DESCRIPTION OF THE IMMATURES OF WORKERS OF THE ANT *CAMPONOTUS VITTATUS* (HYMENOPTERA: FORMICIDAE)

DANIEL RUSS SOLIS[1], EDUARDO GONÇALVES PATERSON FOX[1], MÔNICA LANZONI ROSSI[2], THIAGO DE CARVALHO MORETTI[3] AND ODAIR CORREA BUENO[1]

[1]Centro de Estudos de Insetos Sociais, Instituto de Biociências, São Paulo State University (UNESP), Rio Claro, São Paulo, Brazil

[2]Laboratório de Histopatologia e Biologia Estrutural de Plantas, Centro de Energia Nuclear na Agricultura, University of São Paulo (USP), Piracicaba, São Paulo, Brazil

[3]Departamento de Parasitologia, Instituto de Biociências, São Paulo State University (UNESP), Botucatu, São Paulo, Brazil

ABSTRACT

Camponotus vittatus Forel is a poorly studied Neotropical ant, which is very common in Brazil. Larval descriptions are useful to systematics, as larval characters aid with genus-level differentiation, and ant larvae lie at the basis of ant social organization. This study presents the first description of the immatures of *C. vittatus* with the aid of light and scanning electron microscopy. There are three instars based on the frequency distribution of larval head widths. The larvae had some characteristics typical of *Camponotus*, specifically, a 'pogonomyrmecoid' body shape, 10 pairs of spiracles, antennae with 3 sensilla, mature larvae with pronounced labial pseudopalps, and conspicuous 'chiloscleres' on the labrum. Unique characteristics found would include the greatest diversity of body hair types recorded in an ant larva and 'camponotoid' mandibles with 6 medial denticles over the blade. The number of antennal sensilla proved variable.

Key Words: instars, Formicinae, Camponotini, *Tanaemyrmex*

RESUMO

Camponotus vittatus Forel é uma espécie pouco conhecida encontrada na região Neotropical, principalmente no Brasil. As larvas de algumas outras espécies de *Camponotus* Mayr foram descritas, mas as larvas de *C. vittatus* não foram analisadas. A descrição de larvas é fundamental para a sistemática, pois certos caracteres podem ser utilizados na diferenciação entre gêneros, e as larvas têm um papel fundamental na organização social das formigas. Neste contexto, esse estudo realizou uma descrição detalhada dos imaturos de *C. vittatus* que originarão operárias por meio de microscopia óptica e eletrônica de varredura. O número de instares larvais foi estimado em três, baseado na distribuição das freqüências de larguras da cápsula cefálica. As larvas apresentaram algumas características consideradas como típicas para *Camponotus* Mayr: formato do corpo pogonomirmecóide; dez pares de espiráculos; antenas com três sensilas; presença de 'chiloscleres' no labro e do pseudopalpo labial das larvas maduras. Entretanto, *C. vittatus* apresenta uma grande diversidade de pêlos e mandíbulas de tipo camponotóide com seis dentículos. O número de sensilas antenais mostrou-se variável.

Translation by the authors.

Camponotus vittatus Forel is a Neotropical ant species belonging to the subgenus *Tanaemyrmex* Ashmead, along with other 515 described species and subspecies (Bolton et al. 2006). Although frequently found in collections and diversity studies in Brazil (Soares et al. 2006; Delabie et al. 2007; Silva et al. 2009), this species is poorly studied. Since its first description by Forel (1904), *C. vittatus* has been the subject of 2 theses with a molecular biology approach (Almeida 2006; Rodovalho 2006) and 1 article about feeding behavior (Solis et al. 2009a).

The importance of morphological descriptions of ant larvae has been emphasized by George C. Wheeler and Jeanette Wheeler, who described the larvae of about 800 ant species (Wheeler & Wheeler 1988). Ant larval descriptions can be useful to systematics, as larval characters can aid in identification (Wheeler & Wheeler 1976), and can help resolve phylogenetic relationships between different groups (Wheeler & Wheeler 1976; Schultz & Meier 1995; Pitts et al. 2005). Moreover, larvae stand at the base of social organization in ants (Hölldobler & Wilson 1990), and yet their social role is often not clearly defined. For example, the larvae of some species exhibit morphological specializations which are important to colony nutrition (Cassill et al. 2005; Masuko 2008). Although a number of *Camponotus* Mayr larvae have been described (Wheeler & Wheeler 1953, 1968, 1970, 1974, 1991), the larvae of *C. vittatus* have not been described, although *C. vittatus* is a common and important ant in Brazil.

The present study aimed at describing each immature stage of *C. vittatus* workers with the aid of light and scanning electron microscopy.

MATERIALS AND METHODS

Collection of Samples

Nests of *C. vittatus* were obtained in 2006 in the municipality of Campinas (22°54'09.38"S, 47°05'56.84"W), São Paulo, Brazil, and the ants were reared in the laboratory (temperature 23-27°C and 50-70% relative humidity). From these colonies (n = 3) we obtained immatures to be used in our descriptions. It should be noted that our colonies did not have any alates, thus should contain no sexual larvae, which could interfere with instar determination of workers. Dartigues & Passera (1979) noted that reproductive larvae of *Camponotus aethiops* Latreille could have an additional instar, while minor and major workers had the same number of instars, their larvae differing only in body size. It should be noted that workers of *C. vittatus* are dimorphic.

Voucher specimens of eggs, larvae, and pupae were deposited in the "Adolph Hempel" entomological collection of the Centro de Pesquisa e Desenvolvimento de Sanidade Vegetal in Instituto Biológico, São Paulo, Brazil.

Determining the Number of Instars

As following molts was impracticable, the number of instars was determined based on a method described in Parra & Haddad (1989). We measured the maximum head widths of the collected larvae (n = 427) and plotted the results on a frequency distribution graph, where every distinct peak was considered to correspond to a different instar. The obtained number of instars was tested against Dyar's rule (Parra & Haddad 1989). The first instar and the last instar could be explicitly identified and used as reference to bracket others.

Description of the Immature Forms

The morphological descriptions were made with 20 larvae of each instar (10 by scanning electron microscopy and 10 by light microscopy), given that these larvae belonged to the most frequent head width found for the instar. The larvae were analyzed under a compound light microscope (Zeiss MC80 DX, maximum magnification of 1000X) and a scanning electron microscope (LEO 435 VP at 20.0 kV). With a stereomicroscope (Zeiss Stemi SV11, maximum magnification of 66X) equipped with a micrometric eyepiece, we could rapidly measure length and medial width of eggs (n = 100) and larvae (n = 145), head width and body length of pupae (n = 30).

Terminology used in our larval descriptions was based on Wheeler & Wheeler (1976). Measures, where applicable, are given as mean ± standard deviation followed by the range and number (n) of observations. The following abbreviations are employed: (Tn) thoracic somite, with n being the number of that somite; (An) abdominal somite, with n being the number of that somite; (d) diameter; (h) height; (l) length; (w) width; (bs) body length between spiracles. The following additional terms were adopted to classify hair ramifications: side ramifications at the distal third of hair lengths are termed "tip ramifications", while side ramifications at the proximal third of hairs are referred to as "deep ramifications", and side ramifications at any point between these two marks are termed "moderate ramifications".

All collected samples were fixed in Dietrich's solution (900 mL distilled water, 450 mL 95% ethanol, 150 mL 40% formaldehyde, 30 mL acetic acid) for 24h and then conserved in 70% alcohol. Samples to be analyzed under the scanning electron microscope were dehydrated in an alcohol graded series (80-100%; 10 min for each concentration), and critical-point dried (Balzers CPD/030); dried specimens were then attached to aluminium stubs with double-faced conductive adhesive tape and gold-sputtered with a Balzers SCD/050 sputterer. Observations and images were obtained as soon as possible after sample preparation. Samples to be analyzed under the compound microscope were warmed for 10-30 min (depending on the instar) in KOH 10% and placed in a small drop of glycerin on a glass microscope slide.

RESULTS

Determination of Number of Instars

The frequency distribution of the larvae head capsule widths resulted in a multimodal distribution with 3 distinct peaks (suggesting the existence of 3 instars), the first being formed by first instar larvae and the last entirely formed by prepupae (Fig. 1). The estimated number of instars yielded a good fit with Dyar's rule (R^2 = 0.98).

The mean growth rate between the instars was 1.29 (1.30 to first-second instars, and 1.27 to second-third instars).

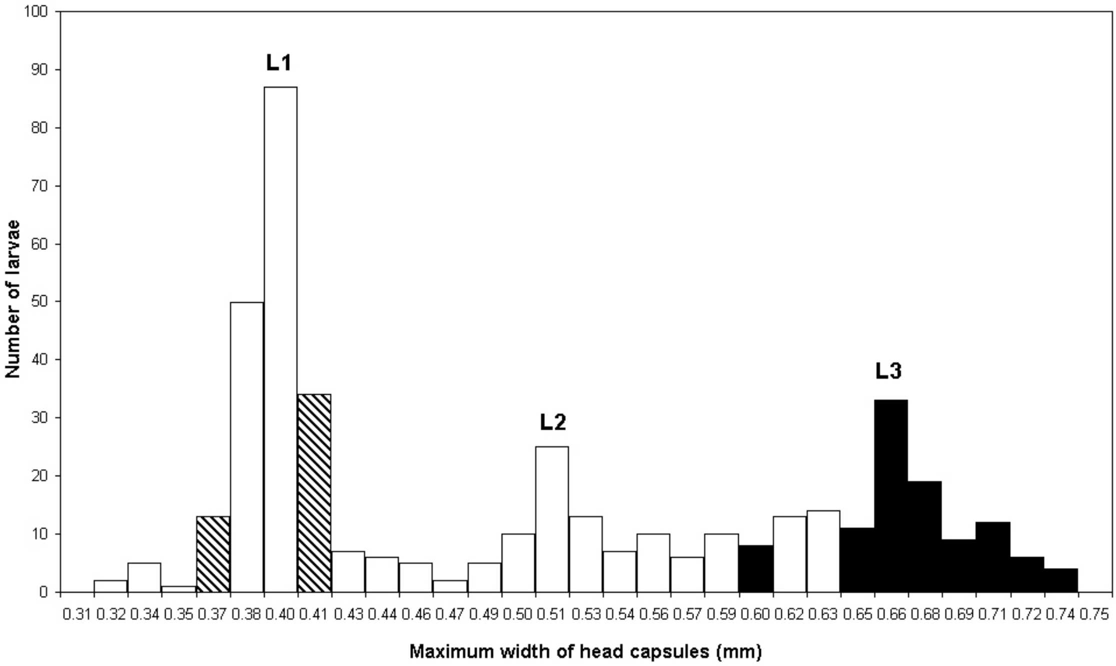

Fig. 1. Frequency distribution of the maximum widths of head capsules of *Camponotus vittatus* worker larvae: (L1) first instar, (L2) second instar, and (L3) third instar. The hatched columns represent intervals in which mature embryos in the eggs were found and the black columns represent the interval in which prepupae were found.

Morphological Description of the Immature Forms

Egg. Ovoid but slightly elongate in shape, with delicate translucent chorion (l = 1.18 ± 0.07 mm, 1.03-1.40 mm; w = 0.57 ± 0.05 mm, 0.46-0.74 mm; *n* = 100). Length: width ratio 2.07.

General aspect of larvae. As the 3 different instars shared many characteristics, a general description is given followed by separate descriptions for larvae of each instar. Body: Body shape 'pogonomyrmecoid' (Fig. 2), defined by Wheeler & Wheeler (1976) as "Diameter greatest near middle of abdomen, decreasing gradually toward head and more rapidly toward posterior, which is rounded; thorax more slender than abdomen and forming a neck, which is curved ventrally". Larvae whitish and markedly hairy, with 13 distinct somites (3 thoracic and 10 abdominal); anus subterminal (Fig. 3A). There were transverse rows of spines over the ventral body region of body segments T2, T3, A1, and A2 which had few hairs (Fig. 3B); spinules were particularly abundant on this region of third instars (Figs. 3C-E). The different types of hairs found with each instar analyzed are shown in Figs. 4 and 5 and summarized in Table 1. Ten pairs of unornamented spiracles, 2 thoracic and 8 abdominal (Fig. 3F). Head Capsule (Fig. 6A): Subelliptical; antennae consisting of 3 (rarely 4) basiconic sensilla that may or may not be arranged in a row placed over a slight elliptical elevation (Fig. 6B). Clypeus clearly delimited. Mouthparts: Labrum subparabolic in shape and not completely detached from the ventral border of clypeus, bearing 6 basiconic sensilla over its ventral border and 6 sensilla on the anterior face, hairs at the number of 8-11, always simple (subtype S1). Mandibles markedly sclerotized and roughly 'camponotoid' in shape, defined by Wheeler & Wheeler (1976) as "subtriangular; base broad (width at least 2/3 the length); apex forming a round-pointed tooth; no medial teeth (or rarely 1 small one)", however presenting 6 denticles over the inner blade (thus presenting medial teeth); there were 2 encapsulated sensilla near the base of each mandible. Maxillae conoidal in shape but prolonged, acquiring a mandible-like appearance (Fig. 6A), and bearing 7-9 hairs (subtypes varying according with instar; see below); maxillary palps paxilliform with 4 basiconic sensilla and 1 enclosed sensillum; galea digitiform with 2 basiconic sensilla on top (Fig. 6C). Labium roughly rounded, presenting a group of spinules arranged in transversal rows on the region above the slit-like sericteries, and 8-11 simple hairs over the ventral border (Fig. 6D). Labial palps with 3 basiconic sensilla and 1 enclosed sensillum (Fig. 6E).

First Instar. Body (l = 1.58 ± 0.20 mm, 1.05-2.25 mm; w = 0.40-0.80 mm; *n* = 87) (bs = 1.72 ± 0.13 mm, 1.55-1.93 mm, *n* = 10): Covered with

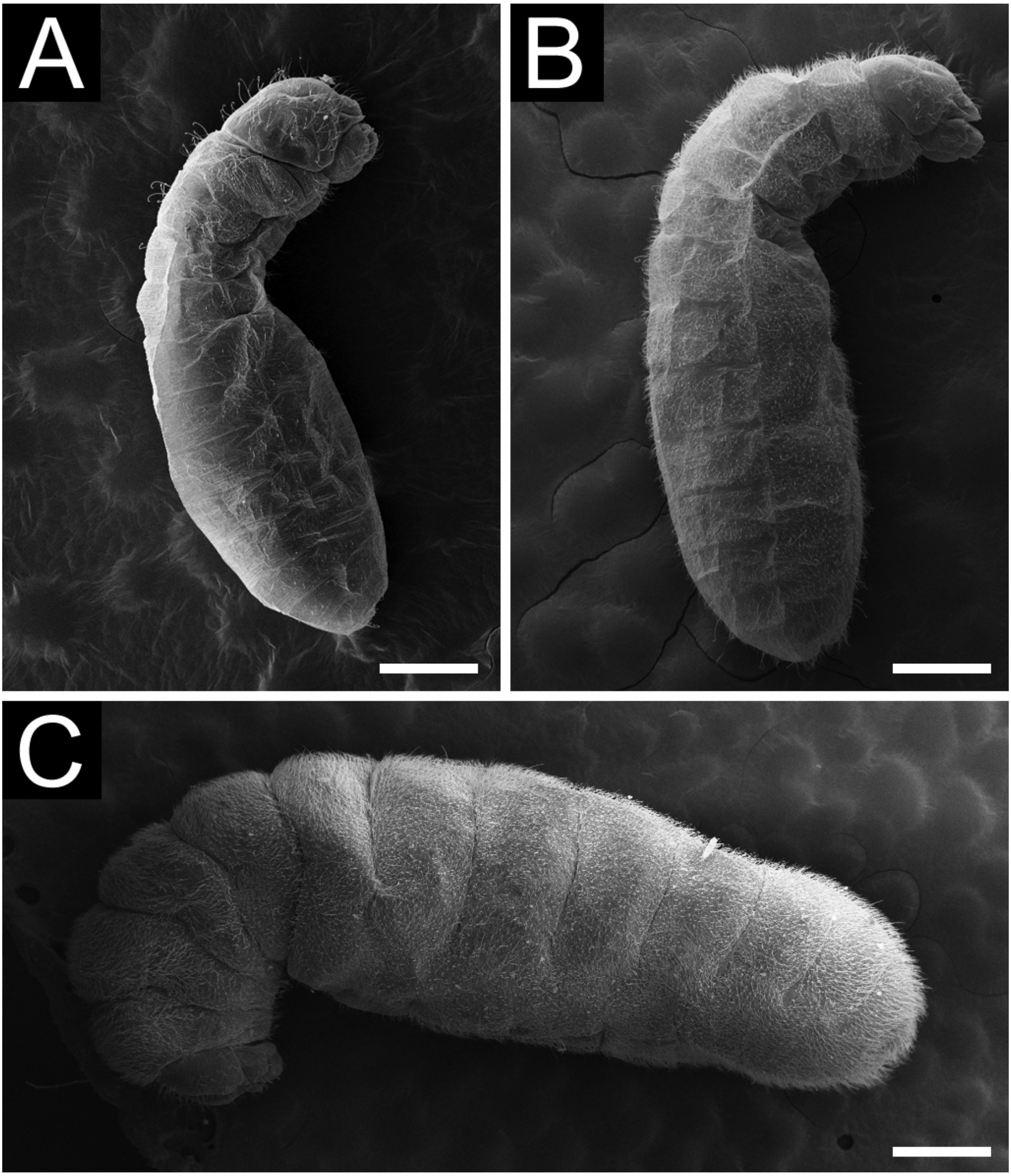

Fig. 2. Larvae of *Camponotus vittatus* on side view: (A) first instar; (B) second instar; (C) third instar. Sizes of scale bars: (A) 0.250 mm; (B) 0.328 mm; (C) 0.581 mm.

200-450 hairs (respective types and lengths given in parentheses): simple (S1: 0.006-0.060 mm, n = 50; S3: 0.055 ± 0.013 mm, 0.025-0.078 mm, n = 50); bifid (B2: 0.032-0.038 mm, n = 3; B3: 0.041 ± 0.012 mm, 0.020-0.075 mm, n = 50); 3-branched (R2: 0.043 ± 0.013 mm, 0.020-0.063 mm, n = 12; R3: 0.050 mm, n = 1; R4: 0.035-0.048 mm, n = 4); 4-branched (E1: 0.040 mm, n = 1). First and third pairs of spiracles slightly larger (d = 0.013 mm, n = 20) than the remaining ones, which are of the same size (d = 0.010 mm, n = 80). Head Capsule (w = 0.40 mm, n = 87): Head hairs distributed as follows: 23-30 hairs over each gena, 14 hairs over the clypeus, 2-4 hairs on the frons, 0-1 over the

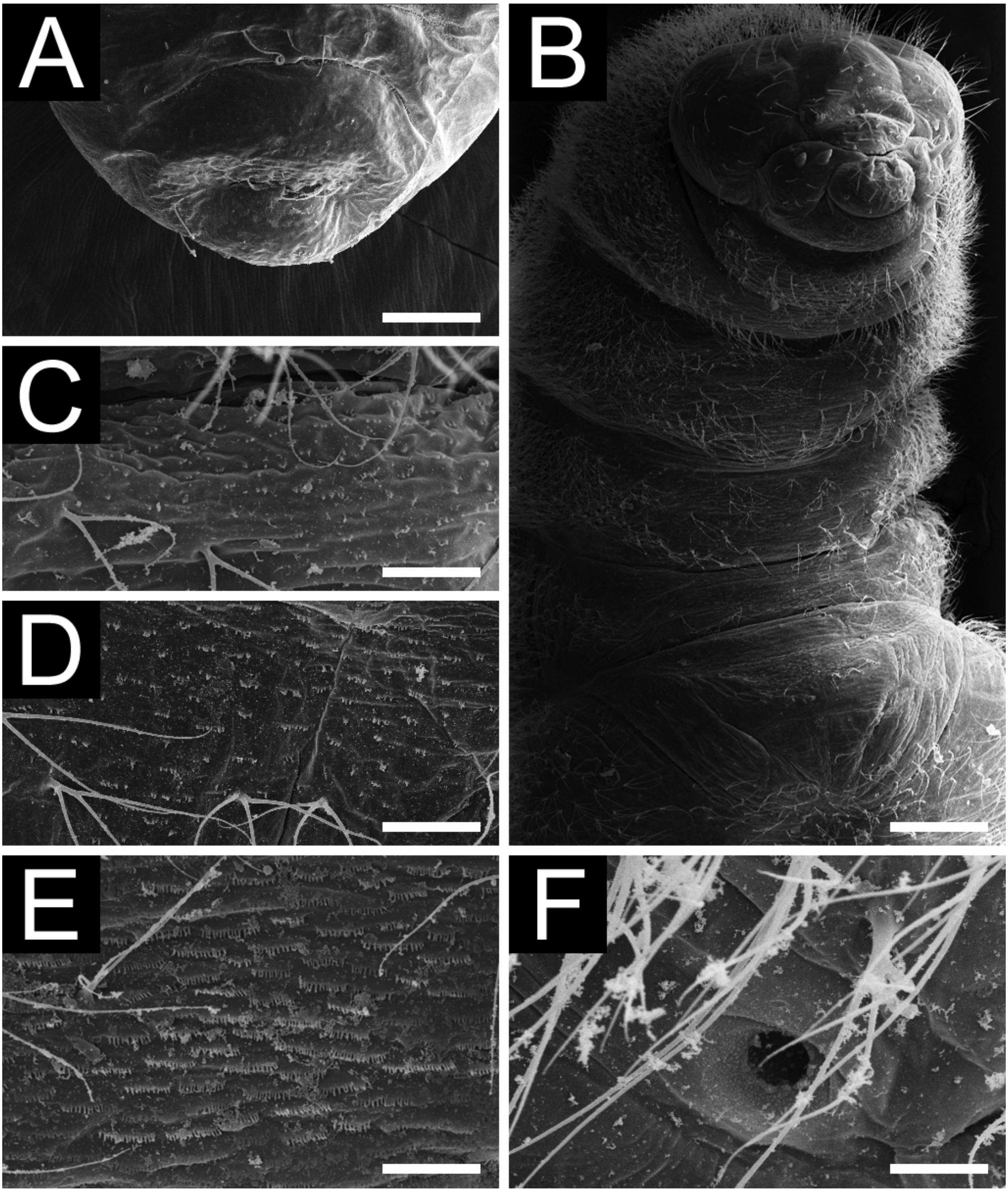

Fig. 3. Morphological aspects of the body of *Camponotus vittatus* larvae: (A) anus of a first instar; (B) anterior ventral region of a third instar ('praesaepium'); (C) surface of the upper ventral integument of a first instar, showing rows of spinules; (D) surface of the upper ventral integument of a second instar, showing rows of spinules; (E) surface of the upper ventral integument of a third instar, showing rows of spinules; (F) thoracic spiracle of a third instar. Sizes of scale bars: (A) 0.059 mm; (B) 0.200 mm; (C) 0.013 mm; (D) 0.029 mm; (E) 0.030 mm; (F) 0.015 mm.

vertex and none on the occipital border. Head hairs of the following types (lengths given in parentheses): simple (S1: 0.042 ± 0.013 mm, 0.018-0.058 mm, n = 11; S3: 0.064 ± 0.008 mm, 0.049-0.084 mm, n = 40); bifid (B2: 0.048-0.060 mm, n = 5; B3: 0.063 ± 0.016 mm, 0.033-0.101 mm, n = 40); 3-branched (R2: 0.065 ± 0.014 mm, 0.043-0.093 mm, n = 22; R4: 0.045-0.058 mm, n = 4); and 4-

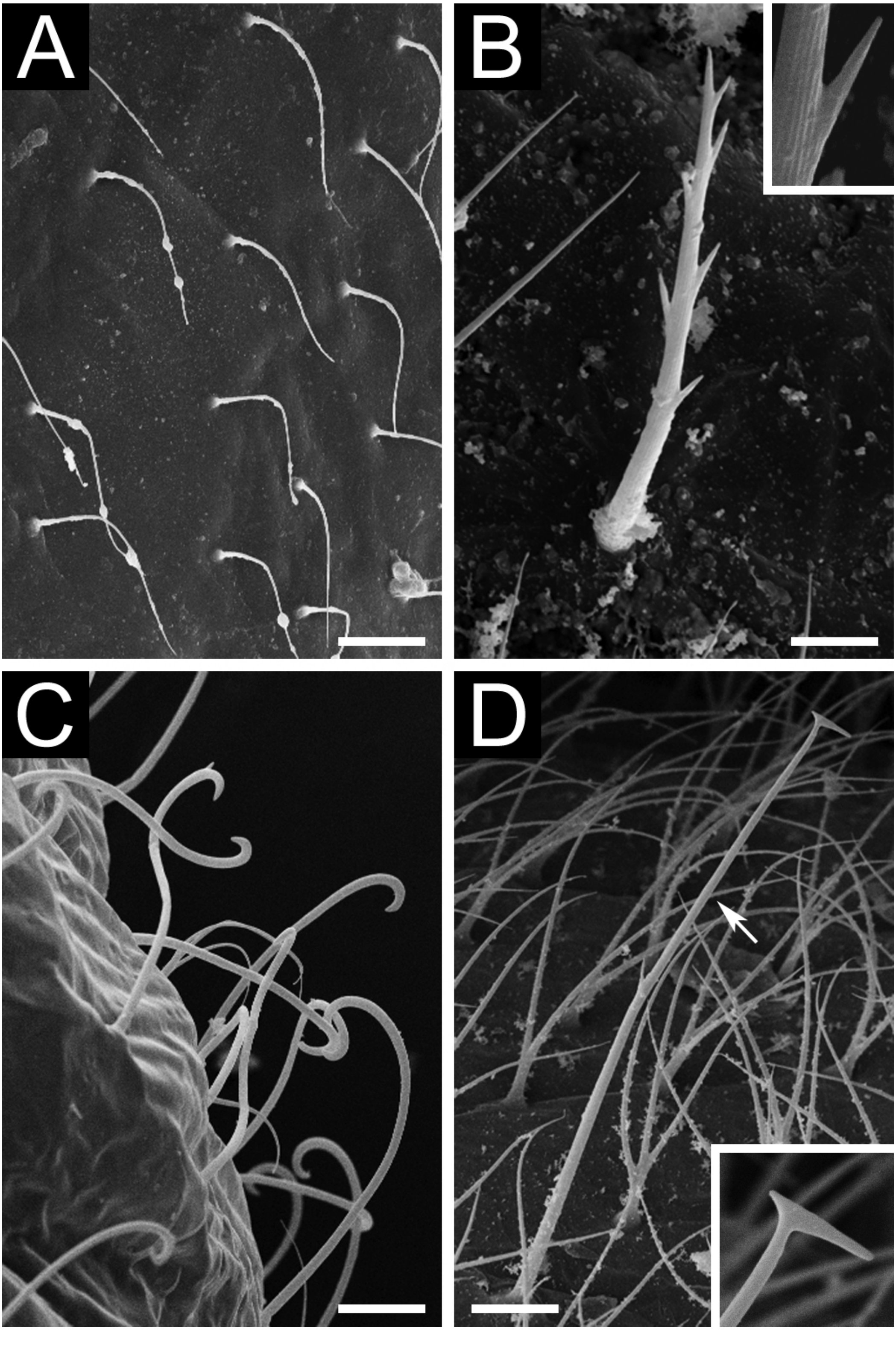

Fig. 4. Types of simple hairs on the body of *Camponotus vittatus* larvae: (A) subtype S1; (B) subtype S2; (C) subtype S3; (D) subtype S4 (arrow). Sizes of scale bars: (A) 0.024 mm; (B) 0.006 mm; (C) 0.015 mm; (D) 0.016 mm.

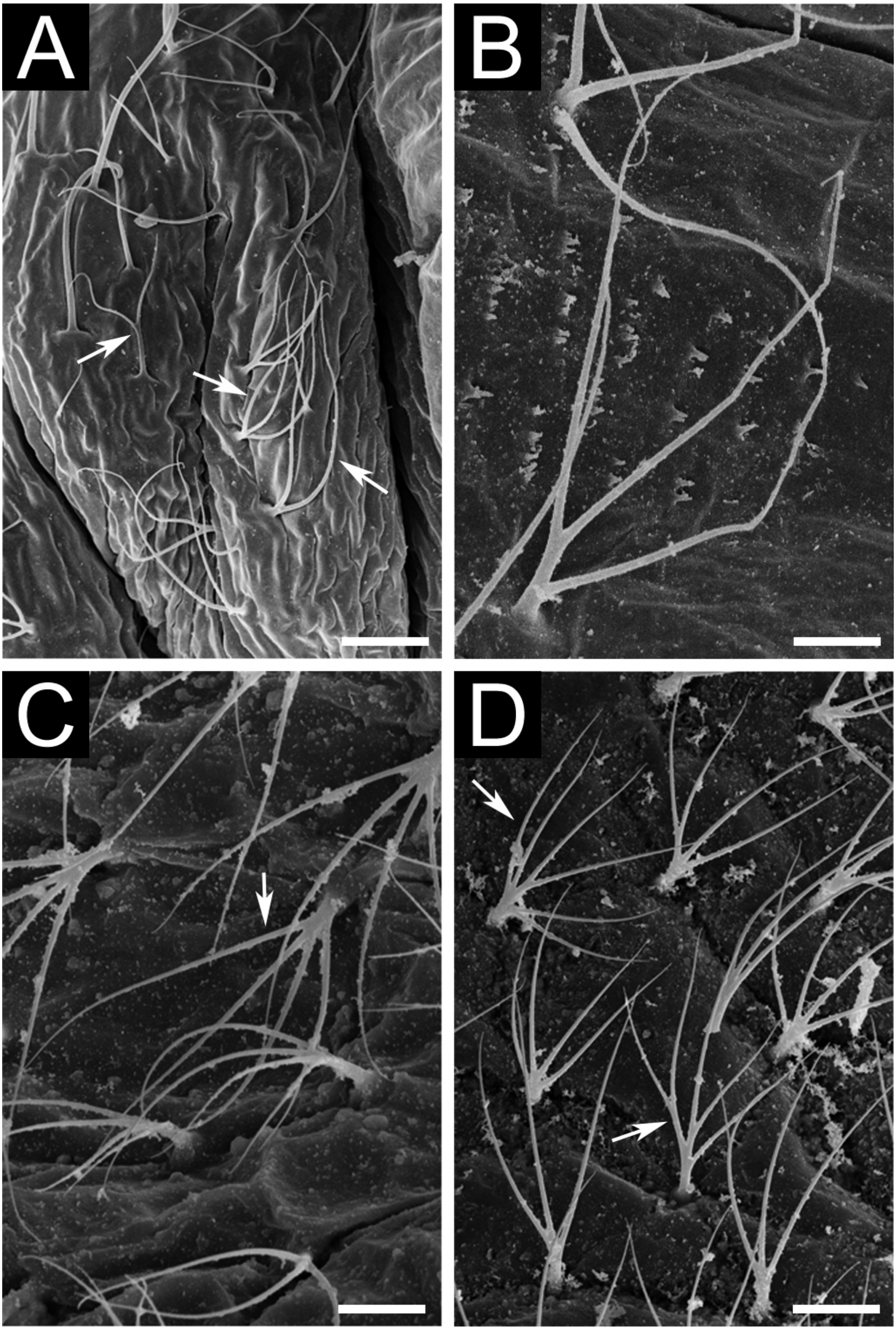

Fig. 5. Types of hairs on the body of *Camponotus vittatus* larvae: (A) subtype B2, subtype B3 and subtype R2 (arrows); (B) subtype R4; (C) subtype E1 (arrow); (D) subtype P3 and subtype H1 (arrows). Sizes of scale bars: (A) 0.023 mm; (B) 0.010 mm; (C) 0.015 mm; (D) 0.020 mm.

TABLE 1. TYPES OF HAIRS OCCURRING ON WORKER LARVAE OF *CAMPONOTUS VITTATUS*.

			Location/Instar		
Hair Type	Subtypes	Description	Body	Head Capsule	Mouthparts
Simple	S1	Unbranched smooth hair (Fig. 4A)	All instars	All instars	All instars
	S2	Unbranched hair with short spike-like side ramifications, surface with longitudinal ridges (Fig. 4B)	L3	L3	L2/L3
	S3	Unbranched hair with coiled hook on tip (Fig. 4C)	L1/L2	L1/L2	Absent
	S4	Unbranched hair with an anvil-shaped apical expansion and side denticle-like ramifications (Fig. 4D)	L3	Absent	Absent
Bifid	B1	Smooth hair with tip bifid	L3	Absent	L2
	B2	Moderately bifid smooth hair (Fig. 5A)	All instars	All instars	L1/L2
	B3	Deeply bifid smooth hair (Fig. 5A)	All instars	All instars	L2
3-branched	R1	Moderately bifid, with another ramification at a lower length	L3	L2/L3	Absent
	R2	Deeply branched, with all ramifications parting at same length (Fig. 5A)	All instars	All instars	Absent
	R3	Moderately branched, with all ramifications parting at same length	All instars	L3	Absent
	R4	Deeply bifid, with another ramification at a lower length (Fig. 5B)	All instars	L1	Absent
	R5	With tip bifid and another ramification at a lower length	Absent	L3	Absent
4-branched	E1	Deeply branched, with all ramifications parting at same length (Fig. 5C)	All instars	All instars	Absent
	E2	Moderately bifid, with 2 other ramifications parting at a lower length	L3	Absent	Absent
	E3	Moderately branched, with all ramifications parting at same length	L2/L3	Absent	Absent
	E4	Moderately 3-branched, with another ramification parting at a lower length	L2	L1/L2	Absent
	E5	Deeply bifid, with moderately bifid ramifications at same length	L3	Absent	Absent
5-branched	P1	Deeply branched, with all ramifications starting at same length	L3	Absent	Absent
	P2	Moderately bifid, with other 3 ramifications parting from a lower length	L3	Absent	Absent
	P3	Deeply 3-branched, with other 2 ramifications parting from a higher length (Fig. 5D)	L3	Absent	Absent
6-branched	H1	Moderately bifid, with other 4 ramifications parting at a lower length (Fig. 5D)	L3	Absent	Absent

(L1) First instar, (L2) Second instar, (L3) Third instar.

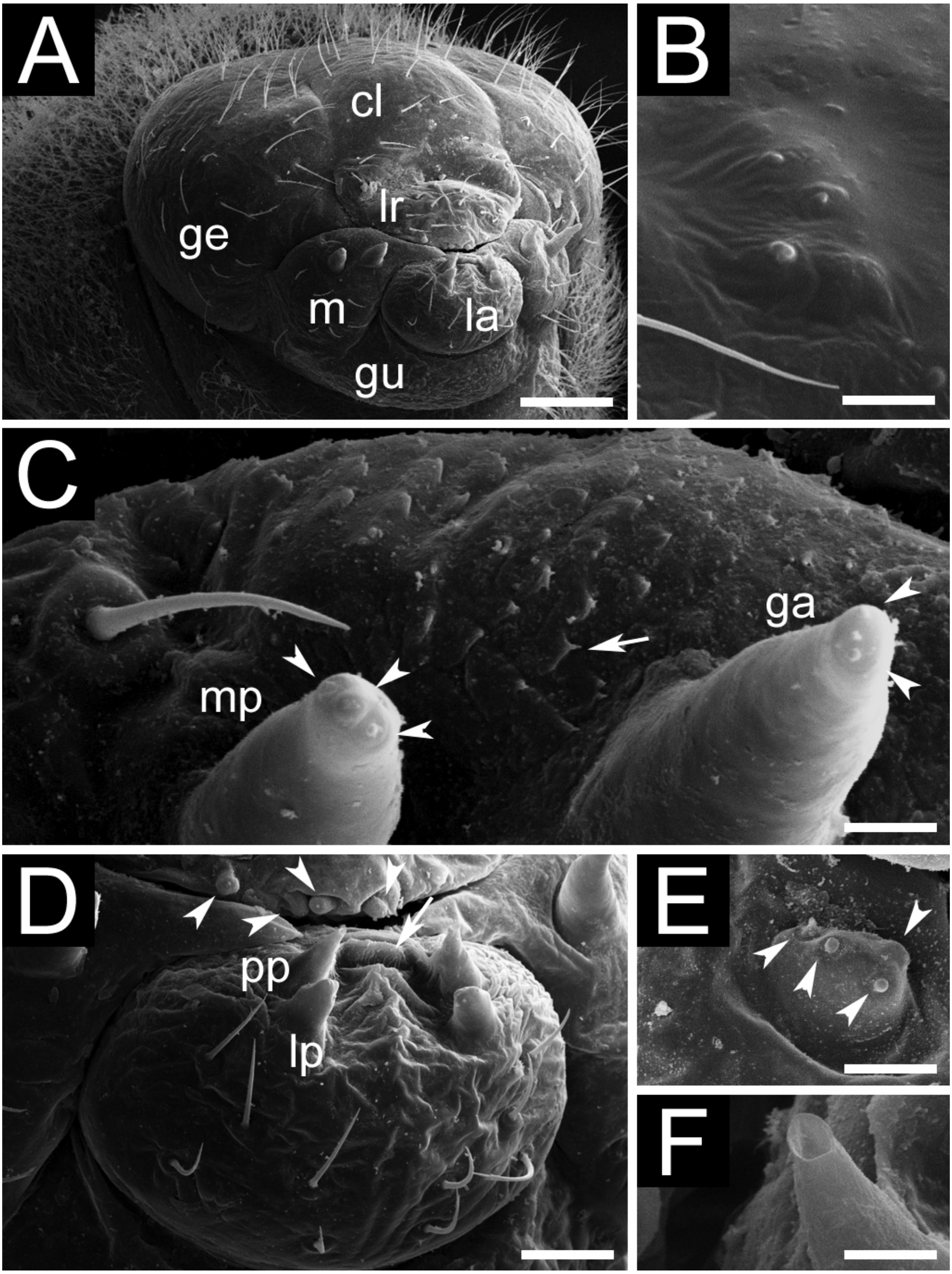

Fig. 6. Head capsule and mouthparts of *Camponotus vittatus* larvae: (A) Head capsule of a third instar and parts: gena (ge), clypeus (cl), labrum (lr), maxilla (m), labium (la), gula (gu); (B) antenna of a third instar; (C) Magnification on the maxilla of figure A: galea (ga), maxillary palp (mp), spinules (arrow) and sensilla (arrowheads); (D) labium of a third instar: labial palp (lp), labial pseudopalp (pp), sericteries (arrow), and sensilla (arrowheads); (E) labial palp of a first instar and sensilla (arrowheads); (F) on the tip of a labial palp, showing aperture. Sizes of scale bars: (A) 0.100 mm; (B) 0.009 mm; (C) 0.010 mm; (D) 0.030 mm; (E) 0.009 mm; (F) 0.005 mm.

branched (E1: 0.055-0.083 mm, *n* = 2; E4: 0.050 mm, *n* = 1). Mouthparts: Labrum (l = 0.150-0.167 mm, *n* = 2); mandibles (l = 0.112 ± 0.006 mm, 0.100-0.120 mm, *n* = 10); maxilla (l = 0.118-0.152 mm; *n* = 2), maxillary palps (h = 0.021 ± 0.002 mm, 0.018-0.025 mm, *n* = 10; in some specimens shaped like a 'skewed peg'), galea (h = 0.022 ± 0.003 mm, 0.018-0.025 mm, *n* = 10); labium (l = 0.094-0.109 mm, *n* = 2), labial palps (h = 0.008-0.010 mm, *n* = 10). Hairs of each mouthpart (types and length given in parentheses): labrum (S1: 0.034 ± 0.008 mm, 0.021-0.048 mm, *n* = 20); maxilla (S1: 0.043 ± 0.009 mm, 0.030-0.061 mm, *n* = 20; B2: 0.027-0.059 mm, *n* = 3); labium (S1: 0.033 ± 0.009 mm, 0.019-0.052 mm, *n* = 20), labial palps shaped as skewed pegs.

Second Instar. Body (l = 2.34 ± 0.31 mm, 1.65-2.95 mm; w = 0.76 ± 0.13 mm, 0.55-1.20 mm; *n* = 25) (bs = 2.88 ± 0.43 mm, 2.42-3.93 mm, *n* = 10): Covered with 2,000-4,000 hairs, of the following types (subtypes and lengths given in parentheses): simple (S1: 0.026-0.048 mm, *n* = 6; S3: 0.055-0.120 mm, *n* = 50); bifid (B2: 0.030 mm, n = 1; B3: 0.040-0.085 mm, *n* = 50); 3-branched (R2: 0.035-0.090 mm, *n* = 40; R3: 0.055-0.065 mm, n = 3; R4: 0.049 ± 0.012 mm, 0.035-0.075 mm, *n* = 20); 4-branched (E1: 0.050-0.065 mm, *n* = 5; E3: 0.050 mm, *n* = 1; E4: 0.060-0.065 mm, *n* = 2). The first and third pairs of spiracles slightly larger (d = 0.015 mm, *n* = 20) than the remaining ones, which were all of same size (d = 0.013 mm, *n* = 80). Head Capsule (w = 0.51 mm, *n* = 25): Head hairs distributed as follows: 26-30 hairs over each gena, 12-15 hairs over the clypeus, 4-5 hairs on the frons, 2-3 over the vertex and 0-2 along the occipital border. Head hairs of the following types (subtype and length given in parentheses): simple (S1: 0.072 ± 0.014 mm, 0.050-0.100 mm, *n* = 20; S3: 0.060-0.075 mm, *n* = 3); bifid (B2: 0.060-0.073 mm, *n* = 2; B3: 0.077 ± 0.013 mm, 0.038-0.103 mm, *n* = 40); 3-branched (R1: 0.040-0.089 mm, *n* = 9; R2: 0.077 ± 0.015 mm, 0.053-0.098 mm, *n* = 11); 4-branched (E1: 0.080 mm, *n* = 1; E4: 0.058-0.074 mm, *n* = 2). Mouthparts: Labrum (l = 0.172-0.195 mm, *n* = 3); mandibles (l = 0.145 ± 0.012 mm, 0.125-0.155 mm, *n* = 10); maxilla (l = 0.161-0.185 mm, *n* = 3), maxillary palps (h = 0.033 ± 0.004 mm, 0.028-0.038 mm, *n* = 10), galea (h = 0.040 ± 0.003 mm, 0.035-0.045 mm, *n* = 10); labium (l = 0.126-0.138 mm, *n* = 3), labial palps (h = 0.010-0.015 mm, *n* = 10). Hairs of each mouthpart (types and length given in parentheses): labrum (S1: 0.043 ± 0.012 mm, 0.017-0.062 mm, *n* = 20); maxilla (S1: 0.051 ± 0.012 mm, 0.032-0.078 mm, *n* = 20); S2: 0.033 mm, *n* = 2; B1: 0.037 mm, *n* = 1; B2: 0.035-0.053 mm, *n* = 3; B3: 0.029-0.047 mm, *n* = 4); labium (S1: 0.038 ± 0.009 mm, 0.024-0.057 mm, *n* = 20), labial palps shaped as skewed pegs.

Third Instar. Body (l = 5.19 ± 1.13 mm, 3.20-7.81 mm; w = 1.56 ± 0.33 mm, 1.05-2.48 mm; *n* = 33) (bs = 6.29 ± 1.30 mm, 3.99-7.90 mm, *n* = 10): Covered with 4,000-7,000 hairs, of the following types: simple (S1: 0.064 ± 0.017 mm, 0.040-0.112 mm, *n* = 20; S2: 0.062-0.141 mm, *n* = 7; S4: 0.122 ± 0.013 mm, 0.095-0.150 mm, *n* = 50); bifid (B1: 0.046 mm, *n* = 1; B2: 0.084 mm, *n* = 1; B3: 0.063 ± 0.016 mm, 0.038-0.115 mm, *n* = 50); 3-branched (R1: 0.069-0.078 mm, *n* = 3; R2: 0.055 ± 0.012 mm, 0.035-0.080 mm, *n* = 50; R3: 0.071-0.089 mm, *n* = 3; R4: 0.060 ± 0.008 mm, 0.046-0.072 mm, *n* = 10); 4-branched (E1: 0.057 ± 0.009 mm, 0.045-0.080 mm, *n* = 17; E2: 0.063-0.083 mm, *n* = 3; E3: 0.084 mm, *n* = 1; E5: 0.086 mm, *n* = 1); 5-branched (P1: 0.048 mm, *n* = 1; P2: 0.055 mm, *n* = 1; P3: 0.060 mm, *n* = 1); 6-branched (H1: 0.058 mm, *n* = 1). First pair of spiracles greater (d = 0.025 mm, *n* = 10) than the equally-sized others (d = 0.018-0.020 mm, *n* = 90). Head capsule (w = 0.66 mm, *n* = 33): Head hairs distributed as follows: 27-39 hairs over each gena, 17-18 hairs over the clypeus, 4 hairs over the frons, 4 hairs over the vertex and 5-7 hairs along the occipital border. Head hairs of the following types (subtype and length given in parentheses): simple (S1: 0.054 ± 0.028 mm, 0.020-0.127 mm, *n* = 20; S2: 0.075 ± 0.010 mm, 0.048-0.090 mm, *n* = 17); bifid (B2: 0.063-0.092 mm, *n* = 3; B3: 0.084 ± 0.017 mm, 0.045-0.120 mm, *n* = 43); 3-branched (R1: 0.086 ± 0.010 mm, 0.070-0.104 mm, *n* = 11; R2: 0.073-0.095 mm, *n* = 2; R3: 0.065 mm, *n* = 1; R5: 0.080 mm, *n* = 1); 4-branched (E1: 0.075 mm, *n* = 1). Mouthparts: Labrum (l = 0.212-0.283 mm, *n* = 4), having conspicuous 'chiloscleres', defined by Wheeler & Wheeler (1953) as ". . . the pair of conspicuous dark brown spots, one at either side of the labrum. Each chilosclere consists of a bar along the lateral margin of the labrum; these bars are apparently formed from enormously thickened and hardened portions of the cuticula"; mandibles (l = 0.221 ± 0.013 mm, 0.200-0.240 mm, *n* = 10); maxilla (l = 0.203-0.264 mm, *n* = 3; dorsally spinulose - Fig. 6C), maxillary palps (h = 0.055 ± 0.004 mm, 0.050-0.060 mm, *n* = 10), galea (h = 0.050-0.060 mm, *n* = 10); labium (l = 0.180-0.206 mm, *n* = 4), labial palps (h = 0.023-0.030 mm, *n* = 10). Larvae of this instar had pronounced labial pseudopalps (h = 0.020 ± 0.003 mm, 0.015-0.023 mm, *n* = 10), with a conspicuous apical opening (Fig. 6F). Hairs of each mouthpart (types and length given in parentheses): labrum (S1: 0.046 ± 0.011 mm, 0.024-0.062 mm, *n* = 20); maxilla (S1/S2: 0.055 ± 0.008 mm, 0.042-0.073 mm, *n* = 20; hair subtypes indistinguishable when seen under the compound microscope); labium (S1/S2: 0.049 ± 0.004 mm, 0.045-0.055 mm, *n* = 20), labial palps paxilliform.

Pupa. During early development, pupae are whitish, with eyes and body getting darker during metamorphosis. Pupae exarate (body: l = 6.64 ± 0.56 mm, 5.71-7.81 mm; head: w = 0.96-2.39 mm; *n* = 30) and enclosed in silky cocoons; dark meconium ejected inside the cocoon. Only white pupae were measured.

Discussion

Determination of Number of Instars

The number of instars was determined for 6 species of *Camponotus*: *Camponotus noveboracensis* Fitch with 3 instars; *Camponotus rufipes* Fabricius and *Camponotus textor* Forel with 4 instars; *Camponotus abdita* Forel, *C. aethiops*, and *Camponotus vagus* Scopoli with 5 instars (Wheeler & Wheeler 1953; Benois 1972; Dartigues & Passera 1979; Bueno & Rossini 1986; Wheeler & Wheeler 1991; Solis et al. 2009b). The number of instars herein recorded for *C. vittatus* was the same of *C. noveboracensis*, but differed from the number of instars of other *Camponotus* species, illustrating how distinct species in the same genus may have different numbers of instars.

Morphological Description of the Immatures

Some traits typical of *Camponotus* larvae (see Wheeler & Wheeler 1953, 1976) were confirmed with this species: general mandible and body shape, presence of chiloscleres, praesaepium (some specimens), pseudopalps, and ten pairs of spiracles. Unique traits would include: mandibular medial teeth, and the greatest recorded diversity of hair types. Moreover, the number of antennal sensilla proved variable.

The mandibles of *C. vittatus* fitted the pattern in the genus—'camponotoid'—however it presented medial 6 denticles, thus being different from mandibles of other described *Camponotus*, with the exception of *C. novaeboracensis* (Wheeler & Wheeler 1953) and *C. textor* (Solis et al. 2009b), which also had medial teeth, although in different numbers.

The antenna of 1 second-instar specimen had 4 sensilla, illustrating variation in the number of antennal sensilla in *Camponotus* larvae. Intraspecific variation in the number of antennal sensilla was observed by Wheeler & Wheeler (1976), thus the phenomenon is fairly widespread. This serves to illustrate the importance of analyzing a large sample while searching for variations.

The larvae of *C. vittatus* had 6 different types of hairs, depending on the body region and instar analyzed, with considerable variation in the number of hairs and hairs types present between different specimens of same instar. Only hair type S1 was found widespread on larvae of all instars. All types of hairs described with larvae of the tribe Camponotini were found on the larvae of *C. vittatus*, which could have up to 6 ramifications. Such elevated diversity of hair types is surprising, contrasting with the statement in Wheeler & Wheeler (1953) that "... no species has all (herein described hair) types."—being only comparable with recent observations with *C. textor* (see Solis et al. 2009b

TABLE 2: CHARACTERS OF *CAMPONOTUS* LARVAE OF THE SUBGENUS *TANAEMYRMEX*.

Species	References	Number of ramifications of body hairs	Number of ramifications of head hairs	Number of hairs on anterior face of labrum	Number of sensilla on anterior face of labrum	Number of sensilla on ventral face of labrum
Camponotus humilior	Wheeler and Wheeler (1968)	Up to 4	Up to 3	5	12	?
Camponotus nigriceps	Wheeler and Wheeler (1974)	Up to 2	?	8	10	6
Camponotus postcornutus	Wheeler and Wheeler (1974)	Up to 2	Up to 2	12	10	8
Camponotus sansabeanus	Wheeler and Wheeler (1953)	Up to 4	?	11	6	6
Camponotus santosi	Wheeler and Wheeler (1968)	Up to 5	Up to 4	8	14	?
Camponotus simillimus	Wheeler and Wheeler (1953)	Up to 4	Up to 2	9	4	6
Camponotus vicinus	Wheeler and Wheeler (1968)	Up to 4	Up to 4	10	14	?
Camponotus vittatus	Present study	Up to 6	Up to 4	8-11	6	6

(?) not given in original description.

and commentaries therein). This find illustrates that the actual maximum number of different hair types that can be found on ant larvae of the same Camponotini species is much higher than credited and the matter still awaits further consideration.

Types of hairs varied among larvae of different instars, including variation in the apical hooks of some hairs of second and third instars. The great diversity of body hairs and variations among instars strongly suggest that hairs play an important role in the biology of these organisms. Some suggestions on the functionality of body hairs have been proposed (Wheeler & Wheeler 1976), but the matter still awaits detailed biological observations.

From comparing the larvae of *C. vittatus* with other described larvae within the subgenus *Tanaemyrmex* (Table 2), it can be seen that *C. vittatus* can be identified based on the number of sensilla on the anterior face of the labrum. Morphometrical differences between the instars are also reported, which can be used as alternatives to the width of head capsules in sorting between different instars: mandible length and diameter of first thoracic spiracle; hair types and abundance proved useful in instar separation. The information provided is thus useful to general ant systematics and taxonomy, and we hope it will help clarify biological aspects and social organization of these ant other ant species in future behavioral studies.

Acknowledgments

We thank Elliot Watanabe Kitajima and Francisco André Ossamu Tanaka (NAP/MEPA ESALQ-USP) for granting access to the microscopy facilities, and Jacques Hubert Charles Delabie (CEPLAC) for kindly identifying the ants. We thank the 2 anonymous reviewers. First author was supported by a grant from CAPES Institution.

References Cited

Almeida, L. O. 2006. Efeitos do ácido bórico no perfil de expressão protéica em *Camponotus vittatus* (Hymenoptera: Formicidae). Uberlândia: Universidade Federal de Uberlândia.

Benois, A. 1972. Évolution du couvain et cycle annuel de *Camponotus vagus* Scop (= pubescens Fabr.) (Hymenoptera, Formicidae) dans la région d'Antibes. Ann. Zool. Ecol. Anim. 4: 325-351.

Bolton, B., Alpert, G., Ward, P. S., and Naskrecki, P. 2006. Bolton Catalogue of Ants of the World: 1758-2005. Cambridge: Harvard University Press.

Bueno, O. C., and Rossini, S. A. 1986. Número de instares larvais em *Camponotus rufipes* (Fabricius, 1775) (Hymenoptera, Formicidae). Cienc. Cult. 38: 1009-1010.

Cassill, D. L., Butler, J., Vinson, S. B., and Wheeler, D. 2005. Cooperation in prey digestion between workers and larvae in the ant, *Pheidole spadonia*. Insect. Soc. 52: 339-343.

Dartigues, D., and Passera, L. 1979. Polymorphisme larvaire et chronologie de I'apparition des castes femelles chez *Camponotus aethiops* Latreille (Hymenoptera, Formicidae). Bull. Soc. Zool. France 104: 197-207.

Delabie, J. H. C., Jahyny, B., Nascimento, I. C., Mariano, C. S. F., Lacau, S., Campiolo, S., Philpott, S. M., and Leponce, M. 2007. Contribution of cocoa plantations to the conservation of native ants (Insecta: Hymenoptera: Formicidae) with a special emphasis on the Atlantic Forest fauna of southern Bahia, Brazil. Biodivers. Conserv. 16: 2359-2384.

Forel, A. 1904. Miscellanea myrmécologiques. Rev. Suisse Zool. 12: 1-52.

Hölldobler, B., and Wilson, E. O. 1990. The Ants. Cambridge: Harvard University Press.

Masuko, K. 2008. Larval stenocephaly related to specialized feeding in the ant genera *Amblyopone*, *Leptanilla* and *Myrmecina* (Hymenoptera: Formicidae). Arthropod Struct. Dev. 37: 109-117.

Parra, J. R. P., and Haddad, M. L. 1989. Determinação do número de instares de insetos. Piracicaba: FEALQ.

Pitts, J. P., McHugh, J. V., and Ross, K. G. 2005. Cladistic Analysis of the fire ants of the *Solenopsis saevissima* species-group (Hymenoptera: Formicidae). Zool. Scripta 34: 493-505.

Rodovalho, C. M. 2006. Detecção de genes diferencialmente expressos na formiga urbana *Camponotus vittatus* (Hymenoptera, Formicinae). Uberlândia: Universidade Federal de Uberlândia.

Schultz, T. R., and Meier, R. 1995. A phylogenetic analysis of the fungus-growing ants (Hymenoptera: Formicidae: Attini) based on morphological characters of the larvae. Syst. Entomol. 20: 337-370.

Silva, T. F., Solis, D. R., Moretti, T. C., Silva, A. C., and Habib, M. E. M. 2009. House-infesting ants (Hymenoptera: Formicidae) in a municipality of Southeastern Brazil. Sociobiology 54: 153-159.

Soares, N. S., Almeida, L. O., Gonçalves, C. A., Marcolino, M. T., and Bonetti, A. M. 2006. Levantamento da diversidade de formigas (Hymenoptera: Formicidae) na região urbana de Uberlândia, MG. Neotrop. Entomol. 35: 324-328.

Solis, D. R., Bueno, O. C., and Moretti, T. C. 2009a. Preferência alimentar da formiga urbana *Camponotus vittatus* Forel (Hymenoptera: Formicidae). Arq. Inst. Biol. 76: 745-749.

Solis, D. R., Fox, E. G. P., Rossi, M. L., and Bueno, O. C. 2009b. Description of the immatures of workers of the weaver ant, *Camponotus textor* (Hymenoptera: Formicidae). Sociobiology 54: 541-559.

Wheeler, G. C., and Wheeler, J. 1953. The ant larvae of the subfamily Formicinae—Parts I and II. Ann. Entomol. Soc. America 46: 175-217.

Wheeler, G. C., and Wheeler, J. 1968. The ant larvae of the subfamily Formicinae (Hymenoptera; Formicidae): supplement. Ann. Entomol. Soc. America 61: 205-222.

Wheeler, G. C., and Wheeler, J. 1970. Ant larvae of the subfamily Formicinae: second supplement. Ann. Entomol. Soc. America 63: 648-656.

Wheeler, G. C., and Wheeler, J. 1974. Ant larvae of the subfamily Formicinae: third supplement. J. Georgia Entomol. Soc. 9: 59-64.

Wheeler, G. C., and Wheeler, J. 1976. Ant larvae: Review and Synthesis. Mem. Entomol. Soc. Washington 7: 1-108.

Wheeler, G. C., and Wheeler, J. 1988. The larva of *Leptanilla japonica*, with notes on the genus (Hymenoptera: Formicidae: Leptanillinae). Psyche 95: 185-189.

Wheeler, G. C., and Wheeler, J. 1991. Instars of three ant species. Psyche 98: 89-99.