Chapter 15.6

Families Dryopidae, Elmidae, and Psephenidae

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Chapter Outline

INTRODUCTION

The suborder Polyphaga is the largest in the order Coleoptera, and it is also the most diverse, with over 300,000 described species in over 150 families. Ecologically, polyphagans run the gamut of life histories from xylophagous species to predators and specialist plant feeders; additionally, many species live a fully aquatic life. In the Neotropical Region, this suborder is represented by 13 families that are regarded as ''predominantly aquatic'' (Jäch & Balke, 2008). In this chapter, we will focus on the families Dryopidae, Elmidae, and Psephenidae, which belong to the superfamily Byrrhoidea.

Dryopidae is an ecologically diverse family, with some members being aquatic, while others are completely terrestrial or semiaquatic. Only five aquatic genera are recognized in the Neotropical Region. They are found on the sandy banks of lotic habitats in soft stream substrate, while others occur on emergent vegetation and sticks protruding from streams. They are often collected near lights at night; for these the habitat is unknown. In the terrestrial dryopids, adults and larvae can be found in forest leaf litter.

This family contains about 300 species in 33 genera worldwide. Dryopids occur in all biogeographic regions, but they are absent from the Australian continent.

Elmidae contains the taxa commonly called "riffle beetles," and it is the largest family of aquatic Byrrhoidea. It includes small- to medium-sized aquatic beetles that are common in running waters with high oxygen content. This family shows a worldwide distribution, though much of their diversity occurs in the Neotropical Region. Riffle beetles are always aquatic as larvae, whereas adults can be aquatic (Elminae) or riparian (Larainae).

Elmidae is a widespread family with two subfamilies, Elminae and Larainae, both present in the Neotropical Region. Riffle beetles are very common in lotic habitats and

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are extraordinarily diverse: there are 47 genera and about 440 species described in this region (Manzo, 2013; Segura et al., 2013).

Psephenidae, or "water penny beetles," are reported for all continents except Antarctica, and they are quite diverse in the Neotropics. The adults are terrestrial, and larvae are strictly aquatic. The larvae are highly modified for a life in fast-flowing water: their very flattened body and the powerful claws permit them to explore food sources on the exposed surfaces of rocks while maintaining their position and resisting swift currents.

The family contains about 272 species in 35 genera. They are comprised of four subfamilies: Eubrianacinae, Eubriinae, Psepheninae, and Psephenoidinae. According to Fernandez et al. (2001), seven genera occur in the Neotropical Region.

LIMITATIONS

There have been few studies on aquatic Dryopidae in the Neotropical Region, perhaps due to the difficulty in collecting specimens in the flow of streams and rivers. The last work concerning the Neotropics is Shepard & Chaboo (2015).

Detailed studies of the Psephenidae are lacking, perhaps due the difficulty in associating their aquatic larvae with adults that are often found out of the water. Recently, work by Shepard & Barr (2014) resulted in the description of a new genus and new species, indicating there is still much work to be done on Neotropical Psephenidae.

Elmidae is the best studied family in Byrrhoidea; however, much of the diversity, particularly in the Neotropics, still awaits discovery. The lack of work on the group is likely due to their small size and external morphologic homogeneity. Also, the larvae of many genera are not known, or remain unassociated with their adult form; as a result, the key presented only applies to genera for which associated larvae are documented in the literature.

TERMINOLOGY AND MORPHOLOGY

Adults of Dryopidae are morphologically characterized by (1) anterior coxae transverse and with exposed trochantin; antennae usually short, with apical articles pectinate or lamellate and forming a club; and (2) female genitalia without styli, usually asymmetrical and resembling two knife blades, functioning as ovipositors; about 4–8 mm long. The larvae feature the following: body cylindrical, with abdominal sternites and pleurites greatly reduced, the tergites almost forming complete rings on first five segments and forming complete ones on segments 6–9; without retractile gills; abdominal spiracles lateral on segments 1–7 and dorsal on segment 8. Larvae of Dryopidae are unlikely to be found in streams (Brown, 1972).

Adults of the elmid subfamily Elminae are aquatic, body scarcely pubescent with plastron, procoxae globose, and trochantin not exposed; adults of the subfamily Larainae are occasionally aquatic, generally fly readily, body densely pubescent, procoxae transverse, and trochantin exposed. Elmid larvae are completely aquatic and are characterized by vermiform to onisciform body, abdomen nine-segmented with retractile tracheal gills.

Psephenidae adults can be distinguished by the following combination of characters: broadly ovoid in body shape and very much flattened, lateral margins of each segment greatly expanded, and the head completely concealed from a dorsal view by the expanded anterior pronotal margin (water pennies). The larvae are rather broad and depressed; the mandibles are typically concealed; and the labrum usually not visible from in front (Brown, 1972).

MATERIAL PREPARATION AND PRESERVATION

Methods used for the collection and preservation of Hydraenidae are similar to those used for other aquatic Coleoptera, which are explained in Chapter 15.

KEYS TO DRYOPIDAE, ELMIDAE, AND PSEPHENIDAE

Keys to these families are in Chapter 15.0.

Dryopidae: Genera (Adults)

1	Dorsal surface matte or with a dense coating of long, erect setae (Figs. 15.6.1 B, D); antennae with 11 or 13 antennomeres (Fig. 15.6.2 B) 2
1'	Dorsal surface shining, with only sparse setae (Fig. 15.6.1 A); antennae with 9–10 antennomeres (Fig. 15.6.2 A) ..... *Elmoparnus*
2(1)	Pronotum without sublateral carinae or incomplete sulci (Fig. 15.6.3 B); pronotum and elytral pubescence variable. 3

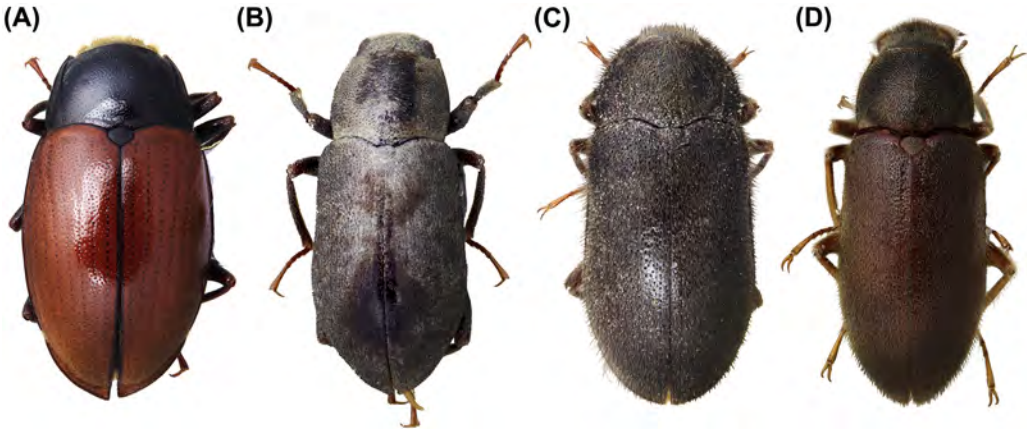

FIGURE 15.6.1 Dryopidae (Coleoptera) adults, habitus in dorsal view: (A) *Elmoparnus*, (B) *Helichus*, (C) *Dryops* sp., (D) *Pelonomus* sp.

FIGURE 15.6.2 Dryopidae (Coleoptera) adults head, frontal view, showing antenna: (A) *Elmoparnus*, (B) *Pelonomus*. *Helichus* (C) head, oblique view, showing expanded antennomere.

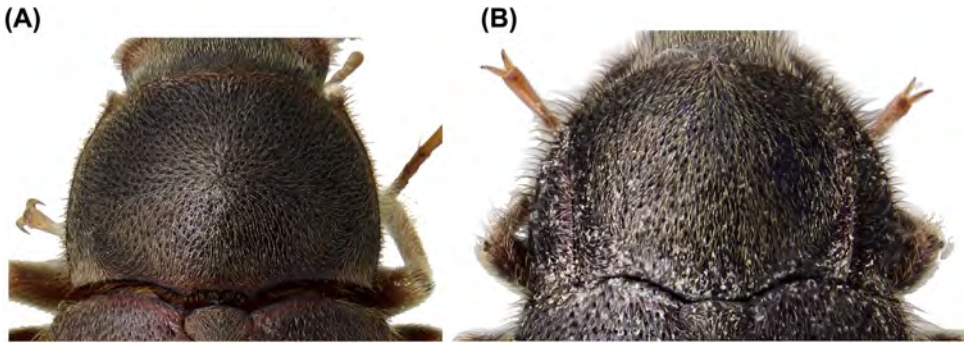

FIGURE 15.6.3 Dryopidae (Coleoptera) adults pronotum, dorsal view, showing sublateral carinae: (A) *Dryops*, (B) *Pelonomus*.

2' Pronotum usually with sublateral sulci (Fig. 15.6.3 A); elytron margin apical fourth without pubescent depression; pronotum and elytra densely and conspicuously pubescent (Fig. 15.6.1 C)..... *Dryops*

3(2) Antenna article II not dilated (Fig. 15.6.2 B); dorsum typically densely pubescent, with conspicuous setae 4

3' Antenna article II dilated, which may partially enclose apical antennomeres (Fig. 15.6.2 C); dorsum typically matte, lacking dense, conspicuous setae (Fig. 15.6.1 B) ..... *Helichus*

4(3) Antennae with 11 antenommeres (Figs. 15.6.1 D, 2 B) ..... *Pelonomus*
4' Antennae with 13 antenommeres ..... *Onopelmus*

Elmidae: Subfamilies (Adults)

1 Adults occasionally aquatic, generally fly; body densely pubescent, without plastron; procoxae transverse, trochantin exposed ..... **Larainae [p. 586]**
1' Adults aquatic; body not or scarcely pubescent, with plastron; procoxae globose and trochantin not exposed ..... **Elminae [p. 586]**

Elmidae: Larainae: Genera (Adults)

1 Body size 2.5−4.5 mm 2
1' Body size 5.1−10.1 mm 7
2(1) Elytron without accessory basal stria (Fig. 15.6.6 A) 3
2' Elytron with one accessory basal stria (Figs. 15.6.4 C, 6 B) ..... *Hydora*
[Argentina, Chile]
3(2) Pronotum without a transverse groove, or with a shallow, wide, V-shaped groove across apical third (Figs. 15.6.5 D, F) 4
3' Pronotum with a deep transverse groove across apical third (Fig. 15.6.5 B) 6
4(3) Pronotum apical third with a shallow, wide, V-shaped groove (Fig. 15.6.5 D); southern Venezuela and Northern Brazil. 5
4' Pronotum without a transverse groove (Figs. 15.6.4 G, 5 F) ..... *Phanocerus*
[Central America, Caribbean, Colombia, Peru. Nearctic]
5(4) Dorsal and ventral surfaces with similar pilosity, setae erect and light brownish; protibiae lacking tomentum fringe (Figs. 15.6.4 D, 6 C) ..... *Hypsilara*
5' Dorsal and ventral surfaces with different pilosity, dorsal setae erect and light brownish. ventral setae recumbent, dense, and silvery (Figs. 15.6.4 F, 6 F); protibiae with tomentum fringe (Fig. 15.6.6 D) ..... *Phanoceroides*
6(3) Pronotum with a median groove and without small prescutellar foveae; pronotum anterolateral angles rounded (Figs. 15.6.4 H, 5 E) ..... *Pharceonus*
[Costa Rica, south to Venezuela]
6' Pronotum without a median groove and with two small prescutellar foveae; anterolateral angles of pronotum declivous (Figs. 15.6.4 B, 5 B) ..... *Hexanchorus*
[Mexico, south to Peru and Caribbean]
7(1) Elytron without distinct longitudinal carinae (Fig. 15.6.4 B) 8
7' Elytron with distinct longitudinal carinae (Fig. 15.6.4 K) ..... *Roraima*
[Venezuela]
8(7) Pronotum apical third with a distinct transverse groove (Fig. 15.6.5 H) 9
8' Pronotum apical third without a transverse groove (Figs. 15.6.4 A, 15.6.5 A) ..... *Disersus*
[Costa Rica, south to Peru]
9(8) Pronotum basal third with a lateral longitudinal carina or arcuate-sinuate groove (Fig. 15.6.5 C) 10
9' Pronotum basal third without a carina or arcuate-sinuate groove (Fig. 15.6.5 H) 11
10(9) Pronotum basally with two prescutellar mammiform tubercles and each posterolateral angle with one similar tubercle, thus appearing bidentate (Figs. 15.6.4 I, 5 G). ..... *Pseudodisersus*
[Panama, south to Ecuador]
10' Pronotum with two short, converging, prescutellar carinae, each with a deep pit laterally (Figs. 15.6.4 E, 5 C) ..... *Neblinagena*
[Venezuela]
11(9) Body narrow; prosternal process sagittate, tapering apically (see Spangler & Santiago 1992: Fig. 215) ..... *Hispaniolara*
[Hispaniola]
11' Body broad; prosternal process apically ligulate (Figs. 15.6.4 J, 6 E) ..... *Potamophilops*
[Argentina, Brazil]

Elmidae: Elminae: Genera (Adults)

1 Eyes and wings greatly reduced or absent, Greater Antilles: Hispaniola 2
1' Eyes fully formed, wings variable 3
2(1) Eyes absent: pronotal sublateral carinae arcuate (see Spangler, 1981 Fig. 1) ..... *Annomatelmis*
2' Eyes greatly reduced; pronotal sublateral carinae sinuate (see Spangler, 1981 Fig. 2) ..... *Lemalelmis*
3(1) Head prognathous (Fig. 15.6.13 F); pronotum variable, but not as previous 4
3' Head opisthognathus (Fig. 15.6.7 L); pronotum with strong anterior and posterior depression adjacent to lateral margin, transverse groove at apical 1/3 and strong oblique groove in basal 1/3; without sublateral carinae (Fig. 15.6.9 F) ..... *Luchoelmis*
4(3) Head, pronotum and elytra with large dorsal areas with plastron (Fig. 15.6.9 L), ventral areas of body with plastron; pronotum without carinae and depressions (Fig. 15.6.9 L); elytra without carinae, may have longitudinal rows of granules (Fig. 15.6.8 K) 5
4' Plastron mainly on ventral surface of body, if present dorsally, then only as small areas (Fig. 15.6.9 G); pronotum usually with carinae and depressions, seldom absent (Figs. 15.6.7 E, 9 G); elytra with or without longitudinal carinae (Figs. 15.6.7 M, 11 B) 6

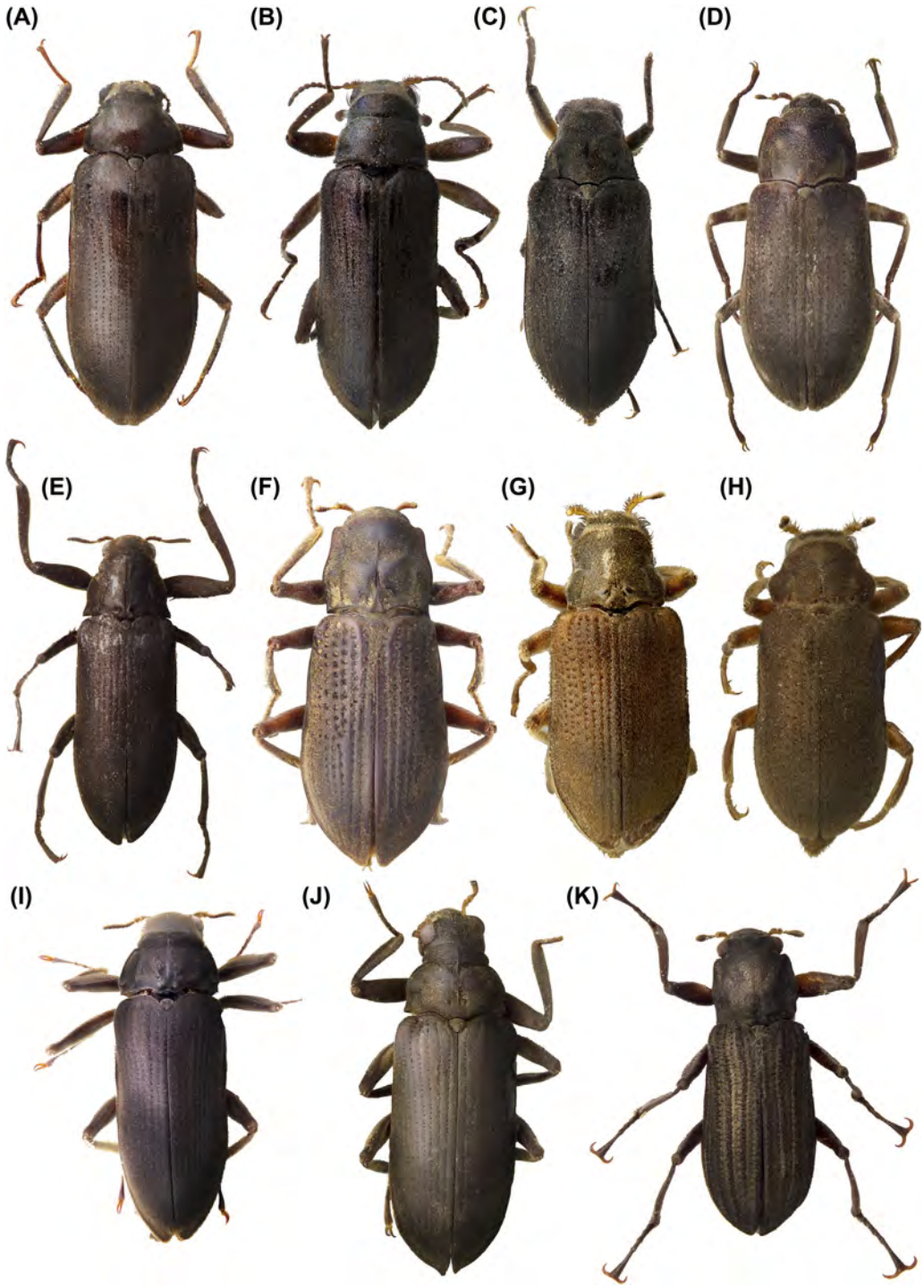

FIGURE 15.6.4 Larainae (Elmidae: Coleoptera) adult, habitus in dorsal view: (A) *Disersus dasycolus* Spangler & Santiago-Fragoso; (B) *Hexanchorus dentitibialis* Maier, (C) *Hydora annectens* Spangler & Brown; (D) *Hypsilara royi* Maier & Spangler; (E) *Neblinagena doyeli* Kodada & Jäch; (F) *Phanoceroides* sp.; (G) *Phanocerus clavicornis* Sharp, (H) *Pharceonus volcanus* Spangler & Santiago-Fragoso; (I) *Pseudodisersus goudotii Guérin-Méneville*, (J) *Potamophilops bostrychophallus* Maier, (K) *Roraima carinata* Kodada & Jäch.

5(4) Tibiae without cleaning fringe (Fig. 15.6.12 A); prosternal process margins parallel and narrow, width ~1/3 length (Figs. 15.6.8 F, 10 C); male metatrochanters with apicoventral tubercle ..... *Pagelmis*

5' Tibiae with apical cleaning fringes (Fig. 15.6.12 B); prosternal process large and wide (Fig. 15.6.10 D); male metatrochanters without apicoventral tubercle (Fig. 15.6.8 K) ..... *Stenhelmoides*

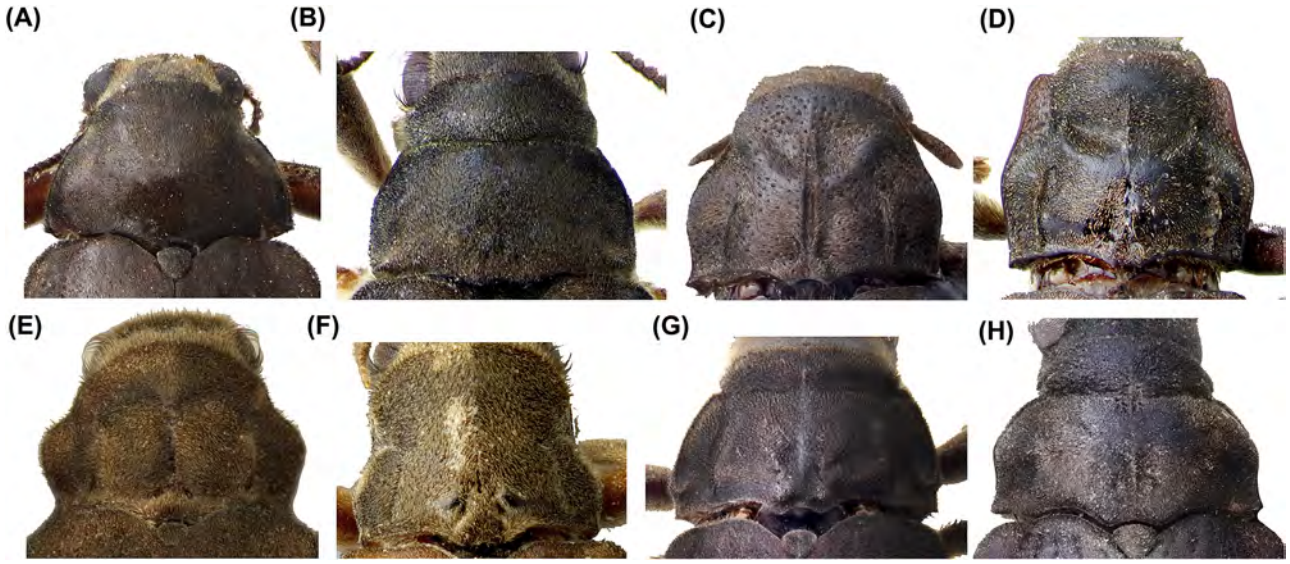

FIGURE 15.6.5 Larainae (Elmidae: Coleoptera) adult pronotum, dorsal view, showing sculpture: (A) *Disersus dasycolus* Spangler & Santiago-Fragoso, (B) *Hexanchorus falconensis* Maier, (C) *Neblinagena prima* Spangler, (D) *Phanoceroides* sp., (E) *Pharceonus volcanus* Spangler & Santiago-Fragoso, (F) *Phanocerus clavicornis* Sharp, (G) *Pseudodisersus goudotii* Guérin-Méneville, (H) *Potamophilops bostrychophallus* Maier.

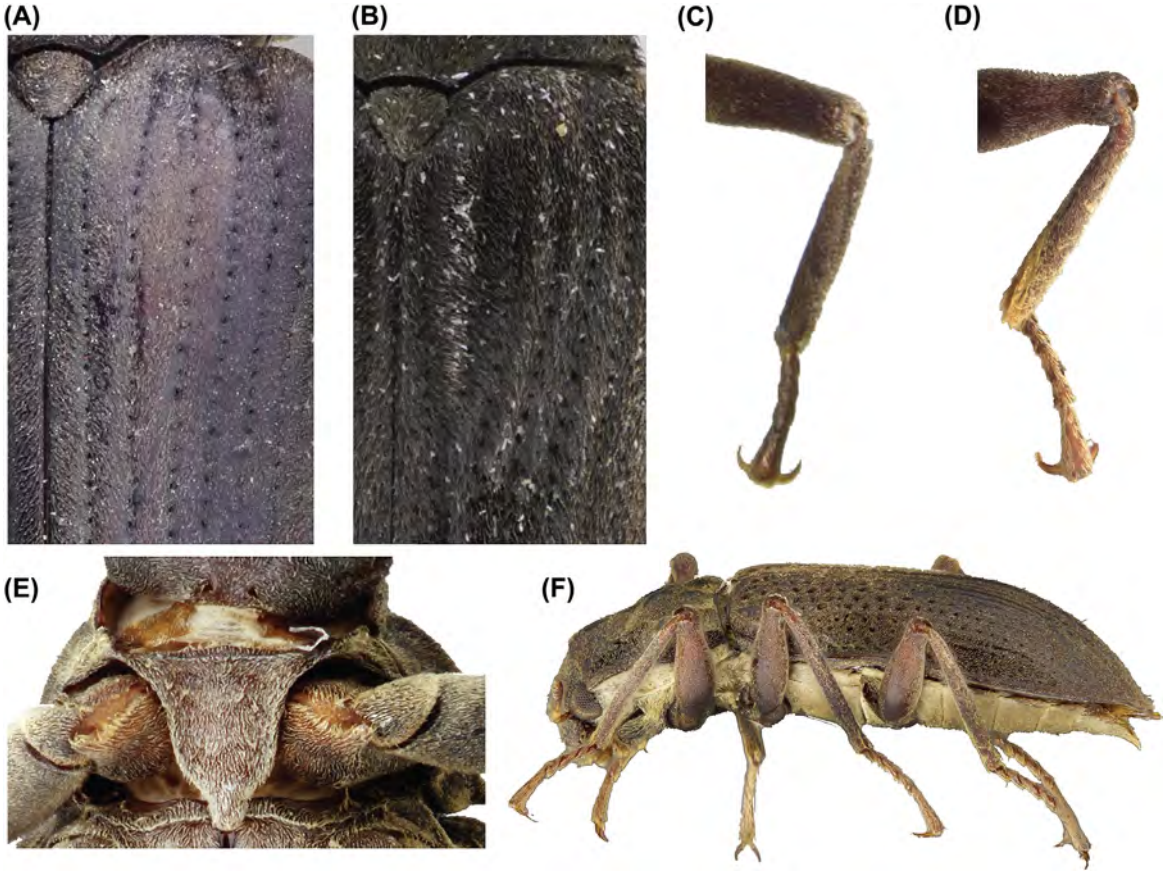

FIGURE 15.6.6 Larainae (Elmidae: Coleoptera) adults. (A) *Potamophilops bostrychophallus* Maier elytron, showing striae. (B) *Hydora annectens* Spangler & Brown elytron, showing accessory stria. (C) *Hypsilara royi* Maier & Spangler protibia, showing setation. (D) *Phanoceroides* sp. protibia, showing setation, with cleaning fringe of tomentum. (E) *Potamophilops bostrychophallus* Maier prosternum, ventral view. (F) *Phanoceroides* sp. habitus, lateral view, showing ventral setation of the plastron.

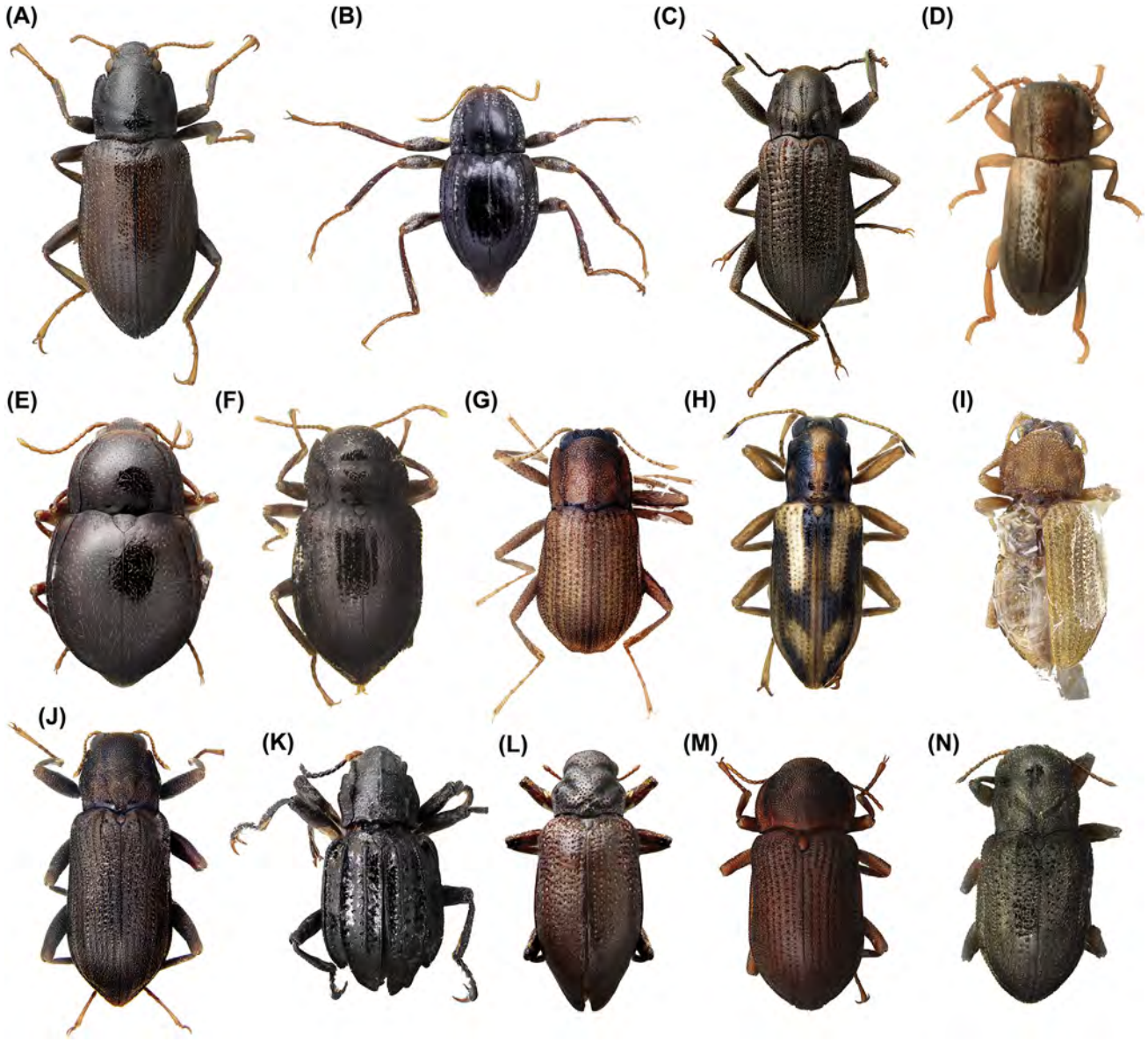

FIGURE 15.6.7 Elminae (Elmidae: Coleoptera) adults, habitus in dorsal view. (A) *Austrelmis consors* Brown; (B) *Austrolmnius* sp.; (C) *Cylloepus* sp.; (D) *Elachistelmis tetramera* Maier; (E) *Gyrelmis* sp.; (F) *Heterelmis* sp.; (G) *Hexacylloepus* sp.; (H) *Hintonelmis* sp.; (I) *Holcelmis woodruffi* Hinton; (J) *Huleechius* sp.; (K) *Jolyelmis* sp.; (L) *Luchoelmis penai* Spangler & Staines; (M) *Macrelmis* sp.; (N) *Microcylloepus similis* (Horn).

6(4) Epipleura without longitudinal line of granules (Fig. 15.6.13 A)..... 7
6' Epipleura with one or two longitudinal lines of granules (Figs. 15.6.7 B, 13 B); elytra with prominent sublateral carinae on fifth and seventh intervals (Fig. 15.6.11 A) ..... *Austrolimnius*
7(6) Elytron without accessory stria (Fig. 15.6.11 A)..... 8
7' Elytron with short accessory stria (Figs. 15.6.7 M, 11 F)..... *Macrelmis*
8(7) Pronotum and elytra without rounded gibbosities or protuberances (Fig. 15.6.7 E); pronotum and elytra generally with sublateral carinae 9
8' Pronotum basal 1/3 with rounded gibbosities or protuberances, usually four transversally, sometimes sublateral gibbosities absent, but medial ones always present (Fig. 15.6.9 O); pronotum with or without longitudinal depression and sublateral carinae; elytra with coarse punctate striae, humeral and subapical areas usually with gibbosities or protuberances (Fig. 15.6.8 J)..... *Stegoelmis*
9(8) Protonotum and elytra with one or two longitudinal carinae (Fig. 15.6.11 B), sometimes absent, metasternum variable, but not as follows 10
9' Pronotum and elytra with three high, longitudinal carinae (Fig. 15.6.7 K); metasternum on each side of disc with an arcuate, lateral carina; each metacoxal cavity with an arcuate carina extending to posterior margin of first abdominal ventrite (Fig. 15.6.13 D)..... *Jolyelmis*
10(9) Elytra without sublateral carinae on intervals fifth and seventh (Fig. 15.6.11 G)..... 11

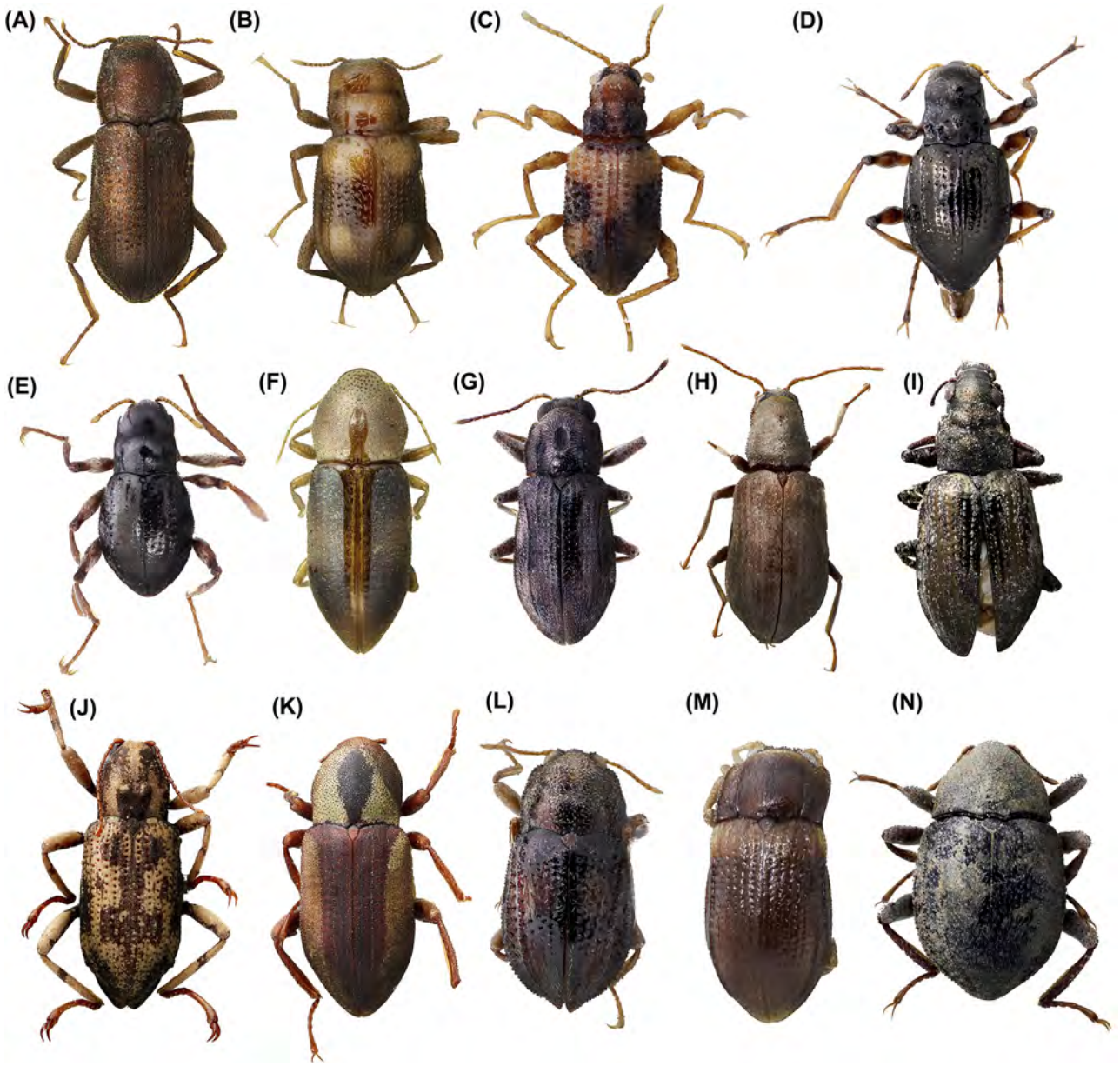

FIGURE 15.6.8 Elminae (Elmidae: Coleoptera) adults, habitus in dorsal view. (A) *Neocylloepus boeseli* Brown; *Neoelmis* sp.; (C) *Neolimnius palpalis* Hinton; (D) *Notelmis* sp.; (E) *Onychelmis* sp.; (F) *Pagelmis amazônica* Spangler; (G) *Pilielmis sara* Hinton; (H) *Portelmis nevermanni* Sanderson; (I) *Stethelmis kaszabi* Hinton; (J) *Stegoelmis* sp.; (K) *Stenhelmoides rufulus*-group; (L) *Tolmerelmis pubipes* (Hinton); (M) *Tyletelmis* sp.; (N) *Xenelmis* sp. [AU2]

10'	Elytra with sublateral carinae on fifth and seventh intervals (Figs. 15.6.7 E, 11 B)	*Gyrelmis*
11(10)	Tarsal claws with one or two teeth (basal and subbasal) (Figs. 15.6.12 E, F)	12
11'	Tarsal claws without teeth (Fig. 15.6.12 D)	15
12(11)	Tarsal claws with only basal tooth (Fig. 15.6.12 F)	13
12'	Tarsal claws with basal and subbasal teeth (Figs. 15.6.8 E, 12 E)	*Onychelmis*
13(12)	Elytra usually without carina, but if present not on fourth interval; pronotum not as previous (Fig. 15.6.11 C)	14
13'	Elytra fourth interval basally with short granule row, with part of interval subcarinate; sixth interval with sublateral carina (Figs. 15.6.8 G, 11 G); pronotum with sublateral carinae, disc center with distinct oval depression, each side of disc in basal 1/5 with another distinct oval depression against sublateral carina (Fig. 15.6.9 M)	*Pilielmis*
14(13)	Hypomera and sides of mesosternum with tomentum; prosternum short, prosternal process long, moderately narrow with apex rounded; protibiae without cleaning fringes; elytra without carina (Fig. 15.6.8 I)	*Stethelmis*

FIGURE 15.6.9 Elminae (Elmidae: Coleoptera) adults head and pronotum. dorsal view. (A) *Austrelmis consors* (Hinton); (B) *Elachistelmis tetramera* Maier; (C) *Heterelmis* sp.; (D) *Hexanchorus* sp.; (E) *Holcelmis woodruffi* Hinton; (F) *Luchoelmis penai* Spangler & Staines; (G) *Macrelmis* sp.; (H) *Microcylloepus similis* (Horn); (I) *Neoelmis* sp.; (J) *Neolimnius palpalis* Hinton; (K) *Notelmis* sp.; (L) *Pagelmis amazónica* Spangler; (M) *Pilielmis sara* Hinton; (N) *Portelmis nevermanni* Sanderson; (O) *Stegoelmis selva* Spangler; (P) *Tolmerelmis pubipes* (Hinton); (Q) *Tyletelmis* sp.; (R) *Xenelmis* sp.

14' Hypomera anteriorly with tomentum, mesosternum without tomentum; prosternum long, prosternal process subquadrate, as broad between coxae as length of coxae, apex bisinuate; protibiae with cleaning fringes; elytra usually with carinae on sixth and eighth intervals, seldom absent (Figs. 15.6.7 H, 11 C) ..... *Hintonelmis*

15(11) Lacinia and galea very long (Fig. 15.6.13 E) 16

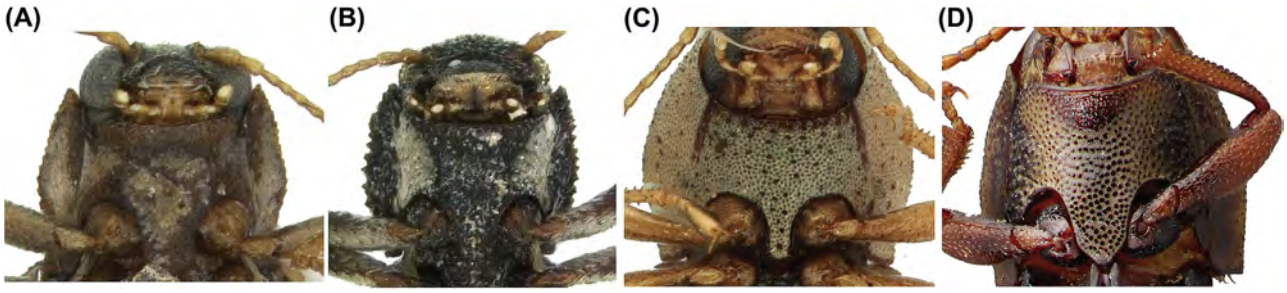

FIGURE 15.6.10 Elminae (Elmidae: Coleoptera) adults prosternum. (A) *Hexanchorus* sp.; (B) *Microcylloepus* sp.; (C) *Pagelmis amazônica* Spangler; (D) *Stenhelmoides variabilis* Spangler.

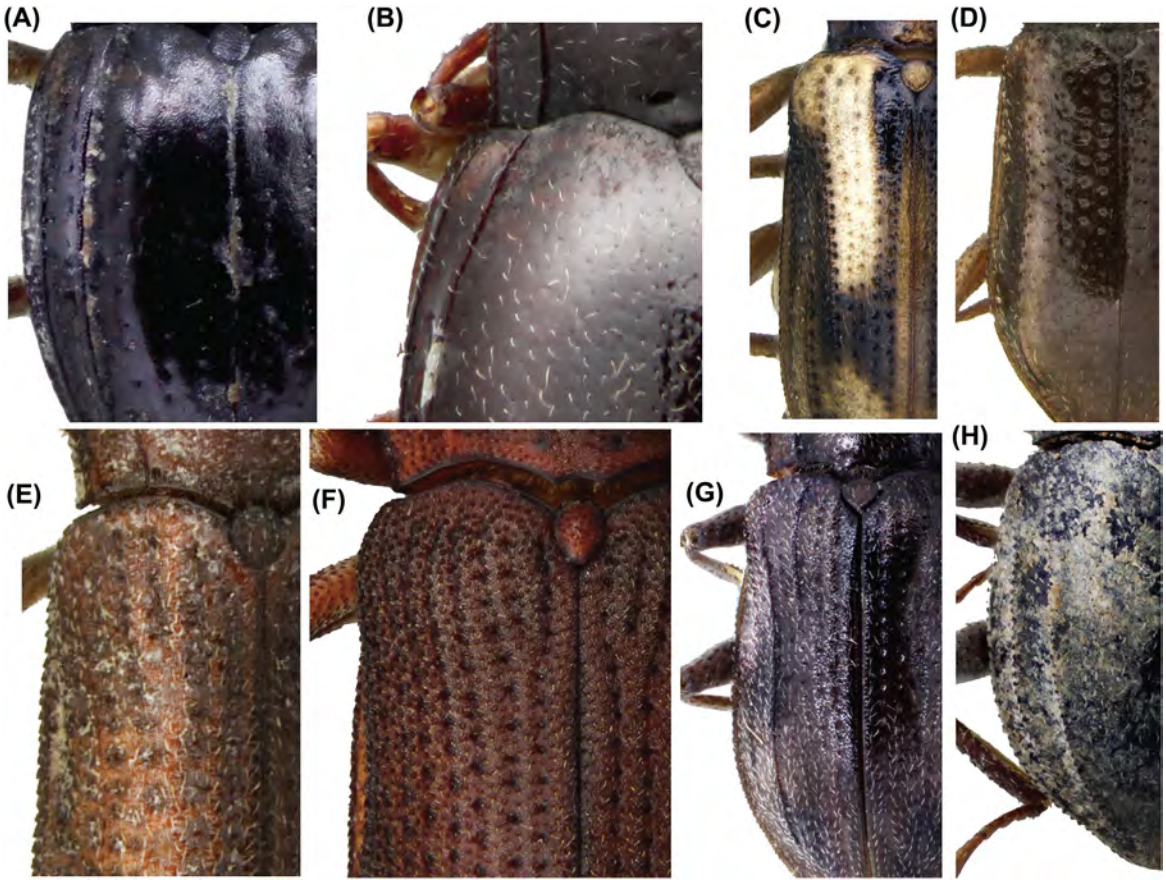

FIGURE 15.6.11 Elminae (Elmidae: Coleoptera) adults, left elytron. (A) *Austrolmnius* sp.; (B) *Gyrelmis* sp.; (C) *Hintonelmis* sp.; (D) *Neoelmis* sp.; (E) *Macrelmis* sp.; (F) *Macrelmis* sp.; (G) *Pilielmis sara* Hinton; (H) *Xenelmis* sp.

15'	Lacinia and galea short and broad	17
16(15)	Pronotum heavily sculptured, apical 2/5 with deep and complete transverse depression, each side of basal 1/4 of sublateral carinae with a nearly complete sublateral longitudinal carina and sublateral carina (Fig. 15.6.9 J); pronotum basal margin in front of scutellum not emarginate; tarsal formula 5-5-5 (Fig. 15.6.8 C)	*Neolimnius*
16'	Pronotum smooth, lacking transverse depression on apical 2/5, with complete sublateral and lateral carinae (Figs. 15.6.7 D, 9 B); tarsal formula 4-4-4 (Fig. 15.6.12 C) or 5-5-5	*Elachistelmis*
17(15)	Disc of pronotum without longitudinal depression (Fig. 15.6.9 R)	18
17'	Disc of pronotum with medial longitudinal depression (Fig. 15.6.9 D)	25
18(17)	Body broad, oval, usually small (2.2 mm) (Fig. 15.6.8 N); pronotum without depressions, subtriangular (Fig. 15.6.9 R)	19
18'	Body sides subparallel (Fig. 15.6.7 G); pronotum subrectangular, sublateral carinae and depressions present or absent (Fig. 15.6.9 D)	21

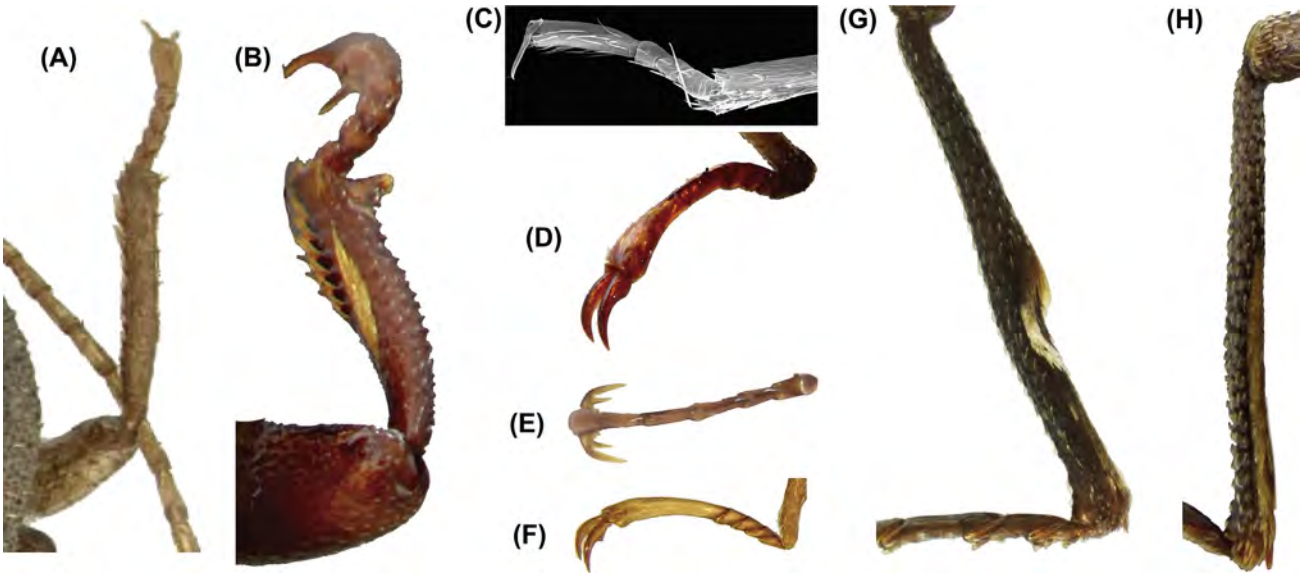

FIGURE 15.6.12 Elminae (Elmidae: Coleoptera) adults, leg. Protibia: (A) *Pagelmis amazônica* Spangler; (B) *Stenhelmoides variabilis* Spangler. Tarsus: (C) *Elachistelmis tetramera* Maier; (D) *Stegoelmis* sp.; (E) *Onychelmis* sp.; (F) *Hintonelmis* sp. tarsos. Metatibia: (G) *Huleechus* sp.; (H) *Cylloepus* sp.

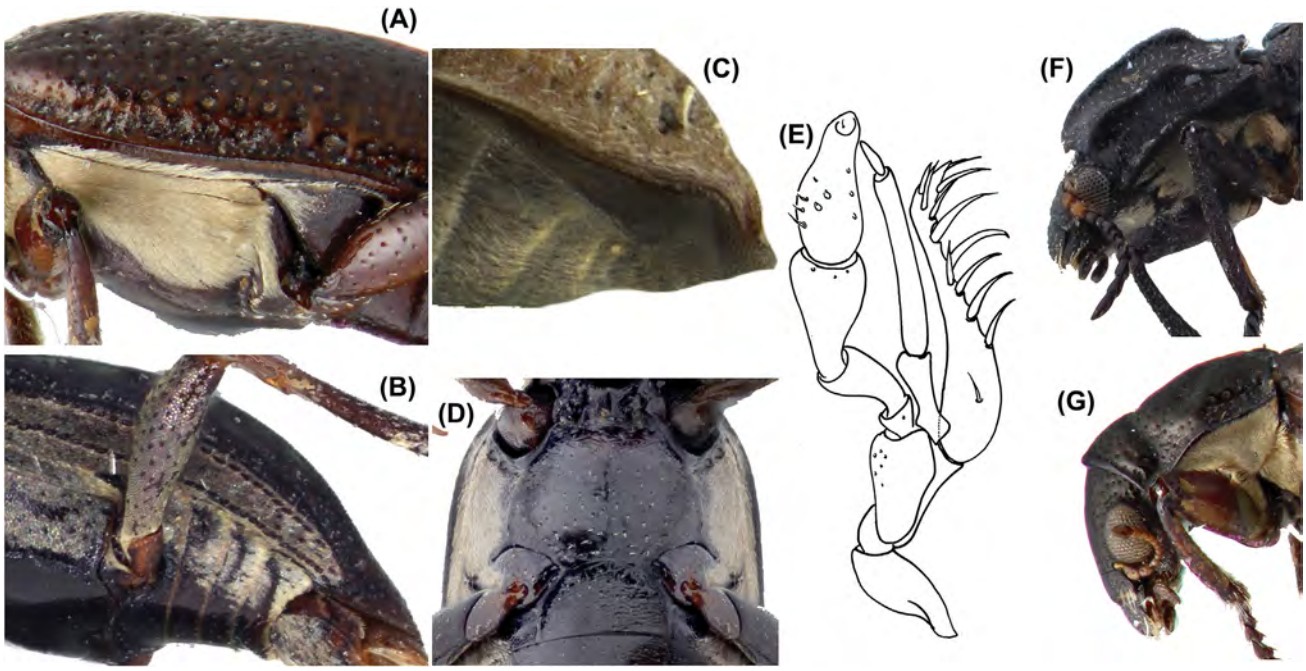

FIGURE 15.6.13 Elminae (Elmidae: Coleoptera) adults, thorax and abdomen, partial lateral view. (A) *Luchoelmis penai* Spangler & Staines epipleuron without granules; (B) *Austrolmnius* sp., epipleuron with granules. (C) *Portelmis nevermanni* Sanderson elytron, lateral view, showing posterior excavation. (D) *Jolyelmis* sp.metasternum and fist abdominal ventrite, showing carinae. (E) *Elachistelmis tetramera* Maier maxilla. Head, lateral view: (F) *Jolyelmis* sp., prognathous mouthparts; (G) *Luchoelmis penai* Spangler & Staines, opisthognathous mouthparts.

19(18)	Body length <2 mm; pronotum tomentose, without sublateral carinae (only *X. granata* presents a sublateral carina extending from base to about apical 1/4) or depressions (Fig. 15.6.9 R) 20
19’	Body length >2 mm; pronotum not tomentose, nearly complete sublateral carinae present (See Hinton, 1939, Fig. 40); elytra with sublateral carinae composed of low rows of granules ..... *Oolimnius*
20(18)	Elytra lacking sublateral carinae, body elongate in overall habitus..... *Xenhelmoides*
20	Elytra with two sublateral carinae (Fig. 15.6.8 N), body rounded in overall habitus (Fig. 15.6.8 N)..... *Xenelmis*

21(18) Pronotum and elytra generally carinate (Fig. 15.6.11 D). Elytra without marginal excavation near elytral apex 22
21' Pronotum usually without carinae (Fig. 15.6.9 N); if present each carina is short and basal; elytra without carinae, but with subapical deep, lateral, marginal excavation (Fig. 15.6.13 C), accompanied by prolonged lateral margins of the fifth sternite, which fits into this cavity (Fig. 15.6.8 H) ..... *Portelmis*
22(21) Pronotum without transverse depression, if present never complete (Fig. 15.6.9 A); elytra with one or two sublateral carinae 23
22' Pronotum with deep and complete transverse depression on anterior 2/5 and with sublateral carinae (Fig. 15.6.9 I); elytra with sublateral carina on sixth interval (Fig. 15.6.8 B); body sometimes very small (Fig. 15.6.8 B)..... *Neoelmis*
23(22) Pronotum with carinae well-developed, transverse depression generally present, carinae never divided at base (Fig. 15.6.9 D). Elytra with one or two carinae 24
23' Pronotum with or without sublateral carinae; if present, carinae much higher and more prominent on apical half; if carinae extend to the base, they are completely divided at basal 2/5 by an oblique depression; transverse depression absent or very shallow (Fig. 15.6.9 A); elytra with two, one, or no sublateral carinae (if present, carinae are on intervals 6 and 8) (Fig. 15.6.7 A)..... *Austrelmis*
24(23) Body sides subparallel (Fig. 15.6.8 M); pronotum with well-developed carinae extending from base to about apical 1/6 (Fig. 15.6.9 Q); elytra with one carina (Fig. 15.6.8 M)..... *Tyletelmis*
24' Body subovate (Fig. 15.6.7 F); pronotum with sublateral carinae, which extend from base to anterior margin; pronotal disc generally with or rarely without a transverse depression at middle (Fig. 15.6.9 C); elytra with carinae on sixth and eighth intervals (Fig. 15.6.7 F)..... *Heterelmis*
25(17) Pronotum without transverse depression (Fig. 15.6.9 D); posterior cleaning fringe of middle tibia in males short 26
Pronotum with shallow transverse depression on basal 2/5 and sublateral carina well-developed; disc of pronotum with a broad, deep, median longitudinal depression (Fig. 15.6.9 P); posterior cleaning fringe of middle tibia, in male, exceptionally long (Fig. 15.6.8 L)..... *Tolmerelmis*
26(25) Hypomera completely tomentose or with complete transverse belt of tomentum (Fig. 15.6.10 A)..... 27
26' Hypomera without tomentum, shining (Fig. 15.6.10 B); occasionally a very narrow belt of tomentum adjacent to sternonotal suture or near procoxae present 29
27(26) Hypomera with a belt of tomentum on anterior part (Fig. 15.6.10 A) 28
27' Hypomera completely tomentose..... *Epodelmis*
28(26) Sides of pronotum strongly dilated (Fig. 15.6.9 E); prosternum and first abdominal sternite disc without sublateral carinae; cuticule without hard and rigid aspect (Fig. 15.6.7 I) ..... *Holcelmis*
28' Sides of pronotum not dilated (Fig. 15.6.9 D); prosternum and first abdominal sternite disc with sublateral carinae; cuticle hard and rigid (Fig. 15.6.7 G) ..... *Hexacylloepus*
29(26) Pronotum with oblique and transverse depressions (Fig. 15.6.9 H); longitudinal depressions sometimes present..... 30
29' Pronotum without oblique and transverse depressions; longitudinal depressions present 31
30(29) Pronotum with sublateral carina and a transverse depression, with a median longitudinal discal depression; basal half on each side with an oblique depression (Fig. 15.6.9 H); elytra with two sublateral carinae (sometimes with one or three) (Fig. 15.6.7 M); epipleura rarely tomentose (Fig. 15.6.7 M)..... *Microcylloepus*
30' Pronotum without sublateral carina; disc with deep and complete transverse depression and median longitudinal depression present; pronotum base with lateral, shallow, oblique depression (Fig. 15.6.9 K); elytra with two sublateral carinae; epipleura tomentose (Fig. 15.6.8 D) ..... *Notelmis*
31(29) Labium with gula distinctly narrower than submentum and mentum; elytra with two sublateral carinae; hind wing without 3A2; male tibiae with pronounced secondary sexual characters (Figs. 15.6.7 J, 2 G)..... *Huleechius*
31' Labium with gula as wide as submentum and mentum; elytra with two sublateral carinae; hind wing with 3A2; male tibiae variable (Figs. 15.6.7 C, 12 H)..... *Cylloepus*

Elmidae: Elminae: Genera (Larvae)

See Limitations section.

1 Body strongly flattened dorsoventrally (platyform larvae); thorax and abdomen lateral margins falcate; abdominal segments I–VIII with pleural sclerites 2
1' Body cylindrical, subcylindrical or slightly flattened dorsoventrally (eruciform larvae); thorax and abdomen lateral margins never falcate; abdomen with pleural sclerites on segments I–IV, I–V, I–VI, I–VII, I–VIII, or pleural suture on abdominal segments I–IX..... 4
2(1) Prothorax ventrally with five sclerites, one anteriolateral pair, one lateral pair, and one posteromedian; thoracic and abdominal sclerite lateral margins strongly falcate 3
2' Prothorax ventrally with two large anteriolateral sclerites, one on each side, and a prosternal sclerite (Fig. 15.6.14 A); thoracic sclerite margins rounded; abdominal sclerite margins slightly falcate..... *Phanoceroides* [Brazil]
3(2) Last abdominal segment not abruptly narrowed at middle, apex slightly emarginated (Fig. 15.6.14 B)..... *Phanocerus*
3' Last abdominal segment abruptly narrowed at middle, apex deeply emarginate (Fig. 15.6.14 C)..... *Pharceonus*
4(1) Body shape variable; abdominal segment IX without pleural suture 5
4' Body cylindrical; pleural suture extending to middle of abdominal segment IX..... *Cylloepus*
5(4) Second antennomere sensory appendage short, < first antennomere; abdominal segment pleural sclerites number variable; thoracic and abdominal segment tubercles arrangement variable 6

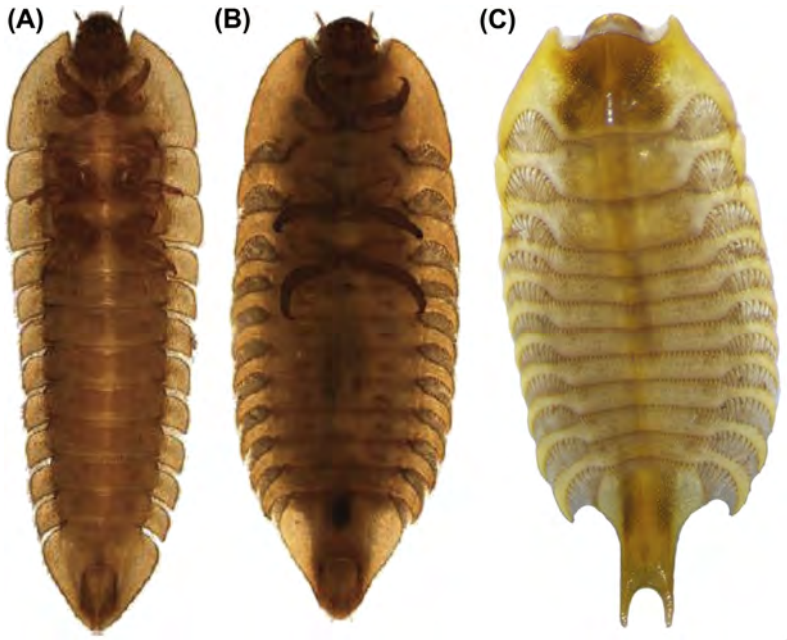

FIGURE 15.6.14 Larainae (Elmidae: Coleoptera) larva, habitus. (A) *Phanoceroides* sp., ventral view; (B) *Phanocerus clavicornis* Sharp, ventral view; (C) *Pharceonus volcanus* Spangler & Santiago-Fragoso dorsal view.

5’	Second antennomere sensory appendage very long, ≥ first antennomere; abdominal segments I−VII with pleural sclerites; thoracic and abdominal segment tubercles arranged in a variable number of longitudinal rows ..... *Austrolimnius*
6(5)	Abdominal segments I−V, I−VI, or I−VII with pleural sclerites 7
6’	Abdominal segments I−IV with pleural sclerites (Fig. 15.6.15 B) ..... *Luchoelmis*
7(6)	Abdominal segments I−V with pleural sclerites 8
7’	Abdominal segments I−VI or I−VII with pleural sclerites 9
8(7)	Body elongate, subcylindrical; meso-, metathoracic, and abdominal segment terga lateral margins slightly expanded; abdominal segment VI with an incomplete pleural suture; mature larva length to 15.5 mm ..... *Pseudodisersus*
8’	Body elongate, narrowing behind abdominal segment I; meso-, metathoracic, and abdominal segment terga lateral margins not expanded; abdominal segment VI without a pleural suture; mature larva length to 6.0 mm ..... *Stethelmis*
9(7)	Abdominal segments I−VI with pleural sclerites, segment VII sometimes may have a partial pleural suture; procoxal cavities open .. 10
9’	Abdominal segments I−VII with pleural sclerites; procoxal cavities open or closed 13
10(9)	Prothorax ventrally with seven sclerites: one anterolateral pair, two lateral pairs, and one anteromedian sclerite; meso- and metathorax ventrally with five sclerites: one anterior sclerite and two lateral pairs; body shape variable. Mature larvae over 4.0 mm long 11
10’	Prothorax ventrally with four sclerites: one anterior pair, one posterior pair; meso- and metathorax ventrally with seven sclerites: one anterior and three lateral pairs (Fig. 15.6.15 C); body convex, hemispherical in cross section; mature larva length to 3.0 mm ..... *Xenelmis*
11(10)	Body cylindrical or subcylindrical, sides subparallel; last abdominal segment apex emarginate; abdominal segment VIII posterior margin without large tubercles; abdominal terga I−VIII with tubercles arranged in longitudinal rows; length to 10.0 mm 12
11’	Body fusiform, slightly dorsoventrally depressed; last abdominal segment apically rounded; abdominal segment VIII posterior margin with a large tubercle on each side; abdominal terga I−VIII without tubercles arranged in longitudinal rows; length to 5.0 mm (Fig. 15.6.16 A) ..... *Hexanchorus* [Widespread]
12(11)	Body cylindrical, sides subparallel; prothorax and abdominal segments I−VIII with tergal tubercles arranged in four longitudinal rows, those of meso- and metathorax arranged in six rows; abdominal segment IX length < length of abdominal segments V−VIII combined; length to 16.0 mm ..... *Disersus*
12’	Body subcylindrical; thorax and abdominal segments I−VIII with tergal tubercles arranged in one longitudinal row on each side of median line (sometimes absent); abdominal segment IX length > length of abdominal segments V−VIII combined (Fig. 15.6.16 B); length to 10.0 mm ..... *Stegoelmis*
13(9)	Last abdominal segment variable in shape and length, but never with length 3× width 14
13’	Last abdominal segment long and slender, length 3× width (Fig. 15.6.16 C) ..... *Hexacylloepus*
14(13)	Procoxal cavities closed; cuticle with tubercles and setae but not as follows 15
14’	Procoxal cavities open; cuticle with modified setae and granules: prominent, round granules, each granule with rounded, adpressed scale with venous surface structures; papillate projections, each projection with an elongate scale with venous surface structures; small, flat, elliptical granules with short, fringed setae; clavate setae with setose surface and fine, moderately long, filiform setae ..... *Roraima*

FIGURE 15.6.15 Elminae (Elmidae: Coleoptera) larva, habitus in dorsal view. (A) *Austrelmis* sp.; (B) *Luchoelmis* sp.; (C) *Xenelmis* sp.

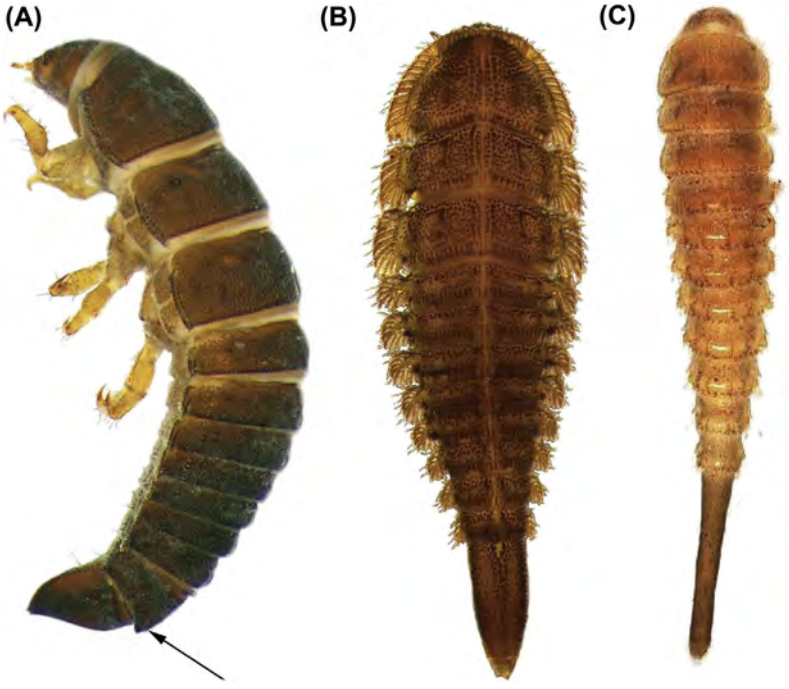

FIGURE 15.6.16 Elminae (Elmidae: Coleoptera) larva, habitus. (A) *Hexanchorus* sp., lateral view; (B) *Stegoelmis* sp., dorsal view; (C) *Hexacylloepus* sp., dorsal view.

FIGURE 15.6.17 Elminae (Elmidae: Coleoptera) larva, habitus in dorsal view. (A) *Neoelmis* sp.; (B) *Macrelmis* sp.; (C) *Huleechius* sp.

FIGURE 15.6.18 Elminae (Elmidae: Coleoptera) larva, habitus in dorsal view. (A) *Microcylloepus* sp.; (B) *Heterelmis* sp.

15(14) Meso- and metathorax ventrally with five sclerites: one anterior subpentagonal, and two lateral pairs; thoracic and abdominal terga with setiferous tubercles, sometimes arranged in longitudinal rows 16

15' Meso- and metathorax ventrally with seven sclerites: one anterior subpentagonal, and three lateral pairs; thoracic and abdominal terga with setiferous tubercles arranged (although sometimes partially) in longitudinal rows 21

16(15) Meso- and metathoracic terga lateral margins not bent ventromedially; meso- and metathorax with five ventral sclerites: one anterior, subpentagonal, and two lateral pairs conspicuous, subrectangular 17

16' Meso- and metathoracic terga lateral margins terga strongly bent ventromedially; meso- and metathorax with five ventral sclerites: one anterior, subpentagonal, and two lateral pairs subtriangular (one pair inconspicuous, under the tergite margin) ..... *Hydora*

17(16) Head capsule anterior border with a tooth on each side, between base of antennae and clypeus or on the sides of the clypeus 18

17' Head capsule anterior border without teeth (Fig. 15.6.17 A) ..... *Neoelmis*

18(17) Frons anterior border with a large blunt tooth on each side, between base of antennae and clypeus; clypeus lateral margin without teeth; body shape variable 19

18' Frons anterior border without teeth between base of antennae and clypeus; clypeus lateral margin with a small tooth on each side; body subtriangular; cuticle usually with dark markings; abdominal segment IX tergum usually with a median keel (Fig. 15.6.15 A) ..... *Austrelmis*

19(18) Body subcylindrical, not flattened; thoracic and first eight abdominal terga as wide as long 20

19' Body flattened dorsoventrally; thoracic and first eight abdominal terga wider than long; suture from procoxal cavity to lateral margin conspicuous; mature larva dark brown, almost black (Fig. 15.6.17 B) ..... *Macrelmis*

20(19) Abdominal segment IX tergum with a median keel; suture from procoxal cavity to lateral margin conspicuous ..... *Neocylloepus*

20' Abdominal segment IX tergum convex, without median keel; suture from procoxal cavity to lateral margin inconspicuous (Fig. 15.6.17 C) ..... *Huleechius*

21(15) Pronotum and abdominal segment IX tergal tubercles randomly distributed, not forming longitudinal rows; remaining terga tubercles arranged in longitudinal rows (Fig. 15.6.18 A) ..... *Microcylloepus*

21' Thorax and first eight abdominal segments with tergal tubercles arranged in 8 or 10 longitudinal rows; abdominal segment IX tergal tubercles arranged in two median and two lateral rows (Fig. 15.6.18 B) ..... *Heterelmis*

Psephenidae: Genera (Larvae)

Modified from Archangelsky et al. (2009) following Artigas (1963), Spangler(1968), Fernández et al. (2001), and Jerez & Moroni (2006).

1	Abdominal segment IX without ventral operculum or gill chamber; abdominal segments with variable number of gills 2
1'	Abdominal segment IX with operculum or gill chamber; abdominal segments without gills 5
2(1)	Abdominal segment VIII without lateral expansions; abdomen with four or five pairs of gills 3
2'	Abdominal segment VIII with lateral expansions; abdomen with four pairs of gills ..... *Eubrianax*
3(2)	Abdomen segments II to VI with five pairs of gills 4
3'	Abdomen with four pairs of gills ..... *Pheneps*
4(3)	Clypeus emarginate; frons with long seta, close to frontoclypeal suture and antenna base; pleural sclerites with lower and anterior margin glabrous ..... *Psephenus*
4'	Clypeus truncate; frons without seta; pleural sclerites with lower and anterior margin with short setae densely arranged in a pecten pattern ..... *Psephenops*
5(1)	Abdominal segment IX gill chamber with three gill tufts; thoracic and abdominal pleurae expansions separate ..... *Ectopria*
5'	Abdominal segment IX gill chamber with two gill tufts; thoracic and abdominal pleurae expansions adjacent ..... *Tychepsephenus*

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Chapter 15.7

Family Scirtidae

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Chapter Outline

INTRODUCTION

Scirtidae comprises over 1800 species distributed worldwide, although the highest diversity of the family is in the tropics and the temperate parts of the Southern Hemisphere. This family is commonly known as "marsh beetles" since larvae often inhabit shallow bodies of stagnant water full of decaying plant material. Larvae, however, are found in other lotic and lentic habitats, including lowland ditches, ponds, microhabitats within rivers and streams, phytotelmata formed both in tree holes and leaf axils, and groundwater as deep as 10 m (Klausnitzer & Pospisil, 1991). Moreover, some larvae are terrestrial and live in wet soil or moist, rotten logs (Ruta et al., 2017). Preference of a particular kind of habitat is usually genus specific, and some geographic correlations can be observed as well. In tropical and subtropical lowland forests, a great diversity of species is especially common in phytotelmata formed in different families of plants (e.g., Agavaceae, Amaryllidaceae, Araceae, and Bromeliaceae, see Greeney, 2001). Cloud forests, tepuis, and high-altitude ecosystems, like paramo formation, are insufficiently studied and host some of the most interesting and the least studied taxa (Ruta, 2016).

Larvae go through 9−12 instars (Zwick & Hecht, 2008; Zwick & Zwick, 2008, 2010), and all are detritus feeders. Mature larvae usually leave the water and pupate in damp soil. Most genera pupate freely exposed or covered, but building pupal cells seems to be rare in Scirtidae (Zwick & Zwick, 2008). Pupal development is often much shorter than in many other families of Coleoptera and takes 1−11 days depending on the genus (Yoshitomi, 2005; Zwick & Zwick, 2008). *Scirtes hemisphaericus* (Linnaeus) (Palearctic), *S. tibialis* Guérin-Méneville (Nearctic), and all species of *Hydrocyphon* (Palearctic and Oriental), however, pupate underwater (Leech & Chandler, 1974; Zwick & Zwick, 2008; Klausnitzer, 2009). Adults are terrestrial, usually inhabit riparian vegetation, and are generally short lived. Scirtidae are commonly pollinophagous (Yoshitomi, 2005; Watts, 2007), although their diet also includes fungal spores and detritus (unpublished). Suggestions on predatory habits of Scirtidae (Klausnitzer, 1967; Lawrence, 2005) were based on morphology of mandibles only and are erroneous.

Scirtidae belong to the least known families of water beetles. Almost 10 years ago, Jäch & Balke (2008) estimated the total number of Scirtidae as 1700. Today, we already know 1800 species, and this is very likely less than a third of the actual number of existing species. It is even more evident in the case of South America, where 200 species are only a small fraction of the real number of species we expect.

We follow the classification of the family proposed by Lawrence & Yoshitomi (2007). About 1800 described species, 69 genera, and 3 subfamilies are presently recognized. In the Neotropical Region, ca. 200 species are known, classified in 10 genera and 2 subfamilies, as follows: Stenocyphoninae (one genus: *Stenocyphon*; one species) and Scirtinae (13 genera: *Anticyphon*, *Chilarboreus*,

Thorp and Covich's Freshwater Invertebrates, Fourth Edition. https://doi.org/10.1016/B978-0-12-804223-6.00028-7

Contacyphon, *Exagonthus*, *Ora*, *Prionocyphon*, *Prionoscirtes*, *Pseudomicrocara*, and *Scirtes* genera). One of the undescribed genera has terrestrial larva that inhabits wet logs (saproxylic) and lacks eyes (Fig. 15.7.1 C). An enigmatic monotypic Brazilian genus *Pentameria* is probably congeneric with one of the saltatorial genera, like *Ora* or *Scirtes* (Friedenreich, 1883).

Of the 10 described genera in the Neotropical Region, only five (*Contacyphon*, *Ora*, *Pseudomicrocara*, *Scirtes*, and *Prionocyphon*) have their mature larvae known; all of them are aquatic and have well-developed eyes (Figs. 15.7.1 A, B). *Ora*, *Pseudomicrocara*, *Scirtes*, and *Prionocyphon* have relatively long, reaching abdomen, antenna (Fig. 15.7.1 A), whereas *Contacyphon* has relatively short, not reaching mesothorax, antenna (Fig. 15.7.1 B). Note that the placement of Neotropical species in the genus *Contacyphon* is preliminary. The mandibles of *Ora* have an obtuse apex (Fig. 15.7.1 F) and maxillary palpomere 4 long, approximately as long as palpomere 3 (Fig. 15.7.1 I). *Pseudomicrocara*, *Scirtes*, and *Prionocyphon*, by contrast, have mandibles with acute apex (Figs. 15.7.1 D, E) and the maxillary palpomere 4 is short, less than 0.5x as long as palpomere 3 (Figs. 15.7.1 G, H). *Pseudomicrocara* has a mandible with bifid apex (Fig. 15.7.1 E), while *Scirtes* and *Prionocyphon* have a mandible with simple apex (Fig. 15.7.1 D). *Scirtes* has tergite 9 with apical setae well-separated (Fig. 15.7.1 L) and lobe of clypeolabrum with five inner setae (Fig. 15.7.1 J). On the other hand, *Prionocyphon* has tergite 9 with apical setae close together (Fig. 15.7.1 M) and lobe of clypeolabrum with nine inner setae (Fig. 15.7.1 K).

LIMITATIONS

Studies on South American Scirtidae date back to 1775 when *Pseudomicrocara livida* Fabricius was described (Ruta, 2013); but despite a long research history, the Neotropical fauna was never treated comprehensively. Except for a few recently described or redescribed species (Lawrence, 2001; Ruta, 2011, 2013; Libonatti & Ruta, 2013; Libonatti, 2014, 2015, 2017; Ruta, 2016; Ruta & Libonatti, 2016), most species are known from original descriptions that date back to the 19th century and the beginning of the 20th century. These are mainly brief, undetailed descriptions that are usually devoid of illustrations. Moreover, many species were misplaced in the Palearctic genera *Elodes* and *Microcara* (Ruta, 2011). Given that many of the species were described in 19th century, and were never redescribed, identification of Neotropical scirtids is difficult, and often impossible without examination of type specimens. In the last years, some local revisions of genera were published (Libonatti & Ruta, 2013; Libonatti, 2014, 2015, 2017; Ruta, 2016).

Adults and larvae may be identified to family level using the keys provided by Trémouilles et al. (1995), Benetti et al. (2006), and Archangelsky et al. (2009). Adults may be then identified to genus level using the valuable keys proposed by Trémouilles et al. (1995), for the genera found in Argentina and bordering countries, and by Ruta (2011) for genera of Chilean Scirtidae. So far, no key to all Neotropical genera, based either on adults or larvae, has ever been published. Since 50% of the genera in this region have described larvae, it is not possible to provide a safe identification key for this life stage.

Although they primarily focus on other biogeographic regions and include only some Neotropical genera, several contributions provide valuable keys to identify larvae of genera from the Nearctic (Leech & Chandler, 1974; White & Roughley, 2008), Florida (USA) (Epler, 2010), Japan (Yoshitomi, 2005), west Palearctic (Klausnitzer, 2009), and Australia (Watts, 2014).

TERMINOLOGY AND MORPHOLOGY

Adults are relatively soft-bodied, usually finely pubescent, slightly flattened to very convex, ovate to elongate, and range between 1−15 mm long, although Neotropical species rarely exceed 6 mm. It is noteworthy, however, that Chilean *"Elodes" russeli* Solier, 1849 is one of the largest representatives of the family, reaching length of 11 mm. Body coloration is often pallid, brown, black, and sometimes presents a distinctive elytral pattern or easily noticeable metallic hue. Many scirtids have enlarged metafemora and, therefore, can jump, like Chrysomelidae Halticinae, with whom they are often confused.

Larvae are elongated, slightly depressed, and sclerotized both in dorsal and ventral parts. Antennae are long and multiarticulate (a feature unique among the Holometabola). The head is wider than long, prognathous, with the labrum fused to clypeus. Mandibles, maxillae, the epipharynx, and the hypopharynx are highly specialized for detritus feeding. Legs are pentamerus, including a hamulate pretarsus. The abdomen has nine segments, and the tracheal system is metapneustic, with the eighth segment bearing the only pair of functional spiracles. Larvae have five digitiform anal papillae, which are involved in osmoregulation and measure oxygen content in water (Wichard & Komnick, 1974; Lawrence, 2005).

A more detailed description of the general morphology is found in Lawrence (2005), Yoshitomi (2005), and Klausnitzer (2009). Larval mouthparts were described in detail by Beier (1949), Hannappel (1991), and Hannappel & Paulus (1991).

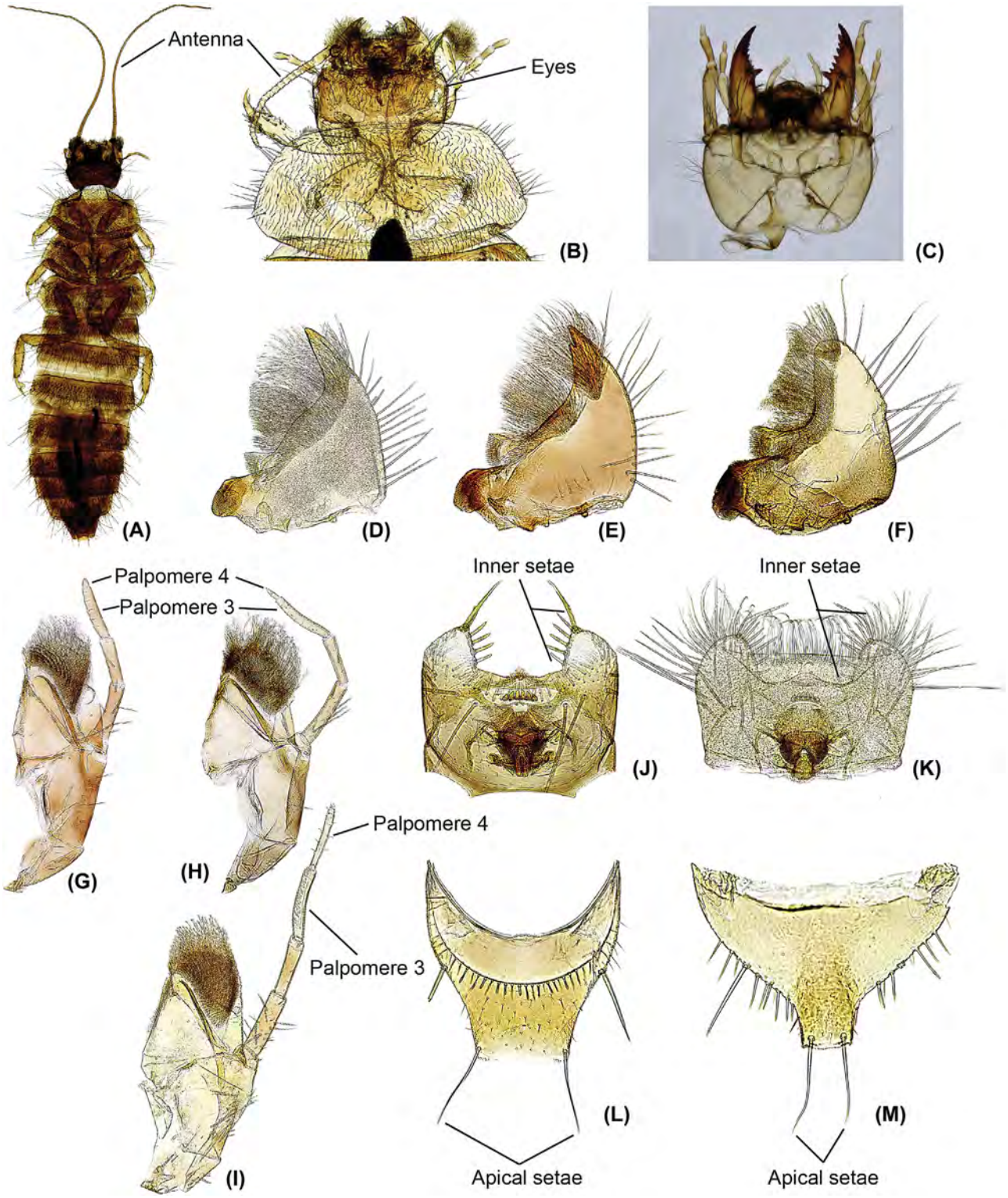

FIGURE 15.7.1 Scirtidae (Coleoptera), larval morphology: (A) *Scirtes* sp. (Argentina) habitus, dorsal view (antennae broken); (B) *Contacyphon cadornai* Pic, head and prothorax, dorsal view; and (C) saproxylic larva, head, dorsal view. Left mandible in ventral view: (D) *Prionocyphon* sp.; (E) *Pseudomicrocara antarctica* Libonatti & Ruta; and (F) *Ora depressa* (Fabricius). Left maxilla, ventral view: (G) *P. antarctica*; (H) *Scirtes* sp.; and (I) *O. depressa*. Clypeolabrum in ventral view: (J) *Scirtes* sp.; and (K) *Prionocyphon* sp. Tergite 9: (L) *Scirtes* sp.; and (M) *Prionocyphon* sp.

MATERIAL PREPARATION AND PRESERVATION

Larvae are collected using the same techniques as employed for other aquatic insects. A wide variety of collecting methods is detailed by Archangelsky et al. (2009) and Campos de Oliveira & Oliveira Pes (2014). Larvae inhabiting dendrotelms tend to float under the water surface when disturbed, and hence, their presence can be easily detected. Larvae inhabiting phytotelmata are collected either sucking out the water accumulated within the plant using a turkey baster or extracting the plant and examining the leaves thoroughly. Larvae living in running waters can be usually collected from underside of submerged stones or pieces of wood. Note that in many cases, even in the areas where adults are common, it is often difficult to locate larvae. Adults are captured using conventional techniques for collecting other terrestrial insects, such as sweeping and beating vegetation, and light and Malaise trapping. Larvae and adults are fixed and preserved in 75%–96% ethanol for examination purposes, and in 100% ethanol or propylene glycol for DNA sequencing. Pampel's fluid can also be recommended, as it preserves color pattern and will keep larvae flexible. Identification of larvae may often be impossible due to poor knowledge of Neotropical Scirtidae. In such cases, rearing is the easiest way to associate larvae and adults of a species. Several attempts have been undertaken, and it seems that rearing larvae developing in stagnant water as well as running water habitats is not difficult (see Zwick, 2007; Zwick & Zwick, 2010; and Watts, 2014 for details). Association of larvae and adults may be also achieved by molecular techniques (Watts, 2014; Cooper et al., 2014).

Identification of larvae to genus level requires close examination of clypeolabrum, mandibles, maxillae, and hypopharynx (abdominal segments 8th and 9th are also recommended to confirm determination) under a compound microscope. To soften and clear the larvae, place the specimens in 10% KOH or 10% NaOH overnight, or in lactid acid for a couple of days. The mouthparts and apical abdominal segments are then dissected and mounted on glass slides with commonly used mounting media, like polyvinyl-lacto-glycerol, gum-chloral medium or Euparal.

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