

## Previously Non-Illustrated Genitalia of Some Known Asilinae Species (Insecta: Diptera: Asilidae)

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### ABSTRACT

Undescribed spermathecae of nine species of Asilidae: Asilinae are illustrated: *Anarmostus iopterus* (Wiedemann), *Dicropaltum rubicundus* (Hine), *Epipamponeurus americanus* Becker, *Leinendera rubra* Carrera, *Lestophonax mallophoroides* Hull, *Negasilus mesae* Tucker, *Prolatiforceps anonymus* (Williston), *Stenasilus tenuis* (Wiedemann), and *Threnia carbonaria* (Wiedemann). Dissections and nomenclature follow Artigas (1971) and Theodor (1976). Specimens used were from the insect collections of the Museo de Zoología, Universidad de Concepción, Chile; Museu de Zoología, Universidade de Sao Paulo, Brazil; and Musée National d' Histoire Naturelle, Paris, France. Differences and similarities between species are discussed.

**Key words:** Diptera, Asilidae: Asilinae, genitalia, spermatheca

### INTRODUCTION

With two exceptions Artigas (1971) and Theodor (1976), little information was available on female asilid genitalia until the publications of Artigas & Papavero (1988, 1997), Papavero (2009), and Papavero *et al.* (2009). Illustrations of genitalia are more common for males than for females, as the latter require painstaking dissections, microscopic slides, and drawings of female spermathecae. Based on previous studies of spermathecae and eggs, Artigas *et al.*, (2011) created an unpublished phylogenetic tree similar to the one based on traditional morphology (Bybee *et al.*, 2004).

The techniques of Artigas (1971) were used to examine the genitalia, mainly spermathecae, of material made available to the authors by the Museo de Zoología, Universidad de Concepción, Chile; Museu de Zoología, Universidade de Sao Paulo, Brazil; and the Musée National d' Histoire Naturelle, Paris, France.

During the present study, the genitalia of nine Asilidae species previously not illustrated were dissected. This was done in order to provide Asilidae researchers with valuable information that can be used in taxonomy, phylogeny, biogeography, and biodiversity studies. Artigas & Papavero (1988, 1997) have shown that female internal organs (spermathecae) are useful for characterizing taxonomic groups and for purposes of identification. These authors dissected (as yet unpublished) series of six or more specimens of the same species, often from the same site, showing that

minimal variation occurred, both in the general plan and in the details that illustrate the reliability of using this character. Only one specimen of *Anarmostus iopterus* (Wiedemann) was dissected. Genital structures (both sexes in most cases) are illustrated for the following species: *Anarmostus iopterus* (Wiedemann), *Dicropaltum rubicundus* (Hine), *Epipamponeurus americanus* Becker, *Leinendera rubra* Carrera, *Lestophonax mallophoroides* Hull, *Negasilus mesae* Tucker, *Prolatforceps anonymus* (Williston), *Stenasilus tenuis* (Wiedemann), and *Threnia carbonaria* (Wiedemann).

## MATERIAL AND METHODS

From one to six specimens of each species (except *A. iopterus* (Wied.)) were dissected. However, the spermatheca of only one specimen per species is illustrated, noting its collection site and date.

For female dissections, a modified Artigas (1971) technique was used as follows: The complete abdomen was removed from the thorax and boiled in KOH 10%, until the hard parts (sclerotized) of the spermatheca could be seen through the cuticle. The abdomen was placed on a slide with glycerin and observed under a microscope; a lucid camera illustration was drawn to show the location and the general plan of the spermatheca inside the abdomen. The abdomen was transferred from the slide to a Petri dish with glycerin, where the abdomen was dissected. The spermatheca was extracted, placed on a slide in a drop of glycerin, then examined and drawn in detail under higher magnification (50x). The remains of the abdomen and spermatheca were deposited in a genital tube and pinned with the corresponding specimen on the same pin. Pencil drawings were copied in Indian ink and scanned. Male genitalia were also boiled in KOH 10% and placed in glycerin in a Syracuse dish. Dissected specimens were labeled indicating that the spermatheca had been placed in a genital tube attached to the pin.

The terminology for the various parts of both the male and female genitalia, along with the abbreviations used in the drawings, is as follows:

aed	aedeagus	gl	gland
aed sh	aedeagal sheath	gty	gonostyli
ar	arm stn 10	hyp mi cap	hypandrium microcapsule
cap duct	capsular duct	sperm	spermatheca
cap sem	capsula seminalis	stn ap	sternal apodeme
cc	cercus	stn 7	sternite 7
com duct	common duct	stn 8	sternite 8
ej ap	ejaculatory apodeme	stn 10	sternite 10
ep	epandria	tg 7	tergite 7
exp duct	expulsory duct	tg 8	tergite 8
gcx	gonocoxite	tg 9	tergite 9

## RESULTS

### *Anarmostus iopterus* (Wiedemann) (Fig. 1A-G)

#### Male genitalia

Epandria in lateral view (Fig. 1C), slightly attenuated, width at apex about half the basal width. Gonocoxites two-thirds the epandria length. Gonostyli (Fig. 1A) extending beyond apex of gonocoxites and curved outwards at tip. Aedeagal sheath (Fig. 1D) almost five-sixths the epandria length; in lateral view, basal two-thirds wide, apical third less than one-third width of basal area, ending in three acute spines; aedeagal apodeme length is subequal to the aedeagal sheath length; its maximum width is subequal to the maximum width of the aedeagal sheath.

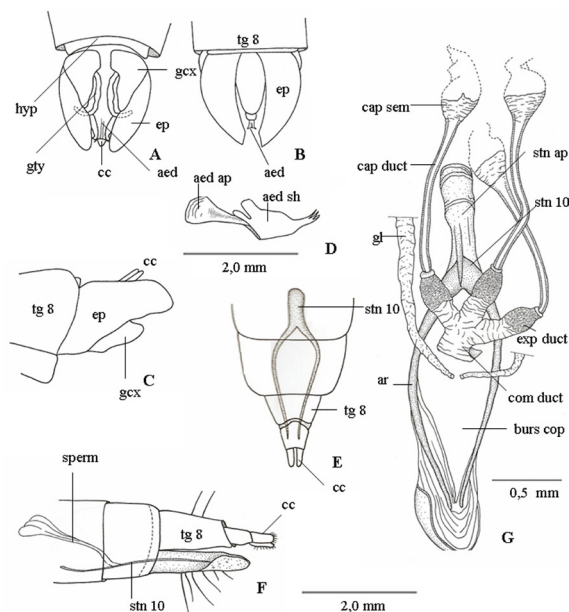


Fig. 1. *Anarmostus iopterus* (Wiedeman). (A) male genitalia in ventral view; (B) male genitalia in dorsal view; (C) male genitalia in lateral view; (D) aedeagus in lateral view; (E) female abdomen in dorsal view; (F) female abdomen in lateral view, shows position of the spermatheca and ovopositor; (G) tenth sternite, spermatheca and details.

#### Female genitalia

Visible terminalia includes tergites eight and nine, cerci, and sternite eight. Tenth sternite (furca) plus spermatheca located inside abdominal segments six to eight (Fig. 1F); sternite with two long, slim arms, slightly attenuated towards apex; sternite apodeme (stn ap) flat, its length three times its width. Spermatheca with three elements connected to a wide common duct that connects widely to bursa copulatrix. Seminal capsulae globose, possibly attenuated distally and ending pointed at apex

(lost); only one specimen of this species was studied; narrow capsular duct, one-third the width of expulsory duct and almost three times longer; expulsory duct strongly attenuated towards apex, upper half subgranulate in texture with a ring at capsular duct connection; basal half membranous, similar to structure of common duct. Two glands rising separately from bursa copulatrix.

Genital structures illustrated: Male and female, Brazil, Pará, Gurupá, N. Cerqueirín XI-948 [November 1948]. Museu de Zoologia, Universidade de São Paulo.

### *Dicropaltum rubicundus* (Hine) (Fig. 2A-G)

#### Male genitalia

Epandria in lateral view subrectangular (Fig. 2A), three times the length of tergite eight, apex slightly cleft in middle. Gonocoxites recurved upwards, apical half attenuated, half the length of epandria. Gonostyli as long as gonocoxites, straight, pointed at apex (Fig. 2B). Aedeagal sheath, in lateral view (Fig. 2E), uniformly curved upwards, extending two-thirds length of epandria, wide at base for a short distance, arms short; apex branches into three long, slender, acute extensions, remaining together; these branches are longer than half the length of aedeagal sheath, the central element straight and shorter than laterals which are slightly curved outward; ejaculatory apodeme minute, less than one-sixth the length of aedeagal sheath, rounded at apex.

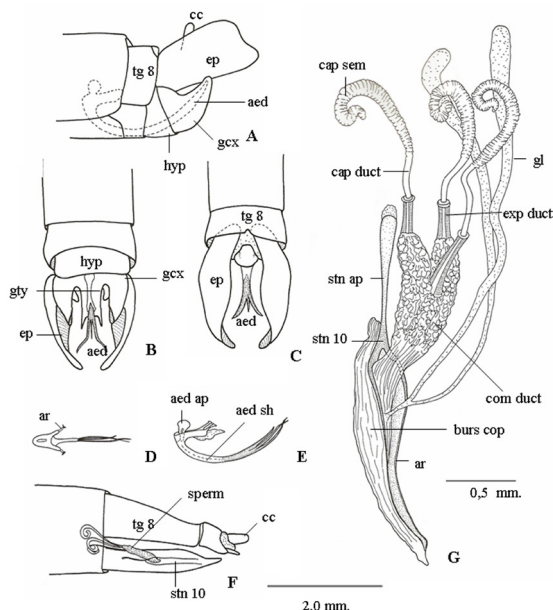


Fig. 2. *Dicropaltum rubicundus* (Hine). (A) male genitalia in lateral view; (B) male genitalia in ventral view; (C) male genitalia in dorsal view; (D) aedeagus in dorsal view; (E) aedeagus in lateral view; (F) female abdomen in lateral view, shows position of the spermatheca and ovopositor; (G) tenth sternite, spermatheca and details.

### Female genitalia

Visible terminalia includes tergites eight and nine, cerci, and sternite eight (Fig. 2F). Tenth sternite plus spermatheca located from apex of tergite seven to nine. Sternite ten with two long, fine arms that are thinner at apical end; sternal apodeme narrow at proximal half; apical half three times wider and rounded at end. Spermatheca with three elements rising from a wide common duct: one at the center of the common duct and the other two at the tip of each branch of the bifurcated apical half of the common duct. Common duct connects widely to bursa copulatrix between the bifurcation of sternite arms. Expulsory ducts as shown in Fig. 2G, one inserted lower, longer than the other two; at the end, all have a ring where capsular ducts are connected. Capsular ducts narrower than common ducts but similar in length. Seminal capsulae corrugated, elongated, recurved at end, more than ten times longer than their width. Glands of spermathecae, long and thin, joined at the base in a single thin tube connected to bursa copulatrix.

Genital structures illustrated: Male and female, USA, 39 mi. city, [Kansas]. 2800 ft elev. 30 June 1931. Don Prentis, col. Museu de Zoologia, Universidade de Sao Paulo, Brazil.

### *Epipamponeurus americanus* Becker (Fig. 3A-C)

#### Male genitalia

Epandria in lateral view (Fig. 3A), two and a half times longer than average width; center of dorsal border with a finger-like expansion, strongly curved frontward with a row of strong, long setae at the apex. Gonocoxite rounded at apex, half the length of epandria. Distal border of hypandrium gently curved, one-third the length of gonopods.

Genital structures illustrated: Male, Ecuador, Río Bamba, Dr. G. Rivet, 1901. Musée National d' Histoire Naturelle, Paris.

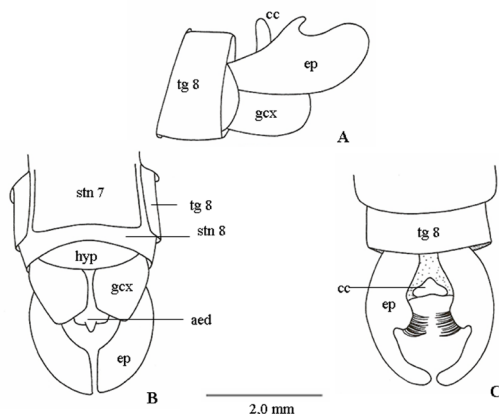


Fig. 3. *Epipamponeurus americanus* Becker. (A) male genitalia in lateral view; (B) male genitalia in ventral view; (C) male genitalia in dorsal view.

***Leinendera rubra* Carrera (Fig. 4A-C)****Female genitalia**

Visible terminalia includes tergites eight and nine, cerci, and sternite eight (Fig. 4A). Tenth sternite and spermatheca located from apical third of segment seven to apex of segment eight. Sternite ten forms a simple arch with two long, fine arms that have two small, rounded processes at base; there is no sternal apodeme. Spermatheca with three rising elements, well separated, from apex of a wide common duct, widely connected to bursa copulatrix. Expulsory ducts short, one-fifth the capsular duct length. At base of expulsory ducts, there are multiple, joined together, short, pointed processes surrounding them. Capsular ducts similar in length, slightly narrower than expulsory ducts, with smooth surface. Seminal capsulae spherical, smooth, narrow at base, as narrow as capsular ducts; width of capsulae subequal to expulsory duct length.

Genital structures illustrated: Female, Brazil, Chapadao, Cantarria, Baepetto H. 1/1/46 [1 January 1946]. Museu de Zoologia da Universidade de Sao Paulo.

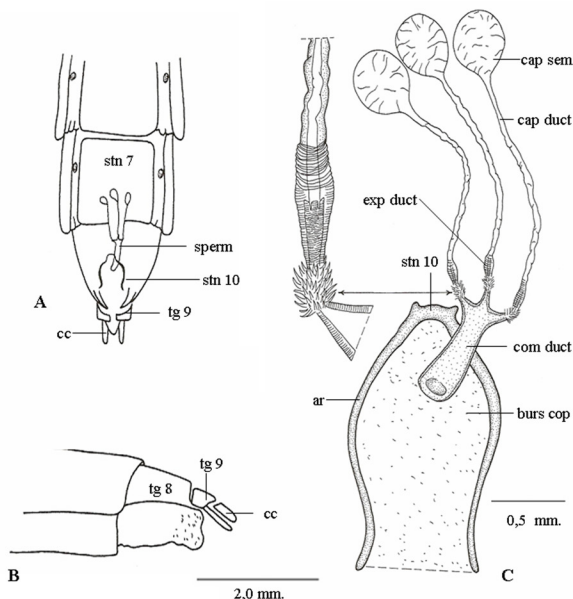


Fig. 4. *Leinendera rubra* Carrera. (A) female abdomen in dorsal view; (B) female abdomen and ovopositor in lateral view; (C) spermatheca and details.

***Lestophonax mallophoroides* Hull (Fig. 5A-H)****Male genitalia**

Epandria in lateral view (Fig. 5A), elongated and rounded at tip, with a dorsal, strongly attenuated expansion, located on basal half. Gonocoxites wider than epandria, attenuated on apical half, almost as long as epandria. Gonostyli large, curved outwardly at tip, as long as gonocoxites. Aedeagal sheaths stout, in lateral

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view as wide as half of the total length, attenuated at tip, forming a short narrow tube; ejaculatory apodeme short, rounded at end, as long as three-fourths the length of aedeagal sheath. Hypandrium short, as short as half the length of the gonocoxites, posterior border slightly extended in center.

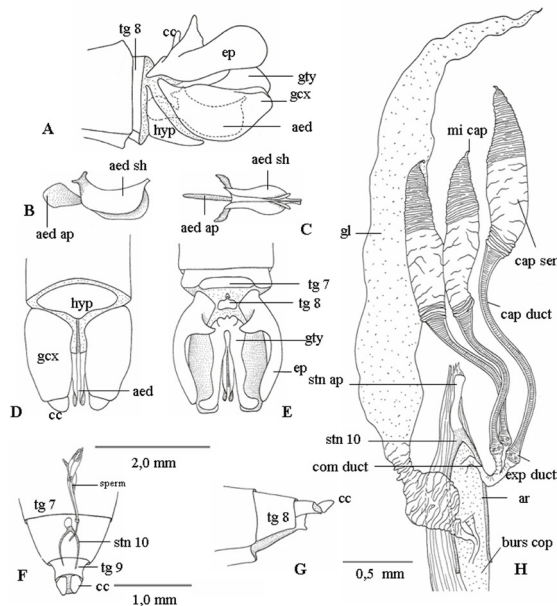


Fig. 5. *Lestophonax mallophoroides* Hull. (A) male genitalia in lateral view; (B) aedeagus in lateral view; (C) aedeagus in dorsal view; (D) male genitalia in ventral view; (E) male genitalia in dorsal view; (F) female abdomen in dorsal view, shows position of the spermatheca and ovopositor; (G) female abdomen in lateral view; (H) tenth sternite, spermatheca and details.

### Female genitalia

Visible terminalia includes tergites eight and nine, cerci, and sternite eight (Fig. 5G). Tenth sternite plus spermatheca located inside segment seven to nine. Sternite ten with slender arms, twice the length of sternite apodeme; apodeme short, rounded at tip. Spermatheca with three elements, one longer by one-fourth its length; all elements similar in shape and structure. Common duct narrow, connected to bursa copulatrix by a narrow tube, opposite end trifurcate where expulsory ducts are connected. Expulsory duct confused, not well defined: it is too short or is fused to the capsular duct with no differentiation. Capsular duct poorly defined at base; seminal capsule appear as a continuous extension of the duct. Seminal capsule elongated, attenuated on both ends, all three similar in size; both ends corrugated, on each tip is a minute microcapsule, as long as the width of the capsular duct at its center.

Genital structures illustrated: Male and female, Ecuador, Km 52.5 from Cuenca, Azuay, elev. 3250, 21-III-65 [21 March 1965]. L. Peña col. Museu de Zoologia, Universidade de Sao Paulo, Brazil.



***Negasilus mesae* Tucker (Fig. 6 A-H)****Male genitalia**

Epandria in lateral view subrectangular (Fig. 6A), two and a half times longer than wide, distal border slightly pronounced on apical third. Gonocoxites fused at base, half the length of epandria, wide at base and attenuated on apical half; gonostyli straight, apex recurved outwards for a very short distance. Hypandrium from ventral view (Fig. 6C) subtrapezoidal, distal border gently curved. Aedeagal sheath (Fig. 6D-E) slightly curved upwards on apical two-thirds, base wide, arms large; ejaculatory apodeme narrow at base, subcircular at apex, subequal in length to arms, apex trifurcate for a short distance, the three elements diverging.

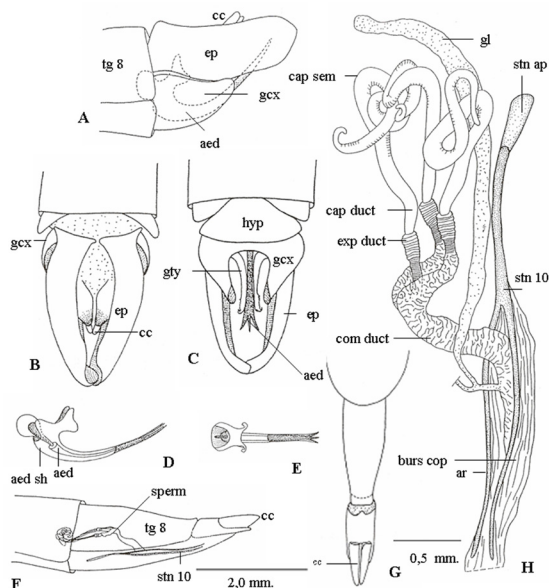


Fig. 6. *Negasilus mesae* Tucker. (A) male genitalia in lateral view; (B) male genitalia in dorsal view; (C) male genitalia in ventral view; (D) aedeagus in lateral view; (E) aedeagus in dorsal view; (F) female abdomen in lateral view, shows position of the spermatheca and ovopositor; (G) female abdomen in dorsal view; (H) tenth sternite, spermatheca and details.

**Female genitalia**

Visible terminalia includes tergites eight and nine, cerci, and sternite eight (Fig. 6F). Sternite ten with two long fine arms separated on basal half and closer on distal half, slightly longer than apodeme; tenth sternite apodeme slightly wider than the arms, gently expanded on apical third and flattened, apex rounded. Spermatheca with three elements (Fig. 6H) raising from a long thick common duct, bifurcate at tip and widely connected to bursa copulatrix, two of the expulsory ducts rising from the tip of the two common duct arms, the third one rises at the base of the bifurcation; expulsory ducts short, wider, and corrugated at distal half; capsulae ducts, narrower at the base than the distal half of expulsory ducts, continue to form the seminal capsule, which



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is attenuated towards the tip and recurved at least twice from the second third; no microcapsule at tip. Spermatheca glands narrow, subequal in length to tenth sternite, both connected to bursa copulatrix by a single narrow tube, as long as half the length of expulsory ducts.

Genital structures illustrated: Male and female. USA: *Hesperus*, 8000ft, Roger C.R., 3-VII-35 [3 July 1935] col. Museo de Zoología, Universidad de Concepción, Chile. Female. Canada, Drumheller, Alta, Alberta, W.R.M. Mason. Museu de Zoología, Universidade de Sao Paulo, Brazil.

***Prolatforceps anonymus* (Williston) (Fig. 7A-H)**

**Male genitalia**

Epandria in lateral view elongated and narrow (Fig. 7A), almost four times longer than average width, rounded at tip; dorsal side with a narrow depression in the center. Gonocoxites elongated, two and a half times longer than wide, upper borders slightly depressed in the center. Gonostyli straight, half the length of gonocoxites, attenuated at end (Fig. 7C). Hypandrium short, reaching base of gonopods. Aedeagal sheath reaching apical third of epandria; in lateral view (Fig. 7D), elongated, upper and lower

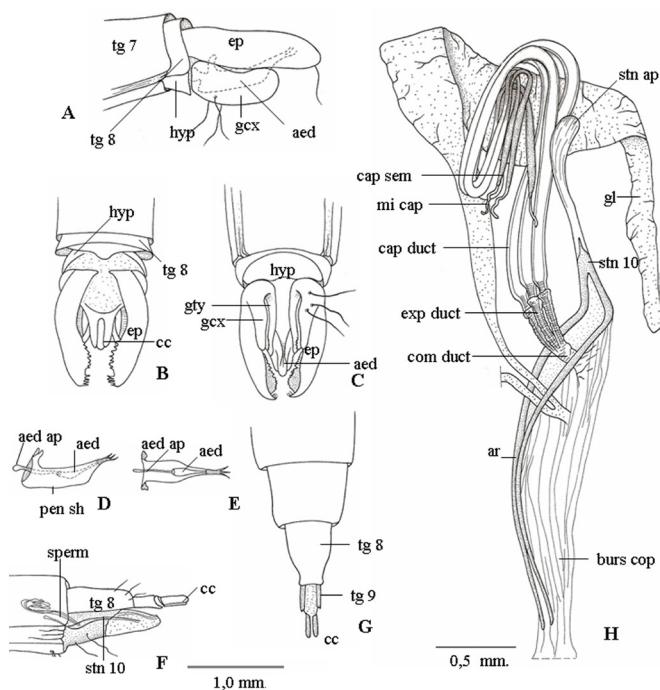


Fig. 7. *Prolatforceps anonymus* (Williston). (A) male genitalia in lateral view; (B) male genitalia in dorsal view; (C) male genitalia in ventral view; (D) aedeagus in lateral view; (E) aedeagus in dorsal view; (F) female abdomen in lateral view, shows position of the spermatheca and ovopositor; (G) female abdomen in dorsal view; (H) tenth sternite, spermatheca and details.

borders parallel on its three-fourths, where the length is two and a half times the width; apical third strongly attenuated; apex slender, with three short, divergent subequal spines at tip; arms short, directed upwardly; ejaculatory apodeme long and slender, as long as the slightly expanded and rounded apex.

### Female genitalia

Visible terminalia includes tergites eight and nine, cerci, and sternite eight (Fig. 7F). Tenth sternite plus spermatheca located inside the middle of segment seven to distal border of segment eight, with two fine, long arms, two and a half times the length of apodeme, bent almost perpendicularly near base; apodeme expanded gradually towards rounded apex. Spermatheca with three elements (Fig. 7H) rising from a short common duct connected widely to bursa copulatrix. Expulsory ducts short, twice the length of the common duct and slightly narrower than the basal portion of capsular ducts, except at base. Capsular ducts long, subequal, about two and a half times the length of capsulae, slowly attenuated towards capsulae; after middle, recurved, forming a tied pack with capsulae. Capsulae fine, elongated, darker than capsular ducts, about ten times longer than wide, with microcapsulae at tip that are, in length, two and a half times the average width of capsulae. Glands of spermathecae wide, longer than tenth sternite.

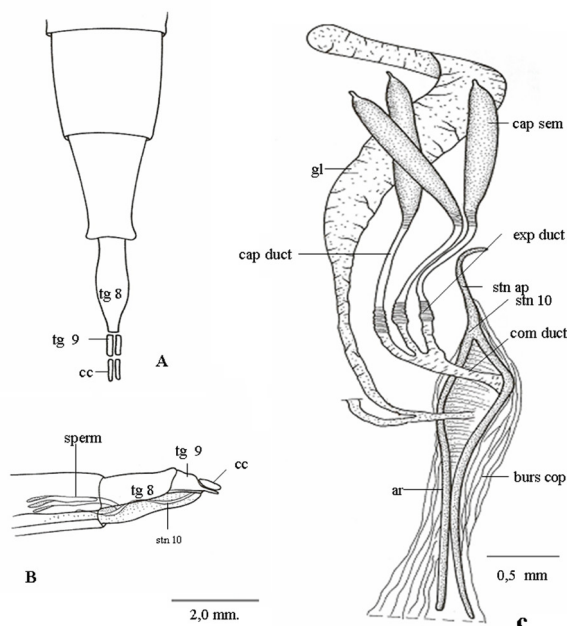


Fig. 8. *Stenasilus tenuis* (Wiedeman). (A) female abdomen in dorsal view; (B) female abdomen in lateral view, shows position of the spermatheca and ovopositor; (C) tenth sternite, spermatheca and details.

Genital structures illustrated: Male. Mexico, Uruapan, Michoacan, 7 September 1960, Chas H. Martin col. Museu de Zoología, Universidade de Sao Paulo, Brazil.

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Female. Mexico, 9 mi W. Palmitas Hy. 40 km, 1068, Sinaloa, 31 August 1962. Museu de Zoologia, Universidade de Sao Paulo, Brazil.

***Stenasilus tenuis* (Wiedemann) (Fig. 8A-C)**

**Female genitalia**

Visible terminalia includes tergites eight and nine, cerci, and sternite eight (Fig. 8A). Tenth sternite plus spermatheca located inside middle of segment seven to distal border of segment nine. Sternite with two long, fine arms curved outwards in basal third, forming a wide angle and in contact along apical third; apodeme short, not flat, as short as one-fourth of the arms, gradually attenuated towards apex. Spermatheca with three elements (Fig. 8C) rising from a trifurcate common duct, which is slightly wider at connection to the bursa copulatrix; trifurcation comprises almost half of the duct. Expulsory ducts short and thick, almost twice the diameter of capsular ducts. Capsular ducts expanded gradually towards the formation of seminal capsulae. Seminal capsulae darker than the ducts, elongated, attenuated at both ends, six times longer than its greatest width; almost as long as expulsory and capsular ducts together; there is a short, thin microcapsule at tip, the length is the average width of the capsular duct. Spermatheca glands long and wide, both connected to a fine tube ending in bursa copulatrix.

Genital structures illustrated: Female, Brazil, Foresta de Tijuca. Distrito Federal, Jan '51[January 1951]. C.A.C. Seabra. Museu de Zoologia, Universidade de Sao Paulo, Brazil.

***Threnia carbonaria* (Wiedemann) (Fig. 9A-H)**

**Male genitalia**

Epandria in lateral view, short (Fig. 9C), narrower at base; in center of dorsal border there is a truncate expansion with a tuft of bristles directed upward; on apical third of dorsal border there is a row of about ten strong bristles forming a line leading upwards; length of epandria is twice its greatest width; its general shape appears recurved upward. Gonocoxite subquadrangular, half the length of epandria; at dorsal end there is a short, attenuated projection. Hypandrium twice as wide as preceding sternite; anterior border with a cleft in center (Fig. 9B). Aedeagal sheath almost twice the length of epandria (Fig. 9G), attenuated on apical half, arms short, ventral border expanded. Ejaculatory apodeme as long as aedeagal sheath, expanded posteriorly about six times as long as its base, apex slightly rounded.

**Female genitalia**

Visible terminalia includes tergites eight and nine, cerci, and sternite eight (Fig. 9D). Tenth sternite plus spermathecae located inside apical third of tergite seven, almost to end of tergite eight (Fig. 9E). Sternite ten with robust arms, widely separated, ending in a sharp point; sternal apodeme wide, flat, almost as long as it is wide; its width is one and a half times the arm width at base. Spermatheca with three elements (Fig. 9H), connected to a common duct that is trifurcate at apex and widely connected to bursa

copulatrix at base; expulsory ducts are short, slightly wider than the corresponding trifurcation of common duct; capsular ducts about half the capsule length and as wide as the branches of common duct trifurcation. Seminal capsulae large, rising gradually from expanded capsular ducts, six times longer than its greatest width, attenuated on both ends, each with a thin microcapsule at the tip, as long as the expulsory ducts. Glands long and wide, connected separately to bursa copulatrix.

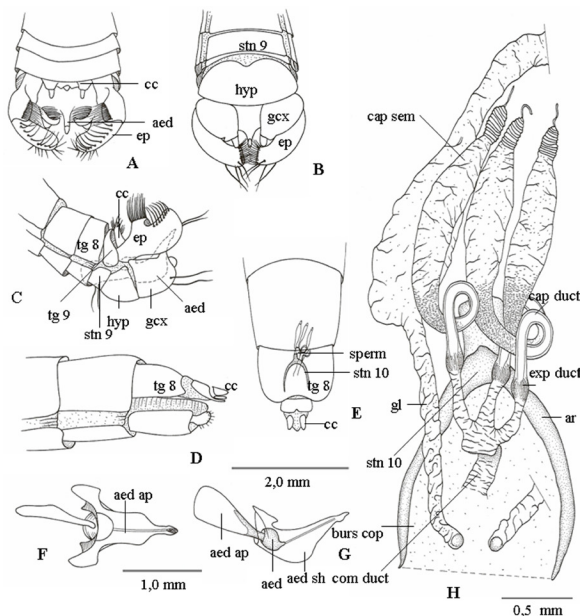


Fig. 9. *Threnia carbonaria* (Wiedeman). (A) male genitalia in dorsal view; (B) male genitalia in ventral view; (C) male genitalia in lateral view; (D) female abdomen in dorsal view, shows position of the spermatheca and ovopositor; (E) female abdomen in dorsal view, shows position of the spermatheca; (F) aedeagus in dorsal view; (G) aedeagus in lateral view; (H) tenth sternite, spermatheca and details.

Genital structures illustrated: Male and female: Brazil, Theresopolis, and E. do Rio. Lopez 22-1-1940 [January 22, 1940]. Museu de Zoologia, Universidade de Sao Paulo, Brazil.

## CONCLUSIONS

Chitinous parts of spermathecae presented in this paper, to the best of the authors' knowledge, have not been previously illustrated. These new illustrations, like other previous publications, show similar bizarre structures that are useful in taxonomy because they are characteristic for each species. All nine species have three spermathecal elements of similar size and shape. Some of the spermathecae of these species differ in size and shape. For example, in *Leinendera rubra* Carrera, seminal capsulae (reservoirs) are spherical, connected to a thin capsular duct (Fig. 4C) like the ones illustrated by Artigas & Papavero (1997:86, Fig. 52) for the North

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American and Neotropical genera of Asilinae. However, in the other eight species, the capsulae are elongated and, on occasions, an extension of the capsular duct (Fig. 6, 7). The comparative lengths of capsular ducts and expulsory duct are, like in most known spermatheca (Artigas 1971; Artigas and Papavero, 1997), of different lengths, with the capsular duct being much longer than the expulsory duct. The expulsory duct shows corrugations or small expansions where muscles are attached. The size, shape, and surface structure of common ducts vary in all species: some are narrow (Fig. 5) and others are wide (Fig. 4). Connections with expulsory ducts vary from a simple connection (Fig. 7) in which the three expulsory ducts connect together with the apex of the common duct to a connection in which the apex of a common duct is trifurcated (Fig. 1, 2, 4, 5). For example, in *Dicropaltum rubicundus* (Hine) and *Negasilus mesae* Tucker (Fig. 2, 6), one of the expulsory ducts connects to a thick, evenly corrugated common duct before its apex.

Important differences are found in the tenth sternite (furca), ranging from wide, open, thick arms (Fig. 4, 9) to long, slender, adjacent arms (Fig. 6, 7, 8). The tenth sternite apodeme also varies from practically absent (Fig. 4) to long, slender, and expanded or pointed towards the apex (Fig. 7, 8). In some cases (see Fig. 6), the apodeme is subequal to the length of the arms. All these characters are not recommended for use in keys but are strongly recommended for inclusion in subfamily to species descriptions.

Note. The objective of this work is to present the description of male and female genitalia, unknown to date, corresponding to valid species of neotropical asilids. The information presented herein will increase the number of species in taxonomic studies, where such structures are especially relevant. Unknown genitalia of other valid species will be published in the near future.

## ACKNOWLEDGEMENTS

The authors thank the Dirección de Investigación, Universidad de Concepción, for help in publishing this paper; and the Museo de Zoología, Universidad de Concepción, Chile; Museo de Zoología, Universidade de Sao Paulo, Brazil; and Musée National d'Histoire Naturelle, Paris, France, for allowing the dissection of their material. We appreciate the valuable collaboration of Mrs. Carmen Medina de Rioseco and Danielle Barriga with the English texts. Finally, we thank the Departamento de Zoología, Universidad de Concepción, where the study was conducted and the anonymous reviewer for valuable assistance correcting the manuscript.

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Received: November 24, 2009      Accepted: March 21, 2011