (n = 6) to 4 days (n = 1). Mean head capsule width = 2.00 mm (s.d. = 0.15, n = 8). Like previous instar with the following observations: Body is very dark brown, some individuals appearing matte black. Non-white bands are more orange-yellow this instar. First day, transverse band on T2 and A8 more strongly colored than previous instar, and orange-yellow like T1, band on T3–A7 white. Second day and beyond, transverse band on segments T3, A1 (only some individuals), and A7 develops yellow tints. Transverse bands extend farthest toward venter on segments A3–6.

4th instar. Figure 3H. Duration: 5 days (n = 3), 6 days (n = 2), 7 days (n = 2). Mean head capsule width = 2.70 mm (s.d. = 0.06, n = 12). Like previous instar with the following observations: Transverse band on T1, T2 and A8 is orange and band on segments T3, A1, A2 and A7 is tinted orange this instar. Transverse band on A7 is wider than other bands except for that on T1.

5th instar. Figure 3I. Duration: 9 days (n = 1), 11 days (n = 7), 12 days (n = 4), 13 days (n = 1). Mean head capsule width = 3.70 mm (s.d. = 0.19, n = 6). Like previous instar with the following observations: Head capsule narrows dorsally with two subtle humps and has short dark setae. Clypeus area is pale grey and frontal sutures pale colored. Body is very dark brown appearing matte black in some individuals. Thorax has additional wrinkles between ridges dorsally. Pale body pubescence more pronounced on ridges. Transverse band on T1 & 2 is orange turning white just above leg where it ends without tapering. Transverse band on segment T3 is white, tinted with orange dorsally and ends above leg without tapering. Transverse band on A1 & A2 tinted orange dorsally, and is white where terminates ventro-laterally in narrow point (A1 narrower point than A2). Segments A3–6 with white transverse band that bends slightly to posterior just before terminating on fleshy bulge above proleg. A7 with white band tinted orange and terminating in rounded point ventro-laterally. A8 band is orange, but not as bright as T1 & T2, and turns white before tapering to a point ventro-laterally. Orange coloration becomes more extensive and white bands on A3–6 darken two to three days before pupating.

Larvae in all instars rest on underside of leaf with head down near where feeding. Larvae tend to feed first at distal end of leaf and subsequently toward leaf base in later instars. Larvae raise thorax off substrate or curl into tight "J" when disturbed.

Pupa. Figure 3E, F, G & J. Duration: 11 days (n = 4) to 12 days (n = 1). Pupa is pendant and bent near abdomen tip but not at abdomen-thorax junction. Pupa is yellow and marked with distinct black spots. Black marks develop within a couple hours of pupating. Head and thorax are slightly darker yellow than abdomen and wing pad. Abdomen dorsum with two rows of black marks that become larger and more rounded toward abdomen apex, and merge into thick line on A10. Laterally, abdomen has seven black spots over spiracles that increase in size toward abdomen apex. Lateral abdomen marks not in a straight line, with marks on A3 & A4 at wing pad margin out of line with the others. Wing pad has three black lines near its center, black spots along its dorsal margin that become lines basally, and black lines along its ventral margin. Ocular caps colored black, with black extending into a line ventrally. Black cremaster. Thorax dorsum has a pair of anterior black spots, a single medial spot near the anterior pair and another spot posteriorly. Venter has rough upside down "T" near the cremaster that surrounds two black tubercles. Some variation observed in extent of dark spots on the thorax (Fig. 3E & F).

Eyes become dark one to two days before eclosion, followed by black and yellow visible in wing pad. Pupa becomes nearly black just before eclosing.

DISCUSSION

Our observations provide several early stage characters useful for distinguishing *Methona confusa* and *M. curvifascia* at this site. Larval coloration differs between these two species with *M. confusa* exhibiting 12 transverse bands similarly yellow in color along the body, whereas *M. curvifascia* has 11 bands with those in the middle of the body white, and those at either end orange. The pupa of these two species can be distinguished by the black spots on the thorax dorsum. *M. confusa*'s anterior spot consists of a single spot and its middle spot is "Y" shaped, whereas *M. curvifascia*'s anterior spot is split into two small spots and its middle spot is round. Observed variation in the extent of black markings on the pupa is illustrated in Fig. 1J and Fig. 3E&F and does not appear to pose problems for identification using the aforementioned pupal characters. *M. confusa* eggs are laid in clusters and are shorter (p = 0.002, t = 13.1, n =3, see above descriptions for means) and narrower (p = 0.001, t = 10.7, n =3, see above descriptions for means) than *M. curvifascia*. *M. confusa* eggs are also relatively more rounded with a lower axes ratio than *M. curvifascia* (p = 0.013, t = 8.2, n = 3, see above descriptions for means).

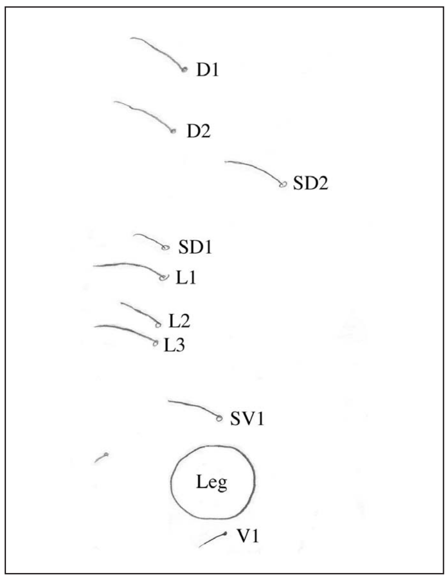

FIG. 2. Schematic of *Methona confusa* first instar chaetotaxy for meso- and metathoracic segments illustrating additional lateral seta (L3). Arrangement of body setae on other segments for *M. confusa* otherwise resembles *M. themisto* (Figure 19.3 in Motta 2003) except for characters 92 and 93 which are described in Appendix 1.

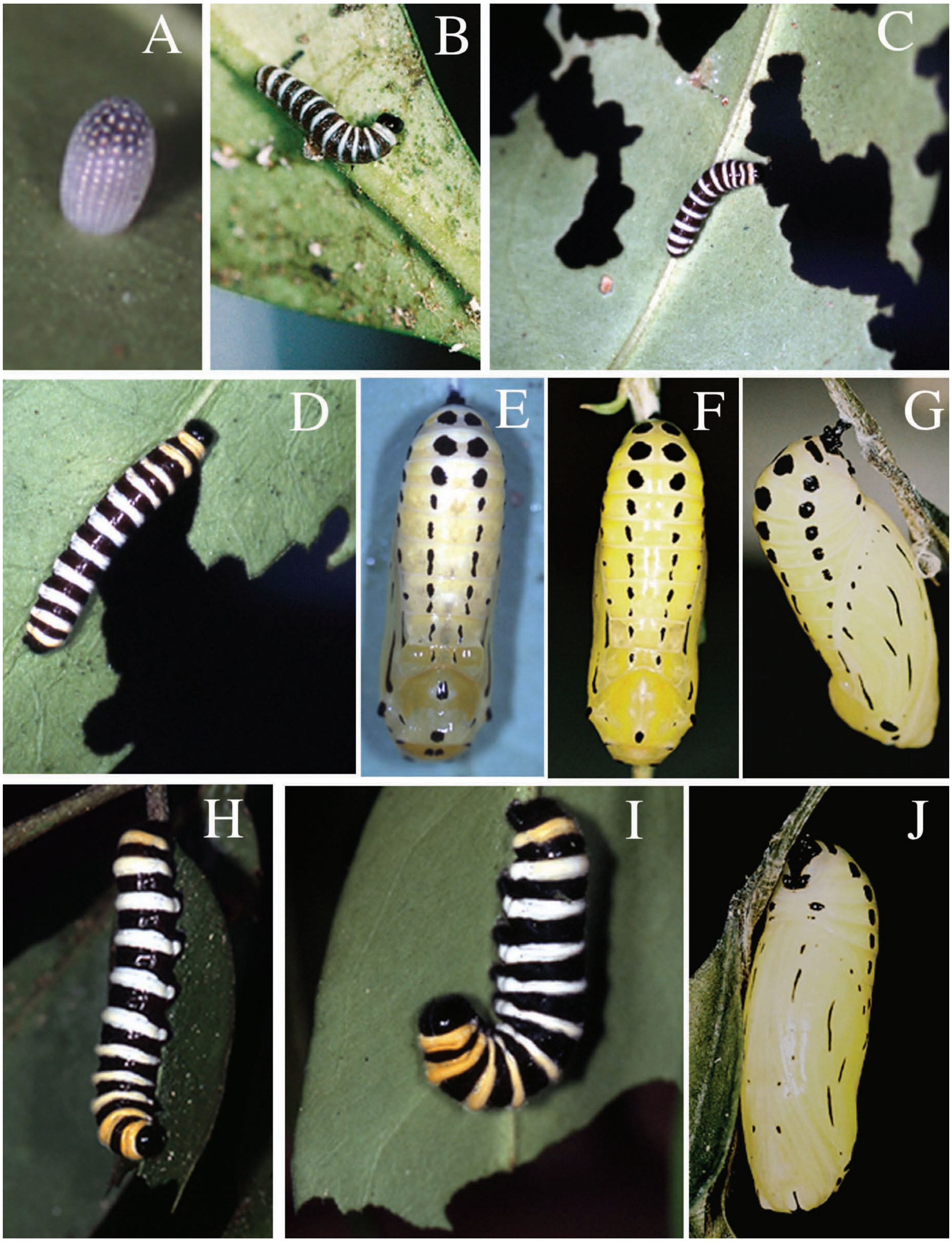

FIG. 3. *Methona curvifascia* immature stages. A. Egg. B. First instar. C. Second instar on leaf showing feeding damage of young instars. D. Third instar. E. Dorsal view of freshly formed (< 1 d) pupa. F. Dorsal view of pupa exhibiting mature coloration. Note variation in black mark on thorax. G. Lateral view of pupa. H. Fourth instar showing feeding position and damage. I. Fifth instar showing resting behavior. J. Ventral view of pupa.

Observations made here also allow comparison of larval morphology within and among *Methona* species. The *M. confusa confusa* larvae observed here are similar to the *M. confusa psamathe* larva figured in Brown (1987). Although it is difficult to see, the larva in Brown (1987) Figure 8X appears to have a transverse band on segment A9 making 12 transverse bands in total. The presence of a transverse band on A9 in *M. confusa* is a trait shared with *M. megisto* and *M. themisto* illustrated in Brown & Freitas (1994) and was identified as a synapomorphy of *Methona* in Willmott & Freitas (2006)(Table 2, character 49:1). However, *M. curvifascia* lacks the transverse band on A9 indicating that not all *Methona* have this character. *M. curvifascia* is placed as the basal *Methona* species in a molecular phylogenetic study (Hill unpublished) suggesting that absence of a transverse band on A9 is the plesiomorphic condition, and evolution of the extra band on A9 occurred after *M. curvifascia* diverged from the rest of the group. *Methona curvifascia* also may be divergent in egg shape with a mean axes ratio observed here just outside of the range indicated for *M. themisto* (Brown & Freitas 1994) and significantly different than *M. confusa* as mentioned above.

Aside from the characters just discussed, observations made here are congruent with most of the synapomorphies for *Methona* larvae listed in Table 2 of Willmott & Freitas (2006). The pupa of both *M. confusa* and *M. curvifascia* exhibit the sharp curve along the dorsum in the posterior half of the abdomen (character 55:1). The following characters, with their states indicated in parentheses, are also the same for *M. confusa* and *M. curvifascia* as listed for *M. megisto* and *M. themisto* in Willmott & Freitas (2006): 22(1), 54(0), 56(0), 59(1).

Willmott & Freitas (2006) report that *M. megisto* and *M. themisto* lay eggs at the border of leaves and this is indicated as a synapomorphy for the genus (table 2, character 9:1), however observations on egg placement for both *Methona* species reported here seem to conflict with this character state. *M. confusa* lay eggs in clusters that covered a large portion of the leaf, including the middle of the leaf (Fig. 1), although scoring this species for this character seems inappropriate because of its cluster-laying habit. It is likely that *M. confusa* lays eggs while resting on the topside of the leaf, but given its cluster laying behavior it would be interesting to confirm this. *M. curvifascia* oviposition location does not seem confined to the leaf border, although this may be a result of relatively small host leaf size observed here, because on hosts with larger leaves, laying from the leaf top and curling the abdomen underneath would result in eggs placed near the border. Thus, it may be useful to re-evaluate this character by focusing more on female oviposition behavior and less on the resulting egg position.

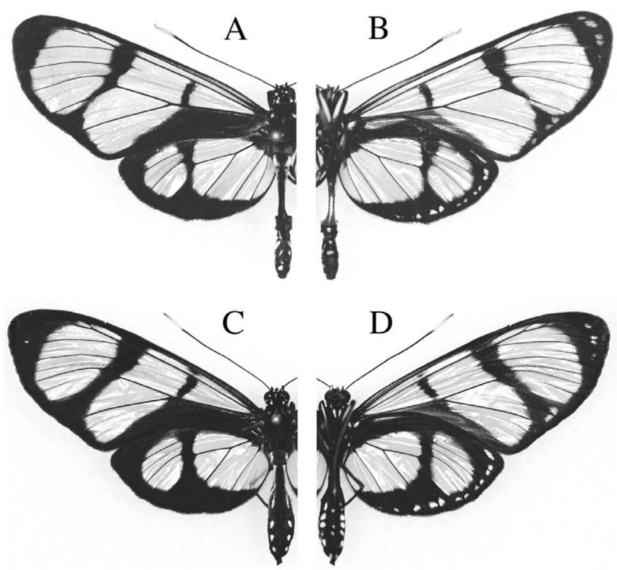

FIG. 4. Adult *Methona* reared in this study. A. Male *M. confusa dorsum*. B. Male *M. confusa* venter. C. Female *M. curvifascia* dorsum. D. Female *M. curvifascia* venter. *M. confusa* were identified by vein Sc coalescing with R1, presence of dorsal hindwing costal "hair pencils" in females, and male last abdominal tergite not produced and block-like or spine-like. *M. curvifascia* were identified by vein Sc not coalescing with R1, absence of dorsal hindwing costal "hair pencils" in females and male last abdominal tergite produced and narrowing into a spine-like process.

Methona confusa is the first species in the genus to be observed laying eggs in clusters. In addition to the observation here, A. Freitas observed a female *Methona* in Acre, Brazil laying a cluster of 12 eggs. The female escaped after ovipositing but was likely *M. confusa* (A. Freitas, pers. comm.). Cluster-laying has been found to be relatively rare in ithomiines, but it is widely distributed across their phylogeny, being present in 12 genera (including *Methona*) (Brown & Freitas 1994; Drummond 1976; Haber 1978; Hill 2006; Willmott & Freitas 2006). Indeed, using the tribal classification of Willmott & Freitas (2006), only the tribes Tithoreini and Oleriini lack any cluster-laying species. In addition to *Methona*, the genera *Hypothyris, Episcada, Ithomia*, and *Pteronymia* contain cluster-laying species as well as species known to lay eggs singly (Brown & Freitas 1994; Willmott & Freitas 2006; Hill pers. obs.). This suggests life history studies on additional ithomiine species could reveal cluster-laying species in other genera presently known to only lay solitary eggs.

Some ithomiine species that are documented laying eggs in clusters also exist in solitary-laying populations, and this may be the case with *M. confusa* as well. In contrast to the *M. confusa* immatures studied here, Brown (1987) illustrated a single *M. confusa* larva from Venezuela suggesting it was solitary. Of course, Brown's (1987) larva could have been part of a cluster of eggs that had dispersed at some larval stage only appearing to be more or less solitary. Larvae studied here were confined to bags and so no observations on dispersal of a larval group were made. It would be interesting to confirm whether *M. confusa* populations vary in cluster-laying because this would be an additional example of intraspecific variation similar to what has been observed in two other ithomiine species. Gilbert (1969) observed *Mechanitis menapis saturata* laying eggs in clusters in Costa Rica, but Drummond (1976) found *M. menapis mantineus* laying single eggs in western Ecuador. Similarly, Gilbert (1969) reported *Hypothyris euclea valora* (called *H. e. leucania*) laying eggs in clusters in Costa Rica, and Drummond (1976) observed *H. euclea intermedia* (called *H. e. peruviana*) laying single eggs at Limoncocha. In contrast to Drummond's (1976) observation we have observed *H. euclea intermedia* laying eggs in clusters at Garzacocha. Such intraspecific variation could be a fruitful area for investigating hypotheses for cluster-laying in ithomiines (Clark & Faeth 1998; Courtney 1984; Haber 1978; Stamp 1980; Vasconcellos-Neto 1986; Young & Moffett 1979), and indicates the continuing importance of immature stages to understanding ithomiine biology.

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Please see Appendix on next page

APPENDIX 1. First instar chaetotaxy of *Methona confusa* and *Methona curvifascia*. For the reasons given in Hill (2006), characters are listed as text here rather than as states of Motta's (2003) characters. No larval specimens of *M. curvifascia* were preserved for study of body chaetotaxy. Descriptions of body setae are based on two larvae for *M. confusa*. Descriptions of head, labrum and mandible chaetotaxy are based on two head capsules for *M. curvifascia* and five head capsules for *M. confusa*.

Character # of Motta	*M. confusa*	*M. curvifascia*
Head capsule		
1	Seta C1 equidistant to frontal and anteclypeal sutures	Seta C1 equidistant to frontal and anteclypeal sutures
2	Seta C2 nearer to C1 than to a medial imaginary line	Seta C2 nearer to C1 than to a medial imaginary line
3	Seta C2 same length at C1	Seta C2 same length at C1
4	Seta F1 undoubtedly more dorsal and medial to C2	Seta F1 undoubtedly more dorsal and medial to C2
5	Seta F1 nearer to C2 than it is to coronal bifurcation	Seta F1 nearer to C2 than it is to coronal bifurcation
6	Seta F1 subtly nearer to frontal suture than to imaginary medial line	Seta F1 subtly nearer to frontal suture than to imaginary medial line
7	Puncture Fa aligned with seta F1	Puncture Fa subtly above seta F1
8	Distance between Fa punctures subtly longer than distance between Fa and seta F1	Distance between Fa punctures similar to that between Fa and F1
9	Puncture AFa, and setae AF1 and AF2 all present	Puncture AFa, and setae AF1 and AF2 all present
10	Puncture AFa slightly medial of line connecting setae AF1 and AF2	Puncture AFa in line with to slightly medial of line connecting setae AF1 and AF2
11	Puncture AFa equidistant to setae AF1 and AF2 (or subtly nearer to AF1)	Puncture AFa equidistant to setae AF1 and AF2 (or subtly nearer to AF2)
12	Setae AF1 and AF2 similar in length	Setae AF1 and AF2 similar in length
13	Seta AF2 subtly above level of coronal suture bifurcation	Seta AF2 subtly above level of coronal suture bifurcation
14	Distance of seta AF2 to coronal suture same as distance of AF1 to frontal suture	Distance of seta AF2 to coronal suture same as distance of AF1 to frontal suture
15	Puncture Aa below imaginary line connecting AF1 and A2	Puncture Aa above imaginary line connecting AF1 and A2
16	Puncture Aa nearer to A2 than to AF1	Puncture Aa nearer to A2 than to AF1
17	Seta A3 posterior to imaginary line between stemma iv and P1; distance of A3 to the imaginary line less than distance of A3 to stemma iv	Seta A3 posterior to imaginary line between stemma iv and P1; distance of A3 to the imaginary line less than distance of A3 to stemma iv
18	Seta A1 slightly closer to stemma i than ii and aligned to slightly above stemma i	Seta A1 closer to stemma i than ii and aligned to slightly above stemma i
19	Seta A2 aligned with imaginary line between stemma ii and AF1	Seta A2 aligned with imaginary line between stemma ii and AF1
20	Seta A3 not much longer in length than A2 and L1	Seta A3 not much longer in length than A2 and L1
21	Puncture Pa ventral to slightly ventral to imaginary line connecting setae A2 and A3.	Puncture Pa ventral to slightly ventral to imaginary line connecting setae A2 and A3.
22	Puncture Pa nearer to seta A2 than to A3	Puncture Pa nearer to seta A2 than to A3
23	Puncture Pb aligned with, to slightly medial of, imaginary line between setae P1 and P2.	Puncture Pb aligned with, to medial of, imaginary line between setae P1 and P2.
24	Puncture Pb closer to seta P2 than P1	Puncture Pb closer to seta P2 than P1
25	Setae P1 and P2 equidistant to coronal suture	Seta P2 slightly farther from coronal suture than is seta P1
26	Setae P1 and P2 same length to P1 slightly longer	Setae P1 and P2 same length to P1 slightly longer
27	Puncture La much closer to seta L1 than A3, and less than 1/3 distance between L1 and A3	Puncture La much closer to seta L1 than A3, and less than 1/3 distance between L1 and A3
28	Alignment of puncture La and setae L1 and A3 somewhat aligned to forming a very obtuse triangle	Alignment of puncture La and setae L1 and A3 somewhat aligned to forming a very obtuse triangle
29	Seta O1 nearly in line with stemmata i and iv, equidistant to ii and iii; O1 slightly closer to iv than i.	Seta O1 nearly in line with stemmata i and iv, equidistant to ii and iii; O1 slightly closer to iv than i

APPENDIX 1. Continued

Character # of Motta	*M. confusa*	*M. curvifascia*
Head capsule (cont.)		
30	Angle formed between O2 and stemmata iv and v less than 90°	Angle formed between O2 and stemmata iv and v less than 90°
31	Seta O2 equidistant to stemmata iv and v	Seta O2 equidistant to stemmata iv and v
32,33	Seta O2 longer than O1 and O3, with O1 and O3 similar lengths	Seta O2 longer than O1 and O3, with O1 and O3 similar lengths
34	Seta O3 aligned with stemma v and "groove"	Seta O3 aligned with stemma v and "groove"
35	Puncture Oa ventral (toward antennal socket) to imaginary line between stemma i and seta A1	Puncture Oa ventral (toward antennal socket) to imaginary line between stemma i and seta A1
36	Puncture Ob aligned to stemma v and O3, and forming a triangle with stemma v and O2.	Puncture Ob aligned to stemma v and O3, and forming a triangle with stemma v and O2
37	Puncture Ob equidistant or nearer to stemma v relative to O2, and farthest from O3	Puncture Ob nearer to stemma v than O2 and farthest from O3
38	SO1 in ventral end of antennal socket so that distance of SO1 to end of antennal socket is less than 1/2 distance between SO1 and SO3	SO1 in ventral end of antennal socket so that distance of SO1 to end of antennal socket is less than 1/2 distance between SO1 and SO3
39	SO2 ventral to imaginary line connecting stemmata v and vi	SO2 ventral to imaginary line connecting stemmata v and vi
40	SO2 equidistant to slightly closer to stemma vi relative to stemma v	SO2 equidistant to slightly closer to stemma vi relative to stemma v
41	SO3 posterior to line between stemma vi and SO1	SO3 posterior to line between stemma vi and SO1
42	SOa between suture and imaginary line joining SO3 and G1, SOa same distance from suture as G1	SOa between suture and imaginary line joining SO3 and G1, SOa same distance from suture as G1
43	SOa falls on line between SO2 and nearest point of maxillary (ventral)suture, SOa is subtly closer to the suture than to SO3 and much closer to the suture than to SO2	SOa falls on line between SO2 and nearest point of maxillary ventral) suture, SOa is subtly closer to the suture than to SO3 and much closer to the suture than to SO2
44	SOb near antennal socket; distance of SOb to antennal socket about 1/2 that of SO3 to antennal socket	SOb near antennal socket; distance of SOb to antennal socket about 1/2 that of SO3 to antennal socket
45	SOb nearer, to slightly nearer, to SO3 than to stemma vi	SOb nearer, to slightly nearer, to SO3 than to stemma vi
46	G1 subtly closer to maxillary (ventral suture) relative to groove	G1 equidistant to groove and maxillary (ventral) suture
47	Ga aligned to line joining G1 and O3	Ga aligned to line joining G1 and O3
48	Ga nearer to O3	Ga nearer to O3
49	V1 nearer to “V” group than P2	V1 nearer to “V” group than P2
50	Stemmata all similar diameter	Stemmata all similar diameter
51	Similar distance between stemma i, ii, iii and iv	Similar distance between stemma i, ii, iii and iv
52	Stemma v closer to vi than to iv	Stemma v closer to vi than to iv
Labrum		
53	Seta M2 aligned or slightly basal to L1	Seta M2 aligned to L1
54	M2 aligned, to slightly dorsal, of line between M1 and L2	M2 basal to line between M1 and L2
55	M1 shifted slightly dorsal relative to M2	M1 aligned to slightly dorsal of M2
56	Distance between M1's greater than distance between M1 to M2	Distance between M1's greater than distance between M1 to M2
57	M2 longer than M1	M2 longer than M1
58	Puncture S located basal to M1 and M2	Puncture S located basal to M1 and M2
59	Puncture S equidistant to M1 and M2	Puncture S equidistant to M1 and M2 or a little closer to M2
60	Angle between the lines that connect M1 and M2, and M1 and the puncture S is 40° - 70°	Angle between the lines that connect M1 and M2, and M1 and the puncture S is 40° - 70°
61	Puncture equidistant to subtly nearer to M1 and M2 relative to posterior border	Puncture equidistant to M1 and M2 relative to posterior border
62	Puncture S basal to widest point of labrum	Puncture S basal to widest point of labrum
63	M3 on the distal border of the labrum	M3 on the distal border of the labrum
64	L2 nearer to L1 than L3	L2 nearer to L1 than L3
65	L1 level to widest point of labrum	L1 level to widest point of labrum
66	Less sclerotized region near the labrum notch and to M1 and M2	Less sclerotized region near the labrum notch and to M1 and M2
67	Less sclerotized basal patches absent	Less sclerotized basal patches absent
68	Internal border of the labral lobe smoothly curved	Internal border of the labral lobe smoothly curved
69	Basal angle of labrum notch obtuse	Basal angle of labrum notch obtuse

APPENDIX 1. Continued

Character # of Motta	*M. confusa*	*M. curvifascia*
Labrum (cont.)		
70	Ratio of notch length (= depth) to overall labral length (labral lobe to base) ~ 0.3; ratio of labral notch width, as measured between apices of lobes, to labral length ~ 1.1	Ratio of notch length (= depth) to overall labral length (labral lobe to base) ~ 0.4; ratio of labral notch width, as measured between apices of lobes, to labral length ~ 1.1
71	Ratio of labrum width (between L1's) to length (labral lobe to base) ~ 2	Ratio of labrum width (between L1's) to length (labral lobe to base) ~ 2
Mandible		
72	Fewer than three small molar teeth	Fewer than three small molar teeth
73	Incisors 2 and 3 similar lengths	Incisors 2 and 3 similar lengths
74	Lateral grooves radiating from each side of 4th incisor, one on outside more subtle than others, 4 grooves in total	Lateral grooves radiating from each side of 4th incisor, one on outside more subtle than others, 4 grooves in total
Body		
75	No tubercles present on the thorax	
77	Average seta length less than segment width	
78,79	Crochets arranged in a circle on segments A3-6, but A10 arranged in a semicircle; all crochet lengths similar	
80	Prolegs with more that 14 crochets on average	
81	Cervical sclerite absent on XD1 and XD2 and D1	
82	Seta D1 shorter than XD1 and XD2, XD1 and XD2 are equivalent in length	
83,87	Setae SD2 and SD1 aligned on T1, SD2 shifted posterior of SD1 on T2-A8, and SD2 shifted slightly posterior of SD1 on A9	
84	On segment T1 setae L1 and L2 slightly dorsal of spiracle with L2 between L1 and spiracle; on T2 and T3, L2 is at level of abdominal spiracles; on A1-A8 L1 and L2 below spiracle	
85,91	Setae D1 and D2 are equivalent lengths	
86	Seta SD2 closer to D2 than to SD1	
88	Seta SD2 ventral and posterior to D1 and D2	
89,94	Seta SD1 longer than L1 and equivalent to L2 on segment T1; on T2 & T3 setae SD1 and L2 equivalent and shorter than L1 and L3 (which are same length); SD1 equivalent to L1 and L2 on abdomen	
90	Seta L2 present on segments T1-A8	
92	Seta SD2 and D1 equivalent lengths and longer than D2	
93	SD2 shorter than SD1 on T1; SD2 longer than SD1 on T2 & T3; SD2 shorter than SD1 on abdomen	
95	L1 shorter than L2 on T1; L1 longer than L2 on T2 and T3 with L3 equivalent to L1; L1 and L2 equivalent on abdomen	
96	Additional SV seta on A2 only	
97	A9 with one less seta (L1 or L2) than A7 and A8	
98	Epiproct setae D1, D2, SD1 and L1 similar lengths	
99	P1 and SP1 setae present on A10	