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External morphology of the adult of *Stalachtis phlegia susanna* (Fabricius, 1787) (Lepidoptera: Riodinidae)

W. I. G. Santos, L. A. R. Leite, L. Queiroz-Santos &
M. M. Casagrande

Abstract

The complete external morphology of the adults of *Stalachtis phlegia susanna* (Fabricius, 1787) is here studied based on optical and scanning electron microscopy. This species shows great abundance in the Atlantic Forest region of the state of Sergipe, Brazil. This is the first study of this kind concerning to Riodinidae in the Neotropics.

KEY WORDS: Lepidoptera, Riodinidae, abdomen, head, thorax, Atlantic Forest, Neotropics.

Morfología externa del adulto de *Stalachtis phlegia susanna* (Fabricius, 1787) (Lepidoptera: Riodinidae)

Resumen

Se estudia aquí la completa morfología externa completa del adulto de *Stalachtis phlegia susanna* (Fabricius, 1787) con base en microscopía óptica y electrónica de barrido. Esta especie es muy abundante en la región del Bosque Atlántico del Estado de Sergipe, Brasil. Se trata del primer estudio de este tipo en Riodinidae neotropicales.

PALABRAS CLAVE: Lepidoptera, Riodinidae, abdomen, cabeza, tórax, Mata Atlántica, Región Neotropical.

Morfologia externa do adulto de *Stalachtis phlegia susanna* (Fabricius, 1787) (Lepidoptera: Riodinidae)

Resumo

A morfologia externa completa do adulto de *Stalachtis phlegia susanna* (Fabricius, 1787) é aqui tratada com base em morfologia ótica e microscopia eletrônica de varredura. Tal espécie é muito abundante na região de Floresta Atlântica do estado de Sergipe, Brasil. Trata-se do primeiro estudo deste tipo para Riodinidae neotropicais.

PALAVRAS-CHAVE: Lepidoptera, Riodinidae, abdome, cabeça, tórax, Floresta Atlântica, Região Neotropical.

Introduction

The order Lepidoptera includes butterflies and moths, comprising holometabolic individuals with membranous wings and body covered with scales. About 160 thousand species have been

described, but it is believed that there are about 500 thousand species throughout the world, which will possibly increase from faunal survey of fauna and other taxonomic studies (GASTON, 1991; KRISTENSEN *et al.*, 2007; DUARTE *et al.*, 2012).

Butterflies are diurnal individuals, being important environmental indicators because they have close relationships with their food resources, a high rate of reproduction, and can play important ecological roles through their herbivory and pollination relationships (FREITAS & MARINI-FILHO, 2011). According to the Neotropical butterflies *Checklist* (LAMAS, 2004), they are divided into two large superfamilies: Hesperioidea and Papilionoidea. In Brazil, the number of already record butterfly species reaches 3,288 (BROWN & FREITAS, 1999).

Riodinidae is a cosmopolitan family of butterflies, most widely distributed however, in the Neotropics, with about 1,300 species. It shows high diversity in the shape and colour of the wings, often having metallic appearance. Males have reduced forelegs with fusion of the tarsomeres, and a well developed uncus (SCOBLE, 1992; DUARTE *et al.*, 2012).

The family is not only notable for numbers of species, but also for phenotypic, morphological and ecological diversity (STICHEL, 1910-1911; CALLAGHAN, 1983; DEVRIES, 1990, 1991, 1997; D'ABRERA, 1994; HALL, 1999; HALL & HARVEY, 2002). *Stalactis phlegia susanna* (Fabricius, 1787) (Figs 1-4) is a medium sized species common in the region, being easily found in Atlantic Forest areas in the state of Sergipe, and tropical and subtropical forests throughout southeastern Brazil. *S. phlegia susanna* is presumably to predators as suggested by its slow flight and bright orange colors (CALLAGHAN, 1986).

Morphological studies on Lepidoptera are of great importance in establishing the systematic relations of various groups (LEITE *et al.*, 2010). Works dealing with the external morphology of head, thorax and abdomen were carried out in several families of butterflies (EHRlich, 1958, 1960; SRIVASTAVA, 1961, 1962, 1965; MILLER, 1971; CASAGRANDE, 1979a,b,c; SORENSEN, 1980; BILOTTA, 1992, 1994a,b; BIZARRO *et al.*, 2003a,b,c; DUARTE *et al.*, 2001; MIELKE *et al.*, 2004a,b,c; DUARTE, 2007; PALUCH *et al.*, 2008; DIAS *et al.*, 2010; LEITE *et al.*, 2010a,b, 2011, 2013), but have not been carried out in Riodinidae, where studies on taxonomy and systematics deal only with venation and / or genitalia of both sexes (CALLAGHAN, 1997; HALL, 1999, 2001, 2003; DOLIBAINA *et al.*, 2012) are recorded.

Material and Methods

Stalactis phlegia susanna specimens of both sexes (n = 13 males and 9 females) were collected in the Atlantic Forest area belonging to the Parque Nacional Serra de Itabaiana - PARNASI (10° 40'S, 37° 25'W), located approximately 45 km from the capital Aracaju. The park is a significant remnant of the Atlantic Forest in the State of Sergipe, Brazil. The sampling was carried out actively with insect net, and individuals were sacrificed by thorax pressure. Some individuals were sacrificed with a killing bottle containing ethyl acetate, to preserve the thoracic structures.

For studies of venation, wings were removed from dry specimens and then cleared in Petri dishes, being first immersed in 70% ethanol (EtOH) and later in sodium hypochlorite (NaOCl) to complete the clearing process, afterwards were again submerged in 70% alcohol for neutralization and subsequently placed on absorbent paper to dry. For the structures of head, thorax, and abdomen, they were boiled in 10% potassium hydroxide (KOH) to soften the structures and facilitate the removal of scales.

The morphological drawings were made with a stereoscopic microscope coupled to a camera lucida. Further details of some structures were obtained using photographs from a scanning electron microscope (SEM) following standard procedures (Leite *et al.*, 2010a).

The terminology applied follows mostly the latest works in the area (DIAS *et al.*, 2010; LEITE *et al.*, 2010a, b, 2011, 2013), though classical works were also consulted to better understand the morphological structures (SNODGRASS, 1935; MATSUDA, 1965; 1970; 1976).

Results

HEAD (Figs 5-9, 38-41)

Hypognathous and sclerotized head, with compound eyes formed by numerous ommatidia, occupying the largest area, without ocelli and covered with numerous scales on its surface.

Frontal view (Fig. 5), post-antennal projections with many bristles and prominent chaetosema (Figs 38, 39), the projections form a semicircular vertex perpendicular to the transfrontal suture, limited laterally by the antennal alveolus which provide prominence to the suture. The fronto-clypeus is a prominent subrectangular plate bounded by the laterofacial suture, narrowing towards to the clypeogenal section of the laterofacial suture. Anterior tentorial pit (Figs 40, 41) located closely between the fronto-clypeus and subgena; compound eye globular limited by the ocular margin.

In dorsal view (Fig. 6) the compound eyes are limited anteriorly by the fronto-clypeus and posteriorly by the postgenal-occipital area which covers a significant part of the posterior portion. Post-antennal projections with triangular aspect on the anterior half and rounded on the posterior half.

The vertex in the posterior view (Fig. 7) is located anterior-medially on the head apex between the post-antennal projections and has under this, a trapezoidal shaped sclerite delimited laterally by the temporal suture and inferiorly by the upper margin of the foramen magnum. The subgenal region occupies the largest part of the posterior view, laterally limited by the compound eyes and dorso-medially by the temporal suture.

In ventral view (Fig. 8) the postgenal-occipital area lateroinferiorly located, limited superiorly by the compound eye and separated from the subgena by the hypostomal subgenal suture and the extension of the paraocular area respectively. Labium in the inferior medium portion as a subpentagonal structure.

In lateral view, the compound eye, wider than high, occupies the largest area of the head (Fig. 9) and is surrounded by the ocular margin. Postgenal-occipital area visible and representing one fourth of the head in lateral view.

CEPHALIC APPENDAGES (Figs 9-11, 34-37)

Mouthparts (Figs 9, 10): Galea three times larger than the width of the compound eye with no significant differences between the sexes. Tri-segmented labial palp. Basal segment slightly curved in the insertion region with the alveolus, median segment cylindrical and larger than the others, distal segment the shortest and narrow dorsoventrally with the presence of Vom Rath's organ distally.

Antennae (Fig. 11A-B, 34-37): Clavate without carina, both sexes with 36-37 flagellomeres, 4.5 times longer than the width of the compound eye. No dimorphism. Dorsoventrally flattened pedicel with 1/3 of the scape size, presenting sensitive bristles (Figs 36, 37); scape rounded and robust. Short and rectangular flagellomeres increasing gradually from the 9th, acquiring a cylindrical shape until the 21st, then flat and tapered near the apex, thus providing the appearance of club.

THORAX (Figs 12-22, 42-46)

Cervical Region (Fig. 13): The most membranous region of the thorax. Cervical sclerite laterally in the middle of the pleural membrane, cervical organ at the posteroventral edge of anterior arm. Anteriorly articulated with the back of the head while posteriorly connected to the propleuron anteriorly to the prothorax.

Prothorax (Figs 12, 14, 15): The smallest thorax division, with a pair of prothoracic legs and the most membranous area among the three segments. Laterally (Fig 12), the first spiracle, located posteroventrally to the patagia and dorsally to the episternum I; this one covers 1/3 of the prothorax region and articulates with the coxa I.

In dorsal view (Fig. 14) pronotum subtriangular, anterior margin flat and laterally connected to the patagia, posterior half narrow towards the anterior margin of the prescutum II.

In ventral view (Fig. 15) the episternum I occupies the largest area of the prothorax, limited anteriorly by the presternum, laterodistally by the patagia and posteromedially by the furca I. Alveolus coxal with cordiform shape.

Mesothorax (Figs 12, 14, 15): In lateral view (Fig 12) tegula (Figs 12, 20A-B) in the anteroventral portion of the scutum II, this one large and occupying half of the mesothorax area, limited posteriorly by scuto-scutellar suture II that separates the scutum II from the scutellum II, this last with an obtuse shape. Mesopleura surrounded posteriorly by the epimeron II and anteriorly by the capisternum II, this one subrectangular in shaped. Second spiracle posterior to the epimeron II.

In dorsal view (Fig. 14) anteriorly articulates with the prothorax through the prescutum II. Scutum II ovoid with smooth lateral invaginations, divided median-longitudinally by the mesoescutal line and posteriorly limited by the scutellum II, this one with losangular form.

Ventrally (Fig. 15), basisternum II anteriorly articulates with the preepisternum II and fuses lateroposteriorly with the epimeron II which surrounds the anterior half of the coxa II externally. Discrimen II median-longitudinally located separating the basisternum II.

Metathorax (Figs. 12, 14, 15): Laterally (Fig. 12) the scutum III occupies half of the segment. Basalare III and basalare III "pad" (Fig. 42) anterior-dorsally to the catepisternum III, this one subrectangular in shape. Meron III situated posteriorly to the catepisternum III with obtuse shape towards the eucoxa III.

In dorsal view (Fig. 14) the scutum III occupies most part of the segment as a pair of lateral plates, and is limited anteriorly by the scutellum II, medially by the postnotum II and posteriorly by the scutellum III.

In ventral view (Fig. 15) the catepisternum III anteriorly located, subrectangular, medially divided by the discrimen III, anteriorly concave and posteriorly surrounding the eucoxa III. The epimeron III internally surrounds the coxa III divided in meron III and eucoxa III separated by the coxal suture III.

THORACIC APPENDAGES (Figs 16-22, 43-46)

Legs (Figs. 16-19, 44-46): Riordinidae males (Figs. 1-2) have reduced prothoracic legs (Fig. 16), located in the anteroventral region of the prothorax. Coxa I, subrectangular, narrowing towards to the ventral extremity and larger than all the others structures; trochanter I has a flattened shape and articulates with femur I, this with cylindrical aspect and smooth dorsoventral curvature; tibia I, larger than the femur I, articulates with the tarsus, this as long as the tibia.

The females (Figs 3-4): have also reduced prothoracic leg (Fig. 17), presenting all the tarsomeres however. Robust coxa I that articulates with trochanter I in an obtuse form. Femur I, the largest among the other segments; tibia I provided with spurs (Fig. 44) located subapically and turned to the inner side. Tarsus formed by five tarsomeres, the proximal being the longest, the second to fourth smaller and quadrangular, the fifth slightly longer than the previous, all provided with spines on the ventral surface and bristles dorso-distally.

The mesothoracic leg (Fig. 18), similar in both sexes, is double the size of the prothoracic leg; rounded coxa II followed by trochanter II; cylindrical and subrectangular. Femur II articulates with tibia II, both elongated, tibia II covered with spines on the ventral surface and a pair of distal spurs; tarsus divided into five tarsomeres, the first being longer than the rest with distal and ventral spines, the second with 1/3 of the size of the first, third and fourth tarsomeres quadrangular and smaller than the second, developed arolium, pulvillus with bristles and a pair of claws distally. Similar to mesothoracic leg, the metathoracic leg (Fig. 19) differs by the femur, which in this case has equal length of tibia, this one without spines on the proximal third.

Wings (Figs. 21-22): Forewing (Figs. 21A, 22A) with subtriangular format for both sexes, with slight convexity in the outer margin. In females the subcostal vein (Sc) and the radial R_1 , R_2 and R_3 end in the costal margin, on males R_3 reaches the apex of the wing which has a more pointed shape if

compared with the females, R_{4+5} reaches the outer margin in both sexes. Discal cell elongated in females and slightly flattened on males with approximately half the length of the wing on both sexes, dci and dcm weakly connected with M_2 , dcs absent. M_1 , M_2 and M_3 in females have a slight curvature on the distal half when reaching the outer margin, in males however they are parallel; CuA1 and CuA2 extends horizontally and parallel in females and curved towards to the anal angle in males, the vein 2A presents rectilinear in males and sinuous in females.

Hindwings (Figs. 21B, 22B) with semi-oval shape, inner and outer margins lightly convex and without significant changes for both sexes. Humeral vein (h) with sharp curvature towards to the basal angle, Sc + R_1 reaches the costal margin followed by R_s reaching the apex of the wing. Discal cell smaller if compared with the forewing; M_1 , M_2 and M_3 antagonistically curved to CuA1 and CuA2 towards the outer margin.

ABDOMEN (Figs 23-26)

Formed by ten segments, the last two in males and last three in females being modified in order to originate the genitalia structures; each segment has a dorsal tergum and ventral sternum well sclerotized and connected by a thin pleural membrane, where the spiracles are located. Both sexes have conspicuous changes in the first segment, both in tergum and sternum due to the connection with the metathorax.

Tergum I dorsally to the spiracle I, rounded shaped in males, subrectangular in females, smaller than the other segments for both sexes. Sternum I narrow, tapered and approaches the tergum II anterolaterally.

GENITALIA (Figs. 27-33)

Male genitalia (Figs 27-31): Uncus originated from tergum X, laterally with sub-oval format, located in the anterior region of the integument involving its end and covered by thick bristles. Tegumen formed by tergum IX, well sclerotized and limited posteriorly by the uncus. Gnatho hook shaped and dorsoposteriorly curved with a conspicuous medial curvature and a sharp curvature in the distal portion. Valvae subrectangular, medio-laterally flat and connected medio-posteriorly through internal projections. Aedeagus elongated, cylindrical in the anterior half and narrow distally where the vesicale is located.

Female Genitalia (Figs 32-33): Consists of modifications of the last three segments of the abdomen. Tergum VIII dorsolaterally covers the genital region, IX and X form the papilla analis, sub-oval plates, very sclerotized and covered with bristles on the distal end. In ventral view the sternum VII is quite small and difficult to see; ductus bursae long with membranous aspect, it stretches gradually originating a translucent bag, the corpus bursae, saculiform and presenting two conspicuous "Y" shaped sings.

Discussion

Studies of complete external morphology are still scarce in the family Riodinidae.

Males and females do not exhibit structural differences in the cephalic region. *Satalactis phlegia susanna* (Fabricius, 1787) presents some morphological aspects of the head similar to *Glaucopsyche lygdamus* (Doubleday, 1841) (Lycaenidae: Polyommatainae) in SORENSEN (1980) and *Hemiargus hanno* (Stoll, 1790) (Lycaenidae, Polyommatainae, Polyommataini) in DUARTE (2001).

Compound and globular eyes occupy more than 60% of head area, with a width exceeding the height, as opposed to what occurs in the superfamily Hesperioidea proposed by MILLER (1971), no eye split forming two distinct areas as seen in (EHRlich, 1960; CARNEIRO, 2012). Convex apex in frontal view, this one located between the postantennal projections, divergent from *G. lygdamus* and *H. hanno* presenting a flat vertex and postantennal projections invisible in frontal view.

S. phlegia susanna has a quadrangular fronto-clypeus, as also evidenced in *Morpho helenor violaceus* Fruhstorfer, 1912 (Nymphalidae), *Iphimedeia hercules* (Dalman, 1823) (Nymphalidae), *Iphixibia anaxibia* (Esper, 1801) (Nymphalidae), *Cytheritis portis thamyris* (C. Felder & R. Felder, 1867) (Nymphalidae), *Cytheritis aega* (Hübner, 1822) (Nymphalidae), *Pessonia epistrophus catenaria* (Perry, 1811) (Nymphalidae), *Grasseia menelaus nestira* (Hübner, [1819]) (Nymphalidae) studied by BILOTTA (1992) and *Heraclides anchisiades capys* (Hübner, [1809]) (Papilionidae) LEITE (2010); transfrontal suture separating the frontoclypeal apex region also present in other Papilionoidea like Lycaenidae (SORENSEN, 1980; DUARTE *et al.*, 2001).

Posterior tentorial bridge similar to a horizontal bar that divides the two regions of the foramen magnum, followed by a subsequent tentorial pit; this differs from *H. hanno* where the tentorial bridge is reduced and foveae are located more ventrally.

The antennae have between 36-37 flagellomeres, without the presence of carina and sexual dimorphism strongly evidenced in other Papilionoidea such as Nymphalidae (BILOTTA, 1992) and Papilionidae (LEITE, 2010).

The labial palp of *S. phlegia susanna* has a similar morphology to *Dachetola caligata* (Stichel, 1911) (Riodinidae) (HALL, 2001) in which the median segment is more robust and twice larger than the others.

S. phlegia susanna has a narrower cervical sclerite when compared to *H. hanno*. Both males and females of *S. phlegia susanna*, have not significant differences in their thoracic structures and appendages, except the prothoracic leg that is reduced in males.

In dorsal view, the species presents a trapezoidal shaped pronotum, different from Lycaenidae as studied by SORENSEN (1980) and DUARTE (2007) where that same sclerite has a subtriangular format.

In lateral view of the metathorax it is possible to see the basilar III "pad" heavily covered with bristles, and located anterodorsally to the catepisternum III. The same was illustrated by DUARTE (2007) for *H. hanno* and *Dynamine postverta* (Cramer, 1779) (Nymphalidae) suggested by LEITE (2013).

The coxal ventral extension in the prothoracic legs of males, is similar to the genus *Panara* Doubleday, 1847 (Riodinidae) reviewed by CALLAGHAN (1997), *Dachetola* Hall, 2001 (Riodinidae) in HALL (2001), *Pseudotinea* Hall & Callaghan, 2003 (Riodinidae) studied by HALL *et al.* (2003).

Vein 3A is absent in the forewing of this species, it has been noted in some genera of Riodinidae (CALLAGHAN, 1997; HALL, 2001; HALL & CALLAGHAN, 2003) and in others groups of Papilionoidea (ERHLICH, 1958a; CASAGRANDE, 1979C; BILOTTA, 1994a; C. MIELKE *et al.*, 2004b).

Tergum II presents projections on the anteroventral region, but there is no evidence of the presence of a prespiracular and postspiracular bar, diverging from the others Papilionoidea groups mentioned above.

Lateral membranous area between uncus and tegumen, a common feature in Riodinidae (CALLAGHAN, 1997; HALL, 1999; 2001; 2003; 2005; HALL & HARVEY, 2002; HALL & CALLAGHAN, 2003; PENZ & DEVRIES, 2006), is absent in *S. p. susanna*.

HALL (2003) showed the presence of pointed or rounded "teeth" at the end of the aedeagus in some specimens of the genus *Pseudotinea*, this characteristic is also observed in *S. phlegia susanna* which features five pointed "teeth" in the ventral region of the aedeagus, posterior to the vesica.

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W. I. G. S., L. Q-S., M. M. C.
 Departamento de Zoologia
 Setor de Ciências Biológicas
 Universidade Federal do Paraná
 Caixa Postal 19020
 81531-980 Curitiba, Paraná
 BRASIL / BRAZIL
 E-mail: wildio.ikaro@gmail.com
 E-mail: luzianyqueiroz@gmail.com
 E-mail: mibras@ufpr.br

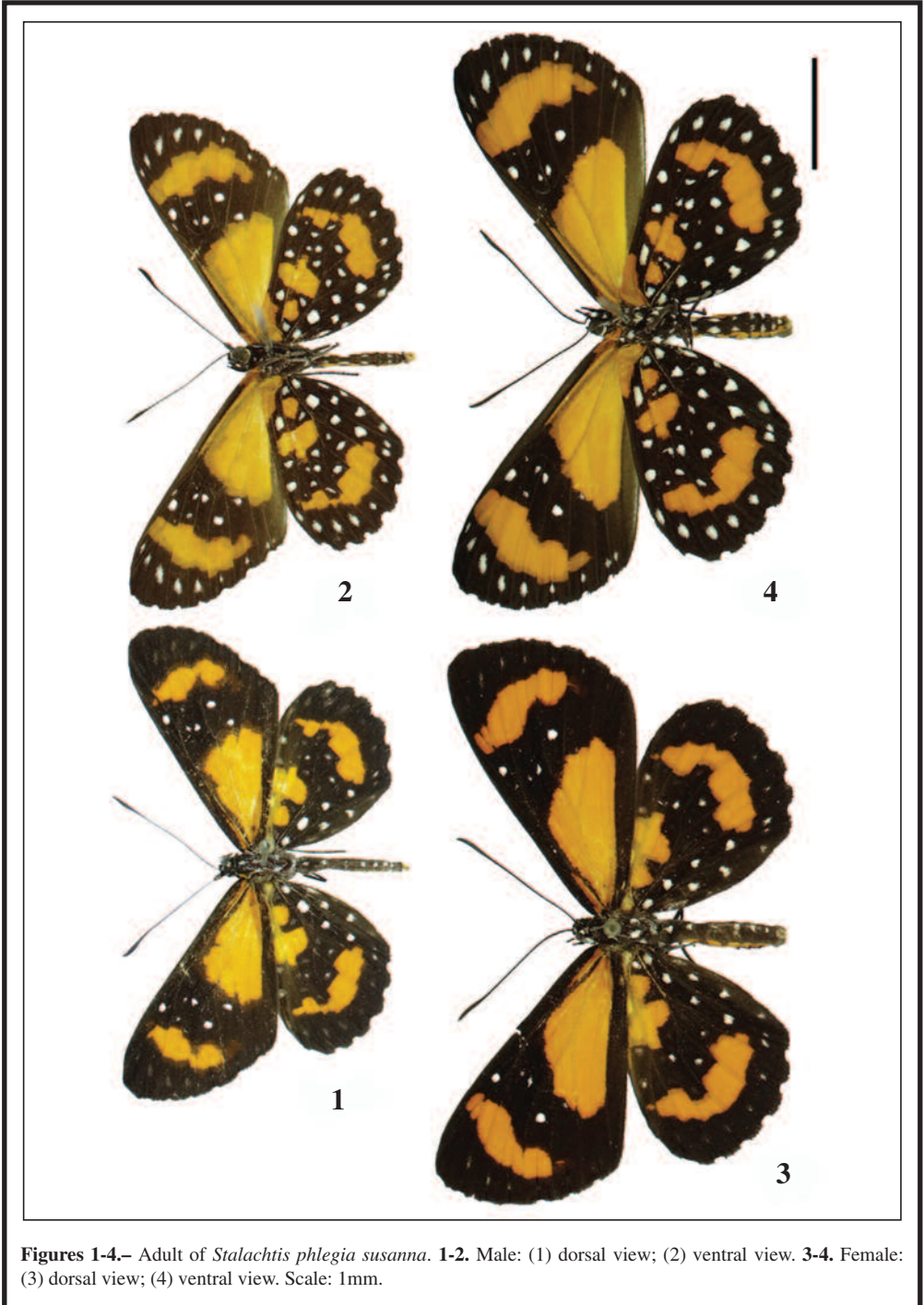
*L. A. R. L.
 Universidade Federal de Sergipe
 Centro de Ciências Biológicas e da Saúde
 Departamento de Biologia
 Laboratório de Entomologia
 Av. Marechal Rondon, s/n, Jardim Rosa Elze
 49100-000 São Cristóvão, Sergipe
 BRASIL / BRAZIL
 E-mail: landersonrleite@gmail.com

*Autor para la correspondencia / *Corresponding author*

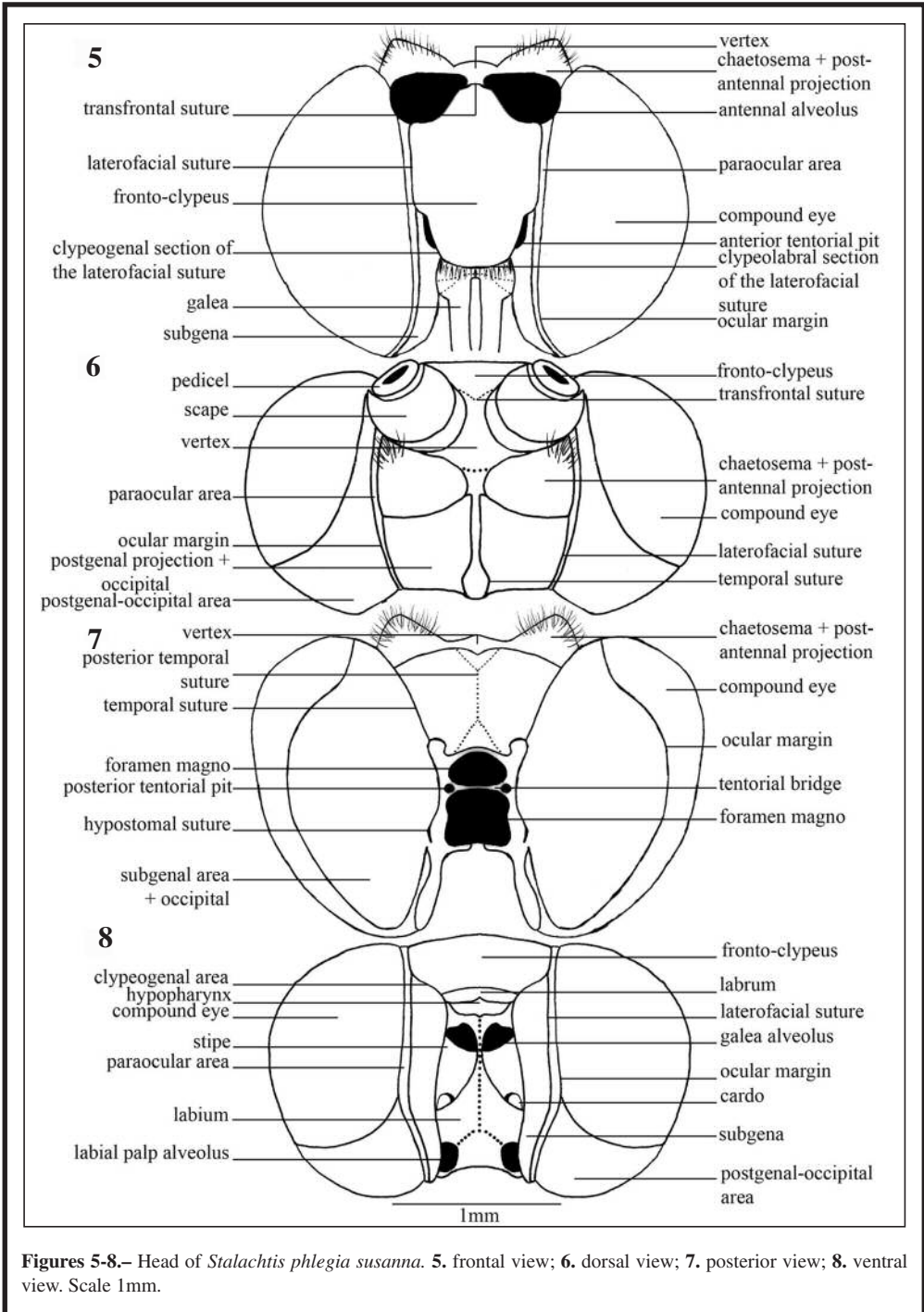
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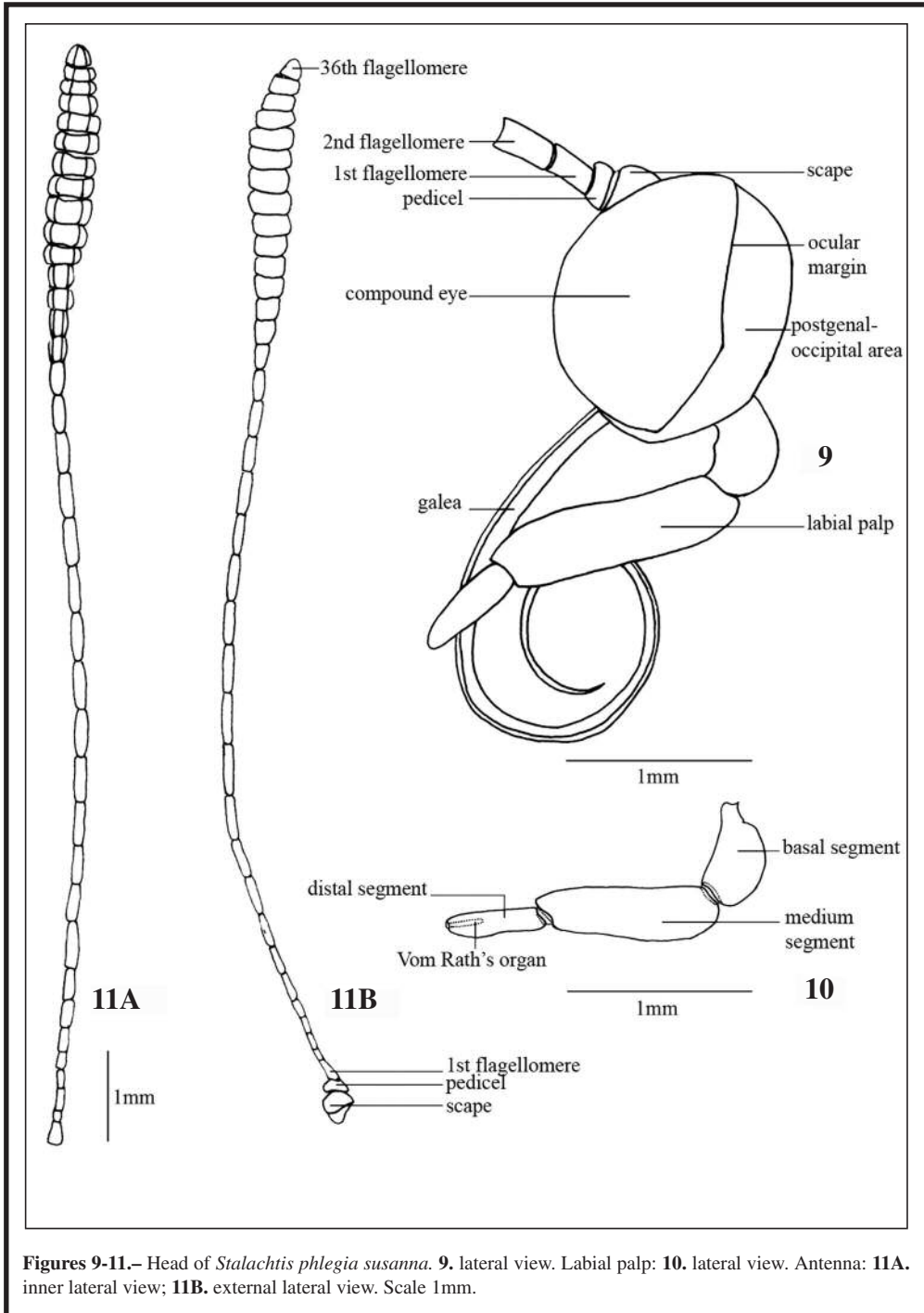
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Figures 1-4.— Adult of *Stalactis phlegia susanna*. 1-2. Male: (1) dorsal view; (2) ventral view. 3-4. Female: (3) dorsal view; (4) ventral view. Scale: 1mm.



Figures 5-8.— Head of *Stalactis phlegia susanna*. **5.** frontal view; **6.** dorsal view; **7.** posterior view; **8.** ventral view. Scale 1mm.



Figures 9-11.— Head of *Stalactis phlegia susanna*. **9.** lateral view. Labial palp: **10.** lateral view. Antenna: **11A.** inner lateral view; **11B.** external lateral view. Scale 1mm.

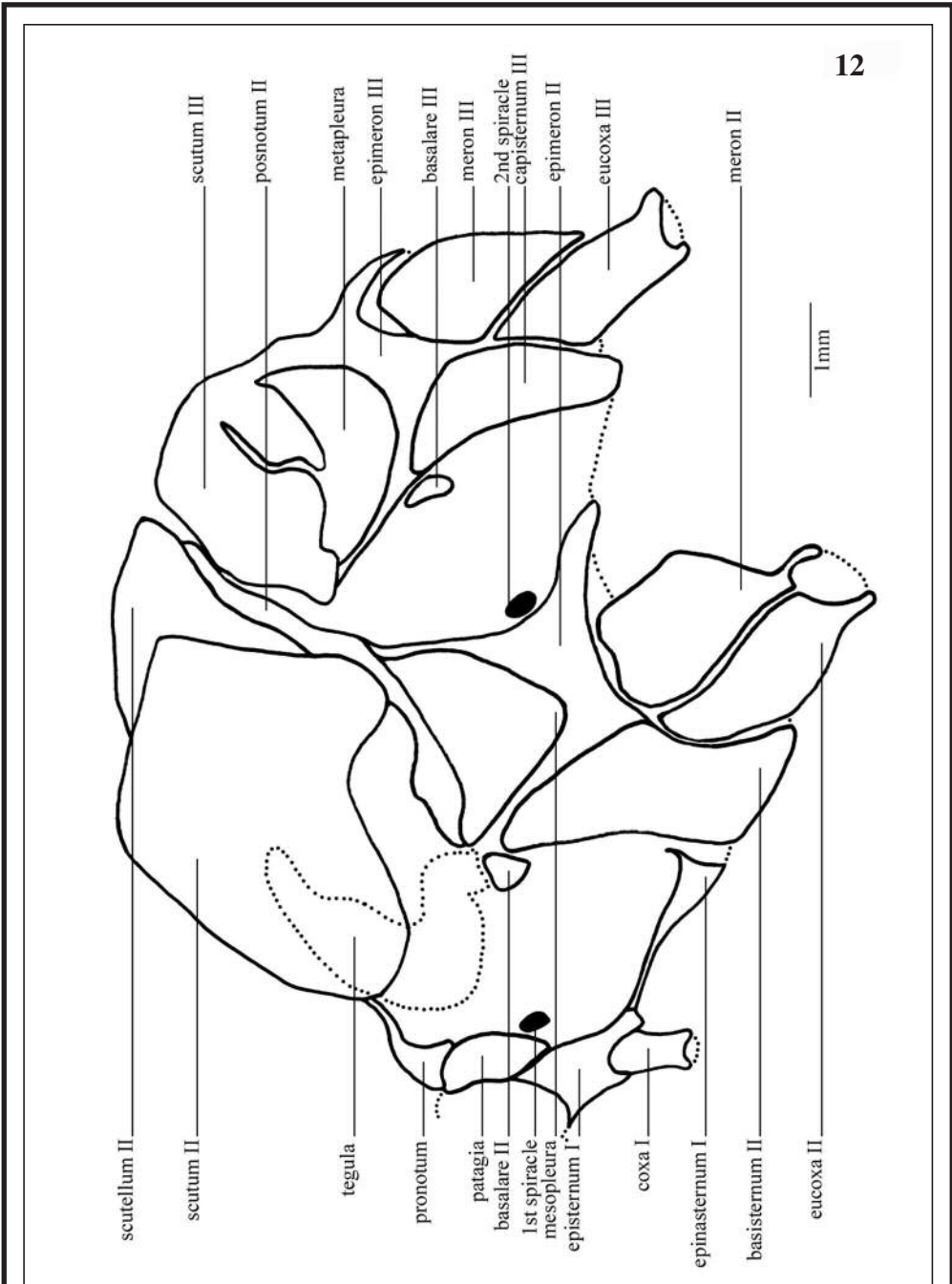
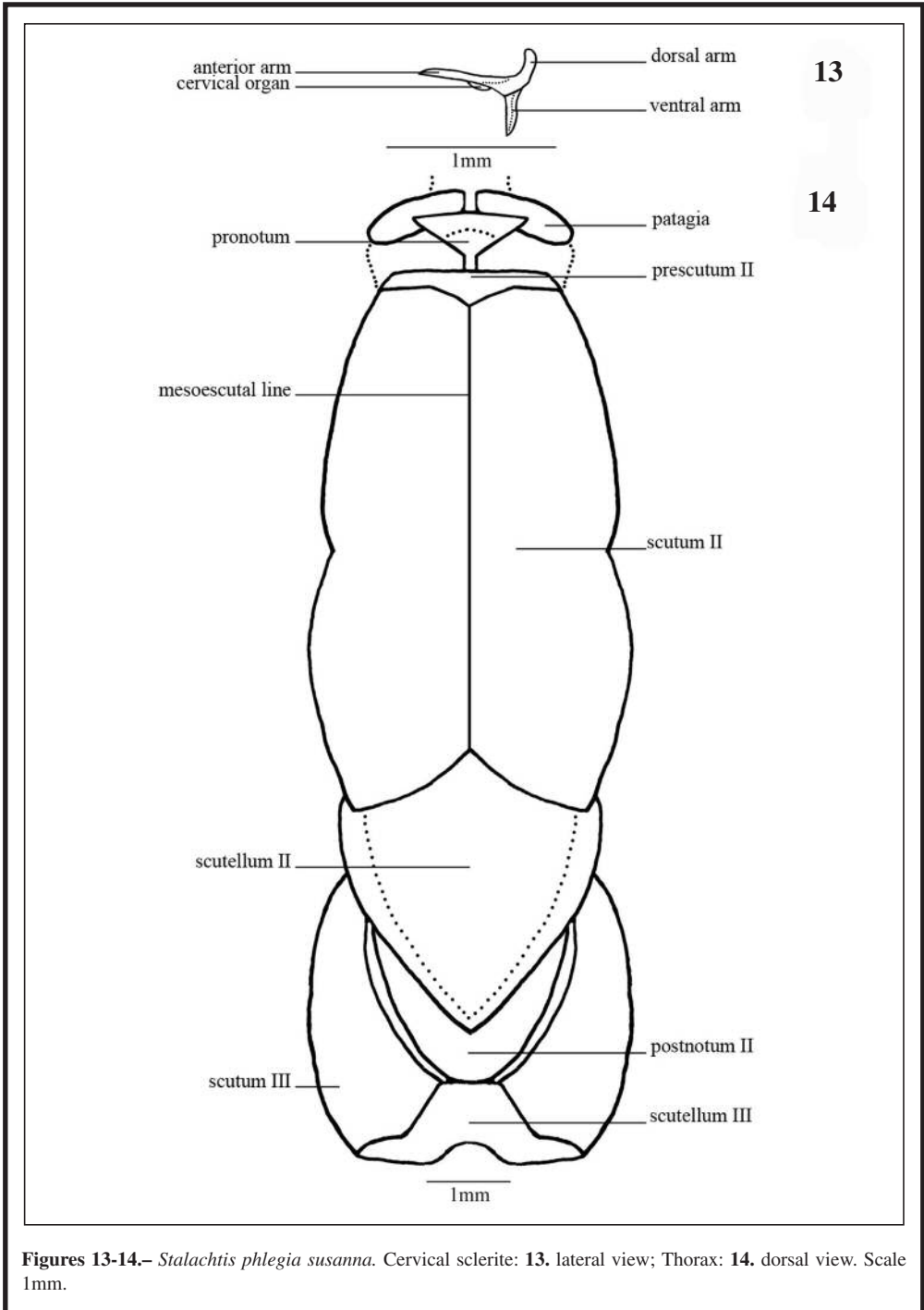
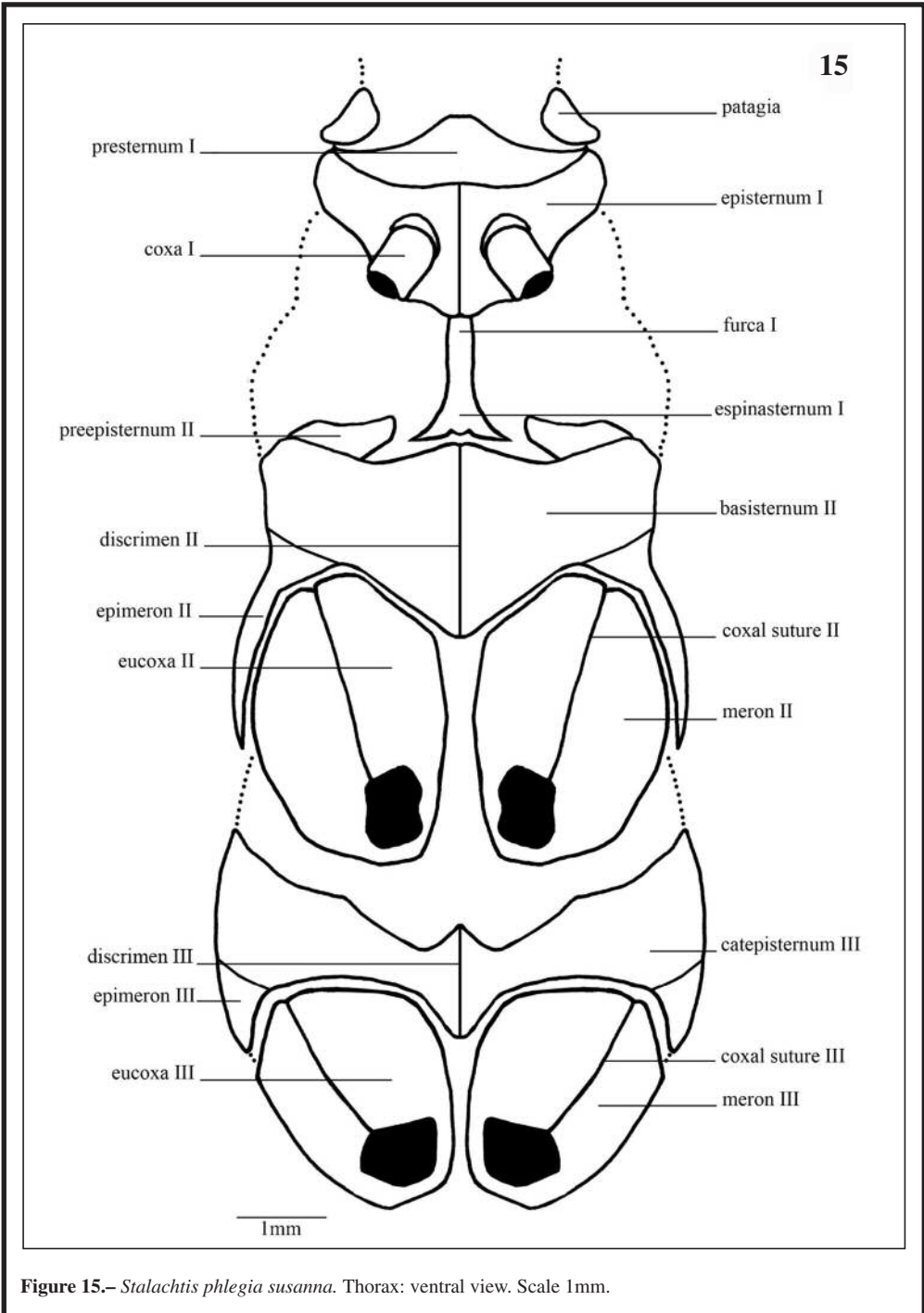
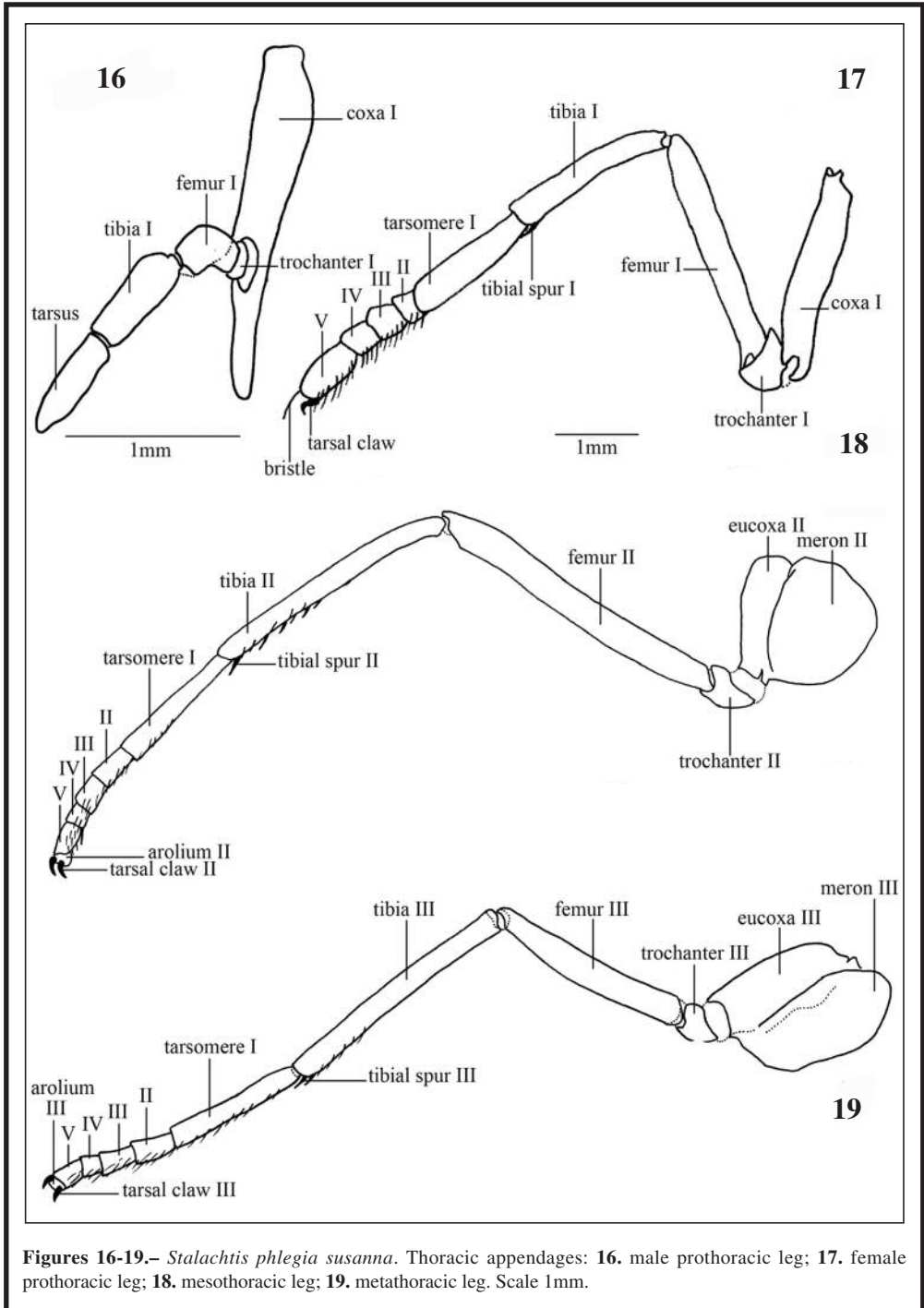


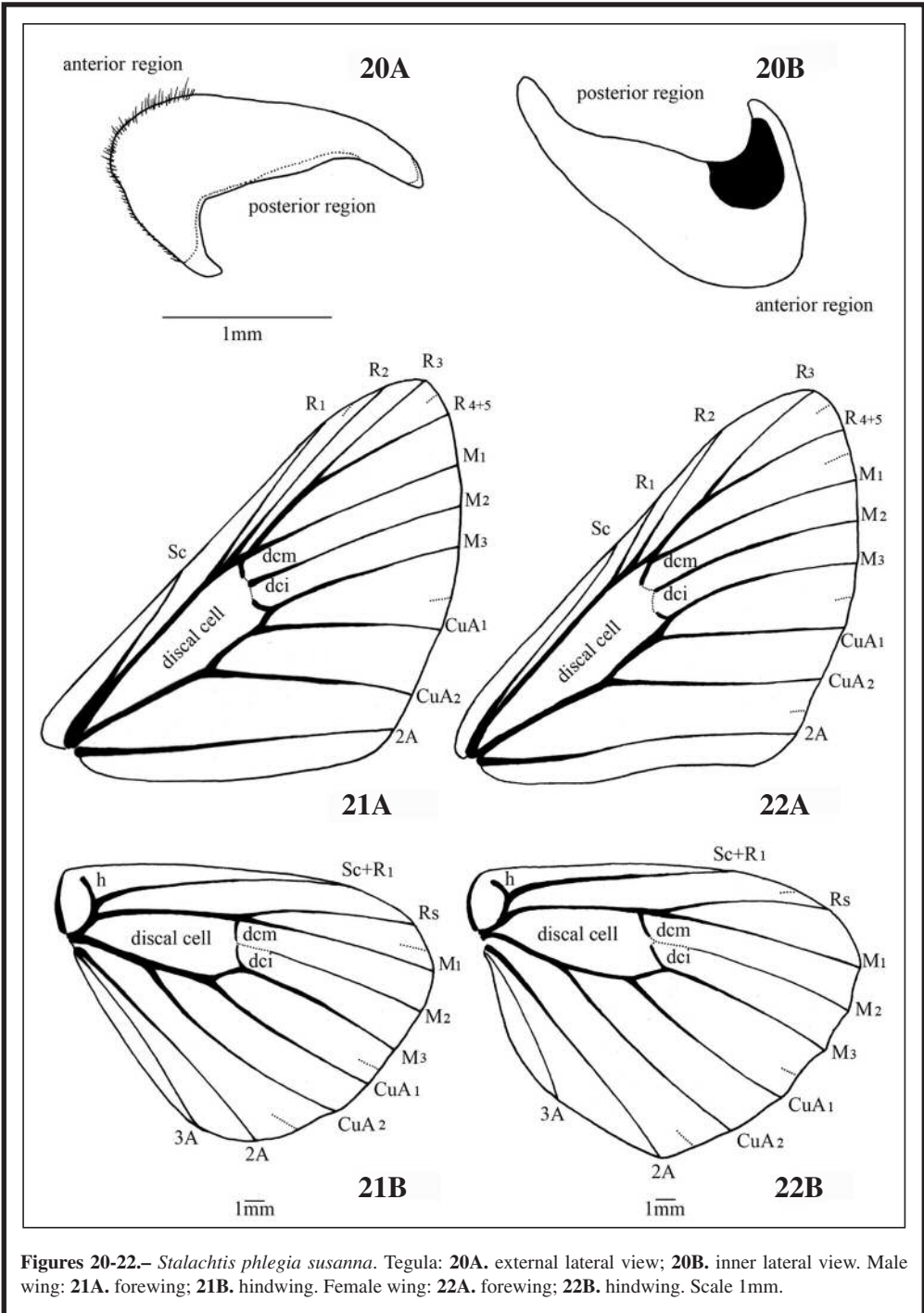
Figure 12.– *Stalactis phlegia susanna*. Thorax: lateral view. Scale 1mm.



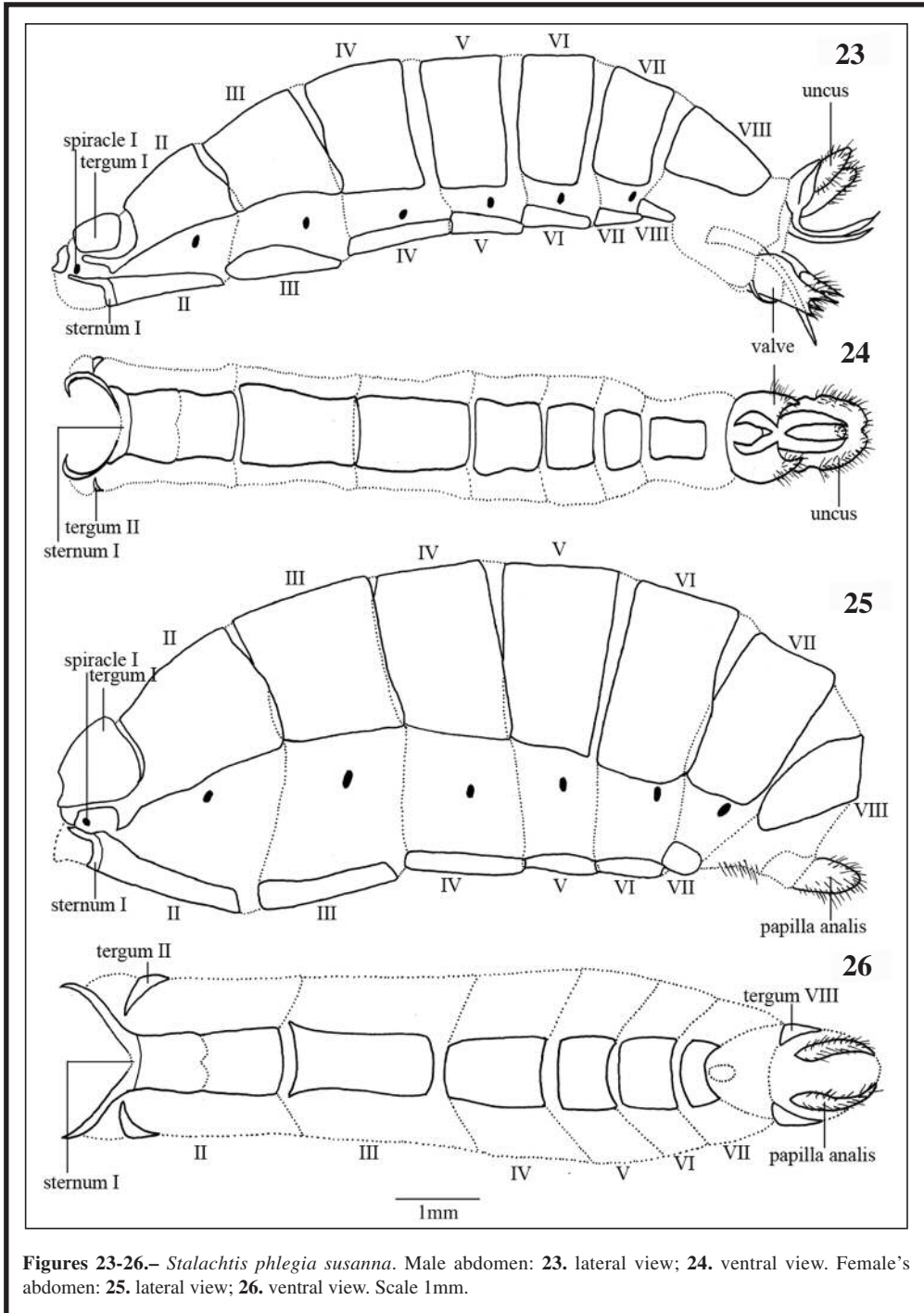




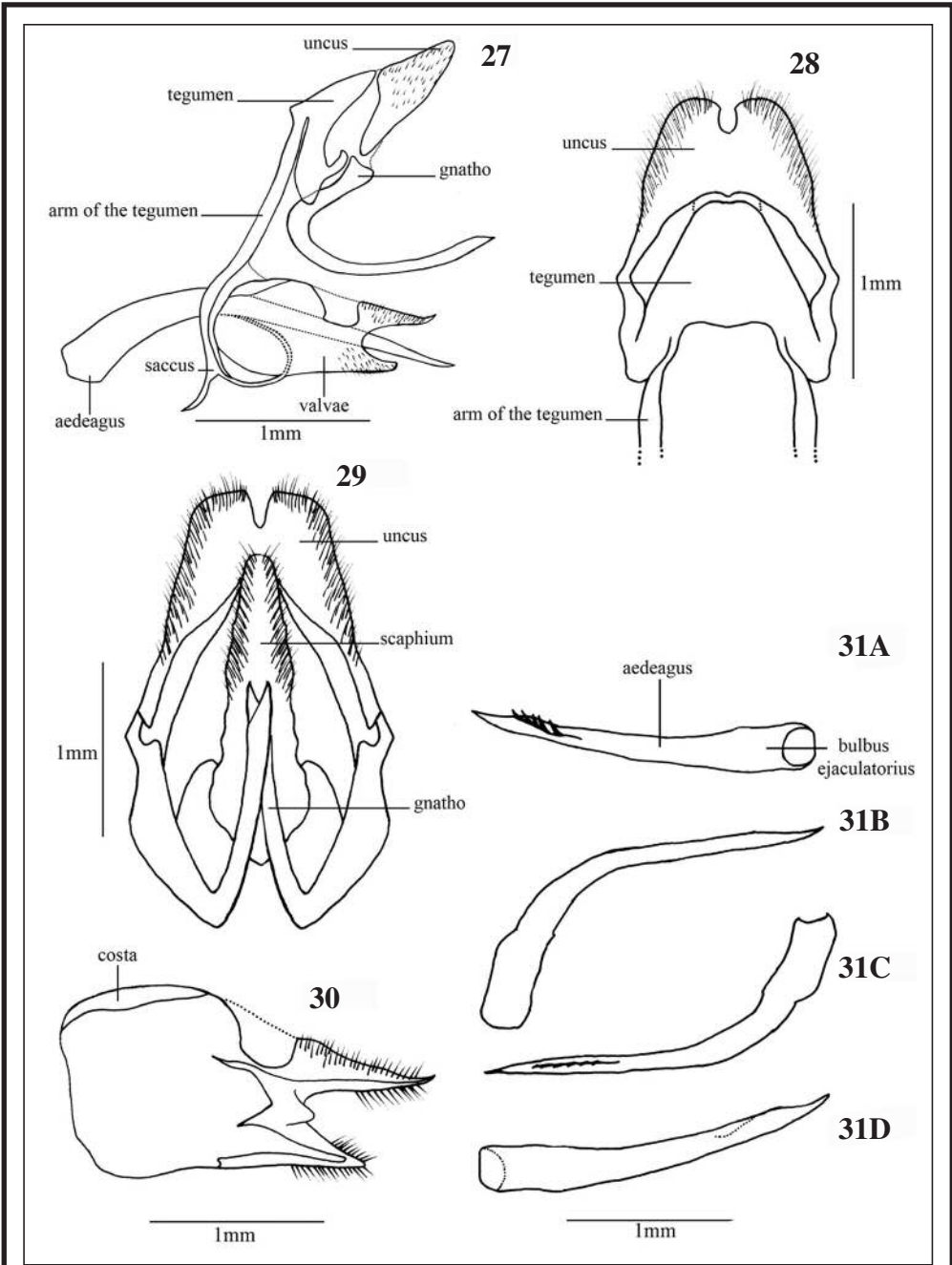
Figures 16-19.– *Stalactis phlegia susanna*. Thoracic appendages: **16.** male prothoracic leg; **17.** female prothoracic leg; **18.** mesothoracic leg; **19.** metathoracic leg. Scale 1mm.



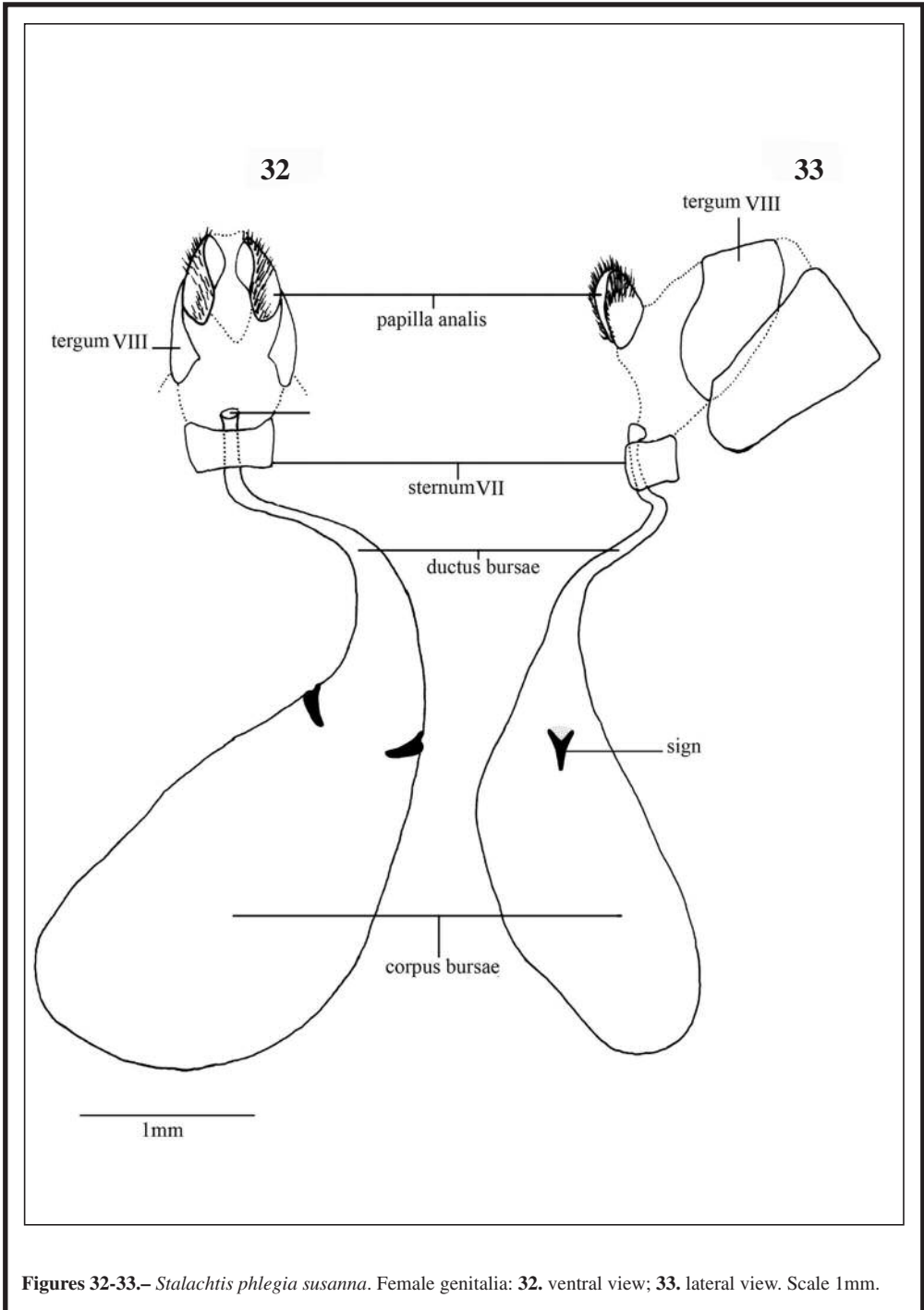
Figures 20-22.— *Stalactis phlegia susanna*. Tegula: **20A**. external lateral view; **20B**. inner lateral view. Male wing: **21A**. forewing; **21B**. hindwing. Female wing: **22A**. forewing; **22B**. hindwing. Scale 1mm.



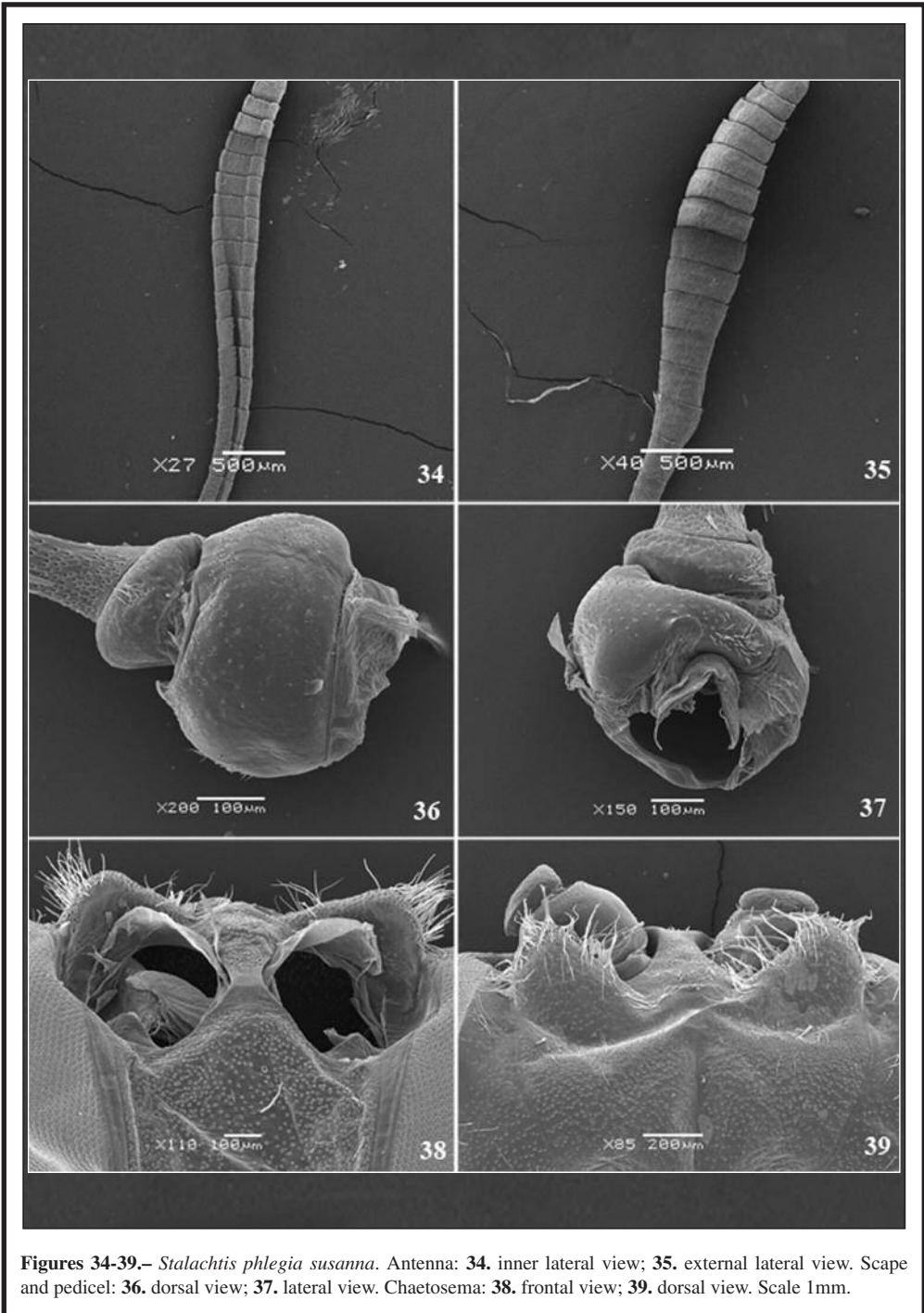
Figures 23-26.- *Stalactis phlegia susanna*. Male abdomen: 23. lateral view; 24. ventral view. Female's abdomen: 25. lateral view; 26. ventral view. Scale 1mm.



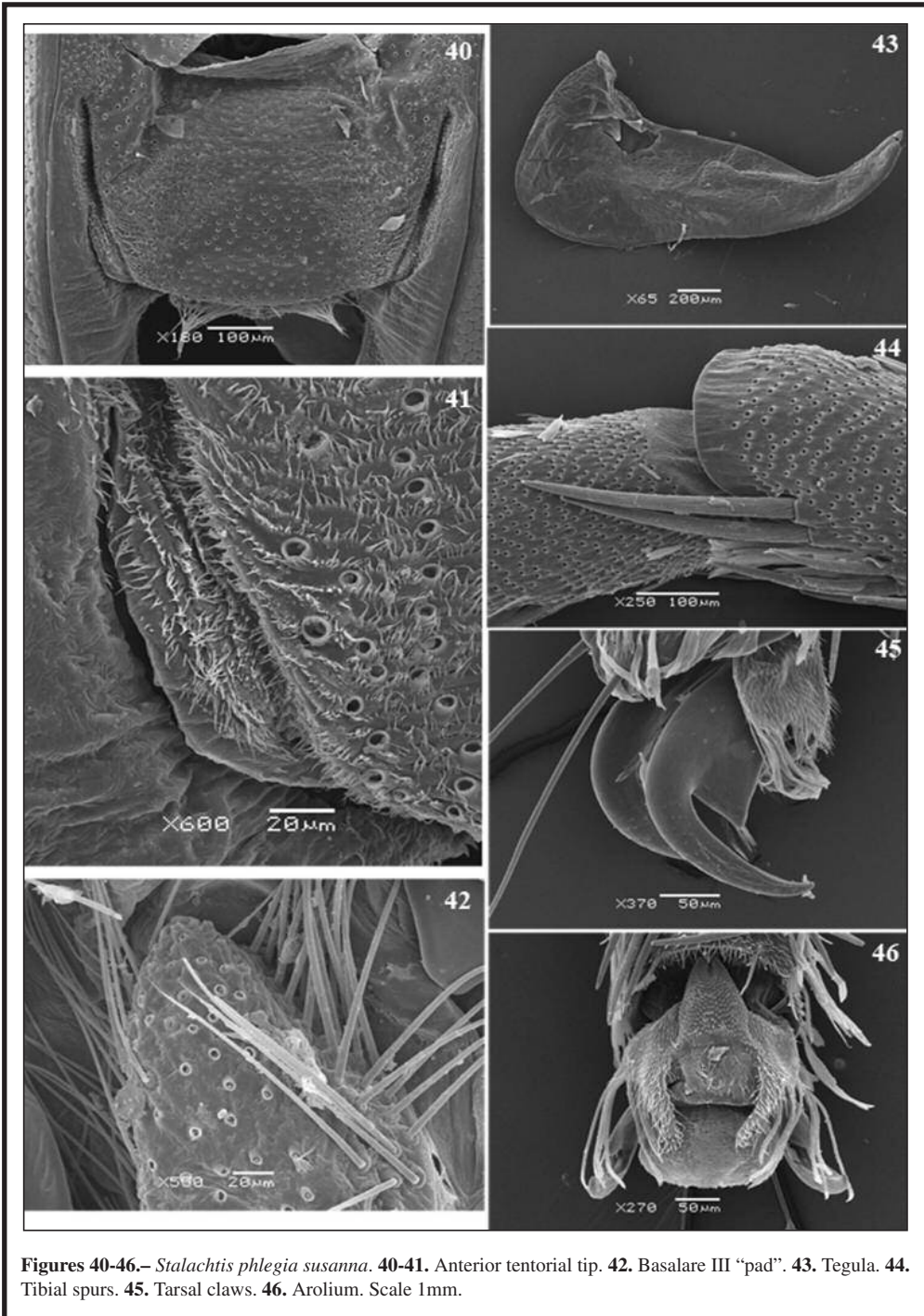
Figures 27-31.– *Stalactis phlegia susanna*. Male genitalia: 27. lateral view; 28. dorsal view; 29. ventral view. Valvae: 30. lateral view. Aedeagus: 31A. ventral view; 31B-C. lateral view; 31D. dorsal view. Scale 1mm.



Figures 32-33.— *Stalactis phlegia susanna*. Female genitalia: 32. ventral view; 33. lateral view. Scale 1mm.



Figures 34-39.— *Stalactis phlegia susanna*. Antenna: **34**, inner lateral view; **35**, external lateral view. Scape and pedicel: **36**, dorsal view; **37**, lateral view. Chaetosema: **38**, frontal view; **39**, dorsal view. Scale 1mm.



Figures 40-46.– *Stalactis phlegia susanna*. **40-41.** Anterior tentorial tip. **42.** Basalare III "pad". **43.** Tegula. **44.** Tibial spurs. **45.** Tarsal claws. **46.** Arolium. Scale Imm.