

Chapter 15 Order Ephemeroptera

The Ephemeroptera, or mayflies, is the most primitive and ancient group of aquatic insects. They have two adult stages, the **subimago** and the **imago**. Both adult stages are short lived and do not feed. Mayflies are cosmopolitan and found in various freshwater habitats ranging from streams and rivers to standing ponds. Taxon richness is greater in lotic habitats. All nymphal stages are aquatic. Nymphs have gills on various abdominal segments, and the last abdominal segment bears three **caudal filaments**, although occasionally the middle one is absent or reduced. Nymphs feed mainly on algae on rock surfaces, on fine-particle detritus or on suspended particles. Only a very few mayflies are predators. Mayflies are used extensively as indicators to assess pollution and environmental change.

Ephemeroptera is a small order of insects, with about 3,000 described species and more than 375 genera and 37 families (Brittain & Sartori, 2003). The ephemeropteran fauna of the Indochina region is relatively poorly studied compared to that of temperate regions (Soldán, 2001). Only the Leptophlebiidae, Neoephemeridae and Potamanthidae have been treated in detail (Peters & Edmund, 1970; Bae & McCafferty, 1991, 1998). To date, approximately 58 genera and species of 18 ephemeropteran families have been recorded from the region, and many unclear taxonomic identifications at the generic level remain. This reflects a need in taxonomic studies for the immature stages to be associated with their respective adults. The following keys of Ephemeroptera of Indochina are modified from several publications (Allen, 1971; Bae & McCafferty, 1991, 1998; Dudgeon, 1999; Hubbard, 1994; Nguyen, 2003; Peters, 1967; Peters & Edmunds, 1970; Sites *et al.*, 2001; Soldán & Braasch, 1984).

KEY TO FAMILIES, GENERA AND KNOWN SPECIES OF MATURE MAYFLY NYMPHS (EPHEMEROPTERA) OF INDOCHINA

- 1 Body smooth and hemispherical (beetle-like); all gills and much of the abdomen covered by a thoracic shield (Fig. 1); PROSOPISTOMATIDAE, *Prosopistoma* ...2
- 1' Body form not as above; abdominal gills partially or completely exposed 5

- 2(1) Mesonotum with posterior and anterior dark brown band separated, with light band as wide as anterior dark one (Fig. 1) *P. funanense*
- 2' Mesonotum with connected band with numerous pale spots or bands separated by narrow W-shaped lighter band (Fig. 2a, 3a) 3

- 3(2') Antennae 4 segmented (Fig. 2c); apical segment of maxillary palps longer than 1/3 length of segment II (Fig. 2b) *P. sinense*
- 3' Antennae usually 5 segmented (sometimes 4 segmented, if 4 segmented they have apical segment of maxillary palps a little shorter than 1/3 length of segment II) ... 4

- 4(3') Apex of inner margin of fore tibiae with 6 or 7 serrated spines (Fig. 3c); segment III of maxillary palps a little shorter than 1/3 length of segment II (Fig. 3b)..... *P. annamense*
- 4' Apex of inner margin of fore tibia with 8 equal-sized fine serrated spines (Fig. 4b); segment III of maxillary palps a little longer than 1/3 length of segment II *P. wouterae*
- 5(1') Head and prothorax with conspicuous crown of bristles; without mandibular tusks; gill ventral; legs are modified for burrowing (Fig. 6a) BEHNINGIIDAE...6
- 5' Head and prothorax lacking crowns of bristles; mandibular tusks present (Fig. 7b); gill lateral or dorsal; legs not modified for burrowing..... 7
- 6(5) Tibiae of hindlegs not reduced (Fig. 5b), tarsi of forelegs fused to tibiae (Fig. 5a), claw present *Protobehningia* (*P. merga*)
- 6' Tibiae of hindlegs reduced (Fig. 6b), tarsi of forelegs not fused to tibiae (Fig. 6a), claw absent *Behningia*
- 7(5') Mandibles with tusk-like projection (except some species of *Afromera* (Fig. 17) bear atrophied tusk); gill II-VII double and uniform in structure with fringed margin (Fig. 7a,8,16a), gill I variable 8
- 7' Mandibles without tusk-like projection, gills otherwise 19
- 8(7) Legs slender for running or crawling, tibiae cylindrical; gills project laterally (Fig. 7a) 9
- 8' Legs (especially tibiae) robust or flattened for digging; gills angled backwards dorsally over the body (Fig. 16a)..... 14
- 9(8) Mandibular tusks with numerous distinct long setae (Fig. 7b); caudal filaments with inconspicuous fine setae (Fig. 7a)..... EUTHYPLOCIDAE, *Polyplocia*
- 9' Mandibular tusks lacking long setae (Fig. 8) or have only inconspicuous setae (Fig. 9b); caudal filaments with distinct long setae POTAMANTHIDAE...10
- 10(9') Mandibular tusks roughly equal to or longer than the length of the head *Rhoenanthus*...11
- 10' Mandibular tusks shorter than one half of the length of the head (Fig. 8) *Potamanthus* (*Potamanthodes*) (*P. formosus*)
- 11(10') Mandibular tusks with a large lateral spine (so that the tusks appear forked) (Fig. 10); maxillary palp slender, with weakly-developed setae on the terminal segment..... *Rhoenanthus* (*Rhoenanthus*)...12

- 11' Mandibular tusks lack a large lateral spine (not appearing apically forked) (Fig. 9a-b), but sometimes have a small lateral spine; mandibular tusks strongly convergent and abruptly curved inward; maxillary palp thick, with strongly-developed setae on the terminal segment..... *Rhoenanthus (Potamanthindus)*... 13
- 12(11) Leg unicolorous, at most with diffuse smudges; 28-46 simple stout setae and 4-5 bipectinate hair-like setae laterally on mandibles; no medial row of spines developed (Fig. 10) *R. (R.) speciosus*
- 12' Leg with conspicuous dark marking (band and stripes) (Fig. 11b); 40-55 simple stout setae and about 15 simple hair-like long setae laterally on mandibles (Fig. 11c); bipectinate setae absent; medial row of 15-20 spines well developed.....
..... *R. (R.) distafurcus*
- 13(11') Mandibular tusks greatly long (1.4x length of head), gradually curved inward; body large (18.2-21.2 mm) *R. (P.) magnificus*
- 13' Mandibular tusks moderately long (0.8x length of head), abruptly curved inward; body medium sized (12.5-16.7 mm)..... *R. (P.) obscurus*
- 14(8') Tusks curved inwards, inner edges concave (Fig. 12)..... POLYMITARCYIDAE... 15
- 14' Tusks curved outwards, inner edges convex (Fig. 16b) 16
- 15(14) Slender tusk with setae and small tubercles (Fig. 12) ; a single gill on abdominal segment I..... *Ephoron*
- 15' Broad and flat tusks which are strongly toothed close to the apex (Fig. 13).....
..... *Povilla*
- 16(14')..... Broad, flat tusks with outer edge notched; tusks with shallow indentation along outer margin (Fig. 15a-b)..... PALINGENIIDAE
- 16' Tusks smooth and slender (Fig. 14, 16b)..... EPHEMERIDAE... 17
- 17(16') Frontal process on the head reduced; rather inconspicuous and not bifid (Fig. 14); mandibular tusks are triangular in cross-section; tarsal claws on forelegs reduced relative to those of the mid- and hindlegs..... *Eatonigenia*
- 17' Frontal process on the head well-developed and bifid (Fig. 16b); mandibular tusks are circular in cross-section; tarsal claws on forelegs not reduce 18
- 18(17') Mandibular tusks well-developed (Fig. 16a-b); abdominal gill I with two lobes of roughly equal size *Ephemera*
- 18' Mandibular tusks reduced or atrophied (Fig. 17); abdominal gill I asymmetrical with a relatively large outer lobe *Afromera*
- 19(7') Gills on abdominal segment II large and plate-like (operculate) (Fig. 18a, 19).... 20
- 19' Gills on abdominal segment II not greatly enlarged..... 27

20(19) Gills on abdominal segment II meet along the midline (Fig. 18a, 19).....	NEOPHEMERIDAE, <i>Potamanthellus</i> ...	21
20' Gills on abdominal segment II overlap along the midline (Fig. 20a).....	CAENIDAE...	23
21(20) Operculate gills with diagonal ridge (Fig. 18a).....		22
21' Operculate gills without diagonal ridge (Fig. 19).....	<i>P. edmundsi</i>	
22(21) Dorsal fore femora with transverse row of setae (Fig. 18b), abdominal terga VI- VIII with distinct posteromedian tubercle	<i>P. caenoides</i>	
22' Dorsal fore femora without transverse row of setae, abdominal terga VI-VIII with rudimentary posteromedian tubercle	<i>P. amabilis</i>	
23(20') Head with ocelli on raised tubercles (Fig. 20b)		24
23' Head lacks ocular tubercles (although ocelli are present)		25
24(23) Femora wide (three times wider than the tibiae); fore coxae nearly contiguous; maxillary and labial palps with 3 segments (Fig. 20c); posterolateral spines on abdomen segments IV-VII (Fig. 20a)	<i>Caenoculis</i>	
24' Femora narrow (no more than twice as the tibiae); fore coxae widely separated; maxillary and labial palps with 2 segments; posterolateral spines on abdomen segments III-VI, those on segment VI are strongly bent medially (Fig. 21a-b); the anterior margin of the mesosternum bear numerous long bristles.....	<i>Cercobrachys</i>	
25(23') Fore tibiae with two transverse rows of filtering setae (Fig. 22), long setae protruding from the front of the head between and below the antennae; gill covers with a simple ridge	<i>Clypeocaenis</i>	
25' Fore tibiae without two transverse rows of filtering setae; gill covers may have a triangular or Y-shaped ridge (Fig. 23a-b)		26
26(25') Gill covers with stout spines on the mesal fork of the triangular ridge; submarginal spine lacking but marginal fringe of hairs is present (Fig. 23b)	<i>Caenodes</i>	
26' Gill covers without stout spines on the upper surface, but a row of submarginal spines is present	<i>Caenis</i>	
27(19') ..Forelegs with conspicuous rows of long setae along the inner margins of femora and tibiae (Fig. 25b).....		28
27' Forelegs without rows of long setae along the inner margins		29
28(27) Body flat, gills are rather small (Fig. 24)	OLIGONEURIIDAE, <i>Chromarcys</i>	
28' Body streamlined (Fig. 25a), possession of coxal gill tufts (Fig. 25b).....	ISONYCHIDAE, <i>Isonychia</i>	

29(27') Flat plate-like head, with dorsally situated eyes, concealing the mouthparts when viewed from above; body dorsoventrally compressed (Fig. 29a, 30a, 32a)	HEPTAGENIIDAE...30
29' Mouthparts clearly visible from above; head not plate like	41
30(29) Two filaments at the end of the abdomen.....	31
30' Three filaments at the end of the abdomen.....	32
31(30) Gills I-VII modified to form 'sucking disc' (Fig. 26).....	<i>Iron</i>
31' Gills I-VII not modified to form 'sucking disc' (Fig. 27).....	<i>Epeorus</i>
32(30') Gills overlap ventrally to form a 'sucking disc' (Fig. 28).....	<i>Rhithrogena</i>
32' Gills not as above	33
33(32') Gill I with tracheal tufts well developed and lamellae reduced or vestiged	34
33' Gill not as above	35
34(33) Labrum laterally elongated; lamellae of gill III vestigial; lamellae of gill VII with hairs on lateral margin (Fig. 29a-e)	<i>Trichogenia (T. maxillaris)</i>
34' Labrum laterally triangular; lamellae of gill III developed; lamellae of gill VII without hairs	<i>Paegniodes</i>
35(33') Spiniform lateral process on segments II-VIII well develop (Fig. 30a-b)	<i>Thalerosphyrus</i>
35' Lateral processes less well develop or lacking.....	36
36(35') Lamellae of gills V and VI with pointed apical prolongation (Fig. 31a-b).....	<i>Cinygmmina</i>
36' Gills lamellate without apical prolongation.....	37
37(36') Gill VII lanceolate with pointed tip, 3x longer than broad and without tracheal tufts (Fig. 33a-b)	<i>Asionurus (A. primus)</i>
37' Gill VII not lanceolate, not more than twice as long as broad, with or without tracheal tufts	38
38(37') Fore femora with patches of stout setae on dorsal surface; gill VII with tracheal tufts	<i>Compsoeuria (C. thienemanni)</i>
38' Fore femora without patches of stout setae on dorsal surface; gill VII with or without tracheal tufts	39

39(38')	Caudal filaments with alternating segmented of light and dark bands.....	<i>Ecdyonurus</i>
39'	Caudal filament not as above.....	40
40(39')	Cerci bear spines as well as lateral bristles and segments of the cerci with stout spines alternate with those lacking such spines (Fig. 32); gills I-VII with row of sparse marginal set.....	<i>Rhithrogeniella (R. tonkinensis)</i>
40'	Cerci not as above; gills I-VII without row of sparse marginal setae	<i>Afronurus</i>
41(29')	Gills on abdominal segment II absent (Fig. 34-39)	EPHEMERELLIDAE...42
41'	Gills on abdominal segment II present (Fig. 44, 45).....	54
42(41)	Larvae with lamellate gills on abdominal segment III-VI; gill III operculate and completely covers the rest of the gill series; head bears tubercle (Fig. 34).....	<i>Hyrtanella</i>
42'	Larvae with lamellate gills on abdominal segment III-VII; gill III maybe semioperculate but does not cover the rest of the gill series completely; head may or may not bear tubercle or spine	43
43(42')	Gills on segment III-VII; gill III enlarged and semioperculate, covering most of remaining gills; maxillary palpi absent	<i>Torleya</i>
43'	Gills on segment III-VII; gill III not enlarged as above; maxillary palpi developed or absent.....	44
44(43')	Femora of mid- and hindlegs expanded and much broader than those of the forelegs; anterolateral corners of the pronotum projecting forward, and the anterior portion of the mesonotum is expanded (Fig. 35-38)	<i>Cincticostella</i> ...45
44'	Femora of forelegs either at least as broad or broader than those the mid- and hindlegs; pronotum and mesonotum not projecting or expanded.....	48
45(44)	Middle and hind femora narrow and margin entire; head without suboccipital tubercles; head with three pale maculae on fronts; maxillae without palpi (Fig. 35).	<i>C. gosei</i>
45'	Middle and hind femora expand and margin serrate; head with suboccipital tubercles.....	46
46(45')	Abdominal terga with paired submedian tubercles on segments I-X (Fig. 36a); fore femora with median band of tubercles; head, body and legs with numerous pale spots (Fig. 36b-c)	<i>C. insolta</i>
46'	Abdominal terga with paired submedian tubercles on segments II-X; fore femora without median band of tubercles; head, body and legs without numerous pale spots	47

- 47(46') Head quadrangular; abdominal terga with paired submedian tubercles on segments II-X (Fig. 37) *C. boja*
- 47' Head round; abdominal terga with paired submedian tubercles on segments IV-IX (Fig. 38) *C. femorata*
- 48(44') Body and appendages covered with long setae (Fig. 39); body lacks tubercles; mandibles are asymmetrical *Crinitella*
- 48' Body not covered with long setae; body with tubercles or spines on the head, thorax or the abdomen 49
- 49(48') Head with spines or tubercles (Fig. 40a); fore femora usually expanded, bearing spines along the anterior margin (Fig. 40b); body robust *Drunella*
- 49' Head lacks spines or tubercles; fore femora not markedly expanded and without spines along the anterior margin 50
- 50(49') Apical mandibular tooth greatly elongated and extending beyond anterior margin of head (Fig. 41) *Kangella* (*K. brocha*)
- 50' Apical mandibular tooth not greatly elongated and not extending beyond anterior margin of head 51
- 51(50') Mesonotum with an anterolateral spine or projection (Fig. 42) *Ephacerella*... 52
- 51' Mesonotum lacks lateral spines or projections 53
- 52(51) Mesonotum with long, acute anterolateral spine and without dorsal tubercles *E. longicaudata*
- 52' Mesonotum with rudimentary anterolateral spine and with 5 dorsal tubercles *E. commodema*
- 53(51') Abdominal terga lack paired tubercles; dorsal surface of the body strongly marked with paired longitudinal stripes (Fig. 43) *Uracanthella*
- 53' Abdominal terga with paired tubercles; body *may* lack stripes; maxillary palpi absent *Serratella*
- 54(41') Gills borne dorsally on abdominal segment II-VII 57
- 54' Gills borne laterally on abdominal segment I-VII 55
- 55(54') Median caudal filament absent; posterior margin of abdominal terga I-X each with mid-dorsal tubercle (Fig. 44) *TELOGANODIDAE*, *Teloganodes* (*T. tristis*)
- 55' Median caudal filament present 56

- 56(55') Lamellate gills on segment II-VII; head with cephalic horns (Fig. 45)
 VIETNAMELLIDAE, *Vietnamella* (*V. thani*)
- 56' Posterior margin of abdominal terga IV-VI forming mid-dorsal notch; terga II-IX
 expanded laterally and well developed projection (Fig. 46); head without cephalic
 horn.....TELOGANELLIDAE, *Teloganella* (*T. umbrata*)
- 57(54) Head rectangular; gills various types; terminal filament well-developed (Fig. 49,
 50, 52, 53)..... LEPTOPHLEBIIDAE...58
- 57' Head round, gills lamellate or plate-like (Fig. 54-59); perinial filament sometimes
 reduced or lacking (Fig. 56, 57) BAETIDAE...64
- 58(57) Abdominal terga extending around to venter of abdomen on segments III-VII
 (Fig. 47) *Isca*
- 58' Abdominal terga extending to lateral sides of abdomen, all abdominal gills lateral
 or dorsal 59
- 59(58') Maxillary and labial palpi greatly elongated and extending beyond side of head
 (Fig. 48); gills present on abdominal segments II-VII, denticle of claws about equal
 length *Choroerterpides*
- 59' Maxillary and labial palpi not greatly elongated and usually not extending beyond
 side of head 60
- 60(59') Middle abdominal gills plate-like with fringed margin (Fig. 49)..... *Thraululus*
- 60' Middle abdominal gills without a fringed margin, *may be* plate or leaf-like, or
 bifurcate and long and slender..... 61
- 61(60') Gill I similar to others in the series (Fig. 50) *Habrophlebiodes*
- 61' Gill I differing from the others 62
- 62(61') Posterolateral spine on abdominal segments III-IX, those on VIII and IX with
 curved inner edge (Fig. 51b), a large tooth-like process on the anterior apex of the
 maxilla (Fig. 51a) *Cryptopenella*
- 62' Posterolateral spine on abdominal segments IV or V-IX; spine on segments VIII
 and IX not as above, no large tooth-like process on the anterior apex of the maxilla
 as above (Fig. 52a)..... *Choroerterpes*...63
- 63(62') Abdominal gills III-VII terminate in 3 slender, subequal process (Fig. 53).....
 *Choroerterpes* (*Euthraululus*)
- 63' Abdominal gills III-VII terminate in 3 processes, with middle one being longer
 than laterals (Fig. 52b)..... *Choroerterpes* (*Choroerterpes*)

64(57')	Abdominal gills on one or more segments bilamellate (double) (Fig. 54,55).....	65
64'	All abdominal gills single (Fig. 56-59)	66
65(64)	Lamellae of gills I-VI doubled (Fig. 54), but gill VII is single.....	<i>Cloeon</i>
65'	Lamellae of gills I-V distinctly asymmetrical and bear small dorsal flap (Fig. 55), gills VI-VII are single.....	<i>Procloeon</i>
66(64')	Terminal filament absent or reduced, always shorter than 0.5x cerci (Fig. 58) ..	67
66'	Terminal filament developed, always longer than 0.5x cerci (Fig. 60)	71
67(66)	Abdominal terga with spiniform tubercles (Fig. 56)	68
67'	Abdominal terga without spiniform tubercles (Fig. 59)	70
68(67)	The tergites of the metathorax and the abdomen (I-IX) bear a single median spiniform tubercle (Fig. 56a)	<i>Gratia</i> ...69
68'	The tergites bear single median (I-III) or paired submedian dorsal tubercles (IV-IX) (Fig. 58); apex of labial palp conical.....	<i>Baetiella</i>
69(68)	Glossae subequal to paraglossae in length; margin of gills with both scales and setae (Fig. 57)	<i>G. sororculaenadinae</i>
69'	Glossae shorter than paraglossae ; margin of gills with fine setae (Fig. 56b)	<i>G. narumona</i>
70(67')	Terminal filament shorter than 1/2 length of cerci (Fig. 59a); margin of gills smooth, without setae (Fig. 59b)	<i>Platybaetis</i>
70'	Terminal filament shorter than 1/4 -1/6 length of cerci; margin of gills with simple hair-like setae (Fig. 60).....	<i>Acentrella</i>
71(66')	Labium with the 2 nd and 3 rd palpal segments almost completely fused together to form one large stout segment; tarsal claws without teeth and strongly hooked at apex (nymph lives in bivalves).....	<i>Symbiocloeon (S. heardi)</i>
71'	Labium not as above.....	72
72(71')	Venter of thorax with distinct thread-like thoracic gills attached near base of forelegs or hindlegs (Fig. 61b)	<i>Heterocloeon</i>
72'	Venter of thorax without thread-like thoracic gills.....	73
73(71')	Dorsal surface of all tibiae with long transverse hair like setae (Fig. 62).....	<i>Centroptella</i>
73'	Dorsal surface of all tibiae without long transverse hair like setae	74

- 74(73') Labial palpi enlarged, terminal segment of maxillary palpi excavate
 *Labiobaetis*
- 74' Labial palpi not enlarged, terminal segment of maxillary palpi not excavate..... 75
- 75(74') Body colour dark brown, posterior margin of abdominal segment V with row of
 acute spines (Fig. 63)..... *Nigrobaetis*
- 75' Body colour light brown, posterior margin of abdominal segment V with row of
 blunt setae (Fig. 64)..... *Baetis*

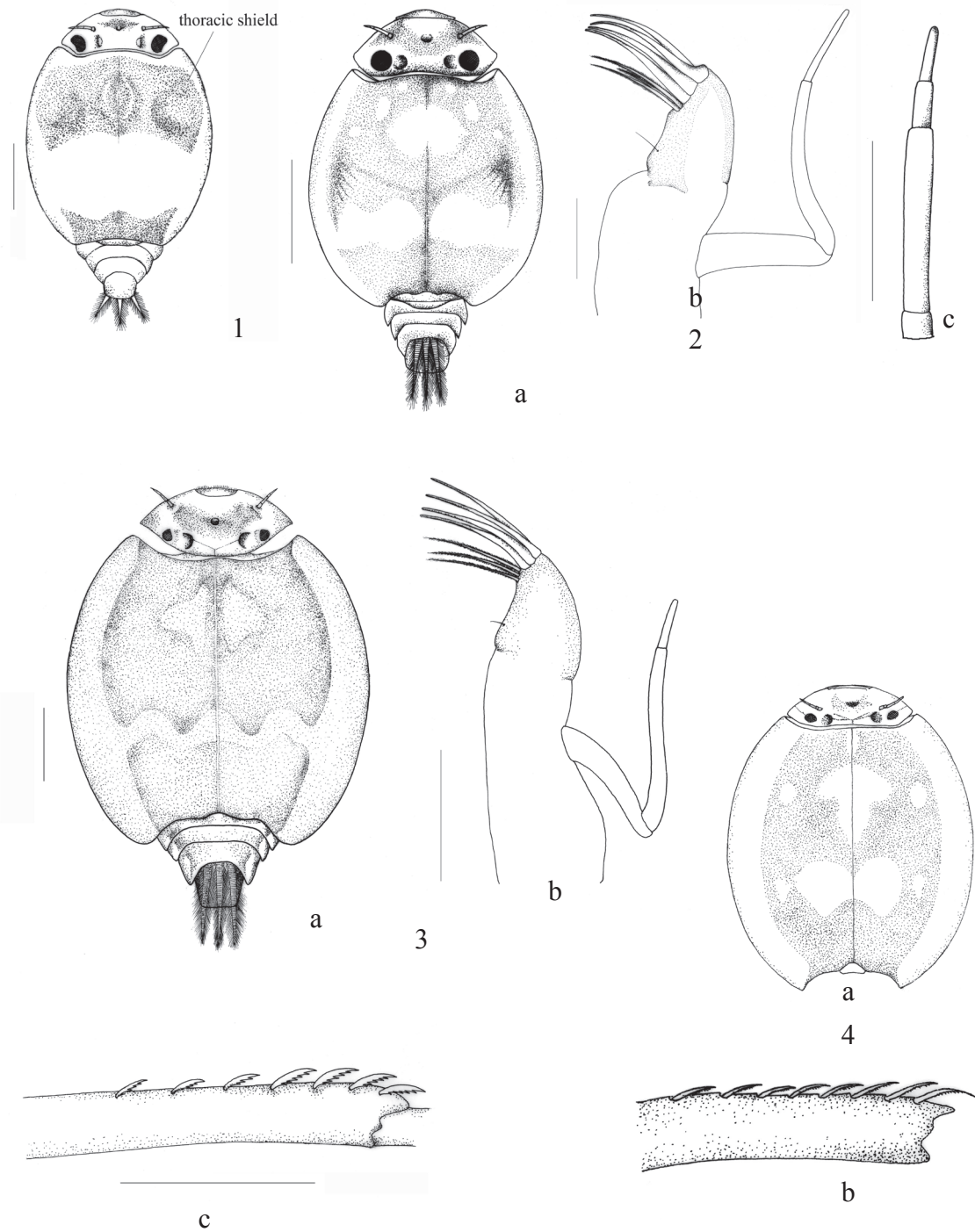


Fig. 1-4 1. Dorsal view of nymph of *Prosopistoma funanense* (redrawn from Soldán & Braasch, 1984, fig. 1); 2. Dorsal view of nymph (a), maxillary palp (b) and antenna (c) of *P. sinense*; 3. Dorsal view of nymph (a), maxillary palp and (b) apex of inner margin of fore tibiae (c) of *P. annamense*; 4. Dorsal view of nymph (a) and apex of inner margin of fore tibiae (b) of *P. wouterae* (redrawn from Peters, 1967, fig. 2, fig. 6).
Scale: (2b, 2c, 3b-c) 0.5 mm; (1, 2a, 3a) 1 mm

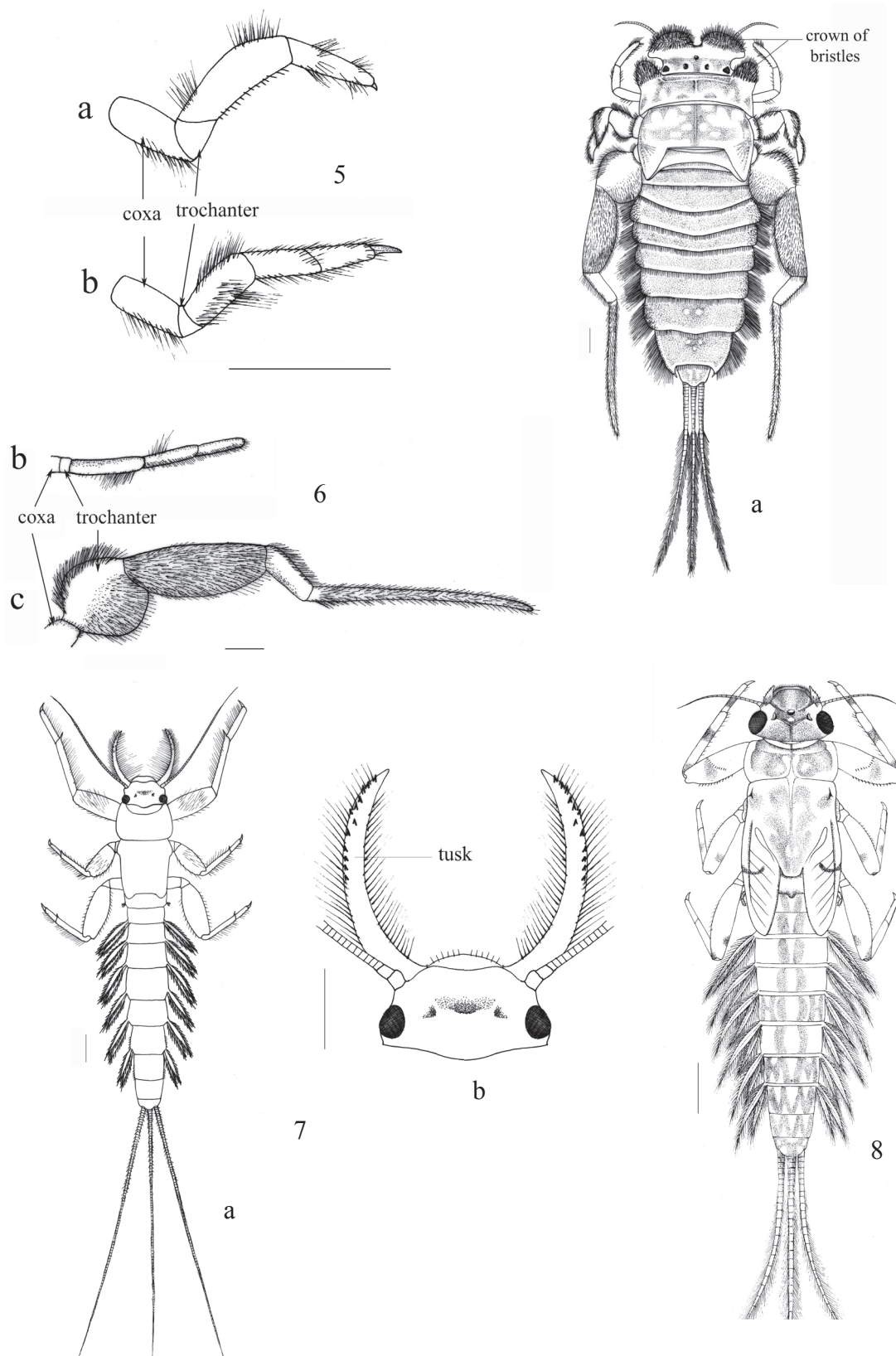


Fig. 5-8 5. Foreleg (a) and hindleg (b) of *Protobehningia merga*; 6. Dorsal view of nymph (a), foreleg (b) and hindleg (c) of *Behningia* sp.; 7. Dorsal view of nymph (a) and dorsal view of head (b) of *Polyplocia* sp.; 8. Dorsal view of nymph of *Potamanthus (Potamanthodes) formosus*.
Scale = 1 mm.

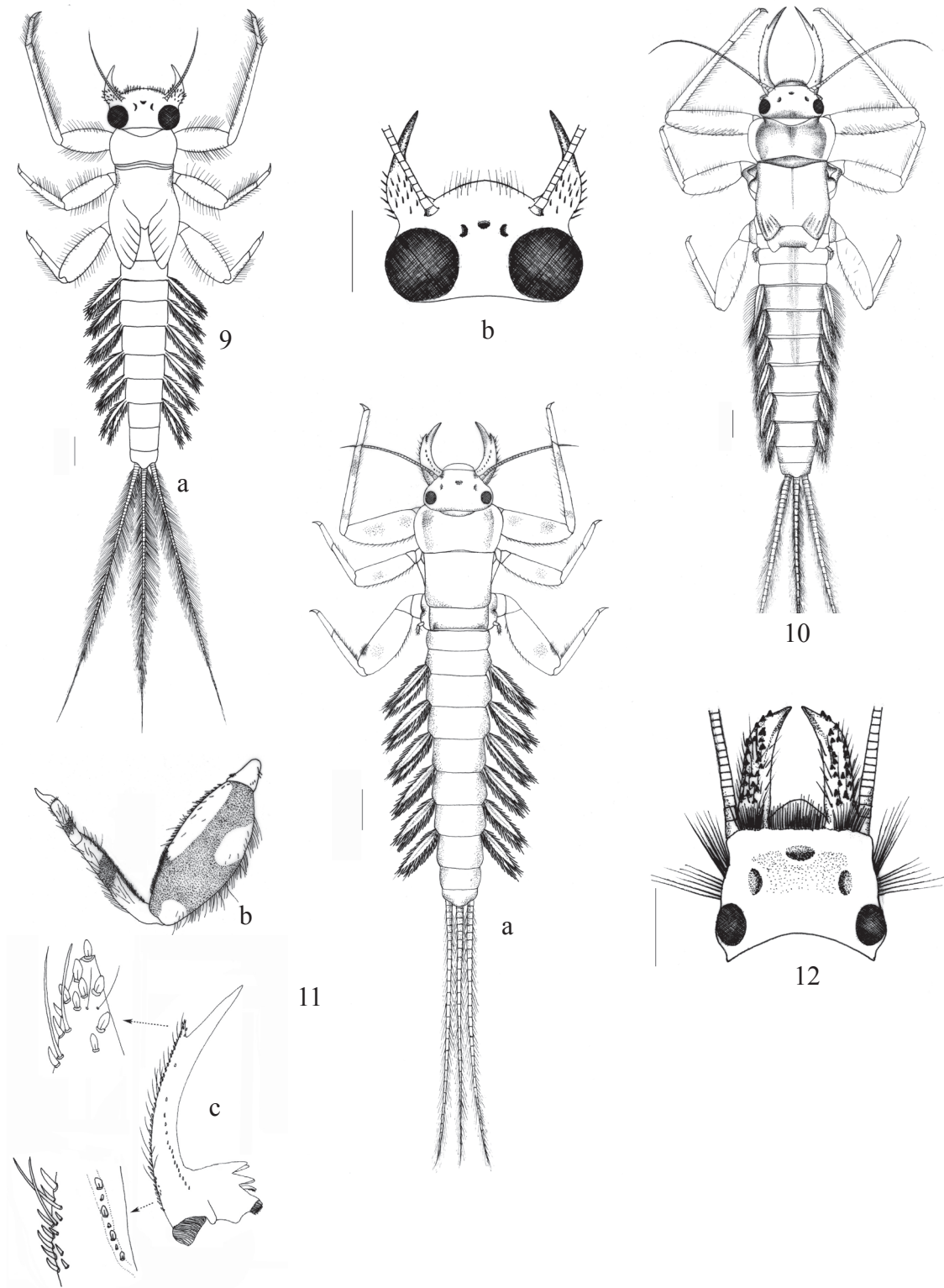


Fig. 9-12 9. Dorsal view of nymph (a) and dorsal view of head (b) of *Rhoenanthus* (*Potamanthindus*) *obscurus*; 10. Dorsal view of nymph of *Rhoenanthus* (*Rhoenanthus*) *speciosus*; 11. Dorsal view of nymph (a), dorsal view of hind leg (b) and mandibular tusk (c) of *R. (R.) distafurcus* (redrawn from Soldán & Putz, 2000, fig. 3, fig. 10); 12. Dorsal view of head of *Ephoron* sp.
Scale = 1 mm.

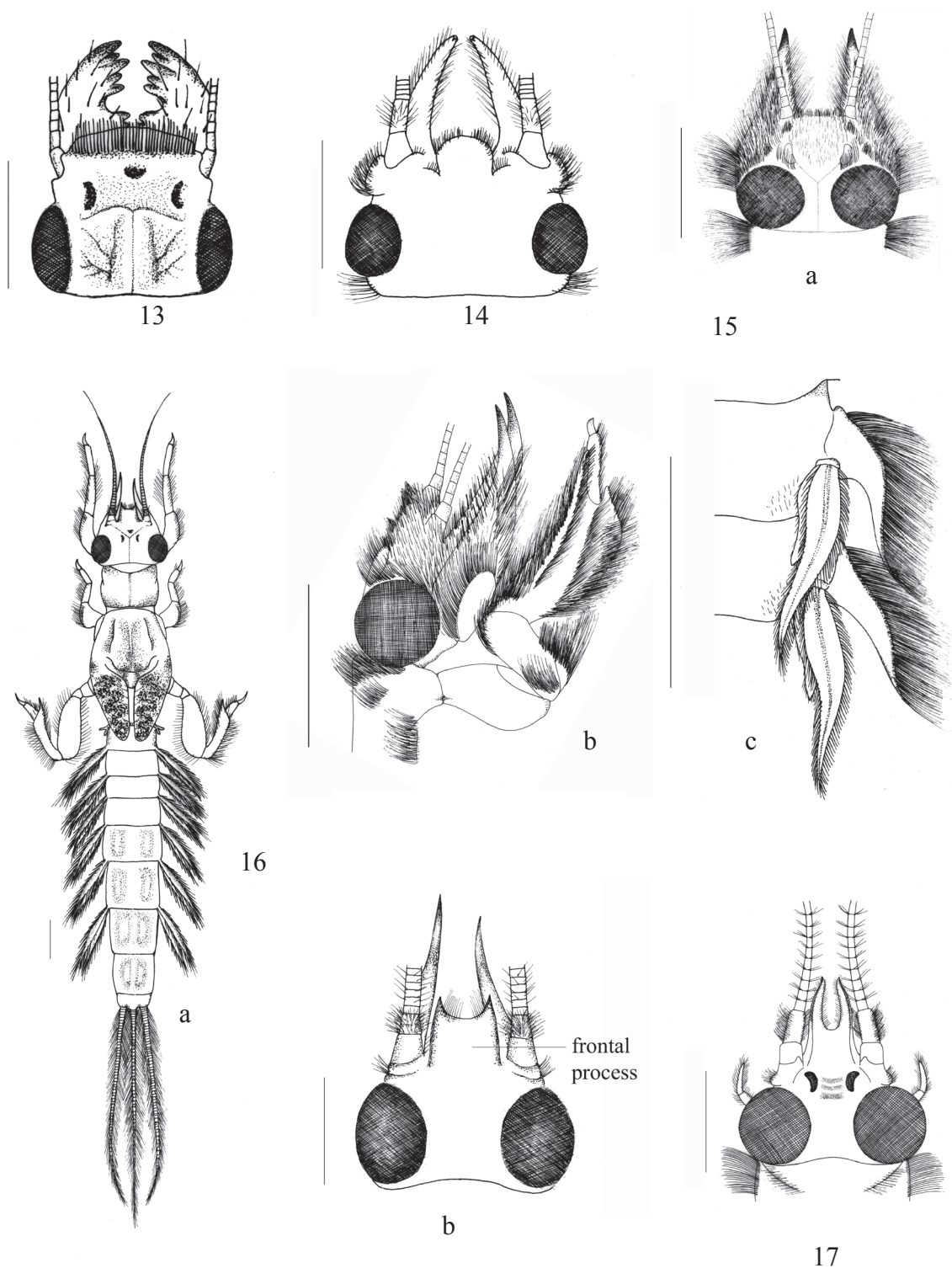


Fig. 13-17 13. Dorsal view of head of *Povilla* (*Povilla*) sp.; 14. Dorsal view of head of *Eatonigenia* sp. 15. Dorsal view of head (a), side view of head (b) and right abdomen (c) of Palingeniidae; 16. Dorsal view of nymph (a) and dorsal view of head (b) of *Ephemera* (*Ephemera*) sp.; 17. Dorsal view of head of *Afromera* sp. Scale = 1 mm.

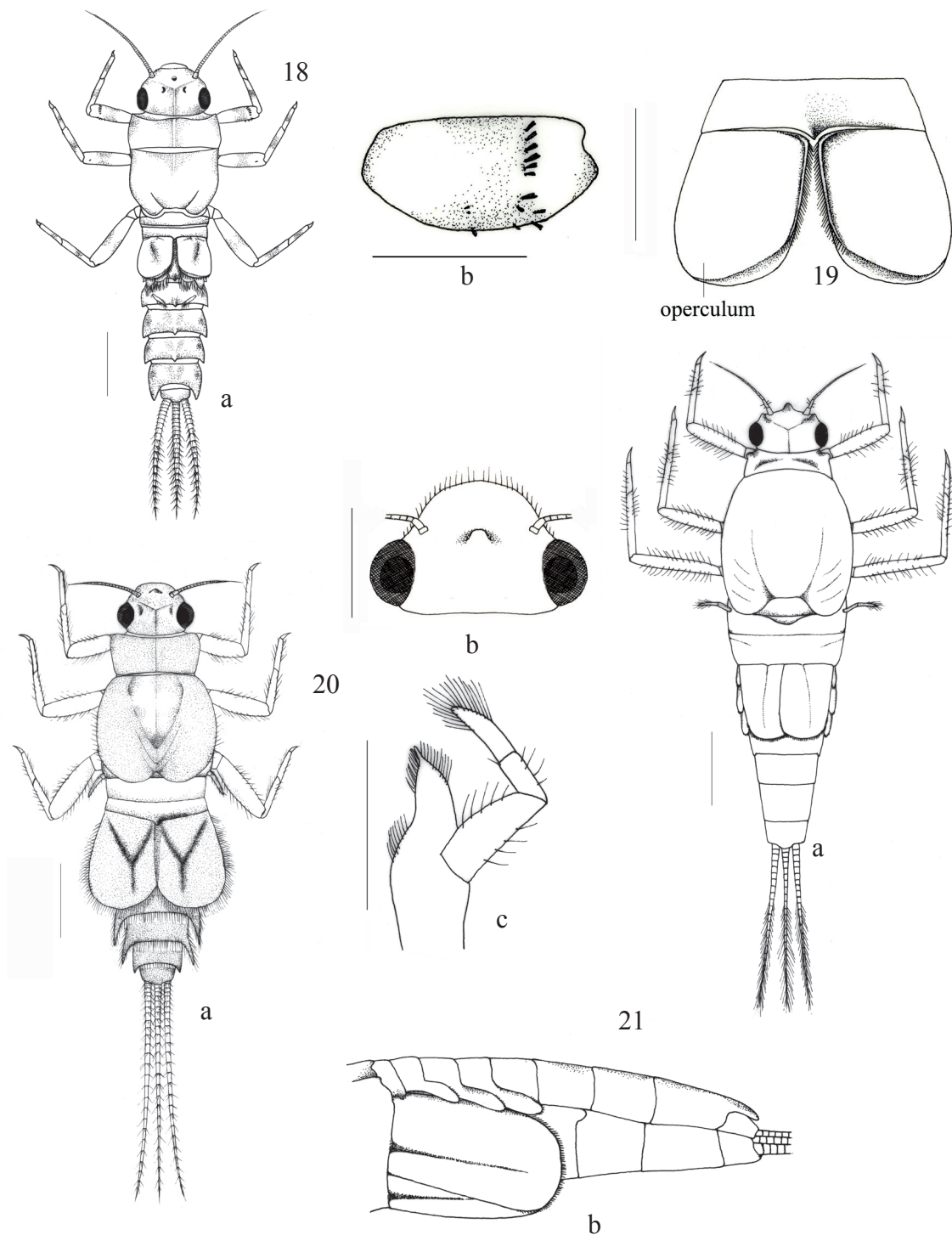


Fig. 18-21 18. Dorsal view of nymph (a) and dorsal view of fore femora (b) of *Potamanthellus caenoides*; 19. Dorsal view of opercular gills of *P. edmundsi*; 20. Dorsal view of nymph (a), dorsal view of head (b) and maxilla (c) of *Caenoculis* sp.; 21. Dorsal view of nymph (a) and side view of abdomen (b) of *Cercobrachys* sp.
Scale: (18b, 20c, 21b) 0.5 mm; (18a, 19, 20a-b, 21a) 1 mm.

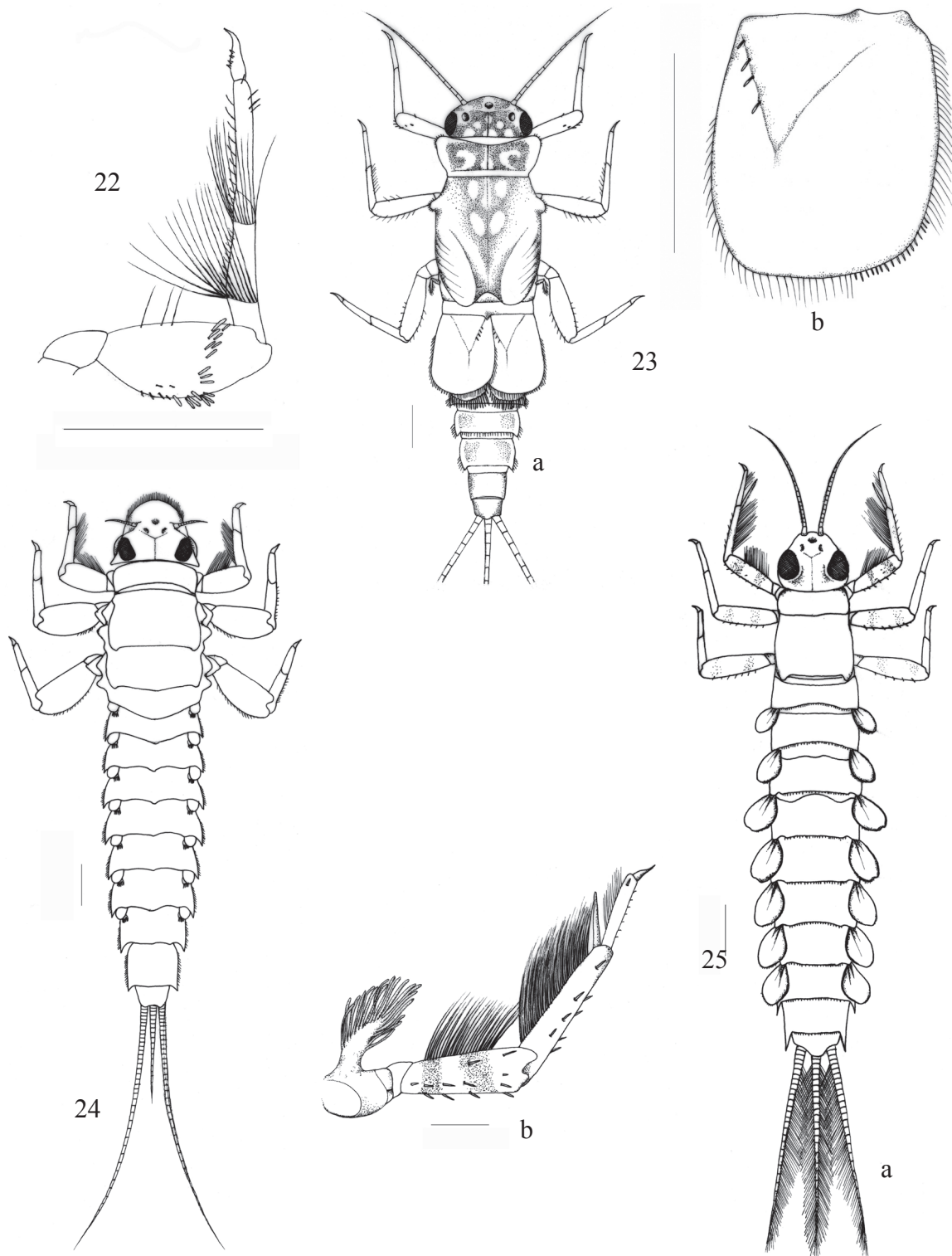


Fig. 22-25 22. Dorsal view of fore leg of *Clypeocaenis* sp.; 23. Dorsal view of nymph (a) and dorsal view of gill cover (b) of *Caenodes* sp.; 24. Dorsal view of nymph of *Chromarcys* sp.; 25. Dorsal view of nymph (a) and dorsal view of fore leg (b) of *Isonychia* sp.
Scale: (22, 23b) 0.5 mm; (23a, 24, 25) 1 mm.

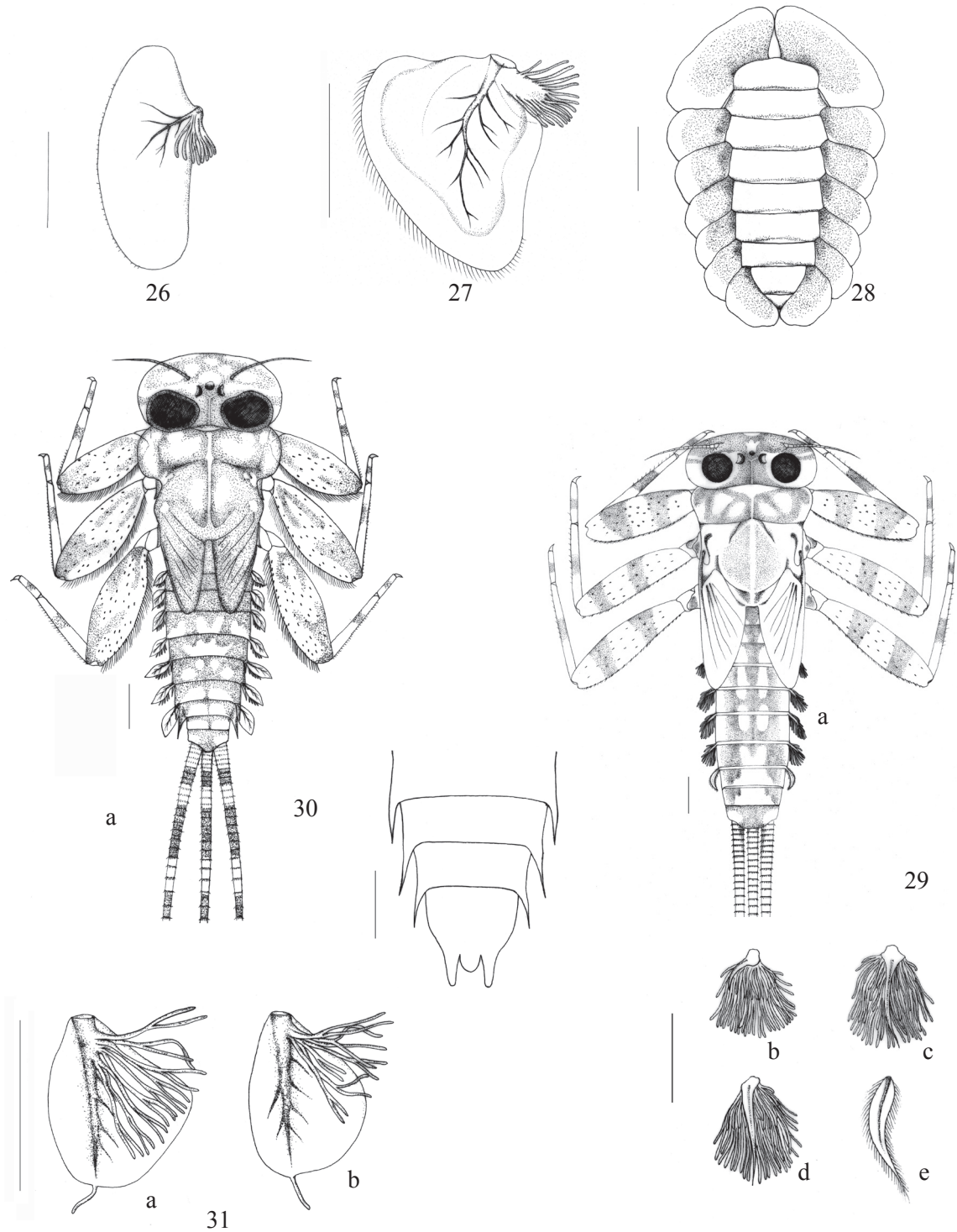


Fig. 26-31. 26. Gill I of *Iron* sp.; 27. Gill I of *Epeorus* sp.; 28. Ventral view of abdomen of *Rhithrogena* sp.; 29. Dorsal view of nymph (a) and gill I (b), III (c), V (d) and VII (e) of *Trichogenia maxillaris*; 30. Dorsal view of nymph (a) and ventral view of abdomen (b) of *Thalerosphyrus* sp.; 31. Ventral view of gills V (a) and VI (b) of *Cinygmmina* sp.
Scale: (26, 27, 29b-e, 31) 0.5 mm; (28, 29a, 30) 1 mm.

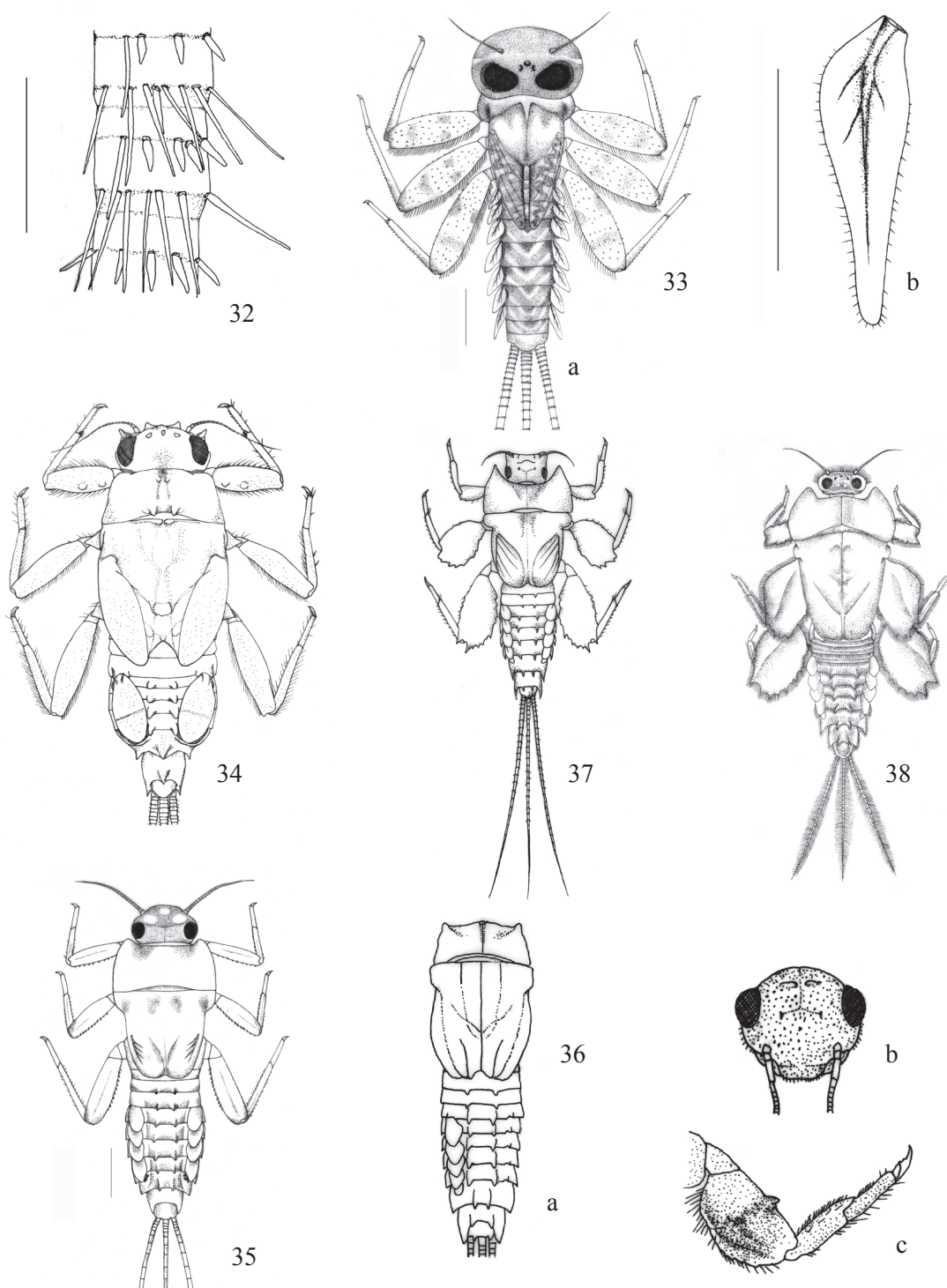


Fig. 32-38. 32. Spines on cerci of *Rhithrogeniella* sp.; 33. Dorsal view of nymph (a) and gill VII (b) of *Asionurus* sp.; 34. Dorsal view of nymph of *Hyrtanella* sp. (redrawn from Allen & Edmunds, 1976, fig.1); 35. Dorsal view of nymph of *Cincticostella gosei* ; 36. Dorsal view of thorax and abdomen (a) head (b) and fore leg (c) of *C. insolta* (redrawn from Allen, 1971, fig. 12, 14, 18); 37. Dorsal view of nymph of *C. boja* (redrawn from Gose, 1961, fig. 23); 38. Dorsal view of nymph of *C. femorata* (redrawn from Tshernova, 1972, fig. 5). Scale: (32, 33b) 0.5 mm; (33a, 34, 35, 37, 38) 1 mm.

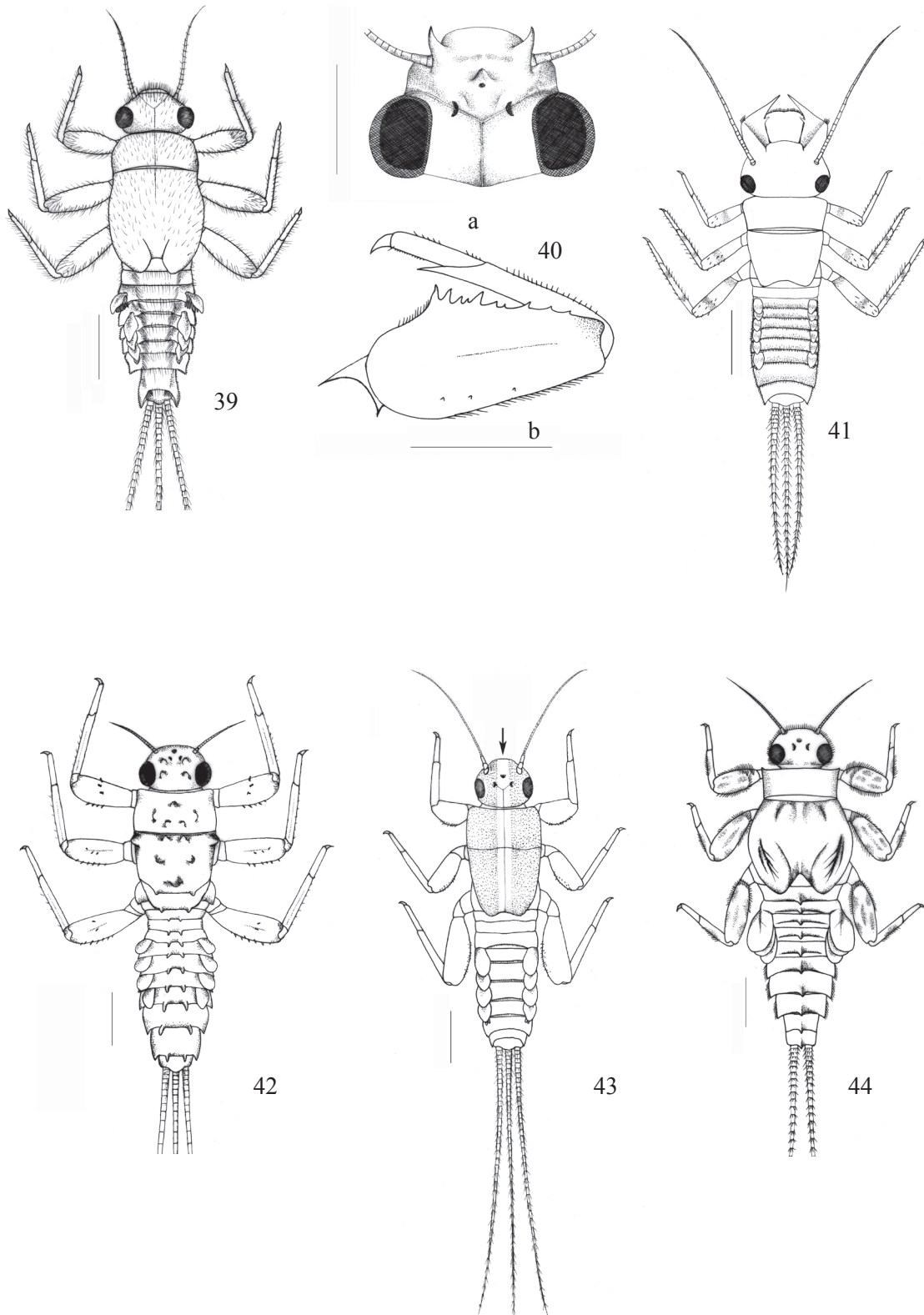


Fig. 39-44 39. Dorsal view of nymph of *Crinitella* sp.; 40. Dorsal view of head (a) and fore femur (b) of *Drunella* sp.; 41. Dorsal view of nymph of *Kangella* sp.; 42. Dorsal view of nymph of *Ephacerella commodema*; 43. Dorsal view of nymph of *Uracanthella* sp.; 44. Dorsal view of nymph of *Teloganodes* sp. Scale = 1 mm.

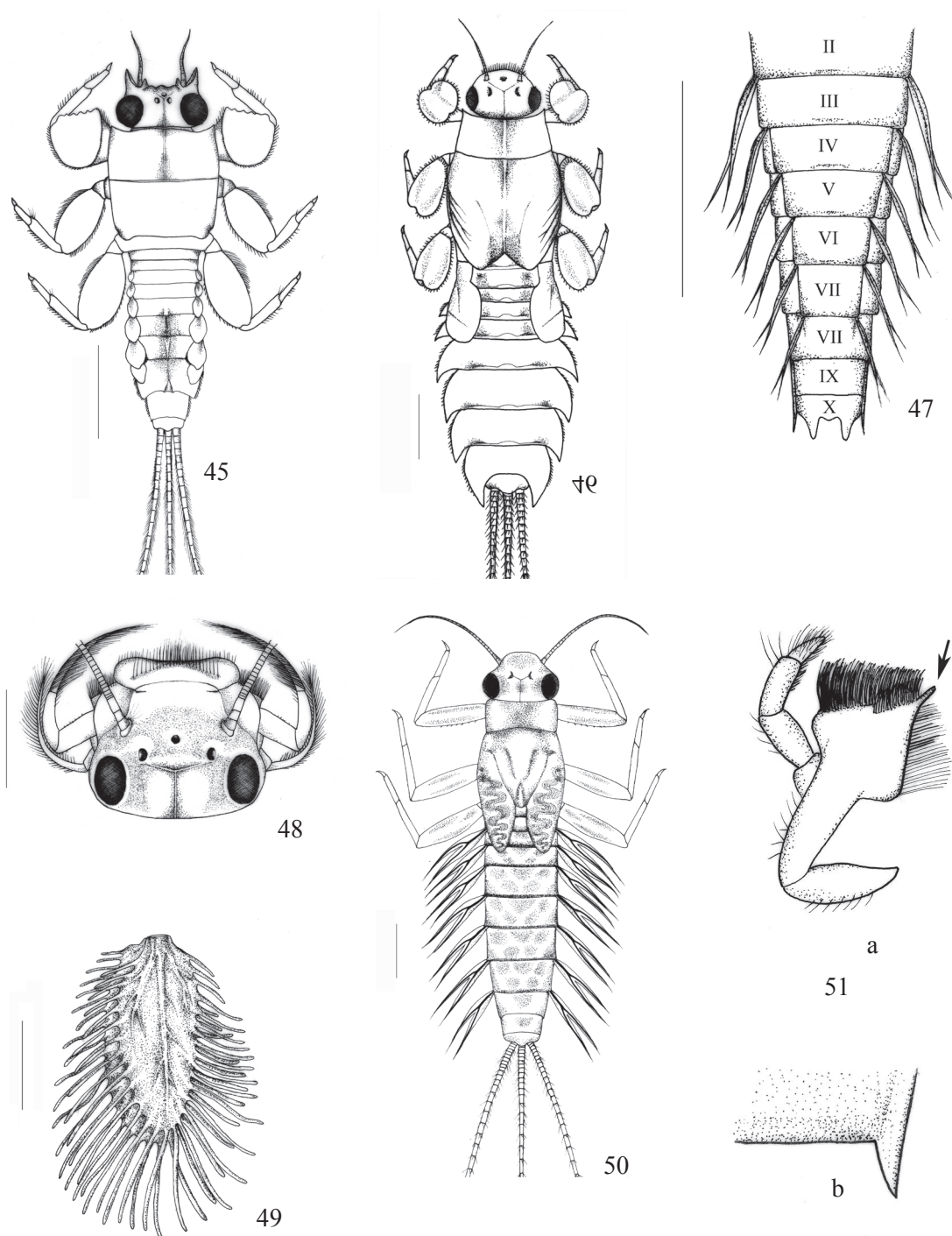


Fig. 45-51. 45. Dorsal view of nymph of *Vietnamella* sp.; 46. Dorsal view of nymph of *Teloganella* sp.; 47. Ventral view of abdomen of *Isca* sp.; 48. Dorsal view of head of *Choroterpides* sp.; 49. Lamellate gill of *Thraulius* sp.; 50. Dorsal view of nymph of *Habrophlebiodes* sp.; 51. Maxilla (a) and posterolateral spine (b) of *Cryptopenella* sp. (redrawn from Peters & Edmunds, 1970, fig. 336, fig. 344). Scale: (49) 0.5 mm; (45-48, 50) 1 mm.

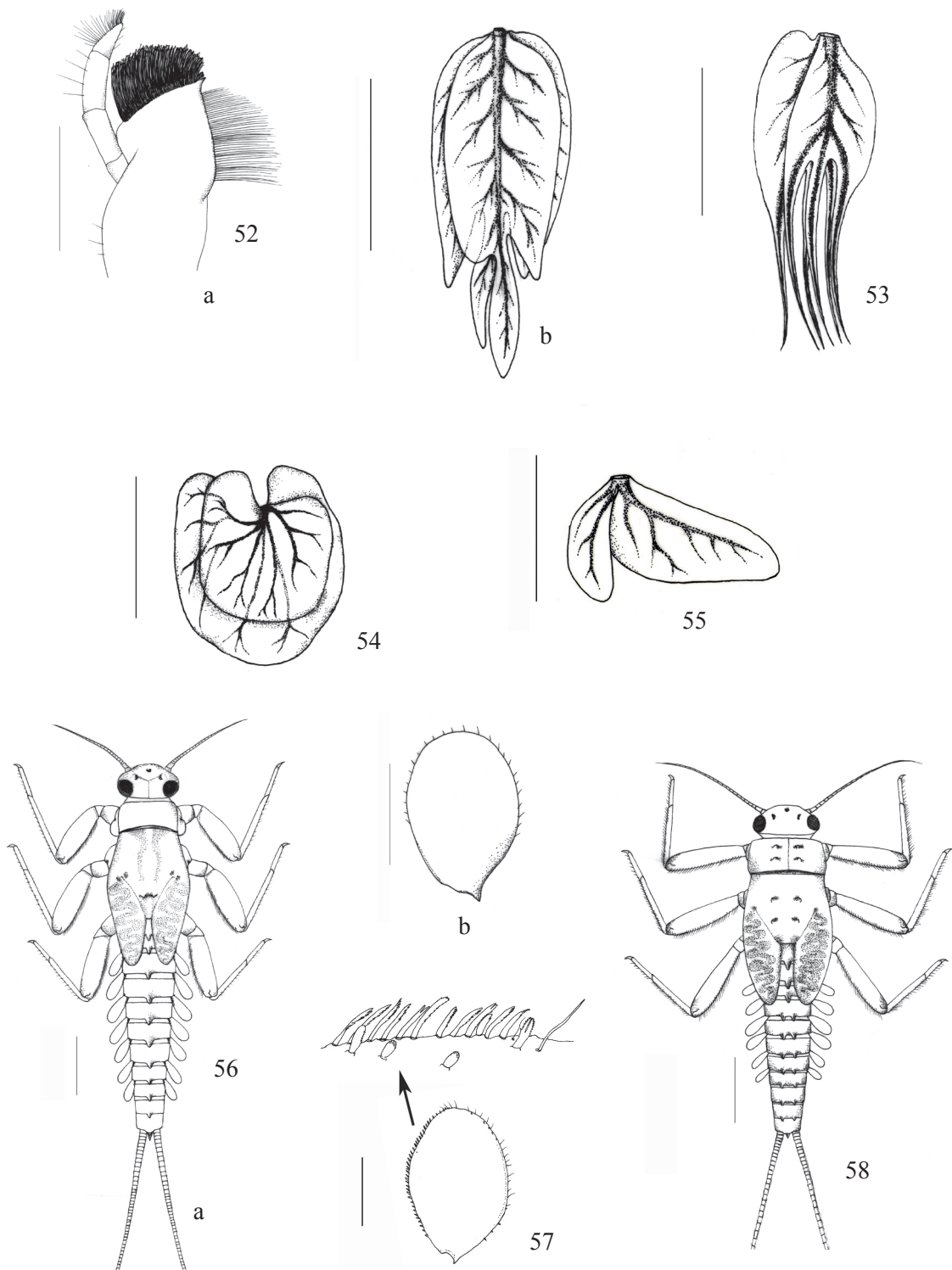


Fig. 52-58 52. Maxilla (a) and gills III-VII (b) of *Choroterpes* (*Choroterpes*) sp.; 53. Abdominal gills III-VII of *Choroterpes* (*Euthraulus*) sp.; 54. Gills I-VI of *Cloeon* sp.; 55. Gill of *Procloeon* sp.; 56. Dorsal view of nymph (a) and gill VI (b) of *Gratia narumonae*; 57. Gill VI of *Gratia sororculaenadinae* (redrawn from Thomas, 1992, fig. 16); 58. Dorsal view of nymph of *Baetiella* sp. Scale: (56b, 57) 0.3 mm; (52-55) 0.5 mm; (56a, 58) 1 mm.

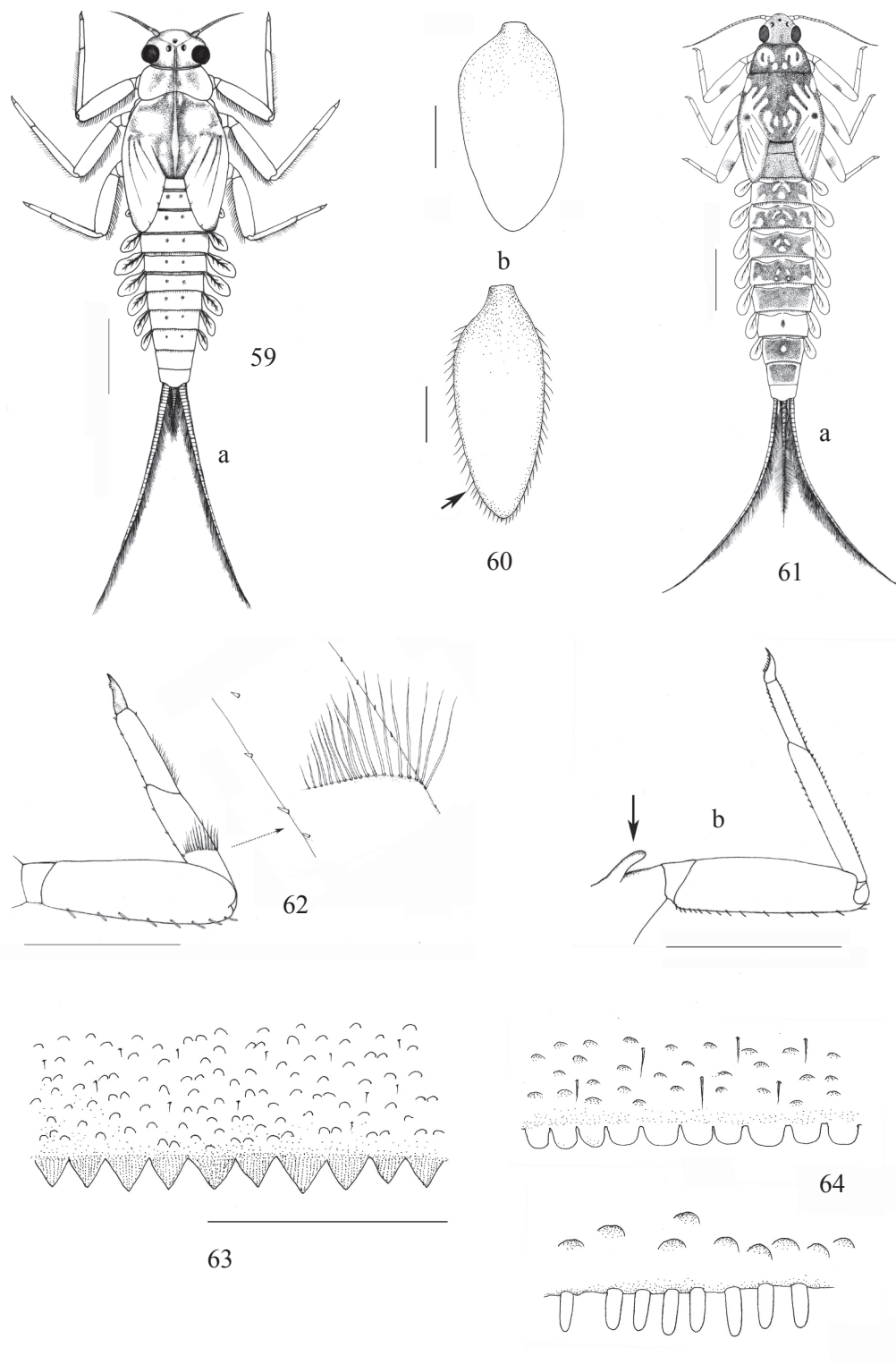


Fig. 59-64 59. Dorsal view of nymph (a) of and gill V (b) of *Platybaetis* sp.; 60. Gill V of *Acentrella* sp.; 61. Dorsal view of nymph (a) and foreleg (b) of *Heterocloeon* sp.; 62. Dorsal view of foreleg of *Centroptella* sp.; 63. Posterior margin of abdominal segment V of *Nigrobaetis* sp.; 64. Posterior margin of abdominal segment V of *Baetis* sp. (modified from Nguyen, 2003, fig. 399,403). Scale: (59b, 60, 63, 64) 0.1 mm; (61b, 62) 0.5 mm; (59a, 61a) 1 mm.

References

- Abel, P.D. (1996) *Water Pollution Biology, 2nd edition*. Taylor & Francis Ltd, London.
- Allen, R.K. (1971) New asian *Ephemerella* with notes (Ephemeroptera: Ephemerellidae). *Canadian Entomologist* **103**(4): 512-528.
- Allen, R.K. (1975) *Ephemerella* (*Cincticostella*). A revision of the nymphal stages (Ephemeroptera: Ephemerellidae). *Pan-Pacific Entomologist* **51**: 16-22.
- Allen, R.K. and Edmunds Jr, G.F. *Hyrantanella*: a new genus of Ephemerellidae (Ephemeroptera) from Malaysia. *Pan-Pacific Entomologist* **52**: 133-137.
- Andersen, N.M. (1989) The old world Microveliinae (Hemiptera: Veliidae). II. Three new species of *Baptista* Distant and a new genus from the Oriental region. *Entomologica Scandinavica* **19**: 363-380.
- Asahina, S. (1993) *A list of the Odonata of Thailand (Part I-XXI)*. Bosco Offset, Bangkok.
- Bae, Y.J. and McCaffery, W.P. (1991) Phylogenetic systematics of the Potamanthidae (Ephemeroptera). *Transaction of the American Entomological Society* **117**: 1-143.
- Bae, Y.J. and McCafferty, W.P. (1998) Phylogenetic systematics and biogeography of the Neoephemeridae (Ephemeroptera: Pannota). *Aquatic Insects* **20**: 35-68.
- Balke, M. and Hendrick, L. (1997) A new species of *Laccophila* Leach, 1815 from Vietnam (Coleoptera: Dytiscidae). *Koleopterologische Rundschau* **67**: 99-100.
- Barnes, R.O. (1963) *Invertebrate Zoology*. W. B. Saunders Company, Philadelphia.
- Bishop, J.E. (1973) *Limnology of a small Malayan river Sungai Gombak*. Dr W. Junk Publishers, The Hague.
- Brandt, R.A.M. (1974) The non-marine aquatic Mollusca of Thailand *Archive Mollusk* **105**: 1-423.
- Brittain, J.E and Sartori, M. (2003) Ephemeroptera (Mayflies). In: Resh, V.H. and Cardé, R.T. (eds). *Encyclopedia of Insects*. Academic Press, Amsterdam. pp. 373-380.
- Cai, Y., Naiyanetr, P. and Ng, P.K.L. (2004) The freshwater prawns of the genus *Macrobrachium* Bate, 1868 of Thailand (Crustacea: Decapoda: Palaemonidae). *Journal of Natural History* **38**: 581-649.
- Cantrall, I. J. and Brusven, M. A. (1996) Semiaquatic Orthoptera. In: Merritt, R.W. and Cummins, K.W. (eds). *An introduction of the aquatic insects of North America, 3rd edition*. Kendall/Hunt Publishing Company, Iowa. pp. 113-125.

- Chaisamsaeng, P. (2003) *Species diversity of plecopteran in Nam Nao National Park, Thailand*. M.Sc. Thesis, Khon Kaen University.
- Chaiyapa, W. (2001) *Species diversity of caddisflies (Trichoptera: Philopotamidae) in Yakrua and Phromlaeng streams, Nam Nao National Park, Thailand*. M.Sc. Thesis, Khon Kaen University.
- Chantaramongkol, P. and Malicky, H. (1989) Some *Chimarra* (Trichoptera: Philopotamidae) from Thailand. *Aquatic Insects* **11**: 223-240.
- Chantaramongkol, P. and Malicky, H. (1995) Drei neue asiatische *Hydromanicus* (Trichoptera: Hydropsychidae). *Entomologische Zeitschrift Mit Insektenborse* **105**: 92-95.
- Chen, P. and Zettel, H. (1996) An illustrated key to the families of Gerromorpha in Thailand. *Amemboa* **1**: 10-13.
- Chen, P. and Zettel, H. (1998) Key to genera and subgenera of Gerridae (Gerromorpha) of Thailand and adjacent countries, with a check-list of species known from Thailand. *Amemboa* **1**: 24-41.
- Cheng, L. and Fernando, C.H. (1969) A taxonomic study of the Malayan Gerridae (Hemiptera: Heteroptera) with notes on their biology and distribution. *Oriental Insects* **3**: 97-160.
- Chitramvong, Y.P. (1992) The Bithyniidae (Gastropoda: Prosobranchia) of Thailand: comparative external morphology. *Malacological Review*. **25**: 21-38.
- Christansen, K.W. and Snider, R.J. (1996) Aquatic Collembola. In: Merrit, R.W. and Cummins, K.W. (eds). *An introduction of the aquatic insects of North America, 3rd edition*. Kendall/Hunt Publishing Company, Iowa. pp. 113-125.
- Courtney, G.W. (1994) Diptera Families. In: Morse, J.C., Yang, L. and Tian, L. (eds.). *Aquatic Insects of China Useful for Monitoring Water Quality*. Honai University Press, Nanjing, China. pp. 400-437.
- Covich, A.P. (1988.) Geographical and historical comparisons of neotropical streams: biotic diversity and detrital processing in highly variable habitats. *Journal of the North American Benthological Society* **7**: 361-386.
- Dudgeon, D. (1995a.) Life histories, secondary production and microdistribution of Psephenidae (Coleoptera: Insecta) from a tropical forest stream. *Journal of Zoology (London)* **236**: 465-481.
- Dudgeon, D. (1995b.) Life histories, secondary production and microdistribution of *Hydrocyphon* (Coleoptera: Insecta) from a tropical forest stream. *Archive Hydrobiologia* **133**: 261-271.
- Dudgeon, D. (1999) *Tropical Asian Streams Zoobenthos, Ecology and Conservation*. Hong Kong University Press, Hong Kong.

- Edington, J.M. and Hildrew, A.G. (1995) *Caseless caddis larvae of the British Isles, A key with ecological notes*. Freshwater Biological Association Scientific Publication No.53.
- Fernando, C.H. and Cheng, L. (1963) *A guide to Malayan water bugs (Hemiptera-Heteroptera) with key to the genera*. Department of Zoology, University of Singapore.
- Fraser, F.C. (1933) *The fauna of British India including Ceylon and Burma. Odonata Vol. I*. Taylor and Francis, London.
- Fraser, F.C. (1934) *The fauna of British India including Ceylon and Burma. Odonata Vol. II*. Taylor and Francis, London.
- Fraser, F.C. (1936) *The fauna of British India including Ceylon and Burma. Odonata Vol. III*. Taylor and Francis, London.
- Gose, K. (1961) Mayflies (Ephemeroptera) from Thailand. *Nature and Life in Southeast Asia* **6**: 125-138.
- Habeck, D.H. and Solis, M.A. (1994) Transfer of *Petrophila drumalis* (Dryar) to *Argyractis* based on immature and adult characters with a larval description of *Argyractis subonata* (Hampson) (Lepidoptera: Crambidae: Nymphulinae). *Proceedings of Entomological Society of Washington* **96**: 726-734.
- Hagen, K.S. (1996) Aquatic Hymenoptera. In: Merritt, R.W. and Cummins, K.W. (eds). *An Introduction to the Aquatic Insects of North America, 3rd edition*. Kendall/Hunt Publishing Company, Iowa. pp. 474-483.
- Harper, P.P. (1994) Plecoptera. In: Morse, J. C., Yang, L. and Tian, L. (eds.). *Aquatic Insects of China Useful for Monitoring Water Quality*. Honai University Press, Nanjing, China. pp. 176-209.
- Hellawell, J.M. (1986) *Biological Indicators of freshwater pollution and environmental management*. Elsevier Applied Science Publisher, London.
- Hecher, C. (1998) Key to genera of Veliidae (Gerromorpha) of Thailand and adjacent countries, with a check-list of species known from Thailand. *Amemboa* **2**: 3-9.
- Hendrick, L. and Balke, M. (1997) Taxonomische Revision der sudostatische Arten der Gattung *Neptosternus* SHARP, 1882 (Coleoptera: Dytiscidae: Laccophilinae). *Koleopterologische Rundschau* **67**: 53-97.
- Hickman, C.P. and Roberts, L.S. (1995) *Animal diversity*. Wm. C. Brown Publishers, Dubuque, IA.
- Hirose, Y. and Itoh, S. (1993) *A Guide to the Dragonflies of Hokkaido*. Self published, Abashiri/Shizunai, Hokkaido.
- Hubbard M. D. (1994) The mayfly family Behningiidae (Ephemeroptera: Ephemeroidea): keys to the recent species with a catalog of the family. *Great Lakes Entomology* **27**: 161-

168.

Humphrey, L.L. and Dastine, P.L. (1994) Development of biological monitoring programs to detect mining-waste impacts upon aquatic ecosystems of the Alligator River region, Northern Territory, Australia. *Mitteilungen Internationalen Vereinsschrift Limnology* **24**: 293-314.

Ishida, K. (1996) *Monograph of Odonata larvae in Japan*. Hokkaido University Press, Sappora.

Jäch M.A. and Ji, L. (eds). (1995) *Water Beetles of China. Vol. I*. Wien: Zoologisch-Botanische Gesellschaft in Österreich and Wiener Coleopterologenverein.

Kawai, T. (1969) Stoneflies (Plecoptera) from Southeast Asia. *Pacific Insects* **11**: 613-625.

Klaythong, N. (1997) *A preliminary study on meiofauna in Yakrua stream, Nam Nao National Park*. Research Project, Faculty of Science, Khon Kaen University.

Kumar, A. and Kanna, V. (1983) A review of the taxonomy and ecology of Odonata larvae from India. *Oriental Insects* **17**: 127-157.

Lansbury, I. (1968) The *Enithares* (Hemiptera-Heteroptera: Notonectidae) of the Oriental region. *Pacific Insects* **10** (2): 353-442.

Lawrence, J. F., Mastings, A. M., Dallwitz, M. J., Paine, T.A. and Zurcher, E. J. (1999) *Beetles of the World: A Key and Information system for Families and subfamilies*. CD-ROM, Version 1.0 for MS-Windows. CSIRO Publishing, Melbourne.

Malicky, H. (1989a) Köcherfliegen (Trichoptera) von Sumatra und Nias: Die Gattungen *Chimarra* (Philopotamidae) und *Marilia* (Odontoceridae), mit Nachtragen zu *Rhyacophila* (Rhyacophilidae). *Mitteilungen der Schweizerischen Entomologischen Gesellschaft* **62**: 131-143.

Malicky, H. (1989b) Odontoceridae aus Thailand (Trichoptera). *Opuscula Zoologica Flumin.* **36**: 1-16.

Malicky, H. (1995) Neue Köcherfliegen (Trichoptera, Insecta) aus Vietnam. *Linzer Biologie Beitrage* **27**:851-885.

Malicky, H. (1998) The net-spinning larvae of the Giant Microcaddisfly, *Ugandatrichia* spp. (Trichoptera, Hydroptilidae). In: *Proceedings of the 9th International Symposium on Trichoptera*. H. Malicky and P. Chantaramongkol, eds. Faculty of Science, Chiang Mai University, Chiang Mai, Thailand. pp. 199-204.

Malicky, H. and Chantaramongkol, P. (1989a.) Einige Rhyacophilidae aus Thailand (Trichoptera). *Entomologische Zeitschrift Mit Insektenbörse* **99**: 17-24.

Malicky, H. and Chantaramongkol, P. (1989b) Beschreibung von neuen Köcherfliegen (Trichoptera) aus Thailand und Burma. *Entomologische Berichte Luzern* **25**: 113-122.

- Malicky, H. and Chantaramongkol, P. (1991) Beschreibung von *Trichomacronema paniae* n sp. (Trichoptera, Hydropsychidae) aus Nord-Thailand und Beobachtungen über ihre Lebensweise. *Entomologische Berichte Luzern* **25**: 113-122.
- Malicky, H. and Chantaramongkol, P. (1992) Neue Köcherfliegen (Trichoptera) aus Thailand und angrenzenden Ländern. *Braueria* **19**: 13-23.
- Malicky, H. and Chantaramongkol, P. (1993a.) The altitudinal distribution of Trichoptera species in Mae Klang catchment on Doi Inthanon, northern Thailand: stream zonation and cool- and warm-adapted groups. *Revue Hydrobiolga Tropicale* **26**: 279-291.
- Malicky, H. and Chantaramongkol, P. (1993b.) Neue Trichopteren aus Thailand. Teil 1: Rhyacophilidae, Hydrobiosidae, Philopotamidae, Polycentropodidae, Economidae, Psychomyidae, Arctopsychidae, Hydropsychidae. *Linzer Biologie Beiträge* **25**: 433-487.
- Malicky, H. and Chantaramongkol, P. (1997.) Weitere neue Köcherfliegen (Trichoptera) aus Thailand. *Linzer Biologie Beiträge* **29**: 203-215.
- Malicky, H., Chantaramongkol, P., Cheunbarn, S. and Sangpradub, N. (2001.) Einige neue Köcherfliegen (Trichoptera) aus Thailand. *Braueria* **28**: 11-14
- Malicky, H., Chantaramongkol, P., Sangpradub, N., Chaibu, P., Thani, I., Changthong, N., Cheunbarn, S., Laudee, P., Prommi, T. and Sompong, S. (2002.) Neue asiatische Leptoceridae (Trichoptera). *Braueria* **29**: 15-30.
- Merritt, R.W. and Cummins, K.W. (eds). (1996.) *An Introduction to the Aquatic Insects of North America, 3rd edition*. Kendall/Hunt Publishing Company, Iowa.
- Metcalfe, J. I. (1989) Biological water quality assessment of running water based on macroinvertebrate communities: history and present status in Europe. *Environmental Pollution* **60**: 101-139.
- Morse, J. C. (ed.) (2004) Trichoptera World Checklist. <http://entweb.clemson.edu/database/trichopt/index.htm>, effective June, 2004.
- Morse, J.C., Yang, L. and Tian, L. (eds.). (1994.) *Aquatic Insects of China Useful for Monitoring Water Quality*. Honai University Press, Nanjing, China, 570 pp.
- MRC. (2003) *State of the Basin Report: 2003*. Executive Summary. Mekong River Commission, Phnom Penh.
- New, T.R. and Theischinger, G. (1992) Megaloptera Alderflies Dobsonflies, Handbuch der Zoologie IV, part 33. de Gruyter, Berlin.
- Ng, P.K.L. (1988) *The freshwater crabs of Peninsular Malaysia and Singapore*. Department of Zoology, National University of Singapore.
- Nieser, N. (1996) An illustrated key to the families of Nepomorpha in Thailand. *Amemboa* **1**: 4-9.

- Nieser, N. (1998) Introduction to the Notonectidae (Nepomorpha) of Thailand. *Amemboa* **2**: 10-14.
- Nieser, N. (1999) Introduction to the Micronectidae (Nepomorpha) of Thailand. *Amemboa* **3**: 9-12.
- Nieser, N. and Polhemus, D.A. (1998) Introduction to the Nepidae of Thailand. *Amemboa* **2**: 19-23.
- Nilsson, A.N. (1995) Noteridae and Dytiscidae: annotated check list of the Noteridae and Dytiscidae of China (Coleoptera). In: Jäch, M.A. and Ji, L. (Eds), *Water Beetles of China. Vol I*. Zoologisch-Botanische Gesellschaft & Wiener Coleopterologenverein, Vienna. pp. 35-96.
- Nguyen, V.V. (2003) *Systematic of the Ephemeroptera (Insecta) of Vietnam*. Ph.D. Thesis, Seoul Women's University.
- Panha, S. (1991) The investigation on host specificity of freshwater pearl mussel, *Hyriopsis (Limnoscapha) myersiana* (Lea, 1856) glochidium. 17th Congress on Science and Technology of Thailand, 24-26 October 1991, Khon Kaen University. pp. 386-387.
- Payupwatanawong, A. (2001) Some Annulipalpia caddisflies of Phromlaeng and Yakrua streams, Nam Nao National Park. Research Project, Faculty of Science, Khon Kaen University.
- Pennak, R. (1989) *Freshwater invertebrates of the United States, 3rd edition*. John Wiley and Sons, New York.
- Pescador, M. L., Rasmussen, A. K. and Richard, B. A. (2000) *A guide to the stoneflies (Plecoptera) of Florida*. Final Report for DEP Contract Number WM671.
- Peters, W.L. (1967) New species of *Prosopistoma* from the Oriental region (Prosopistomatoidea: Ephemeroptera). *Tijdschrift voor Entomologie deel* **110**: 207-222.
- Peters, W.L. and Edmunds, G.F. (1970) Revision of the generic classification of the Eastern Hemisphere Leptophlebiidae (Ephemeroptera). *Pacific Insects* **12**: 157-240.
- Pinratana, A., Kiasuta, B. and Hämäläinen, M. (1988) *List of the Odonata of Thailand and Annotated Bibliography*. The Viratham Press, Bangkok.
- Polhemus, D.A. and Polhemus, J.T. (1988) The Aphelocheirinae of tropical Asia (Heteroptera: Naucoridae). *Raffles Bulletin of Zoology* **36**: 167-300.
- Polhemus, D.A. and Polhemus, J.T. (1995) The Trepobatinae (Heteroptera: Gerridae) of New Guinea and surrounding region, with a review of the world fauna. Part 3. Tribe Trepobatini. *Entomologica Scandinavica* **26**(1): 97-117.
- Polhemus, D.A. and Polhemus, J.T. 1999. Introduction to the Leptopodomorpha of Thailand and adjacent countries. *Amemboa* **3**: 14-21.

- Radomsuk, S. (1999) *Species diversity of Caddisflies (Trichoptera: Hydropsychidae) in Promlaeng and Yakrua Streams, Nam Nao National Park, Thailand*. M.Sc. Thesis. Khon Kaen University.
- Radomyos, P., Tangtrongchitr, A., Looareesuwan, S. and Chongsuphajaisiddhi, T. (1992) *Atlas of Medical Parasitology*. T. P. Print, Bangkok.
- Rosenberg, D.M and Resh, V.H. (1993) *Freshwater Biomonitoring and Benthic Macroinvertebrates*. Chapman & Hall, New York.
- Sangpradub, N., Inmuong, Y., Hanjavanit, C., Asachai, A. and Udonphimai, P. (1999) *Distribution of Ephemeroptern, Plecopteran and Trichopteran (EPT) larvae in watershed streams, Northeast, Thailand*. Research Report to BRT.
- Sirisinthuwanit, K.(2001) *Species diversity and diet composition of calamoceratid caddisflies (Insecta: Trichoptera) in Promlaeng and Yakrua streams, Nam Nao National Park*. Research Project, Faculty of Science, Khon Kaen University.
- Sites, R.W., Nichols, B.J. and Permkam, S. (1997) The Naucoridae (Heteroptera) of southern Thailand. *Pan-Pacific Entomologist* **73**: 127-134.
- Sites, R. W. and Polhemus, J. T. 2000. A new species of Telmatotrepes (Heteroptera: Nepidae) from Thailand, with distributional notes on congeners. *Aquatic Insects* 23(4): 333-340.
- Sites, R.W., Wang, T., Permkam, S. and Hubbard, M.D. (2001) The mayfly genera (Ephemeroptera) of Southern Thailand. *Natural History Bulletin. Siam Society*. **49**: 121-146.
- Sivec, I. 1984. Study of genus Neoperla (Plecoptera: Perlidae) from the Philippines. *Scoplia* 7: 1-44.
- Sivec, I. and Zwick, P. (1989) Addition to the knowledge of genus Chinoperla (Plecoptera: Perlidae). *Aquatic Insects* **11**: 11-16.
- Sivec, I., Stark, B.P. and Uchida, S. (1988) Synopsis of the World Genera of Perlinae (Plecoptera:Perlidae). *Scoplia* **16**: 1-66.
- Soldán T. (2001) Status of the systematic knowledge and priorities in Ephemeroptera studies: the Oriental region. In: Dominguez, E. (ed.). *Trends in Research in Ephemeroptera and Plecoptera*. Kluwer Academics/Plenum Publishers, New York. pp. 53-66.
- Soldán, T. and Braasch, D. (1984.) Two new species of the genus *Prosopistoma* (Ephemeroptera, Prosopistomatidae) from Vietnam, with descriptions of the nymphal stages and biology of the genus. *Acta Entomology Bohemoslov* **83**: 202-212.
- Soldán, T. and Putz, M. (2000.) The Larva of *Rhoenanthus distafurcus* Bae et McCafferty (Ephemeroptera: Potamanthidae) with notes on distribution and biology. *Aquatic Insects* **22**(1): 9-17.

- Stark, B.P. (1983) Descriptions of Neoperlini from Thailand and Malaysia (Plecoptera: Perlidae). *Aquatic Insects* **5**: 99-114.
- Stark, B.P. (1987) Records and descriptions of Oriental Neoperlini (Plecoptera: Perlidae). *Aquatic Insects* **9**: 45-50.
- Stark, B.P. (1989) Oriental Peltoperlidae (Plecoptera): a generic review and description of a new genus and seven new species. *Entomologica Scandinavica* **19**: 503-525.
- Stark, B.P. and Sivec, I. (1991) Description of Oriental Perlini (Plecoptera: Perlidae). *Aquatic Insects* **13**: 151-160.
- Storer, T.I. and Usinger, R.L. (1957) *General Zoology. 4th edition*. McGraw-Hill Book Company, New York.
- Tani, K. and Miyatake, Y. (1979.) The discovery of *Epiophlebia laidlawi* Tillyard, 1921 in the Kathmandu Valley, Nepal (Anisozygoptera: Epiophlebiidae). *Odonatologica* **8**: 329-332.
- Tanida, K., (1986a) A revision of Japanese species of the genus *Hydropsyche* (Trichoptera, Hydropsychidae) I. *Kontyû* **54**: 467-484.
- Tanida, K., (1986b) A revision of Japanese species of the genus *Hydropsyche* (Trichoptera, Hydropsychidae) II. *Kontyû* **54**: 624-633.
- Tanida, K., (1987) A revision of Japanese species of the genus *Hydropsyche* (Trichoptera, Hydropsychidae) III. *Kontyû* **55**: 59-70.
- Thomas, A. (1992) *Gratia sororculaenadinae* n. gen., n. sp., Epheméroptère nouveau de Thaïlande (Ephemeroptera, Baetidae). *Bulletin de la Société d'Histoire naturelle de Toulouse* **128**: 47-51.
- Tshernova, O.A. (1972) Some new species of mayflies from Asia (Ephemeroptera, Heptageniidae, Ephemerellidae). *Entomologicheskoe Obozrenie* **51**: 604-614.
- Upatham, S., Sornmani, S., Kittikoon, V. Lohachit, C. and Bruch, J.B. (1983) Identification key for the fresh- and brackish-water snails of Thailand. *Malacological Review*. **16**: 107-132.
- Wallace, I.D., Wallace, B. and Philipson, G.N. (1990) *A key to the case-bearing caddis larvae of Britain and Ireland*. Freshwater Biological Association Scientific Publication No. 51.
- White, D. S. and Brigham, W. U. (1996) Aquatic Coleoptera . In: Merrit, R.W. and Cummins, K.W. (eds), *An Introduction to the Aquatic Insects of North America, 3rd edition*. Kendall/Hunt Publishing Company, Iowa. pp. 399-483.
- Wiggins, G.B. (1996) *Larvae of the North American Caddisfly Genera (Trichoptera), 2nd edition*. University of Toronto Press, Toronto.

- Wiggins, G.B., Morse, J.C., Yang, L., Tian, L. and Li, Y. (1994) Trichoptera. In: Morse, J.C., Yang, L. and Tian, L. (eds.). *Aquatic Insects of China Useful for Monitoring Water Quality*. Honai University Press, Nanjing, China. pp. 260-319.
- Wood, T. (2001) Bryozoans. In: Thorp, J.H. and Covich, A.P. (eds.). *Ecology and Classification of North American Freshwater Invertebrates*. Academic Press, San Diego. pp. 481-499.
- Xiufu, Z. (1998) Odonata. In: Morse, J. C., Yang, L. and Tian, L (eds.). *Aquatic Insects of China Useful for Monitoring Water Quality*. Honai University Press, Nanjing, China. pp. 135-175.
- Yang , D. and Yang, C. (1994) Megaloptera and Aquatic Neuroptera. In: Morse, J. C., Yang, L. and Tian, L (eds.). *Aquatic Insects of China Useful for Monitoring Water Quality*. Honai University Press, Nanjing, China. pp. 250-259.
- Yoshiyasu, Y., (1985) Lepidoptera. In: Kawai, T. (ed.). *An Illustrated Book of Aquatic Insects of Japan*. Tokai University Press, Tokai. pp. 217-226.
- Yule, C. (2004) Order Diptera. In: Yule, C. and Sen, Y. H. (eds.). *Freshwater Invertebrates of the Malaysian Region*. Academy of Sciences, Malaysia.
- Zettle, H. (1998) Introduction to the Helotrephidae (Nepomorpha) in Thailand and adjacent countries. *Amemboa* **2**: 15-18.
- Zettle, H. (1999a) An illustrated key to the genera of Hebridae (Gerromorpha) in Thailand. *Amemboa* **3**: 22-26.
- Zettle, H. (1999b) Addition to the key to genera of Helotrephidae. *Amemboa* **3**: 13.
- Zettle, H. and Chen, P. (1996) An illustrated key to the Hydrometridae of Thailand. *Amemboa* **1**: 14-17.
- Zwick, P. (1982) A revision of the oriental stonefly genus *Phanoperla* (Plecoptera: Perlidae). *Systematic Entomology* **7**: 87-126.
- Zwick, P. (1986) Contribution to the knowledge of *Phanoperla* Banks, 1983 (Plecoptera: Perlidae). *Bulletin de la Société Entomologique Suisse* **59**: 151-158.
- Zwick, P. and Sivec, I. (1985) Supplements to the Perlidae (Plecoptera) of Sumatra. *Spixiana* **8**: 123-1

Glossary

A

Aboral	The part of the body opposite the mouth.
Acoelomate	Without a body cavity between the outer body wall musculature and gut.
Adductor	A muscle that draws the two valves of a mollusc shell together.
Alloistropic	Protochonch and telechonch are in the different direction.
Ametabola	Without metamorphosis.
Amictic	The diploid eggs produced by female rotifers that can not be fertilized.
Anteapical	Just proximal of the apex.
Anteclypeus	An anterior division of the clypeus.
Antenna	A sensory appendage on the head of arthropods.
Antennal gland	Excretory organ of crustaceans located in the antennal metamere.
Aperture	An opening into the first whorl of a snail shell.
Apopyle	Opening of the radial canal into the spongocoel of the sponges
Apterous	Wingless.
Asconoid	Simple canal system of sponges, with canal leading directly from the water outside to the internal spongocoel.
Auricle	The ear-like lobe in planarians.

B

Benthic	Living on the substrates at the bottom of aquatic habitats.
Biramous	Two branched.
Bipectinate	Having branches on two sides like teeth of a comb.
Brachypterous	With short wings that do not cover the abdomen.
Buccula	One of two ridges on the underside of the head, on each side of the beak.

C

Campodeiform	An active larva with a shape that is elongate and flattened and has well-developed legs and antennae.
--------------	---

Carapace	Shield-like plate covering the cephalothorax of some crustacean such as shrimps and crabs.
Cardiiform	Heart-shaped.
Cardinal (tooth)	One of two basic categories of teeth in bivalves, cardinal teeth and lateral teeth.
Carina	A keel or ridge.
Carpus	Fourth of basically six segments of inner branch (endopod) of a thoracopod.
Caudal	Belonging to or relating to the tail.
Cephalothorax	A body division found in some arthropods in which head is fused with some or all of the thoracic segments.
Cercus (Cerci)	One of a pair of appendages at the posterior end of the abdomen.
Cervical gill	Gill on the neck.
Chelicerae	A pair of anterior appendages in spiders and mites.
Chitin	A horny substance made of nitrogenous oligosaccharides that forms part of the cuticle of arthropods.
Choanocyte	One of the flagellated collar cells that line cavities and canals of sponges.
Claval suture	The suture of the front wing separating the clavus from the corium.
Clitellum	A thickened portion of certain segments of oligochaetes and leeches.
Cnidoblast	Modified interstitial cell that holds the nematocyst in cnidarians.
Cocoon	The protective covering for the developing embryos of some annelids, or the protective covering and its pupa in endopterygote insects.
Coelom	An internal body cavity lying between the outer body wall musculature and gut.
Collophore	A tube-like structure located on the ventral side of the first abdominal segment of collembolans.
Collumella (axis)	Calcareous structure forming central axis of snail shells.
Commissure	A structure that connects the left and right sides of a segment.
Connexival	A line of contact between dorsal and ventral laterotergites on the lateral margin of the abdomen.
Corium	The elongate, thick, basal portion of the front wing.
Corneous	Of a horny or chitinous substance; resembling horn in texture.
Corona	Ciliated disc on anterior end of a rotifer.

Coxa	The proximal joint of an arthropod leg or protopod.
Cruciform	The relatively small muscle spanning posteroventrally between valves; intersect in midbody to form cross.
Cuticle	The noncellular organic protective layer of the body wall secreted by the hypodermis of many invertebrates.
Clypeus	A sclerite on the lower part of the face, between the frons and the labium.
D	
Dactylus	Seventh segment of thoracopod; may serve as movable element in terminal pincer (chela).
Demarcation	The action of fixing boundaries or limits, a dividing line.
Desclerotize	Loss of sclerotin in normally sclerotized parts or structure.
Detritus	Particles of dead organic matter suspended in water or lying on the bottom.
Devoid	Entirely lacking in.
Dextral	On the right; in gastropods, shell is dextral if opening is to right of columella when held with spire up and facing observer.
Dioecious	Having separate sexes.
Diploblastic	Possessing two distinct tissue layers during embryonic development (ectoderm and endoderm).
Discoid	Shape like a disc.
Distal	Near or toward the free end of an appendage.
Divergence	Become more separated distally.
E	
Ectoderm	An outer germ layer of cells of an embryo.
Endoderm	An innermost germ layer of embryo.
Endopterygote	Having the wings developing internally; with complete metamorphosis.
Elytra	A thickened, leathery, or horny front wing.
Endopodite	Medial branch of a biramous appendage of crustacean.
Epistome	Flap over the mouth in some bryozoans.
Exoskeleton	A supporting structure secreted by the epidermis of arthropods.
Exopodite	Lateral branch of a biramous appendage in crustacean.
Exopterygote	With the wing developing on the outside of the body, as in insects

with simple metamorphosis.

F

Femur	The third leg segment, located between the trochanter and the tibia.
Filter feeding	Any feeding process by which particulate food is filtered from water in which it is suspended.
Fouling	i) Contamination of feeding or respiratory area of snail by its waste products. ii) Accumulation of sessile organisms on the hull of a ship or boat.
Fovea	A small pit or depression.
Furcula	The forked spring apparatus of the Collembola.

G

Gastrodermis	Lining of the digestive cavity of cnidarians.
Gastrovascular cavity	Body cavity of the Cnidarians that functions in both digestion and circulation and has a single opening serving as both mouth and anus.
Gemmule	Resistant cyst-like asexual reproduction unit of freshwater sponges.
Globose	Spherical or nearly spherical.
Glossa	One of a pair of lobes at the apex of the labium between the paraglossae.
Glochidium	Bivalve larval stage of freshwater pelecypod.

H

Haltere	A small knobbed structure on each side of the metathorax, formed from a modified hind wing (in Diptera).
Hemimetabolous	Having simple metamorphosis, like that in the Odonata, Ephemeroptera and Plecoptera.
Hemelytra	The front wing of Hemiptera.
Hinge teeth	The teeth along dorsal margin which function during opening and closing of shell.
Hirsute	Having abundant setae on the body, setose.
Homeostrophic	Protoconch and teleconch are in the same direction.
Hypognathous	With the head and the mouthparts directed ventrally.
Hypostomium	A mound-like structure located around the mouth in hydras.

I

Imago	The adult or reproductive stage of an insect.
Infracoxal	Below the coxa.
Ischium	Second of basically six segments of inner branch (endopod) of thoracopod.

L

Labium	The lower lip of insect.
Labrum	The upper lip of insect.
Lamelliform	Plate-like shape.
Laminate	Plate-like structure.
Lanceolate	Spear-shaped, tapering at each end.
Larva	An immature stage in the life history of many invertebrates in which morphology differs from adults.
Ligula	The terminal lobe of the labium, the glossae and paraglossae.
Lorica	A secreted, protective covering in rotifers.
Lophophore	Tentacle-bearing ridge which is an extension of the coelomic cavity in Bryozoa (Ectoprocta).

M

Macropterous	Fully winged.
Malpighian tubules	Excretory organs of insects and some arthropods; they are blind tubes opening into the hindgut.
Mantle	Soft extension of the body wall in molluscs which secretes a shell.
Mastax	Pharyngeal mill of rotifers.
Membranous	Like a membrane.
Mentum	The distal part of the labium, which bears the palps and the ligula.
Mesoepimeron	The epimeron of the mesothorax.
Mesoglea	Jellylike material between the epidermis and gastrodermis of cnidarians.
Mesohyl	The jellylike matrix surrounding cells of sponges.
Mesosternum	The sternum, or ventral sclerite, of the mesothorax.
Metamorphosis	A change in form during development.
Molt	A process of shedding the exoskeleton; ecdysis; to shed the exoskeleton.

Monecious	Having both male and female in one individual.
N	
Nacreous	Innermost layer of mollusc shell, secreted by mantle epithelium.
Nematocyst	Stinging organelle of cnidarians.
Nodate	A strong crossvein near the middle of the costal border of the wing.
Nymph	An immature stage of an insect that does not have a pupal stage.
Nauplius	A free-swimming larval stage of certain crustaceans, with three pairs of appendages: antennules, antennae and mandible; and a median (nauplius) eye.
O	
Occipital ridge	A ridge extending between the compound eyes on the caudodorsal angle of the head.
Occiput	The dorsal posterior part of the head between the occipital and postoccipital sutures.
Ocellus	A simple eye or eye spot in many invertebrates.
Operculum	A lid or plate closing the opening into a snail shell.
Osculum	Excurrent opening of sponges.
Ostium	Any opening through which water enters a sponge.
Ostiole	A small opening.
Oviparous	Reproduction in which eggs are released by female; development of offspring occurs outside the maternal body.
Ovoviviparous	Reproduction in which eggs develop within the maternal body and hatch within the mother, or immediately after laying.
P	
Palp	A segmented process born by the maxillae or labium.
Palpiger	The lobe of the mentum of the labium that bears the palp.
Papilla	A small nipplelike elevation.
Paraglossa	One of a pair of lobes at the apex of the labium, lateral to the glossae.
Paramere	A lobe or process at the base of the aedeagus (in male genitalia).
Parasitoid	An animal that feeds in or on another living animal of a relatively long time, consuming all or most of its tissues and eventually killing it.

Parthenogenesis	Development of an unfertilized egg into a functional adult.
Penultimate	Next to the last.
Pereopod	Last five thoracic appendages, walking legs in decapods.
Peripheral	Structure or location distant from center, near outer boundaries.
Peristome	Around the mouth.
Pilose	Covered with setae.
Pinacocyte	Flattened cells comprising dermal epithelium in sponges.
Plankton	Floating organisms that have limited locomotory capabilities and therefore are distributed by water movements.
Pleopod (Swimmeret)	Abdominal appendages modified as copulatory structures (e.g. gonopod in male, egg brooding structure in female) or as swimming structures.
Pneumostome	The opening of the mantle cavity (lung) of pulmonate gastropods to the outside.
Polyp	The sessile stage in the life cycle of cnidarians.
Prehensile	Adapted for grasping.
Prementum	The distal part of the labium.
Proboscis	A tubular sucking or feeding organ with the mouth at the end found in planarians, leeches and lepidopteran insects.
Prognathous	Having the head horizontal and the mouthparts projecting forward.
Proleg	One of the fleshy abdominal legs of certain insect larvae.
Pronotum	The dorsal sclerite of the prothorax.
Propodus	Sixth segment of appendage, between carpus and dactylus.
Prosternum	The sternum, or ventral sclerite, of the prothorax.
Protoconch (Nuclear whorls)	At apex of shell, whorl or whorls formed by larval snail.
Protonephridia	Primitive osmoregulatory or excretory organs consisting of a tubule terminating internally with flame bulb.
Protuberance	Thing that protrudes.
Pseudocardinal tooth	The cardinal tooth in certain bivalves; cardinal tooth is not separated from lateral tooth on hinge and is somewhat irregular.
Pubescence	Covering of short, fine setae.
Punctate	Pitted or beset with punctures.
R	
Radula	Rasping tongue in some molluscs.

Reniform	Kidney-shaped.
Retractor	Capable of being pushed out and drawn back in.
Retreat	Refuge or isolated place.
Rhabdite	Rodlike structures in the cells of the epidermis or underlying parenchyma in certain turbellarians. They are discharged in mucous secretions.
Rhomboid	A quadrilateral of which only the opposite sides and angles are equal.
Rostrum	A snout-like projection on the head.
S	
Saccoid gill	A swollen sac-like gill.
Scent gland	A gland producing an odorous substance.
Sclerotization	Process of hardening the cuticle of arthropods by the formation of stabilizing cross-linkages between peptide chains of adjacent protein molecules.
Scutellum	A sclerite of the thoracic notum; a mesoscutellum as a more or less triangular sclerite behind the pronotum.
Septa	Mesodermal sheet separating adjacent segments, as in annelids.
Serrate	Toothed along the edge like a saw.
Sessile	Attached or fastened, incapable of moving from place to place; attached directly, without a stem or stalk.
Seta	A needlelike chitinous structure of the integument of annelids, arthropods, and others; a bristle.
Sinistral	Left-handed; pertaining to the left; in gastropods, shell is sinistral if opening is to the left of columella when held with spire up and facing observer.
Siphon	Tubular extension of the mantle margin.
Snout	The projecting nose and mouth of an animal.
Spatulate	Spoon-shaped.
Spicule	Calcareous and siliceous skeletal formations present in the tissues of sponges.
Spiracle	External opening of a trachea in arthropods.
Spongocoel	Central cavity of sponges.
Sternum	Ventral sclerite of an abdominal segment of arthropods.
Sternite	Ventral plate of an abdominal segment.

Stipes	The second segment, or division, of a maxilla, which bears the palp, the galea, and the lacinia.
Stridulate	To make a noise by rubbing two structures or surfaces together.
Subgenital plate	A platelike sternite that underlies the genitalia.
Subimago	The first of two winged instars of a mayfly after it emerges from the water.
Supracoxal	Above the coxa.
Suture	An external line-like groove in the wall, forms a border between two adjoining whorls in gastropod shells.
Syncytium	A mass of protoplasm containing many nuclei and not divided into cells.

T

Tagmata	A compound body section of an arthropod resulting from embryonic fusion of two or more segments.
Tarsomere	A segment of tarsus.
Tarsus	The leg segment immediately beyond the tibia.
Teleconch	All shell whorls exclusive of protoconch.
Telson	The posterior part of the last abdominal segment; the posterior nonmetameric portion of the body.
Tenaculum	A minute structure on the ventral side of the third abdominal segment that serves as a clasp for the furcula of Collembola.
Tergum	Dorsal part of an arthropod body segment.
Trachea	A spirally-ringed, internal, elastic air tube in insects; an element of the respiratory system.
Trapezoidal	A quadrilateral with one pair of sides parallel.
Triploblastic	Three primary germ layers of metazoan embryo: ectoderm, mesoderm and endoderm.
Trochanter	A segment of the insect leg between the coxa and the femur.
Trochantin	A small sclerite in the thoracic wall immediately anterior to the base of the coxa.
Trochophore larva	Free-swimming larva of some snails.
Tubercle	A small knoblike rounded protuberance.
Turret (shaped)	Tower shaped.

U

Umbilicus	Depression or cavity at base of body whorl.
Umbo	The prominences on either side of the hinge region in a bivalve shells.
Urogomphi	Fixed or movable cercus-like processes on the last segment of a beetle larva.
Uropod	One of the terminal pair of lobe-like abdominal appendages.

V

Veliger	Larval form of certain molluscs; develops from the trochophore and has the beginning of a foot, mantle and shell.
Velum	A membrane on the subumbrella surface of jellyfishes of class Hydrozoa; or a ciliated swimming organ of a snail larva.
Verge	Penis; male copulatory structure often located on head of snail.
Vestigial	Small, poorly developed, degenerate, non functional.
Visceral mass	Region of dorsoposterior body of a gastropod, generally well separated from head/foot, containing most of digestive, excretory, circulation and reproduction systems.
Viviparous	Reproduction in which eggs develop within the female body.

W

Whorl	Any complete coil or exposed surface of complete coil in gastropod.
-------	---

Z

Zooecium	Cuticular sheath or shell of Bryozoa (Ectoprocta).
Zooid	A single member of a colony.