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Key to the West Palaearctic genera of stoneflies (Plecoptera) in the larval stage

Peter Zwick*

Limnologische Fluss-Station Schlitz des Max-Planck-Instituts für Limnologie, Schlitz, Germany

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Abstract

An illustrated dichotomous key to larvae of all genera of Plecoptera in the West Palaearctic region (i.e., Europe, Asia Minor and the Palaearctic part of northern Africa) is presented. Brief comments on included species are added for each genus, plus diagnostic details of selected bioindicator species. Two appendices provide a key to larvae of the German species of genus *Nemoura* and taxonomic notes on selected species and operational taxonomic units in genus *Leuctra*, respectively.

Key words: Dichotomous generic key – larval taxonomy – Europe – Asia Minor – Palaearctic North Africa

Introduction

Plecoptera constitute a numerically and ecologically significant component in freshwater ecosystems, mainly in running waters of all sizes, all over the world. The fauna of the vast Holarctic Region is relatively uniform, and its stonefly families are essentially endemic to it, only some extend into the Oriental Region.The East Palaearctic and the Nearctic subregions are particularly similar, sharing the families Pteronarcyidae, Styloperlidae, and Peltoperlidae, and a number of genera and even single species that all lack from the West Palaearctic subregion. The wingless Scopuridae are endemic to Japan and Korea. Europe and the immediately adjacent parts of Asia and Palaearctic North Africa together are relatively distinct from the other subregions, not only by the absence of the beformentioned taxa but also by shared endemic genera.

Adult stonefly taxonomy is well advanced, the terrestrial imagines can reliably be identified, although in certain regions of the world and in some genera limitations remain. However, larvae are generally less well known than adults. Given the fact that many adults can be identified to species only by genital characters, a lastingly lesser taxonomic resolution must be anticipated in larvae, even after further study. In North America, excellent comprehensive literature on larval Plecoptera exists (Stewart & Stark 2002). The genera of the Russian Far East and Siberia have been treated synoptically, although in a less detailed way (Zhiltzova & Teslenko 1997). There is a preliminary key to the genera of the incompletely studied Chinese fauna (Harper 1994).

In Europe, there are several good regional generic keys to larvae in the relatively impoverished faunas in the North and in the center of the continent. Central Europe holds an outstanding position through the work of the late Jaroslav Raušer (1980), who published a key to the species from former Czechoslovakia. However, all these keys are of limited use in many parts of South Europe with much more diverse faunas. These include a number of endemic genera whose larvae have been de-

***Corresponding author:** Dr. Peter Zwick, Limnologische Fluss-Station, Damenweg 1, D-36110 Schlitz, Germany; e-mail: pzwick@mpil-schlitz.mpg.de

scribed, but not all in a comparative way, nor were they distinguished in keys.

The present paper keys all Plecoptera genera of the West Palaearctic Region. Brief comments on each genus are included. Where appropriate, suggestions or critical remarks on specific identifications of central European species are added, especially for species included in official lists of indicator organisms. There are also 2 appendices dealing with the German species of genus *Nemoura* and with selected species level taxa in genus *Leuctra*, respectively.

Geographic range

West Palaearctic Region (i.e., Europe eastwards to Ural Mts and western shore of Caspian Sea; Anatolia, Caucasus, Lebanon and areas to the South, including Israel and Africa North of Sahara). Plecoptera are unknown from Libya and areas to the East, as well as from the Arabian Peninsula.

Included taxa

All genera in the above range. In genera occurring also outside the West Palaearctic Region the key is designed for West Palaearctic species, exotic species of the same genera cannot necessarily be identified with the present key. All of the West Palaearctic families of Plecoptera belong in the suborder Arctoperlaria.

For monotypic genera, the single species is always named. For other genera, an attempt is occasionally made to identify selected species by characters listed in the text accompanying the genus.

Identifiable life stages

Characteristic character expressions of larvae develop stepwise, last instar larvae with fully formed wing-pads are optimal study objects. However, much younger larvae can also be identified with the present key but no larvae of less than *ca* 30% of final size (from about 3 mm body length in Leuctridae and the like to about 10 mm in the large Perlidae), or even first instars.

Counting of body segments

Segments of the trunk are counted from front to rear, parts of appendages from base to tip. Mind that of the 1st abdominal segment only the tergite is visible, the 1st sternite being fused to the metasternum. The first free, visible abdominal sternite is actually of segment 2. The female gonopore develops on sternite 8; its attachment scar moves backward at molts until it reaches the rear margin, interrupting the terminal hair fringe in its middle. The male gonopore is located at the end of sternite 9 but often barely noticeable.

Anal gills

A collective term for gill filaments arising from the soft medial faces of paraprocts. Fine whitish filaments protruding out of the anus are no gills but gut fungi of the group Harpellales, which are common in Plecoptera. If one seizes them with forceps they can easily be pulled out of the rectum.

Nomenclature and systematic arrangement

Nomenclature follows the 4th edition of the International Code of Zoological Nomenclature (1999). The world catalogues by Illies (1966) and Zwick (1973) were used as base. Recent literature, year 2003 included, was added. The system is that of Zwick (2000).

Illustrations

Illustrations are originals by P. Zwick, except when differently indicated. Illustrations were drawn at a variety of magnifications, from whole specimens or mounted parts, in direct or transmitted light. Illustrations are not generally to scale, absolute measurements are given where needed. Overall body length (BL) of fully grown larvae is indicated under each genus.

"Hot-keys"

A few taxa of various taxonomic rank can immediately be recognized, by reference to single key characters:

- Gill tufts on thoracic segments: Perlidae.
- Six tubuliform or sausage-shaped cervical gills (Fig. 11a): *Protonemura.*
- Four branched cervical gills (Fig. 11b): *Amphinemura.*
- One three-segmented telescoping gill filament on the inner face of each coxa (Fig. 8a); abdominal tergites with unpaired projections (Figs 8b, c): *Taeniopteryx.*
- Maxillary palpus with asymmetrically inserted tiny needle-like terminal segment (for example, Figs 7c, 23): Chloroperlidae.
- Head trapezoidal, extremely setose (Fig. 23): *Isoptena.*
- Thoracic dorsum shield-like, with wide parallel wing-pads, setose (Fig. 14); very small: *Capnopsis.*

Key to superfamilies

1 A transverse suture across upper face of head, between antennae and labrum (*L*), separating clypeus (*C*) from frons (*F*) (Fig. 1a). Labrum distinctly less than twice as wide as long. Mandibles plump, inner face with distinct mola (Fig. 2a); in lateral view, mandibles not even twice as long as high at the basal

articulation. Maxillary palpi short and stout (Fig. 1a). No striking large canine-like teeth on lacinia. Glossae and paraglossae subequal (Figs 5b, d). Coxae close together, thorax sternites between coxae small, the area between furcal pits and spina much smaller than a coxa (Figs 4a, b). Last tarsal segment at most as long as two basal segments together. The two basal segments differ between families but are never of equal length and structure (Figs 3b–d) ..... Nemouroidea

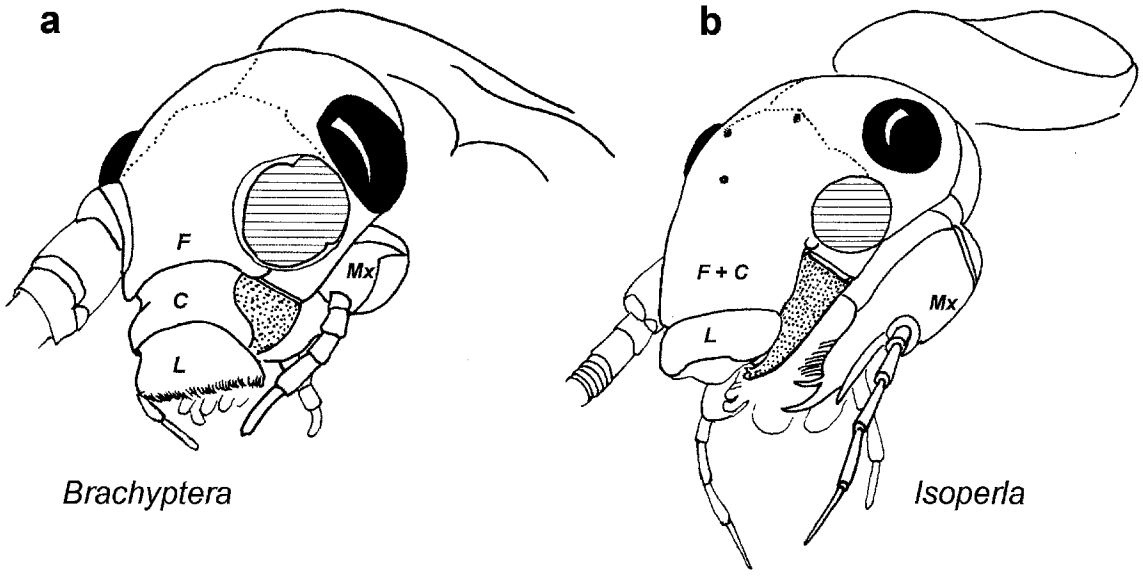

Fig. 1. Head, oblique anterior view. Left antenna removed, antennal foramen striate, left mandible stippled: (**a**) *Brachyptera* sp.; (**b**) *Isoperla* sp. Explanations: C = clypeus, F = frons, L = labrum, Mx = maxilla.

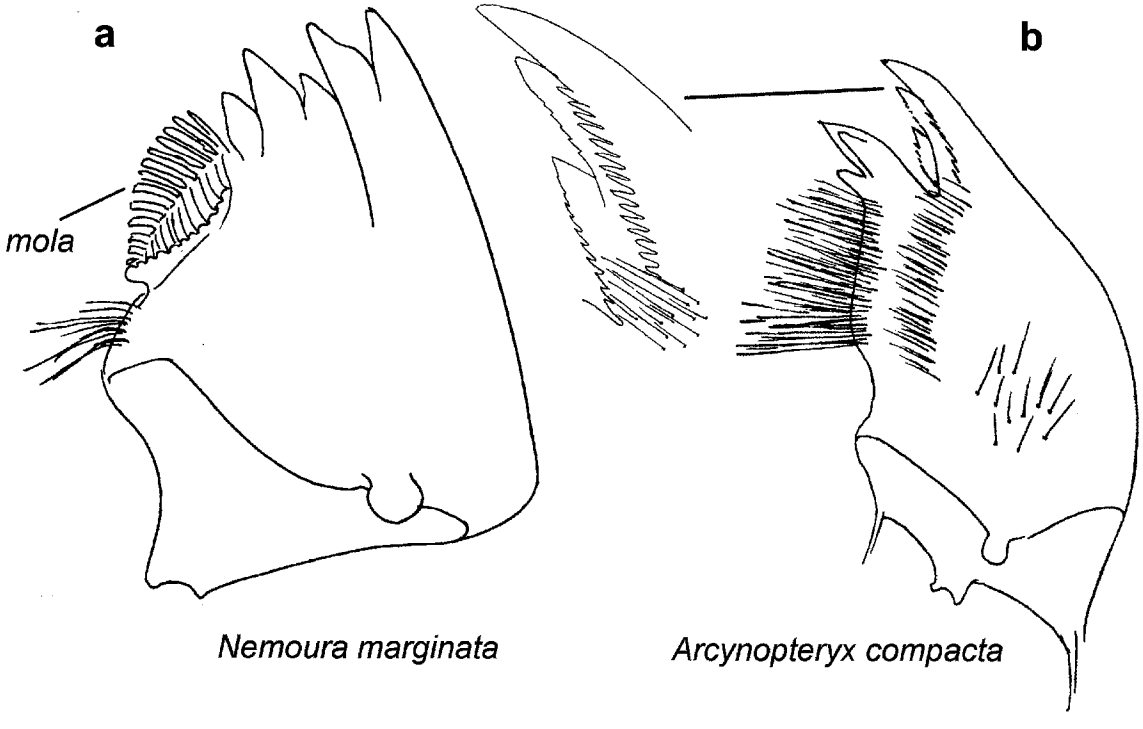

Fig. 2. Ventral view of left mandible of (**a**) *Nemoura marginata* PICTET, 1836 and (**b**) *Arcynopteryx compacta* (MCLACHLAN, 1872) (with enlarged apex of mandible).

1* No transverse suture crossing upper face of head between antennae and labrum (*L*), i.e. frontoclypeus (*F+C*) undivided (Fig. 1b). Labrum transverse, more than twice as wide as long. Mandibles flat and slender, without mola (Fig. 2b); in lateral view, mandibles are several times longer than high at the basal insertion; maxillary palpus long and slender (Fig. 1b). Lacinia with one or two canine- or claw-like large apical teeth (for example, Figs 1b, 20, 22). Glossae much shorter than paraglossae (Figs 6b, 7b). Coxae wide apart, thorax sternites between coxae extended, the area between furcal pits and spina about the size of a coxa (Figs 21b, c). Last tarsal segment about twice as long as two basal segments together; the latter are of equal size and very short (Fig. 3a) ..... Perloidea

Families of Nemouroidea

Conventional keys rely mainly on the orientation of wing-pads. In Plecoptera, first small rudiments of wing-pads appear in the antepenultimate instar (Zwick 2003), the definite shape is attained at subsequent molts. Using wing-pad position, reliable identifications are possible only for specimens in the two last instars. However, much younger larvae can be identified by less obvious characters; the present key uses position of wing-pads only as an auxiliary character.

1 All tarsal segments elongate, increasing in length from 1 to 3. Segment 1 deeply excavated on upper face, receiving base of segment 2. On its lower face, segment 1 projects under 2 like a sole (Fig. 3b) ..... Taeniopterygidae

Habitus very different between subfamilies. Lower face of head resembles Nemouridae.

1* Tarsal segment 2 much shorter than segments 1 or 3. Segment 1 is tubular, with segment 2 attached at its end. Segment 2 is dorsally excavated to receive the base of segment 3. Ventrally, segment 2 projects under 3 like a sole (Figs 3c, d) 2

2 Stout; extended hind legs reach to tip of abdomen or beyond; wing-pads diverge obliquely from body axis (Fig. 5a); pilosity always distinct. Lower face of head: bases of maxillae exposed, between them is the small soft plate of the mentum. On underside of thorax, the trochantinus is the only well defined and sclerotized sclerite. Furcasternum and spinasternum fused, together forming a groove between the huge middle coxae. At the bottom of the groove the tiny furcal pits are difficult to recognize (Fig. 4a). All coxae projecting much from sternal face, transversely extended towards body midline, in particular front and middle legs (Fig. 4c). Ventral face of coxae flat, unsclerotized, transparent. Cervical gills, or no gills ..... Nemouridae

2* More slender, extended hind legs do not attain end of abdomen. Wing-pads parallel to body axis (Abb. 5c),

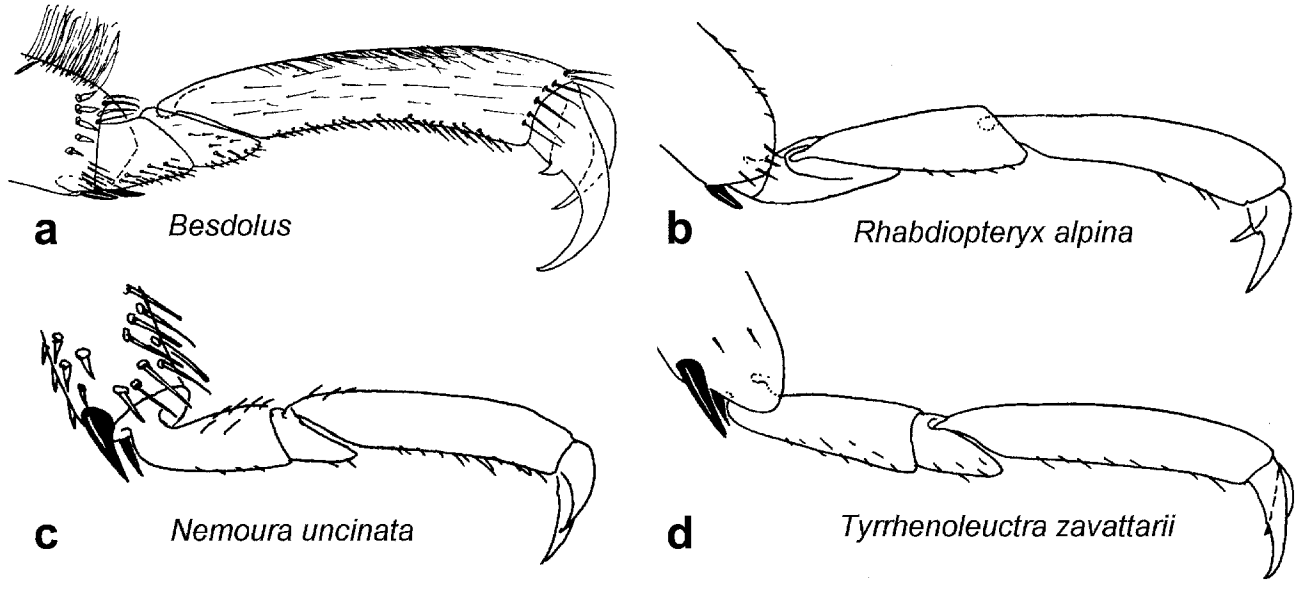

Fig. 3. Hind tarsus of (**a**) *Besdolus imhoffi* (Pictet, 1841), (**b**) *Rhabdiopteryx alpina* (Kühtreiber, 1934), (**c**) *Nemoura uncinata* (Despax, 1934) and (**d**) *Tyrrhenoleuctra zavattarii* (Consiglio, 1956).

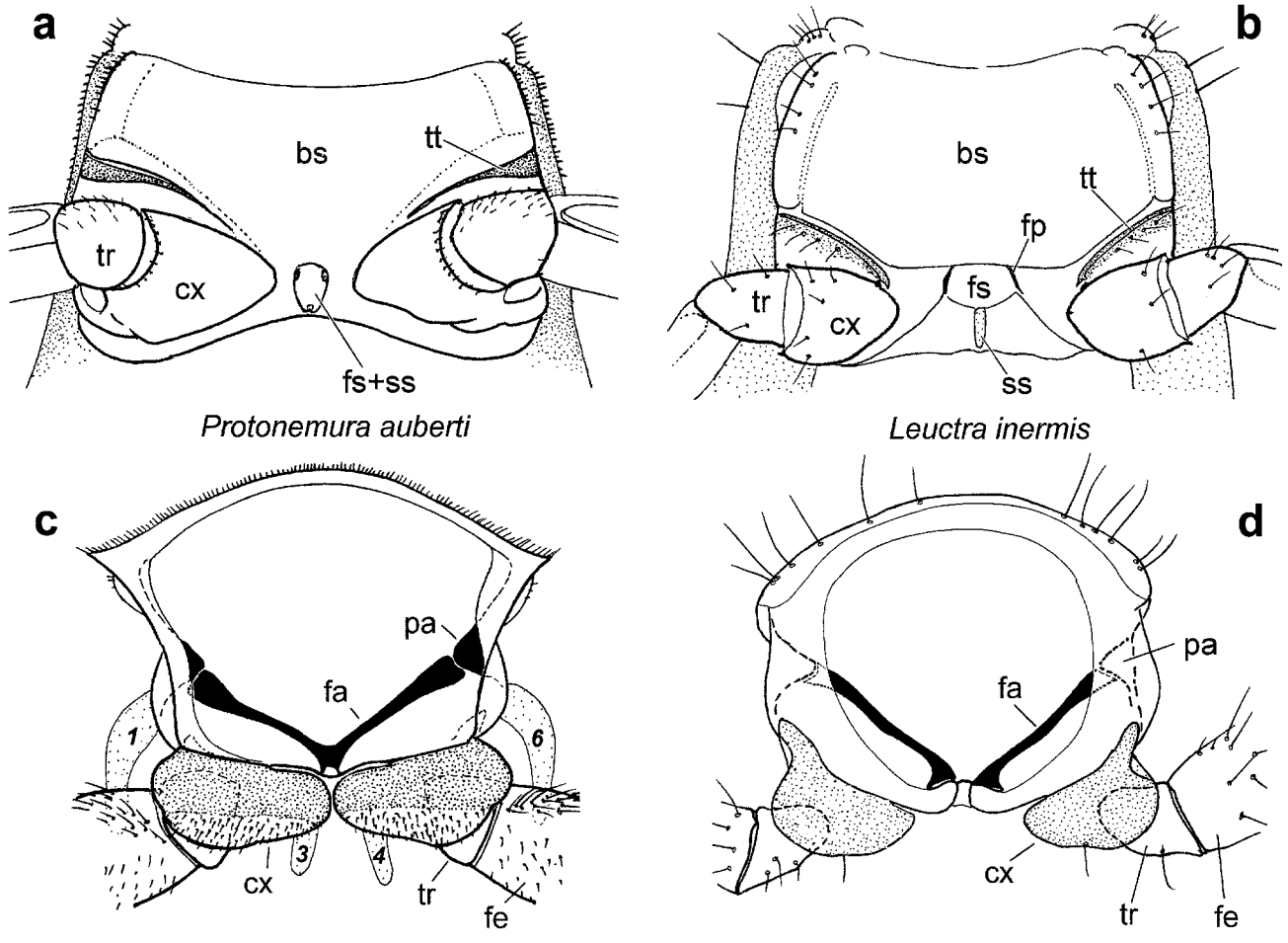

Fig. 4. Thorax of *Protonemura auberti* ILLIES, 1954 (**a, c**) and *Leuctra inermis* KEMPNY, 1899 (**b, d**), diagrammatic.
Explanations: a, b: ventral view of mesothorax, fine stippling identifies the wing pads, in the background; c, d: cross section through prothorax behind fore coxae, seen from behind. Only skeletal elements shown, internal ones exposed by the cut are in black. In c, only 4 of the 6 sausage-shaped gills (numbered) partly visible in background. bs = basisternum; cx = coxa; fa = furcal arm; fe = femur; fp = furcal pit; fs = furcasternum; pa = pleural arm; ss = spinasternum; tr = trochanter; tt = trochantinus.

except divergent in *Capnioneura* (Capniidae) which (unlike Nemouridae) lacks macroscopic pilosity. Thoracic sternites distinctly sclerotized, furca- and spinasternum of mesothorax well delimited, separate, together forming a Y-shaped area between the coxae, furcal pits well visible (Fig. 4b). Coxae of normal shape, medially not extended and not strikingly projecting from sternal surface (Fig. 4d). Never with gills 3

3 Mentum plate-like, extending far sideward and forward, largely covering bases of maxillae (Fig. 5d) ..... Leuctridae

3* Mentum small, base of labium elongate, mouthparts completely exposed (resembling Fig. 5b) ..... Capniidae

Families of Perloidea

1 Thorax with lateral tufts of finely branched gills. Head very wide, its sharp lateral margin conceals the basis of maxilla from above (Fig. 6a). From below, the maxillar base is largely covered by the enlarged postmentum, only cardo and stipes partly exposed (Fig. 6b). Prolonged front corners of postmentum (f) laterally embracing the base of labium. Paraglossae large, soft, cushion-like and swollen (Fig. 6b) ..... Perlidae

Larvae of this family have a distinctive habitus: they appear flat, with laterally extended flat legs with long setal fringes. Wing-pads little apparent even in the last instar, rounded on the outside and medially, separated by a wide shallow V-shaped notch.

1* No gills, head and mouthparts of different structure 2

2 Head and mouthparts very large, together as wide or wider than prothorax. Maxillae much enlarged, their enormous bases visible from above, to the sides of the eyes (Fig. 7a), only partly covered by postmentum from below, leaving even the membraneous articulation exposed (Fig. 7b). Maxillary palpi slender, last segment of normal size, symmetrically inserted in middle of penultimate segment (Figs 1b, 7a, b). Long cerci. Wing-pads roughly parallel to body axis, straight on outside, medially widely separated by U-shaped notch ..... Perlodidae

2* Head normal, at most as wide as prothorax, mouthparts not enlarged, bases of maxillae hidden under head capsule. Terminal segment of maxillary palpus small, peg-like, asymmetrically inserted on penultimate segment (Figs 7c, 23a, 24a, 25e). Cerci short, distinctly conical, especially in small individuals. Wing-pads rounded on outside, medially separated by narrow V-shaped cleft (Fig. 25e) ..... Chloroperlidae

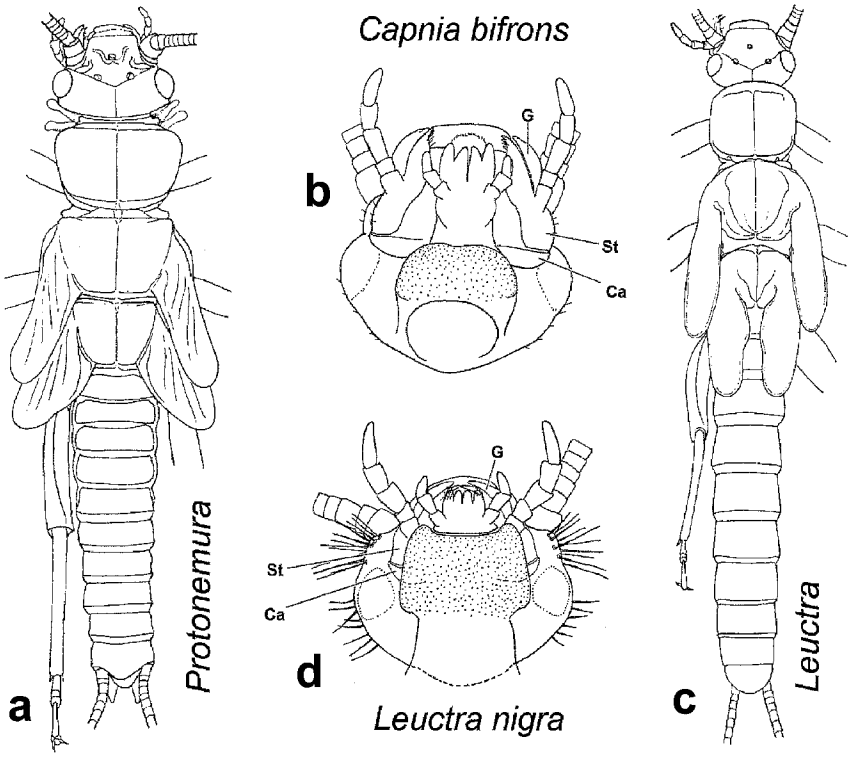

Fig. 5. (**a**) Habitus of *Protonemura* sp.; (**b**) head in ventral view, mentum stippled of *Capnia bifrons* (Newman, 1839); (**c**) habitus of *Leuctra* sp. (from Raušer 1980); (**d**) head in ventral view, mentum stippled of *Leuctra nigra* (Olivier, 1811).
Explanations: Ca = cardo, G = galea, St = stipes.

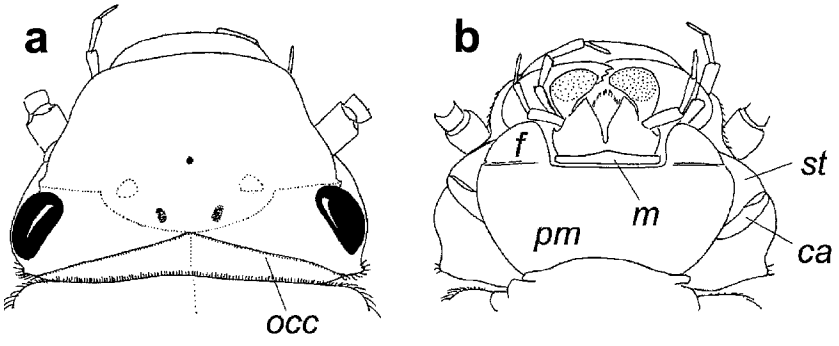

Fig. 6. *Dinocras cephalotes* (Curtis, 1827), head in dorsal (**a**) and ventral (**b**) views; the cushion-like paraglossae stippled.
Explanations: ca = cardo; f = front corner of postmentum; m = mentum; pm = postmentum; occ = occipital fold; st = stipes.

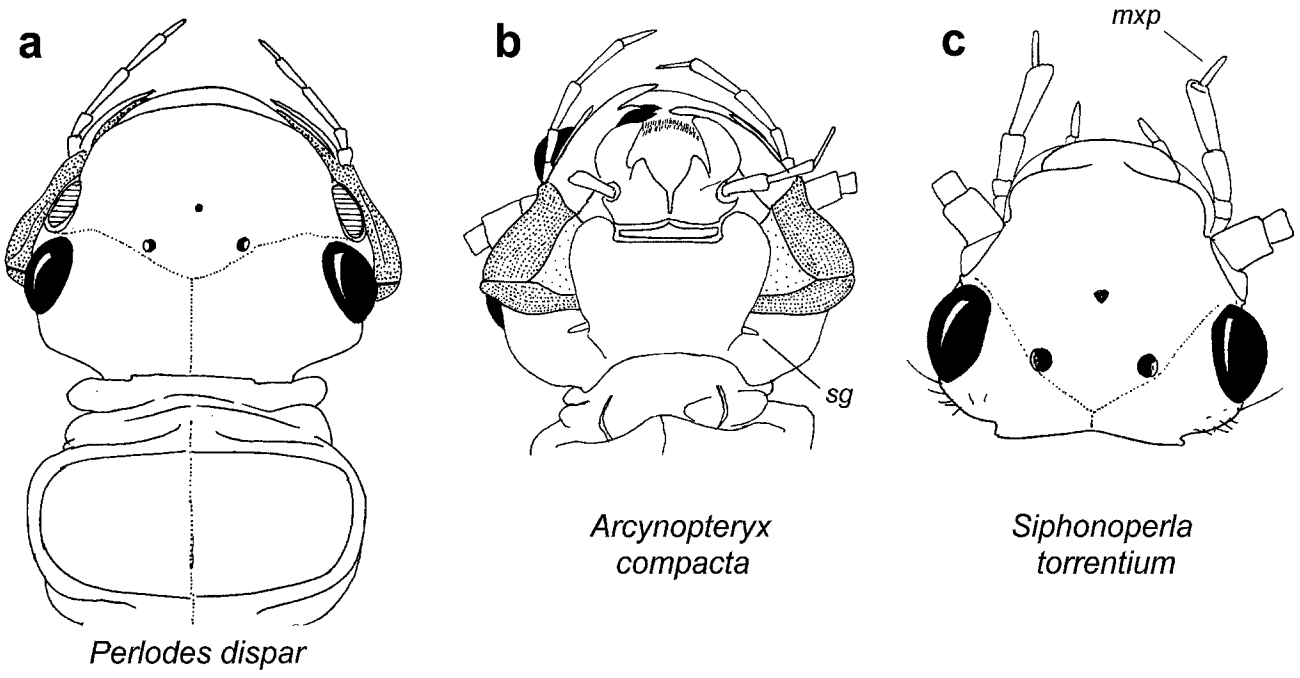

Fig. 7. (**a**) *Perlodes dispar* RAMBUR, 1842, head and thorax in dorsal view; cardo, stipes and lacinia of maxillae stippled; antennae removed, foramina striate. (**b**) *Arcynopteryx compacta* (MCLACHLAN, 1872), head in slightly oblique ventral view, only right eye and mandible (black) partly visible, only basal segment of labial palpus shown; cardo and stipes of maxillae stippled. (**c**) *Siphonoperla torrentium* (PICTET, 1841), head in dorsal view.
Explanations: mxp = reduced, asymmetrically inserted terminal segment at tip of maxillary palpus; sg = submental gill.

The genera of the families of Nemouroidea

Genera of Taeniopterygidae

Genus *Oemopteryx* KLAPÁLEK is not included. A single species, *O. loewii* (ALBARDA, 1899) once occurred in large European streams; it is missing for about 100 years. A few females are preserved in museums, but no single male. The larva was never found. Larvae of the four North American species of *Oemopteryx* differ between themselves, inferences on *O. loewii* are therefore impossible.

1 A telescoping 3-segmented retractable gill protruding from inner face of each coxa (Fig. 8a). Long-legged larvae resembling Nemouridae except that they possess unpaired processes on adominal tergites (Figs 8b, c). In most species, entire abdominal dorsum appears serrate, sometimes also thorax, especially pronotum, with prominent processes. Sternite 9 normal, paraprocts freely visible ..... *Taeniopteryx* PICTET

BL up to 13 mm. The only genus of subfamily Taeniopteryginae, unmistakable by the coxal gills. *Taeniopteryx* has a disjunct North Atlantic distribution. The numerous North American species lack tergal processes. Most of the approximately 10 Palaearctic species occur in South Europe, several of them also in central European mountains. In potamal streams of European lowlands north of the Mittelgebirge only *T. nebulosa* (LINNÉ, 1758) is found which ranges from South to North Europe and East to central Asia. *T. nebulosa* can be identified by missing tergal processes on segments 8 and 9 (Fig. 8c) which the other Palaearctic species have (Fig. 8b). *T. araneoides* KLAPÁLEK, 1902 (wingless; Elbe, Danube) not found for over 100 years, larva unknown.

1* Gill-less sprawlers often clinging to stones in fast current. Dorsal profile smooth, not serrate, hair fringes on legs present; ventral face soft, pale, little sclerotized. Upon disturbance larvae roll up which is often also seen in preserved specimens (Fig. 9). Sternite 9 strikingly enlarged, covering paraprocts (Fig. 10c) (Brachypterainae) 2

2 Marginal setae of abdominal tergites distinct in profile even though very short. Cercus base with sparse

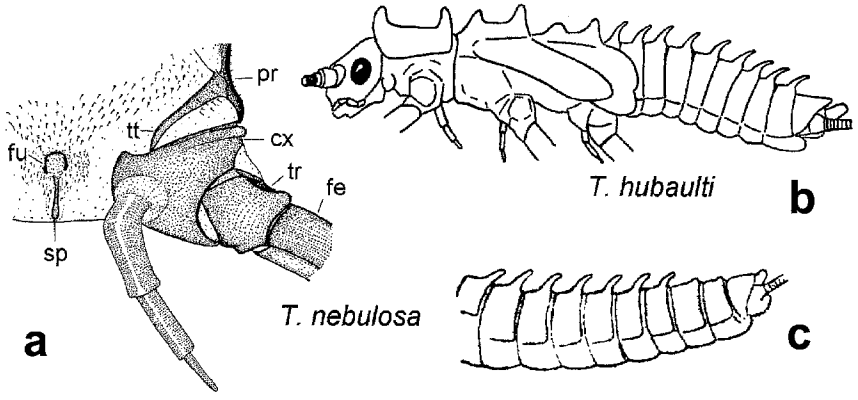

Fig. 8. (**a**) *Taeniopteryx nebulosa* (LINNÉ, 1758), oblique ventro-anterior view of left half of middle thorax, with 3-segmented telescoping gill originating from coxa. (**b**) *T. hubaulti* AUBERT, 1946, lateral view, contour (after AUBERT, 1950). (**c**) *T. nebulosa*, contour of abdomen, lateral view (after ILLIES, 1955).
Explanations: cx = coxa; fe = femur; fu = furcal pit; pr = pleural ridge; sp = spina; tr = trochanter; tt = trochantinus.

erect hair fringe[1]. Behind ocelli, branches of epicranial suture connected at a very blunt angle (Fig. 10a)[2] ..... *Brachyptera* NEWPORT

BL up to 12 mm. Endemic West Palaearctic genus. *B. risi* (MORTON, 1896) occurs in all of Europe and is the only Scandinavian species. In central European mountain streams *B. seticornis* (KLAPÁLEK, 1902) is the commonest species. Several species from potamal stream sections that had disappeared for decades were recently again found in a few places. Many species are endemic in the Mediterranean Region. The literature suggests specific colour patterns but there are examples of striking variation. Last instars can reliably be identified by structural details of sternite 9 and paraprocts illustrated by ILLIES (1955; Fig. 10c) and AUBERT (1959); allegedly distinctive colour patterns to be viewed with caution!

2* Setae along distal tergal margins barely projecting from insertion points, not visible in profile. Cercus without hair fringe[3]. Branches of occipital suture meet at a more acute angle (Fig. 10b) ..... *Rhabdiopteryx* KLAPÁLEK

BL up to 12 mm. Several species, even in central Europe; *Rh. alpina* KÜHTREIBER, 1934 and *Rh. neglecta* (ALBARDA, 1889) in the Alps are most frequently found; both are very pale.

Genera of Nemouridae

The present key works for larvae of near 2 mm body length or larger. The two genera with cervical gills do not yet have these in the first instar and the characteristic number and shape of gills develop stepwise, at early molts. *Nemurella* is in the literature normally diagnosed by a characteristic length relation of tarsal segments; however, this relation develops only late in larval life.

1 With cervical gills (Amphinemurinae) 2
1* No gills (Nemourinae) 3
2 Six sausage-shaped or tubuliform cervical gills; in some species each gill has a prominent subapical constriction (Fig. 11a) ..... *Protonemura* RIS

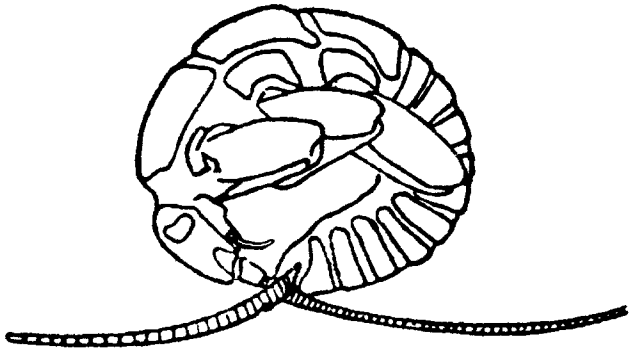

Fig. 9. Rolled larva of *Brachyptera* sp. (from ILLIES, 1955).

[1] Character proposed for *B. risi* and *B. braueri* (KLAPÁLEK, 1900) by LILLEHAMMER (1988) and here also confirmed for *B. seticornis, B. monilicornis* (PICTET, 1841) and *B. trifasciata* (PICTET, 1832); often only single hairs per segment. The character was not checked in other members of the genus.

[2] The larvae of some recently described Southern European species of *Rhabdiopteryx* are unknown, it cannot presently be tested whether the difference holds for all. However, as noticed by AUBERT (1959), the Alpine *B. trifasciata* (PICTET, 1832) is intermediate towards genus *Rhabdiopteryx*. *B. trifasciata* occurred abundantly in Alpine rivers, but was entirely missing during most of the second half of the last century. It was recently again found, at few sites and in low numbers (GRAF & HUTTER 2003).

[3] Character proposed for *Rh. acuminata* KLAPÁLEK, 1905 by LILLEHAMMER (1988), confirmed for *Rh. alpina* and some more central European species but not consistently checked across the genus.

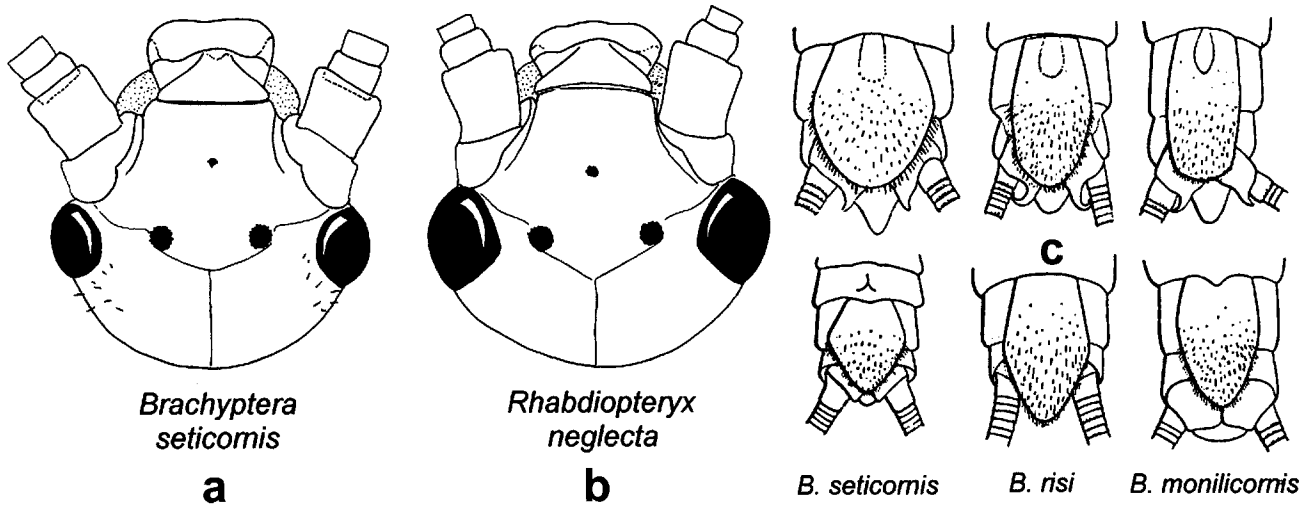

Fig. 10. Dorsal view of heads of (**a**) *Brachyptera seticornis* (KLAPÁLEK, 1902) and (**b**) *Rhabdiopteryx neglecta* (ALBARDA, 1889); note angle at which branches of occipital suture meet. (**c**) *Brachyptera* spp. (from ILLIES, 1955), ventral view of abdominal tip with subgenital plate of males (top) and postgenital plates of females (bottom).

BL up to 10 mm. Numerous species, many Mediterranean endemics. With some practice and sufficent comparative material, central European larvae can rather reliably be identified with the key by RAUŠER (1956, also 1980). These keys do not include *P. austriaca* THEISCHINGER, 1976 whose larvae resemble *P. lateralis* (PICTET, 1836) and *P. algovia* MENDL, 1968, a close relative of *P. montana* KIMMINS, 1941.

2* Four branched, brush-shaped cervical gills (Fig. 11b) ..... *Amphinemura* RIS

BL close to 7 mm. According to the (partly contradictory) literature (ILLIES 1955, RAUŠER 1963) larvae of the common central European species, *A. standfussi* RIS, 1902, *A. sulcicollis* (STEPHENS, 1835) and *A. triangularis* RIS, 1902 can be identified by cercal and femoral setation. Study of pharate males did not confirm these claims. Identification of *A. borealis* (MORTON, 1894) (after RAUŠER 1963, 1980) was not checked.

3 Very long-legged: end of hind tibia lies clearly on coxa when folded back. Ground pilosity of femora weak, but several spreading setae in distal third exceed femur width. In late instars 1st and 3rd tarsal segments of hind legs about equal (Fig. 12c). Body normally held in a characteristic posture, with upcurved abdomen and arched long antennae and cerci (Fig. 12a). Late instar male unmistakable, with enlarged upcurved paraprocts (Fig. 12b). Marginal setation of

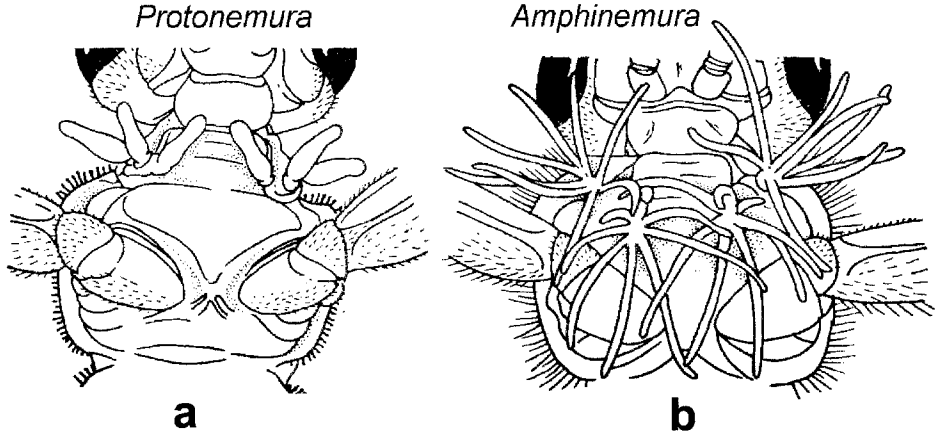

Fig. 11. *Protonemura* sp. (**a**) and *Amphinemura* sp. (**b**), ventral view of prothorax and neck showing sausage-shaped and branched gills, respectively (from RAUŠER, 1980).

tergites consisting of only 4 large setae, others not larger than weak intercalary pilosity[4] (Fig. 12d). Lateral setae longer and stronger than paramedian ones, setae on tergite 9 strongest. Setae along tibiae long, several longer than tibial width, exceptionally long erect sensory hairs, especially in small larvae. Occiput often strikingly lighter than dark purplish central portion of head. Setation of cerci sparse but strong and spreading, most developed and distinctly longer than segments around segments 5–7; distal setae fine and increasingly short. Small larvae (Fig. 12e) best identified by cerci attaining body length, unique long setae on several basal flagellar segments (Fig. 12g; disappear in larger specimens), long and strong pilosity of legs, and details of tergal and cercal setation described above . . *Nemurella* KLAPÁLEK

[4] The term "intercalary" designates pilosity on the surface of a sclerite, not at its edge, for example on the surface of tergites or on the surface of a cercus segment, between base and apical setal ring.

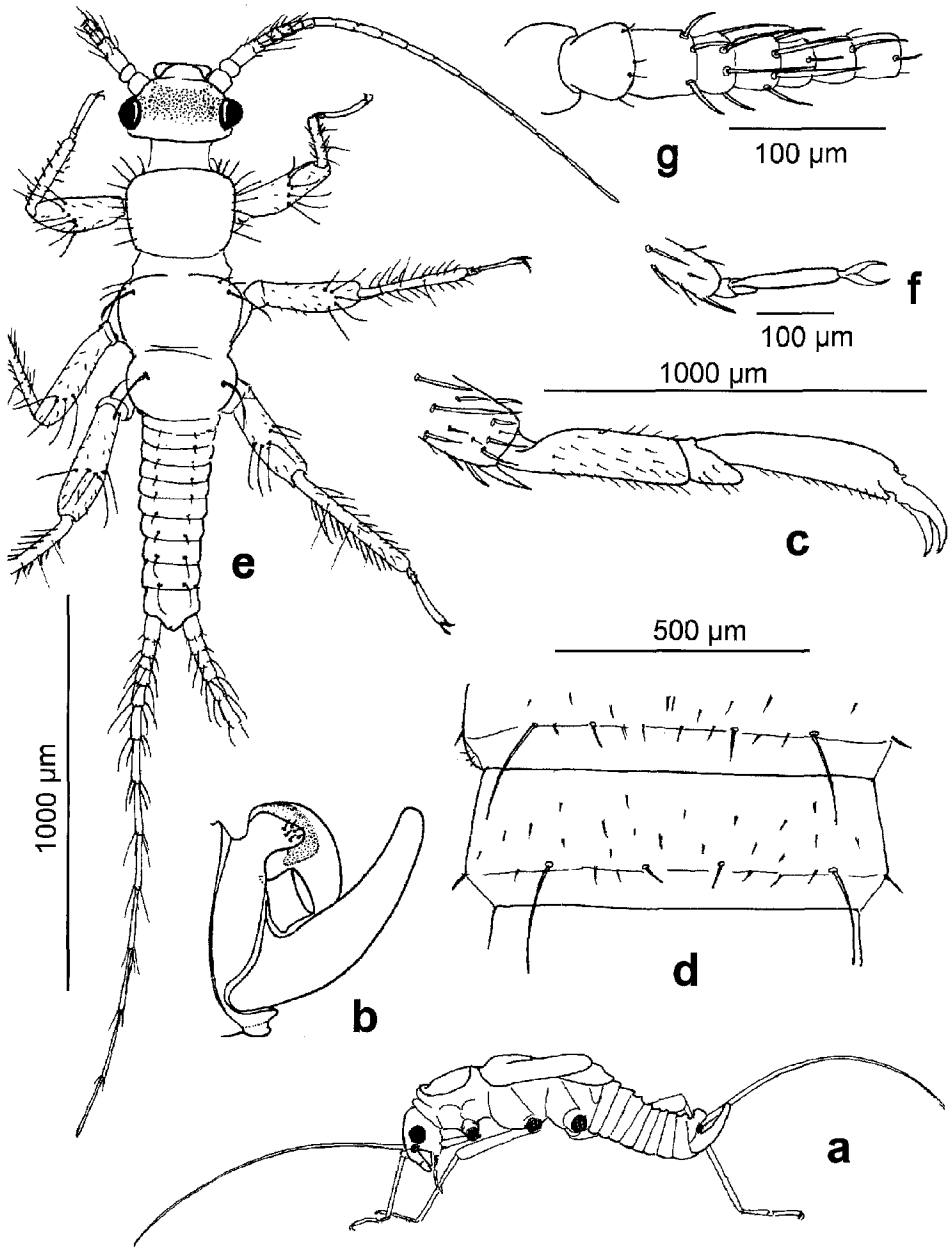

Fig. 12. *Nemurella pictetii* KLAPÁLEK, 1900. Characteristic curved posture (**a**; only right appendages shown), left paraproct of last instar male (**b**; lateral view), hind tarsus (**c**) and tergite 5 (**d**) of last instar specimen. Small larva, habitus (**e**), hind tarsus (**f**) and base of antennal flagellum (**g**). Figures without scale are not to scale.

Only *Nemurella pictetii* KLAPÁLEK, 1900. BL up to 11 mm. From northern Spain to central Siberia. Common at sites with few other Nemouridae, especially in swampy springs, upper courses with diffusely entering groundwater, outlets of drain water, spring basins etc., but also in strongly acid waters like outlets of peat bogs. Occasionally said to be ubiquituous, but actually not resistant against pollution. Voltinism varies; most central European populations are bi- to trivoltine, univoltine in cool mountain sites, North European mountain populations semivoltine.

3* Body shape, length of legs, shape of cerci and setation very different between the numerous species; 1st tarsal segment always shorter than last. Occiput of central European species not distinctly paler than middle of head. If legs are long and slender, they lack very large spreading femoral spines. Tibiae usually with dense and strong setae along outer edges, but setae not longer than tibial width. Large setae different from intercalary tergal setation along tergal margins more numerous. Male paraprocts short, unmodified. Antennae never with long setae near base of flagellum ..... *Nemoura* LATREILLE

BL mostly 8–9 mm, some species up to 11 mm. Many species stout and more plump than *Nemurella*, cerci usually straight and shorter. See Appendix I for a preliminary key to German species.

Genera of Leuctridae

1 Abdominal segments 5 ff ring-shaped, no pleural membrane..... *Leuctra* STEPHENS

BL up to 12 mm or even more, but most species are less than 10 mm long. The genus occurs on both sides of the Atlantic Ocean, in North America as well as in the West Palaearctic. One single European species, *L. fusca* (LINNÉ, 1758), extends across Sibiria into the Russain Far East. Otherwise, the Easternmost outlying representative is *L. kopetdaghi* ZHILTZOVA, 1972 (Kopetdagh, Iran, Libanon).

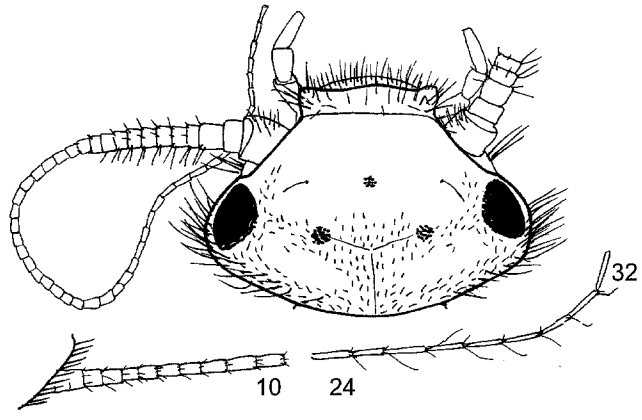

Fig. 13. *Pachyleuctra* sp., head and cercus (with segment numbers) of last instar larva; all to same scale.

Males and females of most of the over 100 European species can be well distinguished (for example, RAVIZZA & VINÇON 1999, VINÇON & RAVIZZA 2001). In contrast, larval identifications are not consistently possible. Body pilosity very variable between species, from missing to very dense and rough. See Appendix II for a few central European species and Operational Taxonomic Units that can be reliably recognized.

1* Pleural membranes divide also abdominal segments 5–8 into tergites and sternites 2

2 Resembling *Leuctra*, head rounded, pronotum normal, pilosity fine, short, inconspicuous ..... *Tyrrhenoleuctra* CONSIGLIO

BL up to 7 mm. West Mediterranean, on fragments of the former Tyrrhenian land mass: North Africa, Iberian Peninsula, Baleares, Sardinia and Corsica. Limits between the 3 nominal species doubtful, despite studies applying gel electrophoresis (SEZZI 2001).

2* Head trapezoidal, widest posteriorly, narrowed in almost straight line towards front (Fig. 13a). Clypeus with prominent anterior corners. Pronotum transverse, *ca.* 1.5 times wider than long. Long erect hairs along sides of body and legs. Antennae with normal base, rapidly thinning apically, distally very fine and slender. Cerci multi-segmented but thin, thread-like, at base thinner than antennae (Fig. 13), miserable in comparison with large (up to 11.5 mm long) massive body ..... *Pachyleuctra* DESPAX

BL up to 11 mm. *P. benllochi* (NAVÁS, 1917) and two closely related species in the Pyrenees. Through their pilosity, half grown specimens greatly resemble *Leuctra nigra* (OLIVIER, 1811) and *L. braueri* KEMPNY, 1898; the latter has also angular front corners of clypeus. Both *Leuctra* species have normally shaped roundish heads (Appendix II, Fig. 34), and in both, pronotum, antennae and cerci are average.

Genera of Capniidae

1 Upper face with long erect setae. Pronotum approximately heart-shaped, front much wider than rear. Abdominal segments 1–5 completely, 6 partly divided by pleural membrane. Anterior wing-pads much expanded towards median line, their medial edges closely opposed, leaving only a narrow cleft between them. Mandibles with exceptional setal pocket just in front of apical teeth, and labrum with very dense and short setal seam resembling the ones found in scrapers, like *Brachyptera* spp. Brownish larva (Fig. 14) ..... *Capnopsis* MORTON

BL only 5–7 mm. The only species, *C. schilleri* (ROSTOCK, 1892) ranges from the Caucasus to western North Africa and to the polar North of Europe. Several geographical subspecies exist; only the nominate subspecies occurs in central and North Europe. One of the smallest European

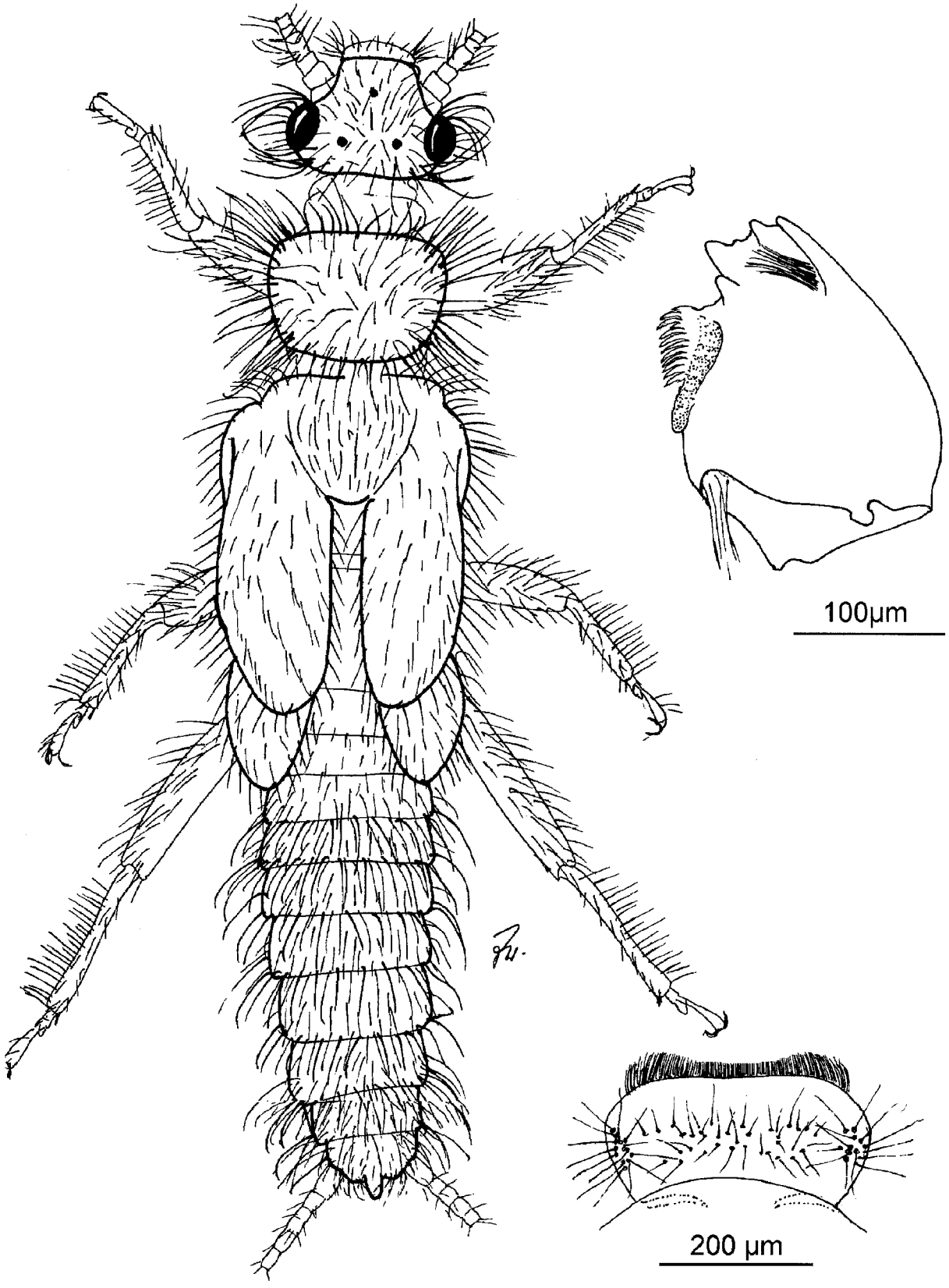

Fig. 14. *Capnopsis schilleri* (Rostock, 1892), last instar larva, habitus (not to scale; the long cerci cut) and labrum in dorsal, left mandible in ventral view.

Plecoptera, not often found. Larvae live concealed in loose accumulations of detritus, details of habitat preference not known.

1* Pilosity inconspicuous, at most individual long hairs, larvae sometimes appearing completely bare. Abdominal segments 1–8 divided by pleural membrane. Pale larvae 2

2 Wing-pads parallel to body axis. Antennae and cerci normal. Body with sparse long pilosity ..... *Capnia* PICTET

BL up to 9 mm. Numerous species in Asia and North America, only a few in Europe. These belong to several distantly related species groups; nevertheless, specific larval identifications are difficult. Males of several species brachypterous to almost apterous. *C. bifrons* (NEWMAN, 1839), the most widespread of these sexually dimorphic species appears to comprise several presently unnamed biospecies (RUPPRECHT 1997).

2* Wing-pads diverge obliquely from body axis, thereby resembling Nemouridae. Antennae long and thin, base narrower than the plump cercus base. No macroscopic body pilosity, but abundant tiny intercalary setae on the body surface .. *Capnioneura* RIS

BL up to 7 mm. Of the 12 named species in this genus, only two, *C. nemuroides* RIS, 1905 and *C. mitis* DESPAX, 1932 occur in central Europe but are seldom found; habitat preferences not known. The remaining species occur in the Mediterranean Region, from western North Africa to the Caucasus; several are completely apterous.

The genera of the families of Perloidea

Genera of Perlidae

Among the West Palaearctic Plecoptera, the tufts of highly branched thoracic gills are characteristic. Each consists of 1 to 3 trunks which may fork into several branches each of which carries many straight fine filaments. These gills occur in characteristic positions to which the traditional gill nomenclature refers. It is followed here because it underlines homologies with similar gills observed also in other related families (within the infra-order Systellognatha). However, such examples do not exist among West Palaearctic representatives. The following gills are observed in Perlidae:

- a substigmatic gill below each of the 3 first spiracles;
- an anterior supracoxal gill above and in front of the fore coxa;
- a posterior supracoxal gill above the middle and hind coxa, behind the pleural fold.

Cercus pilosity provides important characters. Because cercus tips are often missing in specimens only characters concerning the cercus base appear in the key. However, distal cercus segments of *Dinocras, Eoperla* and *Helenoperla* have dense long fine pilosity in addition to the short setae at the base of each segment, while the other genera have only the latter.

1 Postmentum with transverse lines separating each front corner from main plate-like part (Fig. 6b); marginal setation of sternite 7 complete 2

1* Front corners continuous with main part of postmentum; marginal setation of sternite 7 medially incomplete, setal fringe divided[5] 3

2 Transverse fold across occiput regularly curved, crossing unpaired median branch of occipital suture distinctly behind forking point of suture. Long, club-shaped setae stand in a single row along transverse fold (Fig. 15b), also laterally where the fold is curved down regularly, merging into the sharp lateral edge of head below the eyes. Abdominal tergites only with fine pilosity contrasting markedly with strong marginal spines (Fig. 15c). Small; 2 pale longitudinal dorsal bands on abdomen (Fig. 15a) ..... *Eoperla* ILLIES

The only species is *Eoperla ochracea* (KOLBE, 1885), BL up to 17 mm. Strictly Mediterranean: North Africa, Spain, Southern France, Makedonia, Greece, Asia Minor. Absent from the Italian region.

2* Transverse occipital fold angled forward, medially almost touching the forking point of occipital suture (Fig. 6a). Setae along transverse fold short, barely projecting over fold when viewing intact specimens. Well visible setae occur only laterally behind eyes where fold enters into sharp lateral edge of head, and are irregularly placed instead of in an orderly row. In slide preparations of exuviae, the setae are better seen; they are stouter than in *Eoperla*, almost spatulate (Fig. 15d). Abdominal tergites with dense cover of short fairly strong spines that differ less strikingly from marginal spines (Fig. 15e). No pale longitudinal bands on abdomen ..... *Dinocras* KLAPÁLEK

BL up to 35 mm. *D. cephalotes* (CURTIS, 1827) is widely distributed over most of Europe, males brachypterous. The very similar *D. ferreri* (PICTET, 1841) (restricted to the southern edge of the Alps and small parts of the northern Appennines) and *D. megacephala* (KLAPÁLEK, 1907) (Balkans, and locally in a strip along northern edge of Alps, to French Jura) have long-winged males. Allegedly distinctive colour patterns of larval *D. cephalotes* and *D. megacephala*, respectively (AUBERT 1946, 1959; ILLIES 1955) occur within pure populations of only *D. cephalotes*, apparently representing individual variation (A. DORN & A. WEINZIERL, personal communication); structural differences between larvae not known.

[5] Much used in the world generic key to larvae of Perlinae (SIVEC et al. 1988); however, may be difficult to assess when there are finer and much smaller setae in the centre of setal fringe VII than on the sides which is not exceptional.

3 Transverse occipital fold bent angularly forward behind inner edge of eye and meeting the fold running around eye and to side of head at a distinct, forward-directed angle[6]. Sidewards from this point, setation includes much longer pointed setae (Fig. 16a, inset); cercus base never with seam of erect soft hairs 6

3* Transverse occipital fold and fold running around eye merging in a regularly curved or only slighty undulating line (Fig. 18); except in very small larvae (≤10 mm) no striking change in setation at fusion

[6] The same is true of the closely related East Asian genus *Oyamia* KLAPÁLEK.

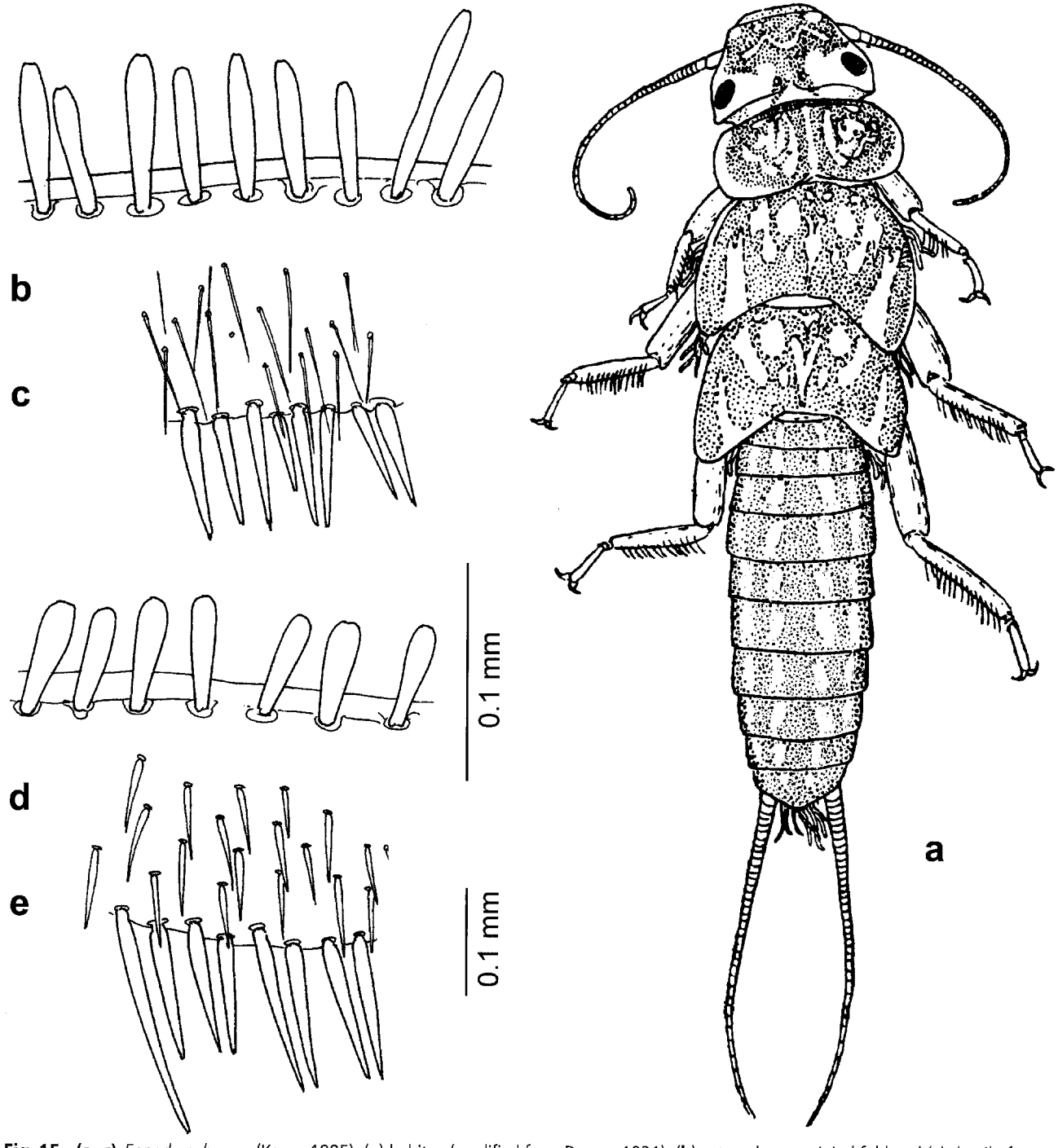

Fig. 15. (a–c) *Eoperla ochracea* (KOLBE, 1885): (**a**) habitus (modified from DESPAX, 1931), (**b**) setae along occipital fold and (**c**) detail of setation of tergite 5. (**d–e**) *Dinocras cephalotes* (CURTIS, 1827): (**d**) setae along occipital fold and (**e**) detail of setation of tergite 5. Figures b and d, and c and e, respectively, are to the same scale; mind that *Eoperla* is not even half the size of *Dinocras*!

point. Cercus base with (Fig. 17b) or without seam of erect fine hairs 4

4 Cerci already on basal segments with striking rings of dark spines which are not much longer on distal segments (Fig. 17a). Fine pilosity between spines about half as long as segment, closely appressed to segment surface. Silky fine hairs on cercus form a dorsal longitudinal fringe, especially on basal segments[7]. Most species bright yellow with contrasting dark brown pattern 5

4* Semi-erect fine pilosity forms dense hair whirls all around cercus segments, especially medially; many hairs longer than corresponding segment (Fig. 17b). Rings of spines missing from basal cercus segments, appearing only from about segment 8, blond, much shorter than fine hairs, inconspicuous; spines grow progressively longer on distal segments, eventually attaining half segment length. Cerci without dorsal hair fringe. Light brownish with indistinct pattern on head and thorax, abdominal tergites with pairs of light spots ..... *Helenoperla* SIVEC

Larvae of the single species, *H. malickyi* SIVEC, 1997 are up to 27 mm long. The discovery of this new genus was a great surprize; the insect is presently known only from two rivers in Epirus, Greece.

5 Setation along occipital fold extends only to behind eye but not forward along edge of flat expanded side of head. No wavy section of occipital fold near inner corner of eye. Mesothoracic supracoxal gill with single or double trunk, depending on species ..... *Perla* GEOFFROY

[7] The supposed larva of *P. bipunctata* PICTET, 1833 of BERTHÉLEMY & LAUR (1975) lacks this fringe.

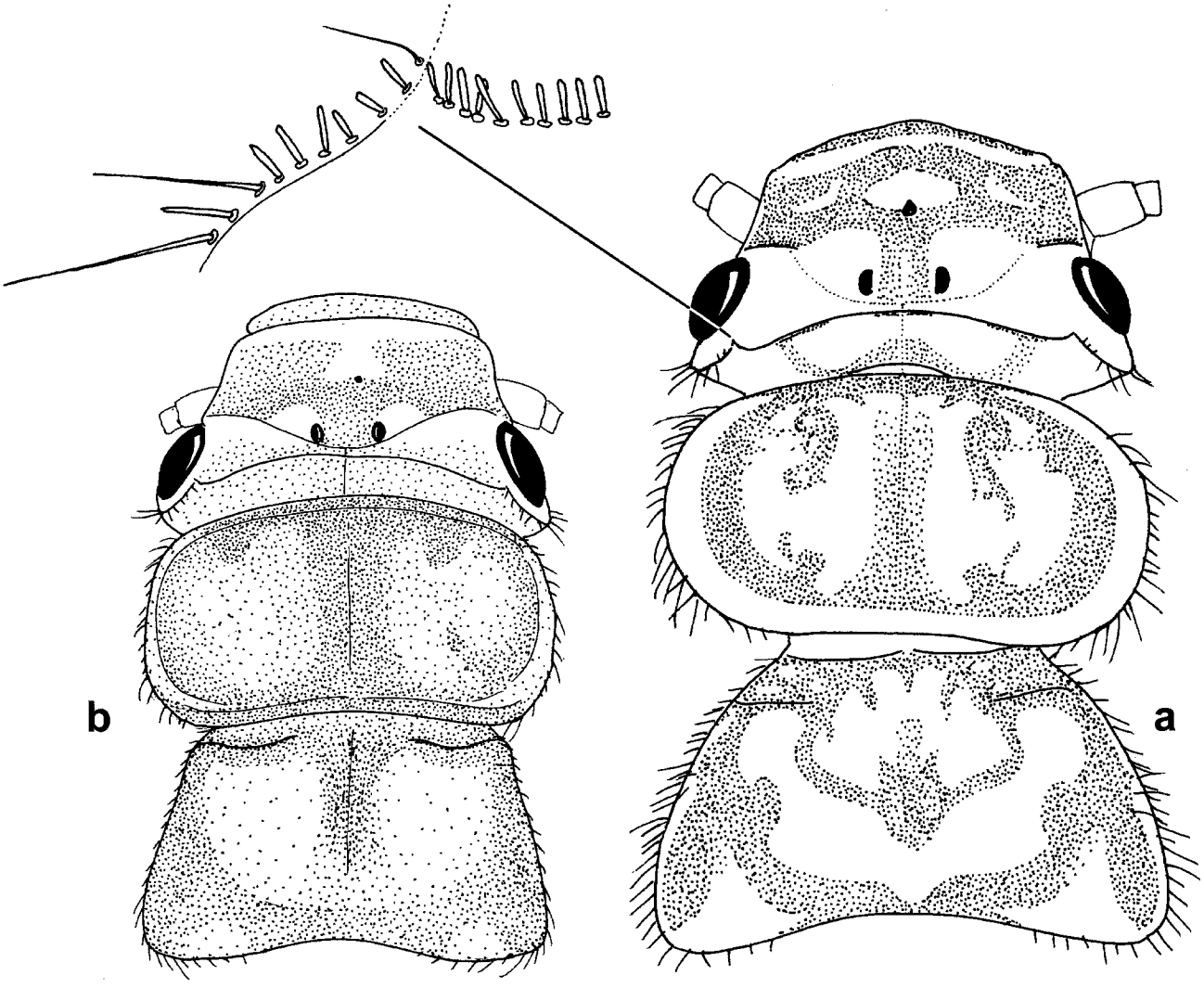

Fig. 16. (**a**) *Agnetina elegantula* KLAPÁLEK, 1905, habitus of fore body and detail of occipital crest and its pilosity at bend behind left eye (specimen from Austria, Burgenland, Lafnitz); (**b**) *Marthamea selysii* (PICTET, 1841), fore body of brachypterous last instar male from River Moselle.

BL up to 40 mm. *Perla* is endemic to the West Palaearctic Region but absent from North Europe. Species occur from North Africa and Great Britain to Iran; Cyprus is the only Mediterranean island with a *Perla* species (*P. caucasica* GUÉRIN, 1838). Species identities seemed to be clear until SIVEC & STARK (2002) showed convincingly that species taxonomy is chaotic. There seem to be many more species than presently recognized. The authors studied only the eggs, other life stages can presently not be identified to the same degree. Therefore, specific identifications in *Perla* are presently preliminary and as of *status quo*.
Provided the study area is rigidly restricted to Germany[8], *P. marginata* (PANZER, 1799) can be recognized by lack of gills on paraprocts (so-called anal gills); head pattern distinctive (Fig. 18b). *P. abdominalis* BURMEISTER, 1839[9] has stout femora (hind femora about 3 times as long as wide), head pattern also distinctive (Fig. 18c). The long-legged (hind femur ca. 4 times as long as wide) Alpine larvae with largely yellow fore body would (according to SIVEC & STARK 2002) all belong to a species presently called *P. grandis* RAMBUR, 1842 (Fig. 18d).

5* Setation along occipital fold continues around eye and extends far forward onto expanded flat side of head, laterally in front of eye. Occipital fold just inside from each eye distinctly wavy. Mesothoracic supracoxal gill consisting of two separate main trunks, each with many filaments ..... *Paragnetina* KLAPÁLEK

The only West Palaearctic species, the Caucasian-Anatolian *P. spinulifera* (ZHILTZOVA, 1967) was orginally described as a separate genus, *Caucasoperla* ZHILTZOVA, 1967 but was later synonymized with *Paragnetina*. The presumed larva (conspecificity unconfirmed; BL of the only known specimen 24 mm) described by Zwick (1971; Fig. 18a) was compared with Asian *P. flavotincta* (MCLACHLAN, 1872) and Nearctic *P. immarginata* (SAY, 1823) which it resembles structurally.

6 Center of meso- and metanotum with a complex brown pattern consisting mainly of a median band and mediolateral curved bands which meet it posteriorly (Fig. 16a). Dark pattern on head between bases of antennae forming a broad dark band in front of median ocellus that extends far forward; the band includes 3 pale spots, setae along margins of fore body very long (Fig. 16a) ..... *Agnetina* KLAPÁLEK

[8] The polytypic *P. pallida* GUÉRIN, 1838 (Slovenia and eastward) and *P. madritensis* RAMBUR, 1842 (Iberian Peninsula) are siblings of P. marginata and easily confused with it (SIVEC & STARK, 2002). *Perla carantana* SIVEC & GRAF, 2003 from Austria and Slovenia is indistinguishable from the sympatric *P. abdominalis* except in the characteristic egg stage (SIVEC & GRAF, 2003)!

[9] This species was long known as *P. burmeisteriana* CLAASSEN, 1936; TIERNO DE FIGUEROA ET AL. (2003) re-instate the orginal name but give no reason for the change. CLAASSEN thought that *Perla abdominalis* GUÉRIN was a senior homonym of *P. abdominalis* BURMEISTER and proposed the long-used but unnecessary replacement name. However, GUÉRIN's name is actually the junior homonym. The work in which it appeared was published since 1829, in fascicles; publication was not complete until 1844. Page 394 naming the Caucasian *Perla* appeared in December, 1843 (HAGEN, 1862). *P. abdominalis* GUÉRIN is not available, its identity is completely obscure; therefore, no replacement name is proposed at this time.

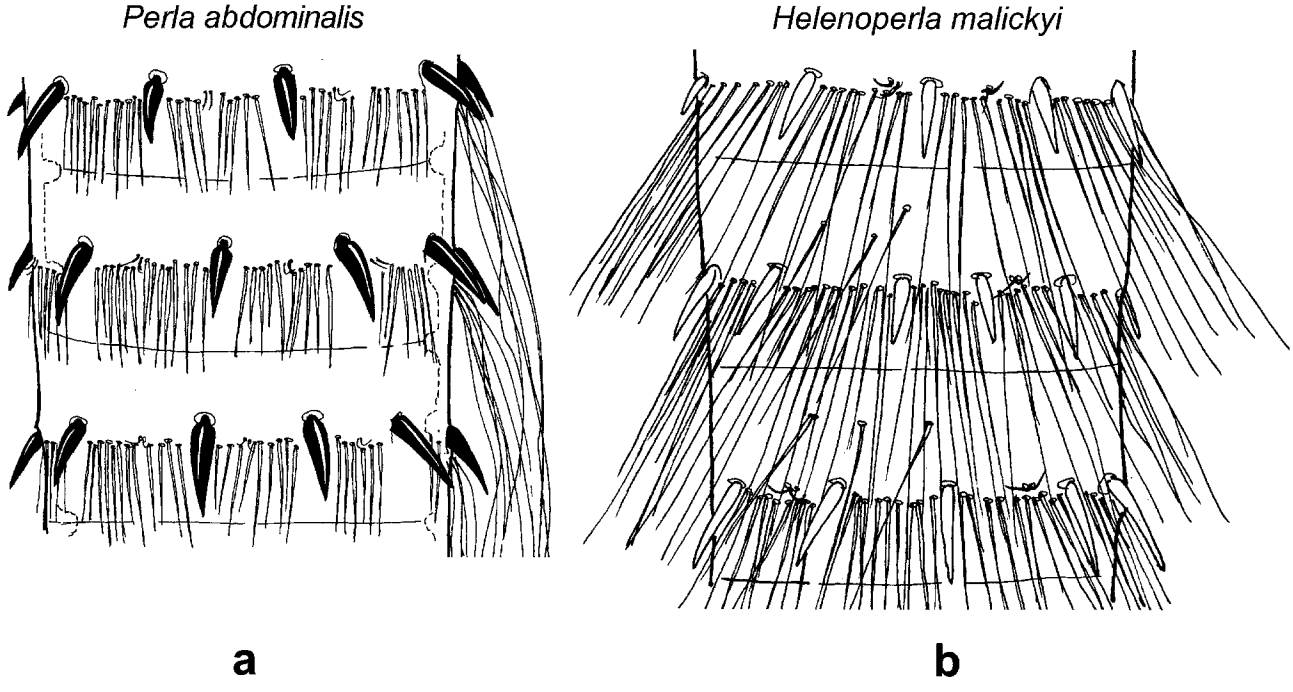

Fig. 17. Right cercus (dorsal side to the right), segments 6–8, of (**a**) *Perla abdominalis* BURMEISTER, 1839 and (**b**) *Helenoperla malickyi* SIVEC, 1997; not to scale.

BL up to 25 mm. The genus was for a long time known by the name *Phasganophora* KLAPÁLEK; see ZWICK (1984) for the confused history and the identity of the 3 West-Palaearctic species. Unfortunately, upon discovery (SCHOENEMUND 1925) the larva of *A. elegantula* was mistaken for *Marthamea vitripennis;* for a long time this severely hindered distinction of the two genera. Only *A. elegantula* KLAPÁLEK, 1905 occurs in central Europe. It is very rare and known from very few central European localities (GRAF, 1997). *A. senilis* KLAPÁLEK, 1921 and *A. werneri* (KEMPNY, 1908) are poorly known Caucasian and Anatolian species, respectively. The dark brown dorsal pattern on yellow ground of *A. elegantula* resembles the American *A. capitata* (PICTET, 1841) much. Figures of the habitus of *A. elegantula* are in SCHOENEMUND (1925; as *Marthamea vitripennis*) and GRAF (1997; photography).

6* Meso- and metanotum with a brown median band in a wide pale area. Dark pattern between bases of antennae medially interrupted in front so that a pale area remains in front of anterior ocellus; marginal setae on fore-body less long (Fig. 16b)
..... *Marthamea* KLAPÁLEK

BL up to 20 mm. *M. vitripennis* (BURMEISTER, 1839) occurred in rivers of central and Southeast Europe but is today largely extinct. *M. selysii* (PICTET, 1841) used to occur in the River Moselle, a complete habitus figure of a specimen is in SCHOENEMUND (1925). *M. selysii* is a West European species which was recently collected at several localities in Spain. Specific identifications of *Marthamea* larvae are presently impossible; mind that the distinctly different larva illustrated as *Marthamea vitripennis* by SCHOENEMUND (1925) is actually *Agnetina elegantula*.

Genera of Perlodidae

1 Paraprocts pointed (Figs 19a, b). Fine dorsal hair fringe lacking from base of cerci. Distally, hair fringe not longer than whorls of setae around tips of cercal segments. Fine procumbent black pilosity closely appressed to body surface, resembling delicate dark lines on integument. Lacinia wide, with 2 apical teeth and along inner edge with a row of strong spine-like setae which grow successively finer and shorter towards base (Fig. 20a). Transverse setal row across occiput indistinct, irregular and medially more or less widely interrupted. Only first 2 abdominal segments divided into tergite and sternite
..... *Isoperla* BANKS

BL up to 17 mm. Holarctic genus. The numerous European species are best distinguished by male genitalia and drumming signals. Identification of larvae with existing keys (ILLIES 1952, 1955; RAUŠER 1980) which rely on numbers of setae along lacinia fails because the numbers depend on body size, i.e., change during growth and differ between sexes. KONAR (2000) claims easy and safe species identification is possible in Carinthia. He relies on a combination of dorsal colour patterns with shape of ter-

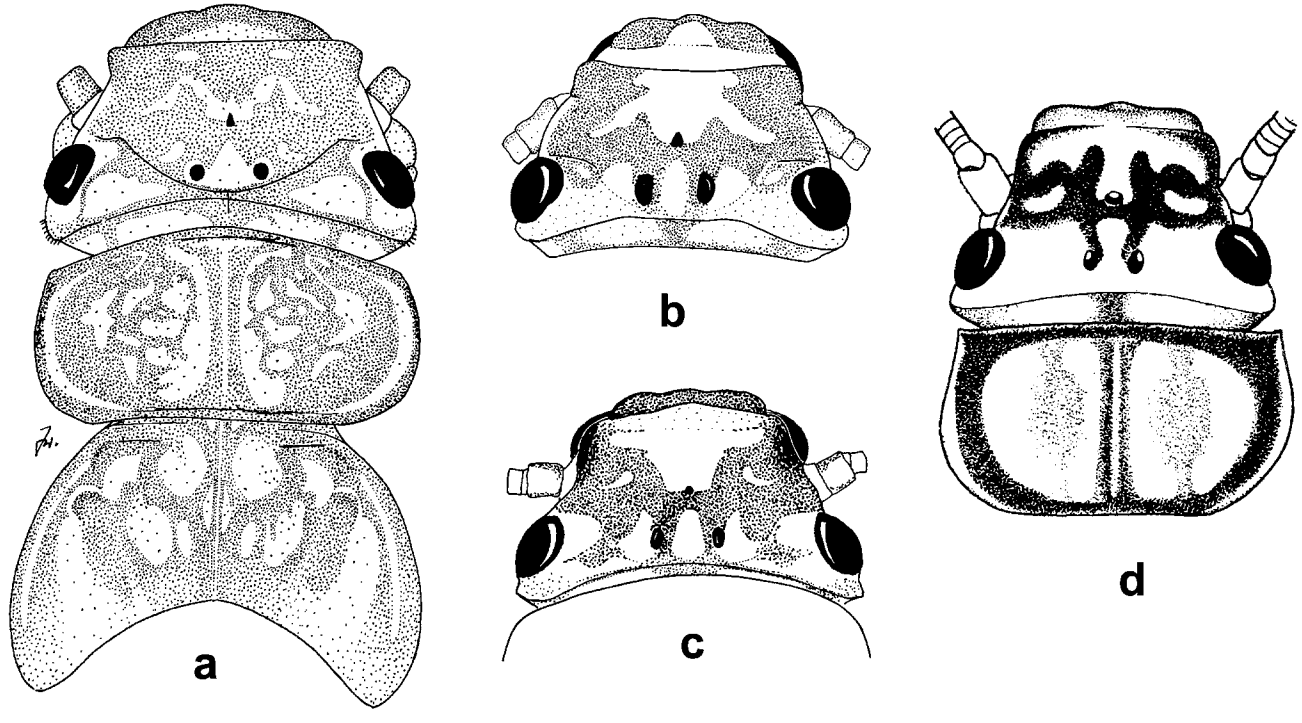

Fig. 18. (**a**) *Paragnetina spinulifera* (ZHILTZOVA, 1967), fore body (from ZWICK, 1971); (**b**) dorsal view of head from *Perla marginata* (PANZER, 1799), (**c**) *P. abdominalis* BURMEISTER, 1839 and (**d**) *P. grandis* RAMBUR, 1842 (from RAUŠER, 1980); not to scale.

gal setae (blunt as opposed to pointed). For some reason, the common *Isoperla* larvae are frequently misidentified for the much larger rare *Isogenus*, which has short stout bristles on meso-and metasternum (GRAF & SCHMIDT-KLOIBER, 2003); they are lacking in *Isoperla.*

1* Paraprocts blunt, their sclerotised portion apically surrounded by soft, membraneous strip; dorsal cercal hair fringe long, distinct, also at base (Figs 19c, d). Body surface bare or with different kinds or colour of pilosity; fine procumbent black hairs like in *Isoperla* occur only in a Spanish species with narrow unidentate lacinia. Occipital setation variable. Variable number of abdominal segments divided into tergite and sternite 2

2 Lacinia narrow, claw-like, unidentate, lacking subterminal tooth (Fig. 20b); endemic to western part of Mediterranean area 3

2* Lacinia with 2 unequal tips, basally from these usually with some setae along medial edge (for example, Figs 20c, 22a, e) 4

3 Head and prothorax shiny, completely hairless ..... *Afroperlodes* MIRON et ZWICK

Afroperlodes lecerfi (NAVÁS, 1929), the only species, occurs only in North Africa. BL up to 17 mm.

3* Head and prothorax with fine procumbent pilosity, like in *Isoperla* ..... *Hemimelaena* KLAPÁLEK

The single species, *Hemimelaena flaviventris* (PICTET, 1841) lives in intermittent streams in the Iberian Peninsula (not in the Pyrenees) and in northwest Africa. BL up to 14 mm.

4 No transverse row of setae across occiput, between rear margins of eyes (Fig. 7a). Lacinia with 2 closely appressed teeth, from there enlarged in a curved line towards bulging base. Only occasional setae along inner edge of lacinia basally from apical teeth (Fig. 20d) 5

4* An (often irregular or incomplete) row of setae across occiput, between rear margins of eyes (Fig. 21a). Body surface more or less densely pilose or setose. Lacinia variable, apical teeth diverge, setation along inner edge distinct (for example, Figs 20c, 22a, e) 6

5 Abdominal segments 1–4 divided into tergites and sternites by hairless pleural membranes. Segments 5 and following are sclerotized rings with continuous setal fringe along rear edge. Inner margin of lacinia basally from subapical tooth smooth, no angle or knob. Body surface bare or with fine pilosity, no interspersed short strong spines. Front and rear egde of pronotum (but not the sides!) and rear edge of abdominal segments with marginal setae ..... *Perlodes* BANKS

BL up to 26 mm. Europe, Caucasus, Asia Minor. Several species, best distinguished by structural details of their eggs. Presently, not all central European biospecies seem to be named or recognized. In central Europe, *P. microcephalus* (PICTET, 1833) and *P. dispar* RAMBUR, 1842 are widely distributed and common. Larvae are contrastively patterned in yellow and dark brown. Larvae of *P. intricatus* (PICTET, 1841) and *P. jurassicus* AUBERT, 1946 pale, pattern mainly olive green.

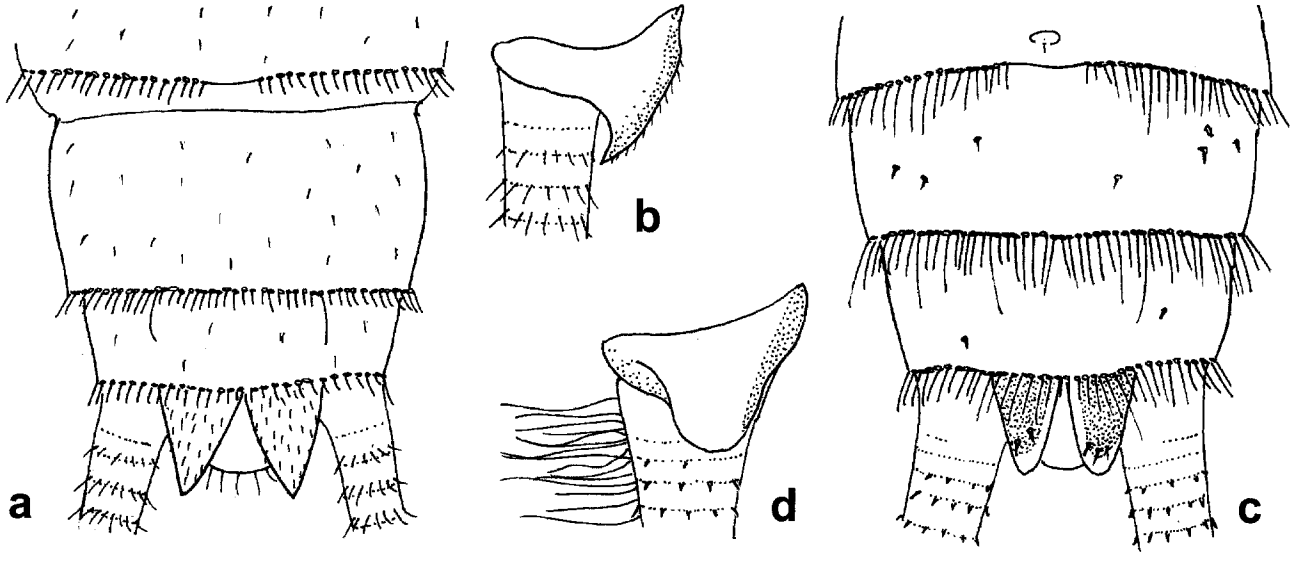

Fig. 19. (**a, b**) *Isoperla* sp. and (**c, d**) *Dictyogenus alpinum* (PICTET, 1841), abdominal tip of female larvae in ventral view, and lateral view of detached left paraproct and cercus. In the figure of *Dictyogenus*, stippling identifies sclerotized parts of paraprocts; the strongly bulging anal membrane is concealing both edge and setal fringe of tergite 10.

5* Only abdominal segments 1–3 divided into tergites and sternites by hairless pleural membranes, already segment 4 forming a sclerotized ring with continuous caudal setal fringe. Basally from apical lacinial tooth is a small knob with a group of small setae, or even a short row of relatively strong hairs ..... *Filchneria* KLAPÁLEK

Filchneria is one of several closely related nominal Asian genera. One species, *Filchneria balcarica* (BALINSKY, 1950) occurs in the Caucasus; its larva is unknown. The present key is based on specimens of *F. mongolica* (KLAPÁLEK, 1903) and *F. amabilis* (JEWETT, 1958) (from the Himalaya). Both have strong pilosity, distinct also along sides of pronotum. Differences in details between the two species preclude inferences on the Caucasian species. BL of the mentioned Asian species are around 25 mm.

6 On mesosternum, lines directed forward from spina meet front corners of furcal pits (Fig. 21c). Lower edge of outer mandibular tooth distinctly serrate (Fig. 2b); galea shorter than, or equal to, 3 basal segments of maxillary palpus (Fig. 22a); a short finger-shaped gill on either side of base of postmentum (Fig. 7b). Setae across occiput forming an irregular plurilinear band. Basal 3 abdominal segments divided into tergite and sternite ..... *Arcynopteryx* KLAPÁLEK

Several Asian species and the circumpolar *Arcynopteryx compacta* (MCLACHLAN, 1872), the only European species. Disjunct boreomontane distribution with pleistocene relict populations in central and even Southwest Europe (for example, Black Forest, Carpathians, Balkans, Koralpe and adjacent sites in Steiermark (GRAF & HUTTER, 2002), Pyrenees; not in main Alpine chain). BL up to 26 mm.

6* On mesosternum, lines directed forward from spina meet posterior corners of furcal pits (Fig. 21b). Lower edge of outer mandibular tooth smooth (not serrate as in Figure 2b), or so finely serrate (*Bulgaroperla*) that this is not recognized at magnifications <50; galea longer than basal 3 palpus segments (Figs 22b, e); no gills. Only basal 2 abdominal segments divided, others ring-shaped..... 7

7 Setation across rear of head plurilinear only behind eyes, medially turning into an irregular single row ending far from middle. Setal fringe along inner edge of lacinia begins at a short distance from apical teeth (Figs 22b, f) 8

7* Row of setae across rear of head almost continuous, only narrowly divided in middle. Setal fringe along inner edge of wide lacinia begins immediately next to apical teeth (Figs 20c, 22c–e, g)..... 9

8 Distinct marginal setae present on pronotum and abdominal tergites. Marginal setation of lacinia begins on a small projection below subapical tooth; margin between teeth and projection concave and hairless (Fig. 22b) ..... *Diura* BILLBERG

Two circumpolar species occur in Europe: *D. nanseni* (KEMPNY, 1900) only in North Scandinavia, *D. bicaudata* (LINNÉ, 1758) additionally on the British Isles, plus relict populations in central European highlands North and East of the Alps, not in the Alps themselves, except a single record at their northern edge, in Vorarlberg (GRAF & HUTTER, 2002). BL up to 25 mm.

8* Marginal setae on pronotum and abdominal tergites short, inconspicuous. Fine serration on outer cusp of

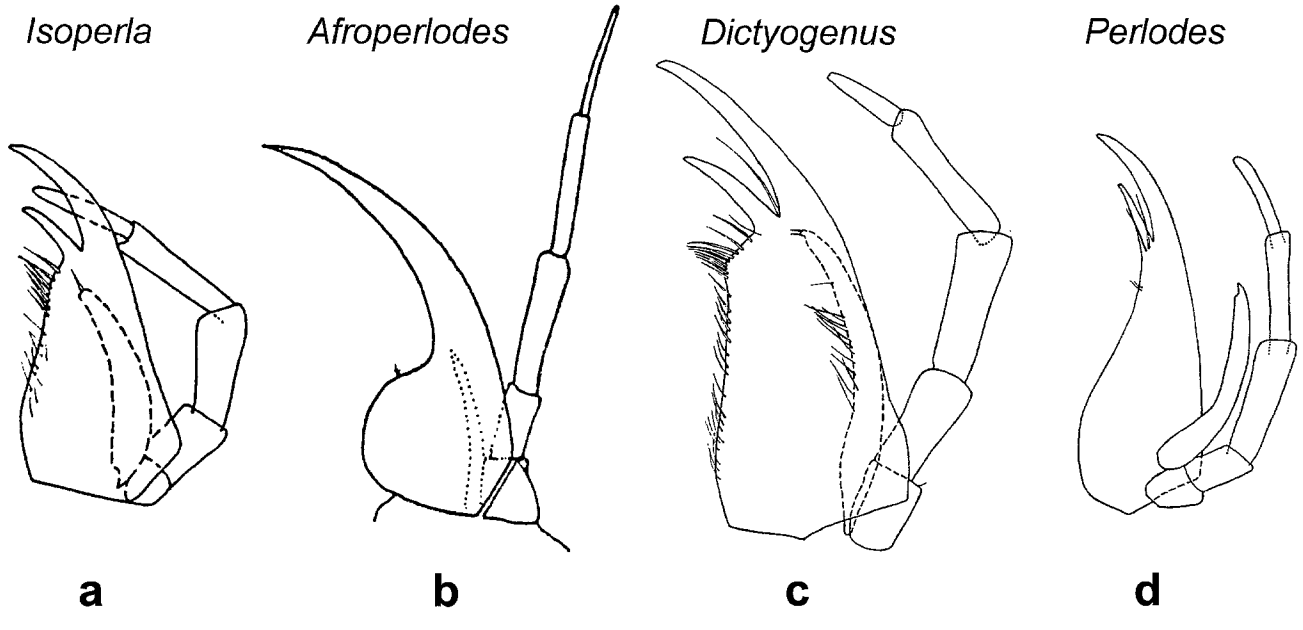

Fig. 20. Left maxillae of several genera of Perlodidae.

lower mandibular tooth present. Lacinia without subterminal notch, row of setae along inner edge sparse, discontinuous, mainly on slightly bulging lacinial base (Fig. 22f) ..... *Bulgaroperla* RAUŠER

BL up to 23 mm. *Bulgaroperla mirabilis* RAUŠER, 1966 from the Eastern Balkans and the Caucasus.

9 Teeth of lacinia about half length of lacinia; inner margin of lacinia only with about 3 marginal setae close to subapical tooth (Fig. 22g)
.... *Guadalgenus* STARK et GONZÁLEZ DEL TÁNAGO

The single species, *G. franzi* (AUBERT, 1963) (= *Dictyogenus franzi* AUBERT), lives in intermittent streams on the Iberian Peninsula. BL up to 18 mm.

9* Teeth of lacinia less large, about 1/3 lacinial length. Convex inner edge of lacinia with prominent marginal setation (Figs 20c, 22c, e) 10

10 Inner edge of lacinia below subapical tooth projecting, shoulder-like. In the same area, marginal setae form a small setal patch (Figs 22c, d)
..... *Besdolus* RICKER

BL up to 24 mm. *B. imhoffi* (PICTET, 1841) in the northern forefield of the Alps was very abundant for example in the Rhine at Basel around 1915. It disappeared and was missing for long, because of pollution. Recently, it reappeared in several larger streams and small rivers in South Germany and northern Austria. Together with it occurred another incompletely known species whose males were redescribed as *B. ventralis* (PICTET, 1841) but may actually be an unnamed species that is presently known only from Hungary. Additional species of *Besdolus* exist in the Balkans, in North Italy and in Spain. Setation differs much between species.

10* Inner edge of lacinia below subapical tooth less strongly projecting, marginal lacinial setae in a single long row (Figs 20c, 22e) 11

11 Long erect setae along front and rear edges of pronotum; marginal setae of abdominal tergites conspicuous, attaining 1/3 of segment length. Lacinia broad, contour slightly bulging (Fig. 20c)
..... *Dictyogenus* KLAPÁLEK

The distinction of the 2 nominate Alpine species (*D. alpinum* (PICTET, 1841), *D. fontium* (RIS, 1896)) is doubtful. BL up to 25 mm.

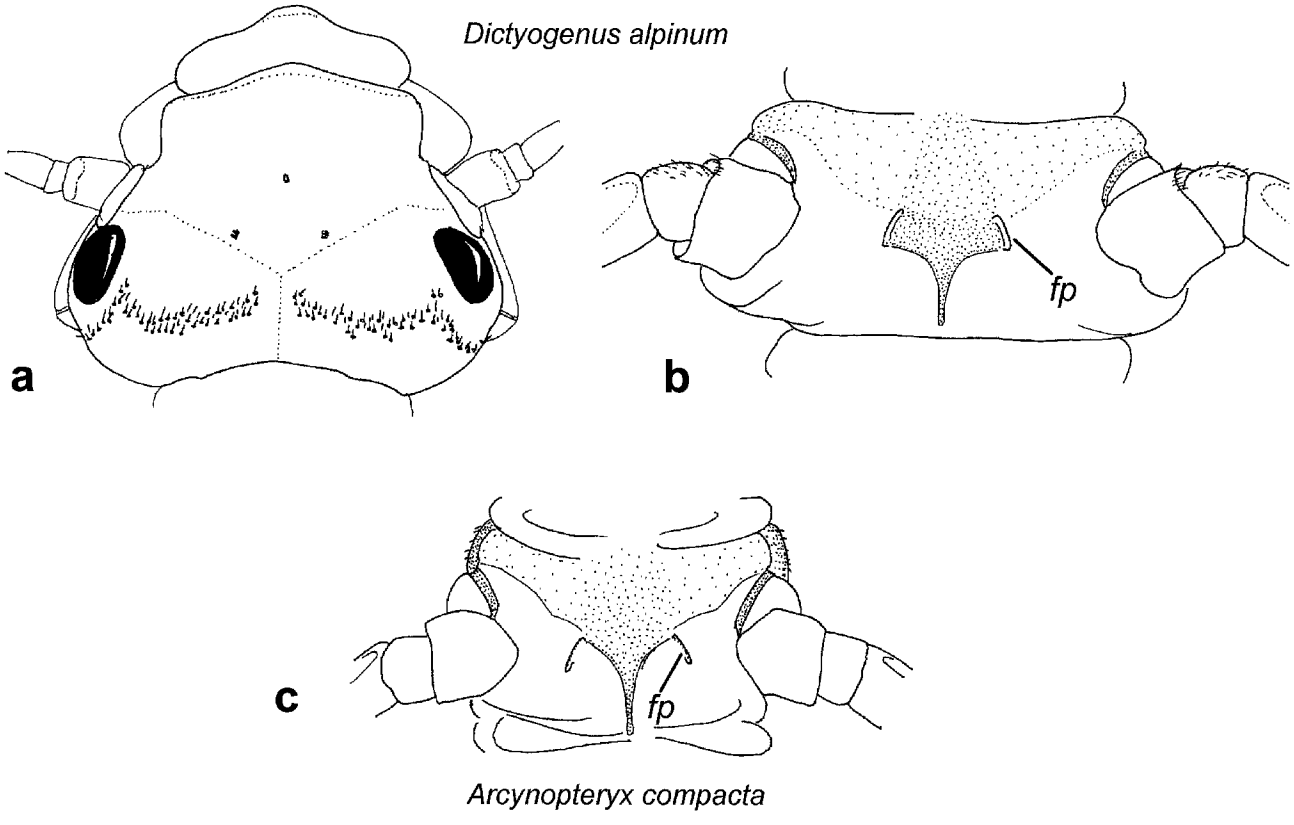

Fig. 21. (**a, b**) Head and ventral view of mesothorax of *Dictyogenus alpinum* (PICTET, 1841) and (**c**) ventral view of mesothorax of *Arcynopteryx compacta* (MCLACHLAN, 1872). Density of stippling varies to indicate degree of sclerotisation on the largely soft ventral face of thorax. fp = furcal pits.

11* Entire circumference of pronotum with very short, easily overlooked marginal setae. Marginal setae of abdominal tergites equally inconspicuous and short, attaining less than 1/5 of segment length, except a single slightly longer paramedian seta on either side. Lacinia slender (Fig. 22e)
..... *Isogenus* NEWMAN

BL up to 21 mm. The only species, *I. nubecula* NEWMAN, 1833 used to be widespread and common in major European rivers, occurring "by the thousands" along the Seine in Paris (RAMBUR, 1842). It was still found in the Danube at Vienna, in 1949 (my coll.). There are extant central European populations in Hungary and adjacent Austrian rivers, but most contemporaneous records from central Europe are of misidentified larvae of *Isoperla*; notice that stout bristles on meso-and metasternum of *Isogenus* (GRAF & SCHMIDT-KLOIBER, 2003) distinguish the two genera. However, among Isogeninae the sternal setation is not unique; slightly more delicate sternal setae occur, for example, in *Besdolus imhoffi* but not in other *Besdolus* species studied.

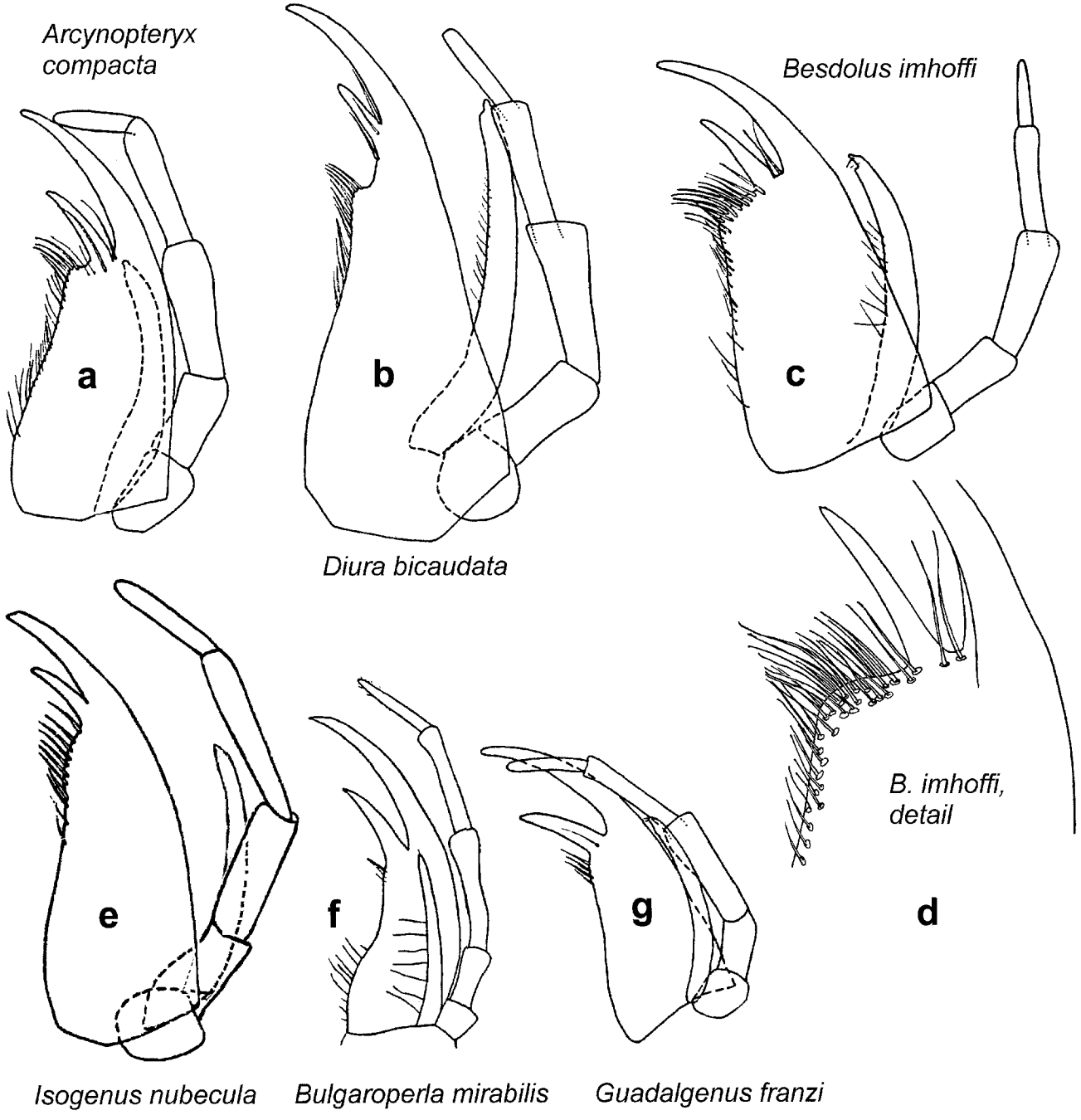

Fig. 22. Maxillae of several genera of Perlodidae; *Bulgaroperla* after BRAASCH & JOOST (1971).

Genera of Chloroperlidae

Family Chloroperlidae comprises two subfamilies. The three genera constituting the Paraperlinae are restricted to the East Asian mainland and to North America, while Chloroperlinae are of Holarctic distribution, with five genera in the West Palaearctic Region. Chloroperlinae are structurally very homogenous. While adults of the European species can easily and reliably be assigned to the various genera by genital characters, distinction of larvae (except *Isoptena*, which is globally unique and cannot be mistaken for any other stonefly larva, from the first instar on) is tricky, in all faunal regions.

The various European species within a given genus differ a little between them which renders generic distinctions difficult; for example, the habitus of *S. montana* (PICTET, 1841) has resemblances with *Chloroperla*-species. At the same time, the various species are not sufficiently characteristic to be recognized at the specific level. In a regularly sampled population of *S. torrentium* (PICTET, 1841), ontogenetic change in all characters was found to be important, creating great problems. For example, not only segment number but also general shape and relative length of cerci change importantly during growth, from short with few segments and a strongly conical contour in early instars to relatively longer, with up to 16 segments and a much more slender overall shape in the last instar. Similarly, eyes of early instars are much smaller in relation to the head capsule than they are in later and especially in the last instar. Early instars tend to be unicolorous and generally pale, but patterns may develop and be distinct in late instars; however, no comparative study of the patterning of the European *Siphonoperla* has so far been made. *Chloroperla* larvae tend to be generally pale.

The present key is based on study of last instar specimens. Users are warned to attempt to identify single young specimens. Only if much material collected at the same site over a longer period of time is available it may be possible to follow ontogenetic change and assign also middle sized larvae to a particular taxon with confidence.

Present illustrations are of mounted whole last instar specimens observed in transmitted light and only this way (or at best when specimens are viewed from all sides in strongly oblique illumination) can the length of the sometimes exceedingly thin and usually colourless setae be precisely recognized. In slide mounts, and consequently also in the present illustrations, not all setae are in their natural positions. Therefore the direction in which they point in the figures is not decisive. The present figures never show the very fine procumbent ground pilosity. Four pore-like sensilla on the head are

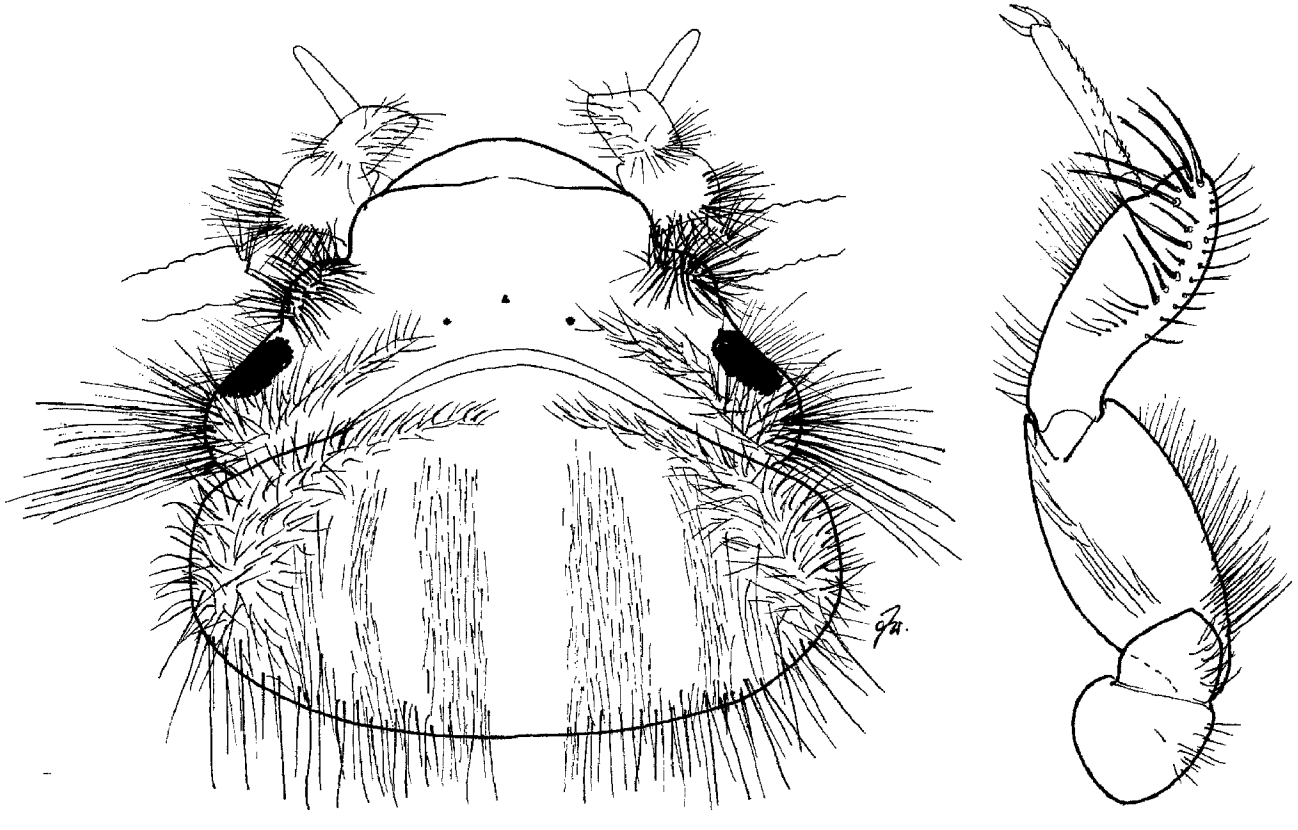

Fig. 23. *Isoptena serricornis* (PICTET, 1841), dorsal view of head and prothorax; ventral view of right foreleg.

visible only in transmitted light; they provide no means for distinctions. W. GRAF kindly drew my attention to the setation on sternite 9; the character was checked on mounted specimens, in transmitted light.

Proportions of pronotum mentioned in the key refer to measured (not estimated!) distances between insertion points of setal rows surrounding the notum. The notal sclerite itself is frequently only partly delimited by a fine edge resembling a delicate line.

1 Exceedingly dense and rigid setae, especially on fore body, less on abdomen. Head trapezoidal, much enlarged behind, setation very conspicuous, especially near rear corners of head. Fossorial legs, tibiae with spine combs, mainly on front leg (Fig. 23) ..... *Isoptena* ENDERLEIN

BL up to 11 mm. The single species, *I. serricornis* (PICTET, 1841), occurs in North and central Europe, mainly in areas with Pleistocene sands where larvae live in shifting sand at the bottom of streams, sometimes at considerable depth.

1* Shape normal, pilosity sparse and usually soft (for example, Figs 24, 25) 2

2 Eyes large and strongly convex, distinctly longer than temples (Fig. 24a); ocelli large. All of pronotal circumference pilose, lateral portions not hairless; pronotum about 1.7 times wider than long 3

2* Eyes small, flat, not longer than temples (Fig. 24b, c); ocelli small. Marginal setation of pronotum laterally discontinuous, concentrated on corners of thorax (Fig. 24b); pronotum about 1.5 times wider than long 4

3 Distal setation of sternite 9 medially widely interrupted. Cercal pilosity short, nowhere as long as the segment over which hairs extend (Figs 25b, e). Body distinctly patterned, brown longitudinal bands on abdomen[10] ..... *Pontoperla* ZWICK

P. teberdinica (BALINSKY, 1950) (BL ca. 7 mm) and the slightly larger *P. katherinae* (BALINSKY, 1950), in the Caucasus and Anatolia.

3* A continuous distal setal fringe on sternite 9. At least some cercal setae as long as or longer than the respective cercus segment (Fig. 25a). Various patterns ..... *Siphonoperla* ZWICK

[10] *Xanthoperla* may have paramedian sections of the tergal antecostae darker than the rest, which may resemble banding; however, the tergite itself behind the darker portion is not pigmented!

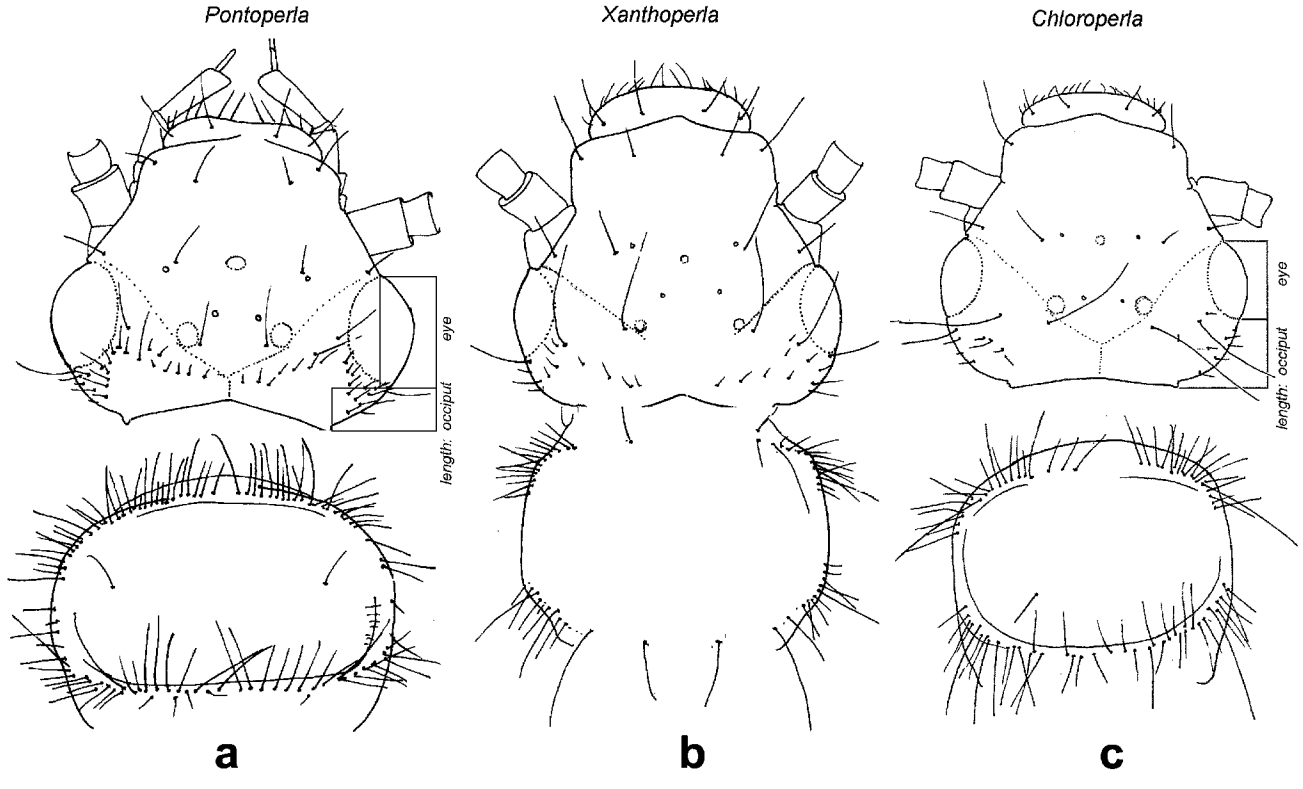

Fig. 24. Head and pronotum of (**a**) *Pontoperla teberdinica* (BALINSKY, 1950), (**b**) *Xanthoperla apicalis* (NEWMAN, 1836) and (**c**) *Chloroperla susemicheli* ZWICK, 1967; whole mounts, in transmitted light.

BL up to 12 mm, most species slightly smaller. Endemic in the West Palaearctic Region, about 9 species. Whether the North African *S. lepineyi* (NAVÁS, 1935) belongs here is not entirely clear. *S. torrentium* (PICTET, 1841) is the most common and most widely distributed species; in Scandinavia occurs only *S. burmeisteri* (PICTET, 1841).

4 Small delicate species whose pronotal sclerite lacks a delimiting fold; instead, the sclerite is only delimited by hair fringes. Hair fringes along front and rear margins are sparse, lateral ones widely interrupted (Fig. 24b). Distal setation on sternite 9 short, stout, continuous. Setal fringe on tergite 10 very short, comb-like. Cerci on outer and inner face with a few setae (almost) as long as the segment (Fig. 25c). Abdominal antecostae may be darker on either side of midline (not always distinct) resulting in some banding ..... *Xanthoperla* ZWICK

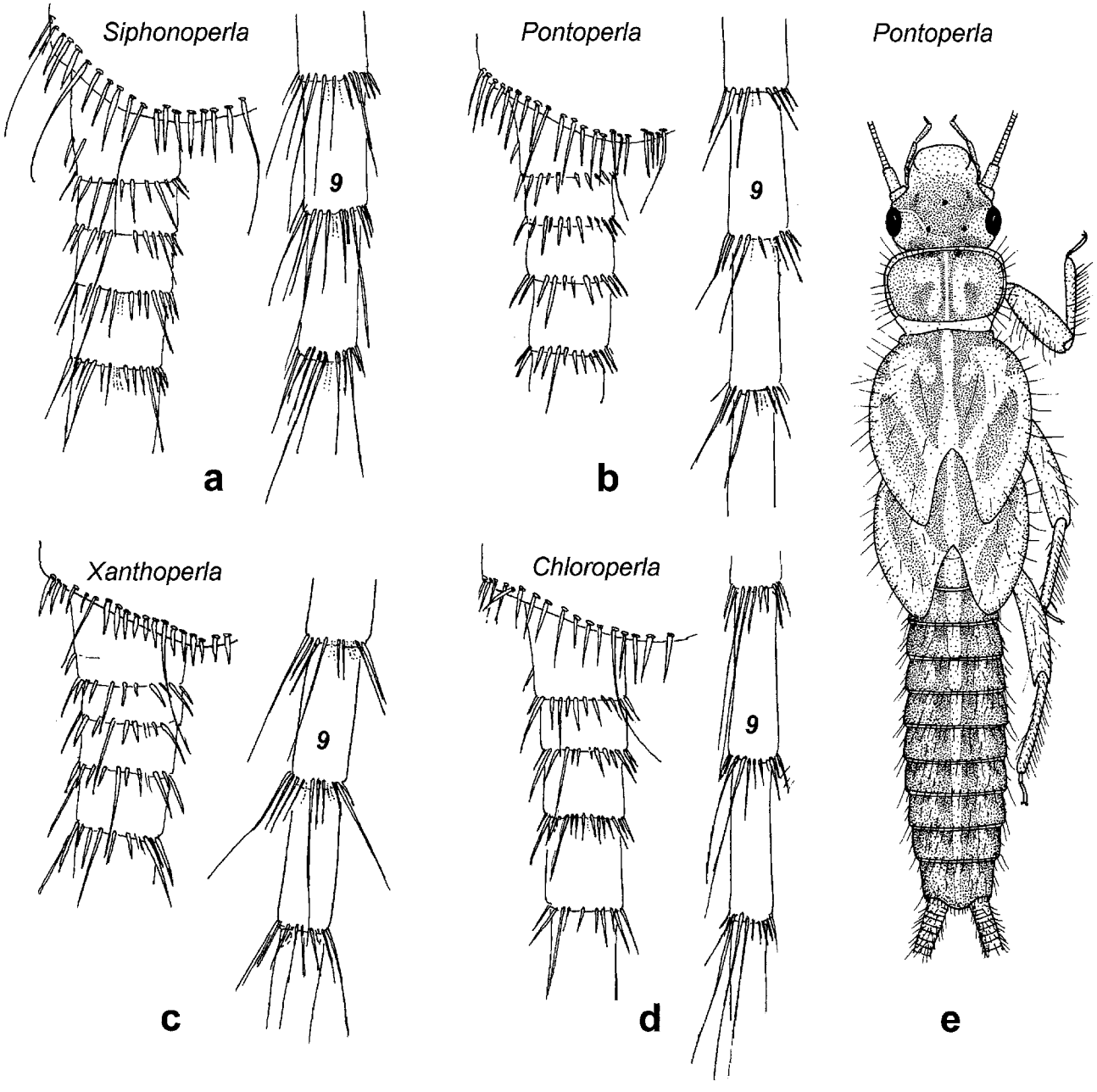

Fig. 25. Dorsal view of left cercus (base and segments 9 and 10) of (**a**) *Siphonoperla torrentium* (PICTET, 1841), (**b**) *Pontoperla teberdinica* (BALINSKY, 1950), (**c**) *Xanthoperla apicalis* (NEWMAN, 1836) and (**d**) *Chloroperla susemicheli* ZWICK, 1967; whole mounts in transmitted light. (**e**) Last instar larva of *Pontoperla teberdinica* (from ZWICK, 1971).

The single European species, *X. apicalis* (NEWMAN, 1836), is very widely distributed; BL up to 7 mm. At least in central Europe this is a potamal species. It had disappeared for decades but returned recently; for example, it is again common in the River Neisse. Specimens illustrated in this key are from Sardinia where the present species is the only Chloroperlidae. Characters of these specimens agree with descriptions by AUBERT (1953) and BRITTAIN (1983), but cannot be reconciled with LILLEHAMMER's (1988) figures; from the strongly transverse pronotum with blunt setae he illustrated he seems to have had some different taxon before him. Additional species of the genus occur in Middle Asia and the Himalaya.

4* Elongate pale larvae whose pronotal sclerite is distinctly delimited in front and posteriorly (Fig. 24c). Pronotal hair fringes much denser than in preceding species (Fig. 24c), hair fringe on tergite 10 much more slender. Distal hair fringe on sternite 9 medially interrupted. Setation of cerci along inner face near base short, not as long as segments. However, distally individual setae along dorsal and ventral faces of cerci are very long and fine (Fig. 25d)
..... *Chloroperla* NEWMAN

BL up to 8 mm. Endemic in central and South Europe and Anatolia. The typical species, *C. tripunctata* (SCOPOLI, 1763), is very widely distributed, preferably at moderate elevations. Regionally endemic additional species occur in the major European mountains, at higher elevations. Larvae apparently live relatively deep in stream bottom substrata, probably in the hyporheic zone. *C. tripunctata* has 5–7 very long dorsal and ventral hairs on each distal cercus segment, while *C. breviata* NAVÁS, 1918 (Pyrenees) and *C. susemicheli* ZWICK, 1967 (Alps) have only about 3 on each side (Fig. 25d).

Appendix I:

Preliminary key to the German species of genus *Nemoura*, with notes on a few South European species

RAUŠER, in his masterly pioneer work (1980), provided a key to the Czechoslovakian species of *Nemoura* in which the relative length of setation on particular cercus segments is of prime importance. This approach requires that segments be accurately counted because the diagnostic proportions change along the cercus. Generally, the relative length of setae increases from the base to about the basal third of the cercus and then decreases again. Although these characters are basically valid, there are two problems. First, the cercus grows during development by addition of segments near the base, similar to the base of the antennal flagellum where new segments are also added. Even in last instar larvae, this basal cercal area is usually incompletely segmented, the number of dividing sulci on the outside may exceed the number on the inside. Similarly, the most basal setal fringes at the end of segments are often only developed on the outer side. Therefore, the "first" segment after the cercus base is hard to identify. Second, the angle at which setae diverge from the segment varies, which influences estimates of relative length. These details may also be perceived differently in slide mounts and in intact specimens viewed in direct light under a dissecting microscope.

An alternative preliminary key was proposed by ZWICK in a lecture handout, in 1993. Although not formally published this document was nevertheless circulated by users. The present key is a re–arranged and extended version of this earlier key, a definite key to all species can still not be presented. Because of the need for future work and also because of the wider geographic frame of the present key at generic level, a few southern European species (whose larvae were previously inadequately described, or completely unknown) are also included.

Exuviae of reared males or mature males in their larval skin of all German species were available. Intact specimens were studied under direct light and slide mounts of entire larvae (or of exuviae) in transmitted light. Magnifications ~100× are sometimes required.

1 Pilosity of femora fairly homogenous, regular, procumbent; even though some setae may be distinctly longer than others they form no groups and remain inconspicuous. Hind femur long and slender, 3 or more times longer than wide at widest point (Figs 26a, 27a) 2

1* Femora with procumbent small setae plus distinctly larger spine-like setae, pilosity sometimes markedly heterogenous, large setae in regular (Figs 26c, 27c) or irregular arrangement (Figs 26b, d, 27b). Shape of hind femur variable, sometimes as long as above but often also strikingly short and thick (only about 2.5× longer than wide) 3

2 Setae along caudal margin of abdominal tergites short, the longest barely half as long as the corresponding tergite, of normal spine shape. Setae around pronotum and along wing margins pointed. Setae on cerci inconspicuous, the longest not quite as long as the respective segment. Pedicellus concolorous with scapus and antennal flagellum
..... *N. cinerea* (RETZIUS, 1783)

Ubiquituous stream species, tolerates some pollution, found also in acid peat bogs. Rare in typical Plecoptera habitats, but may be very common in marginal habitats that other Plecoptera fail to colonize.

2* Setation along caudal margin of abdominal tergites heterogenous: most setae very short and apically truncate and frazzled (Fig. 28), while several others are extremely thin, pointed and attain segment length; they are apically thinned and turn into a very fine, thin, flexible hair that is easily overlooked.

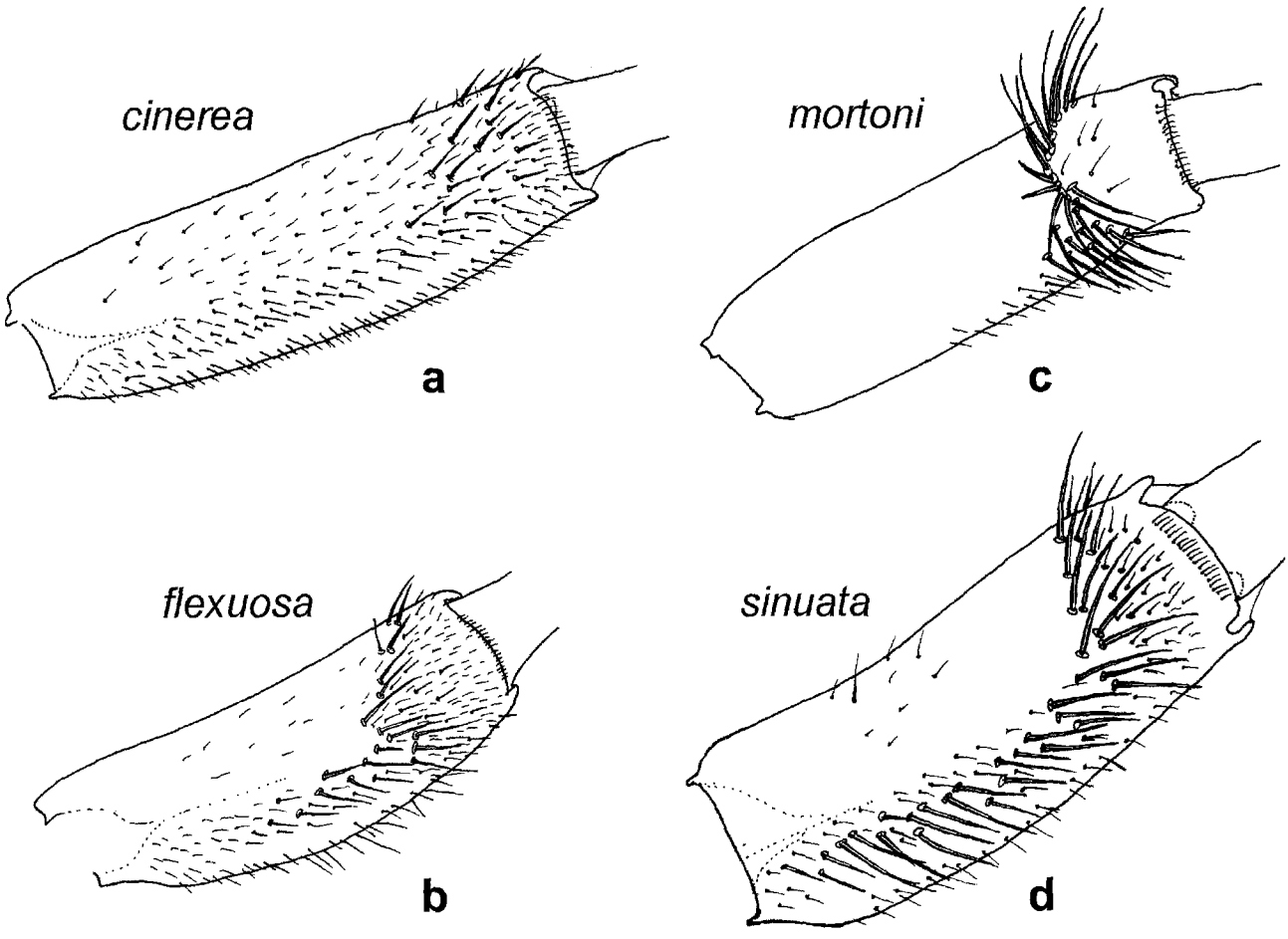

Fig. 26. *Nemoura* spp., right front femur in dorsal view; not to scale.

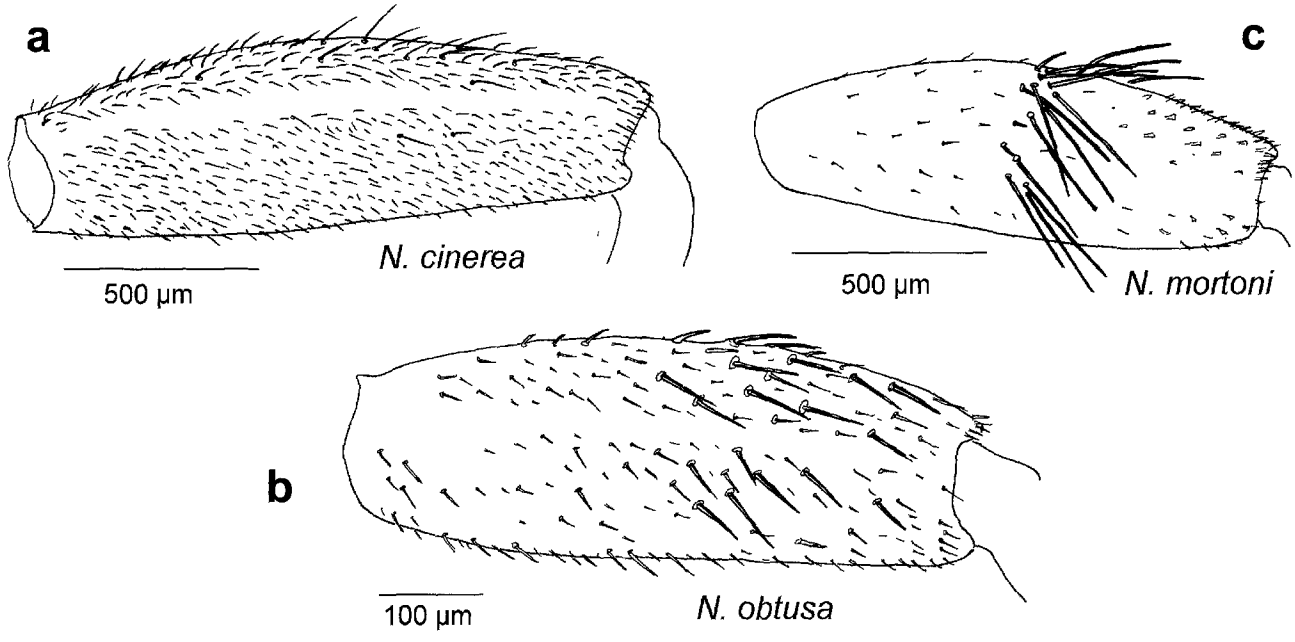

Fig. 27. *Nemoura* spp., examples of shape and setation of left hind femur.

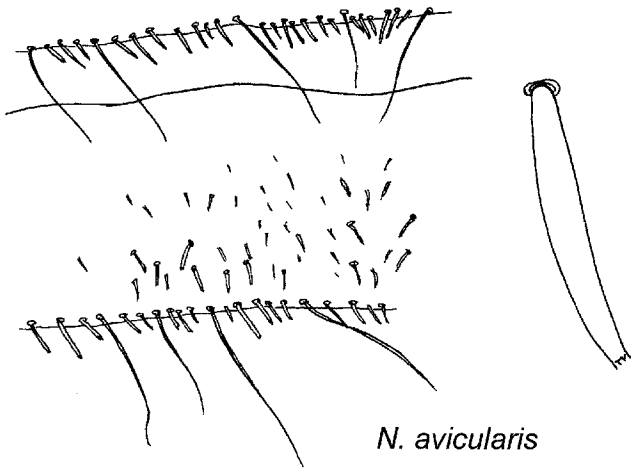

Fig. 28. *Nemoura avicularis*, left half of tergites 4 and 5, and detail of a marginal seta with frazzled apex; not to scale.

Setae along pronotal and wing margins truncate, the truncate end often a little wider than the section just basally from it. Cercal setation conspicuous, forming dense hair screens on segments 10–15 that are longer than the corresponding segments. Scape paler than both head or pedicle and flagellum
..... *N. avicularis* MORTON, 1894

In large and small streams and along lakeshores in Scandinavia, in North Germany typically along shores of oligotrophic lakes, in the central European highlands in rhithral streams.

3 Along distal margin of abdominal tergites only densely placed short setae attaining at most 1/4 of tergite length (Figs 29b, d) 4

3* Armature along distal margin of abdominal tergites composed of longer spine-like setae, or of a mixture of spatulate setae plus several long hairs (Figs 30, 31)..... 5

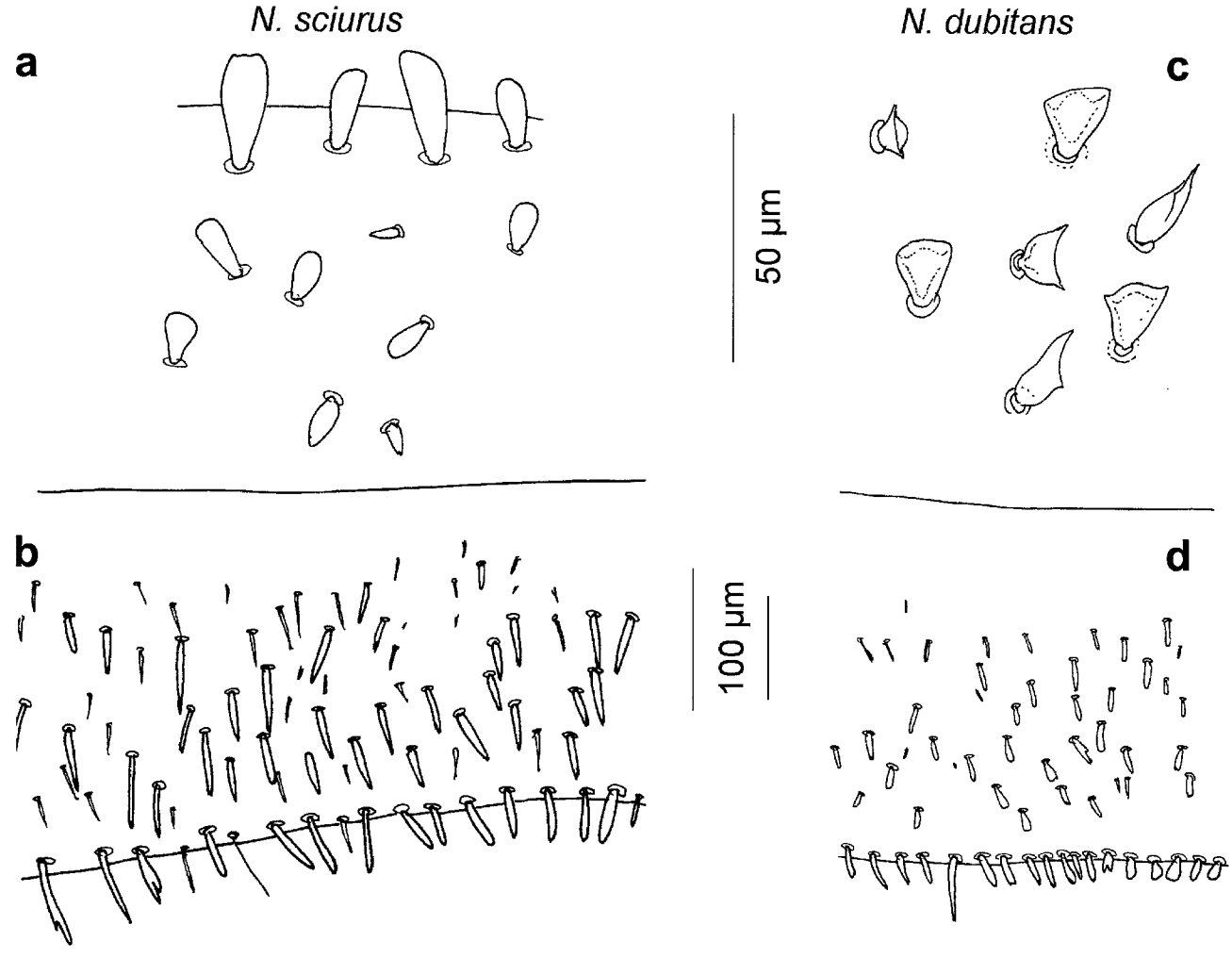

Fig. 29. (**a, b**) *Nemoura sciurus* AUBERT, 1949 and (**c, d**) *N. dubitans* MORTON, 1894. Setae on disc of pronotum, near midline and along front margin (a, c) and left half of tergite 5 (b, d).

4 Setal fringe around pronotum distinct everywhere from short blunt spines on disc (Fig. 29a). Setae along abdominal tergites short, blunt, club-shaped, but not spatulate (Fig. 29b). Setal ring of distal cercus segments sparse, not longer than half segment, intercalary pilosity insignificant
..... *N. sciurus* AUBERT, 1949

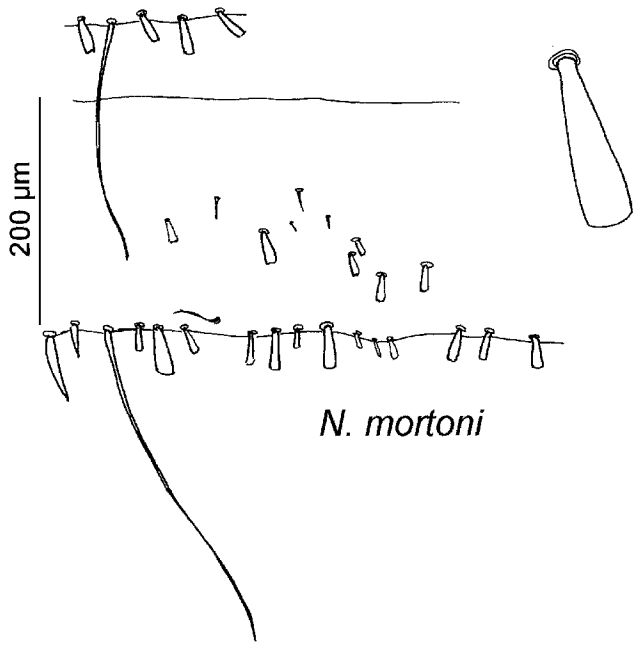

Fig. 30. *Nemoura mortoni* RIS, 1902, left half of tergites 4 and 5; detail of a spatulate marginal seta not to scale.

In rhithral streams, with an evident preference for waters rich in carbonate.

4* Setal fringe on pronotum distinct along sides, but along front and especially hind margins barely discernible from the short spines on disc; these are thick and end in a sharp transverse edge with slightly extended corners (Fig. 29c). Abdominal setae straight, very short in comparison with segment length, blunt, club-shaped, those in centre spatulate (Fig. 29d). Setal rings of distal cercal segments dense, longer than half segment, soft, forming a fine brush-like pilosity, together with well developed fine intercalary hairs..... *N. dubitans* MORTON, 1894[11]

Characteristic strikingly long-legged inhabitant of reedy and swampy areas near the influx of little streams, in reedy shore-line pockets of little lakes in North Germany, often also in tiny puddles around stands of *Phalaris* or *Juncus*, apparently as long as some groundwater is seeping in.

5 Large bristles forming a narrow ring near middle or apical third of femur (Figs 26c, 27c). Pronotal setae very long, pointed 6

5* Large setae on femora less orderly, shaggy on hind femur (Fig. 27b)..... 7

6 Tergal marginal setation consisting of a mixture of short spatulate spines and long, distally fine, hair-like setae. The longest ones are lateral and are much longer than the corresponding tergite (Fig. 30). On

[11] LILLEHAMMER (1988) says the first tarsal segment to be curved which is not the case in German specimens.

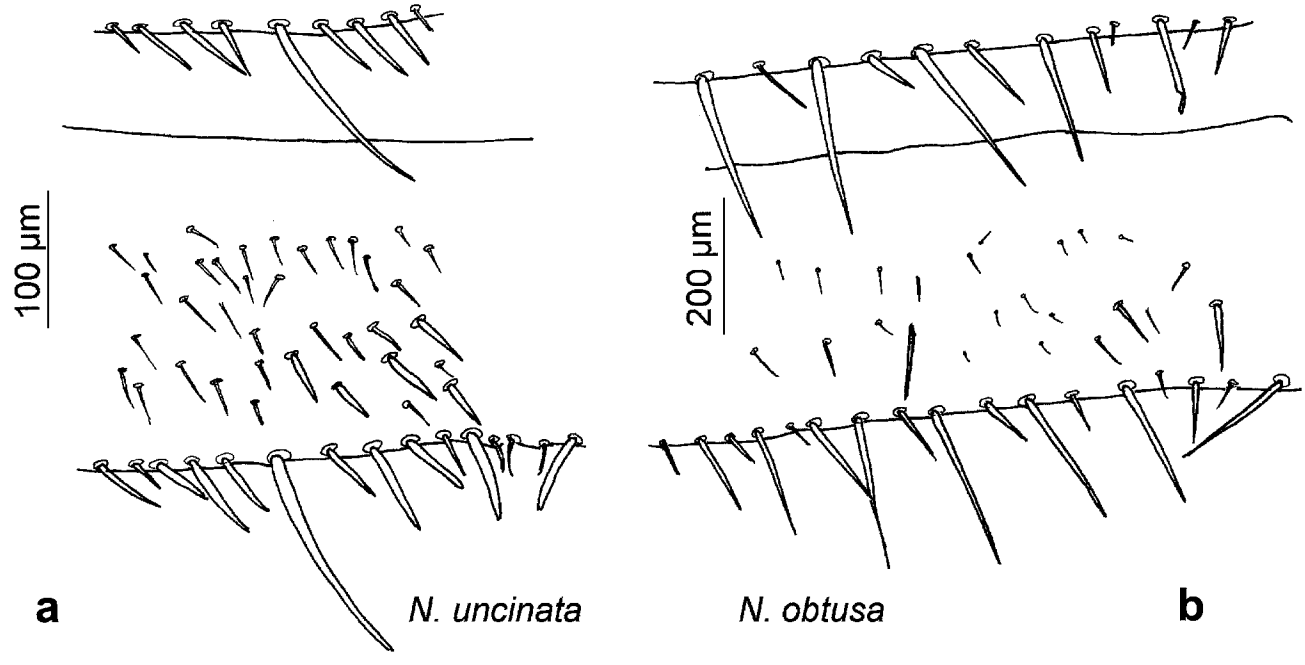

Fig. 31. (**a**) *Nemoura uncinata* DESPAX, 1934 and (**b**) *N. obtusa* RIS, 1902, left half of tergites 4 and 5; to different scales.

posterior tergites (T7-9), spatulate setae and fine hairs alternate almost regularly, and hairs are not longer than the respective segment. Pronotal setation straight..... *N. mortoni* Ris, 1902

Alpine and montane areas in central Europe, typically in springs and spring runs; often covered with debris.

6* Tergal marginal setation consisting exclusively of pointed and rather long sparse spines, the longest about as long as the corresponding tergite. Pronotal setation a little wavy.. *N. palliventris* Aubert, 1953

Widespread rhithral Italian species, from the Maritime Alps to Sicily.

7 Setae in lines on surface of wing-pads are short spines of various forms..... 8

7* Wing-pads with fine, erect long hairs in linear arrangement ..... *N. lacustris* E. Pictet, 1865

Along tiny, slow-flowing streams in southern France and on the Iberian Peninsula.

8 Integument matt, rough through numerous intercalary little spines on all thoracic and abdominal tergites. Tergite margins with series of slightly curved spines that grow progressively longer from middle towards sides (Fig. 31a), lateral spine pair much longer than other spines, especially central pair. Large setae on fore femur leaving an extended distal area covered with only small setae (Fig. 26b) ..... *N. marginata*-group

Several species inhabiting springs and rhithral stream sections share a common appearance and are too similar, and at the same time too variable, to be presently separated. I examined the following: *N. arctica* Esben-Petersen, 1910, *N. cambrica* Stephens, 1835, *N. erratica* Claassen, 1936, *N. flexuosa* Aubert, 1949, *N. marginata* Pictet, 1836, *N. minima* Aubert, 1946, *N. uncinata* Despax, 1934, *N. undulata* Ris 1902. Still more species may fall in the same group.

8* Integument shining. Erect marginal setae along posterior edges of tergites prominent, intercalary setation weak (Fig. 31b), very sparse on posterior abdominal segments. Length of marginal setae relatively uniform, no size cline from short paramedian to long lateral setae. Femora covered with erect spines, the largest ones are close to apex, barely any fine procumbent pilosity distally from them (Fig. 26d) 9

9 Setae on antero-lateral margin of pronotum acute. Tiny setae in lines on wing-pads are small pointed spines and occasional slender hairs (Fig. 32a, b) ..... *N. obtusa* Ris, 1902

Springs and little streamlets in the Alps. A single record from the Polish Tatra.

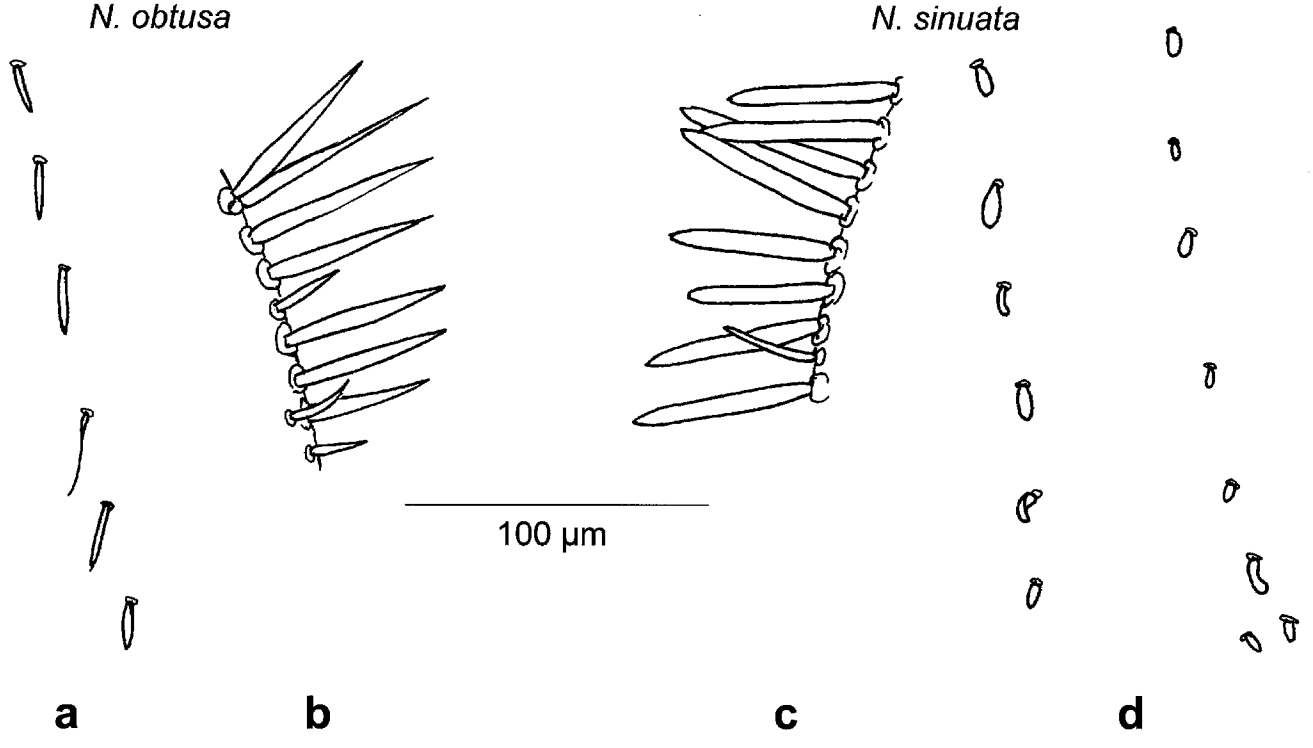

Fig. 32. (**a, b**) *Nemoura obtusa* Ris, 1902 and (**c, d**) *N. sinuata* Ris, 1902, rows of tiny setae on wing-pads (a, d) and lateral marginal setae of pronotum, near anterior corner (b, c).

9* Setae on antero-lateral margin of pronotum almost cylindrical, only apex narrowed to a short point. Tiny setae in lines on wing-pads ovoid (Figs 32c, d) ..... *N. sinuata* RIS, 1902

Springs and little streamlets in the Alps.

Appendix II:

Diagnoses of selected characteristic species and species groups of *Leuctra*

RAUŠER (1980) offered a key to the Czechoslovak species of *Leuctra*. However, in this very large and difficult genus specific identifications remain problematic, with few exceptions. Below, new diagnoses are presented for a few individual species that can be reliably identified, and for two major species groups that are proposed as Operational Taxonomic Units (OTU) until more precise identifications become possible.

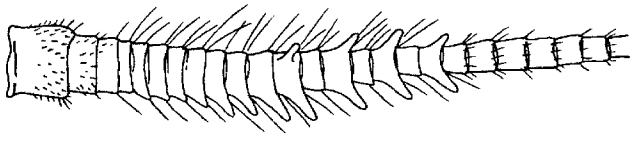

Fig. 33. *Leuctra geniculata* (STEPHENS, 1835), base of antenna (from RAUŠER, 1980).

- Body flattened, large. Near basal part of antennal flagellum several segments with one or two outgrowths (Fig. 33); fairly hairy ..... *L. geniculata* (STEPHENS, 1835)

BL up to 12 mm. Western species, North Africa, British Isles, Iberian Peninsula, Sardinia (not on Italian mainland) and Corsica; West and Central Europe north of the Alps, east to Lower Austria. In a wide range of running waters, from tiny mountain creeks (Vogelsberg, Germany) to larger lowland streams and rivers.

- Very hairy, especially head (Fig. 34) and sides of pronotum:
  - Clypeus with prominent pointed corners (Fig. 34a); basal part of antennal flagellum with striking long setae. Lower side of head below antennal insertion normal ..... *L. braueri* KEMPNY, 1898

BL up to 10 mm. Central European mountains east of Rhône and Rhine, mainly in deep aerated deposits of fine detritus. Isolated among the Central European species, close relatives known only from Spain.

  - Clypeus normal. Setae on antennal flagellum much shorter than segments, setation inconspicuous. Lower contour of head below antenna bulging outwards (Fig. 34b); on this blunt swelling arise long setae. Body of preserved specimens tends to be completely straight ..... *L. nigra* (OLIVIER, 1811)

BL only 6–8 mm. Mainly in sandy deposits. A phylogenetically isolated species; by the male paraprocts, the only close relative is *L. bidula* AUBERT, 1962, from Spain. In the greater part of Europe, except the south of the Balkan Peninsula.

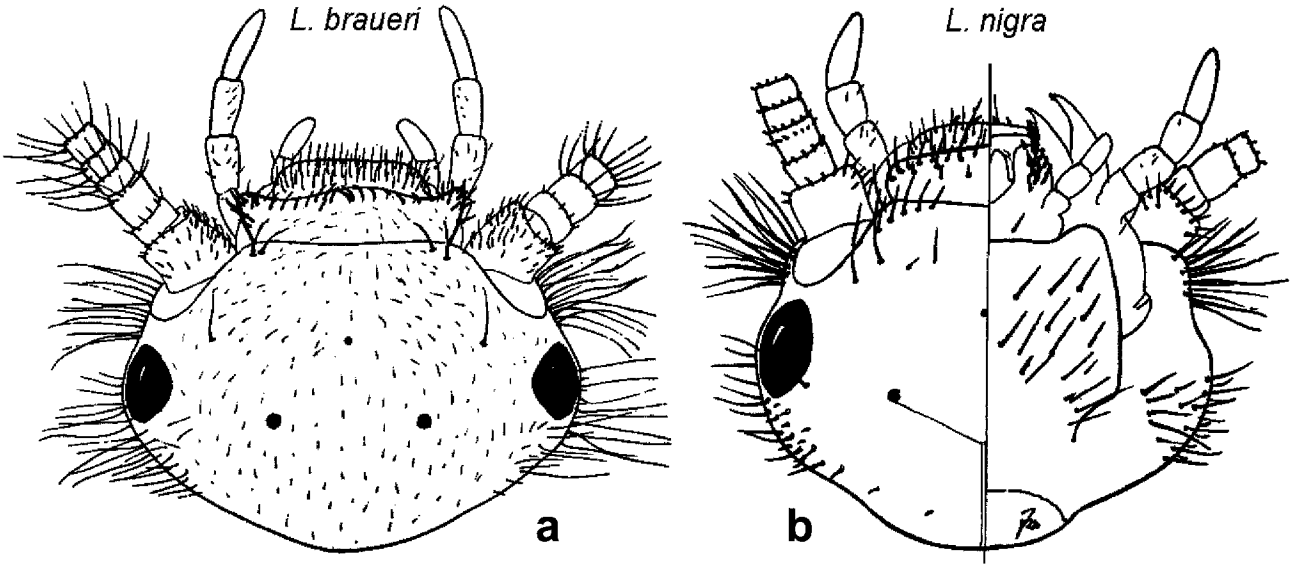

Fig. 34. (**a**) *Leuctra braueri* KEMPNY, 1898, head in dorsal view, and (**b**) *L. nigra* (OLIVIER, 1811), head in combined dorsal and ventral views.

- Macroscopic pilosity of normal density, or sparse, sometimes almost absent:
  - Rear edge of thorax between front wing-pads oblique, between hind wing-pads the thorax margin forms little pointed extensions (Fig. 35a) ..... *prima–hippopus–inermis*–group

  Some species in this group emerge in late winter, most in spring, only one or two are autumnal.

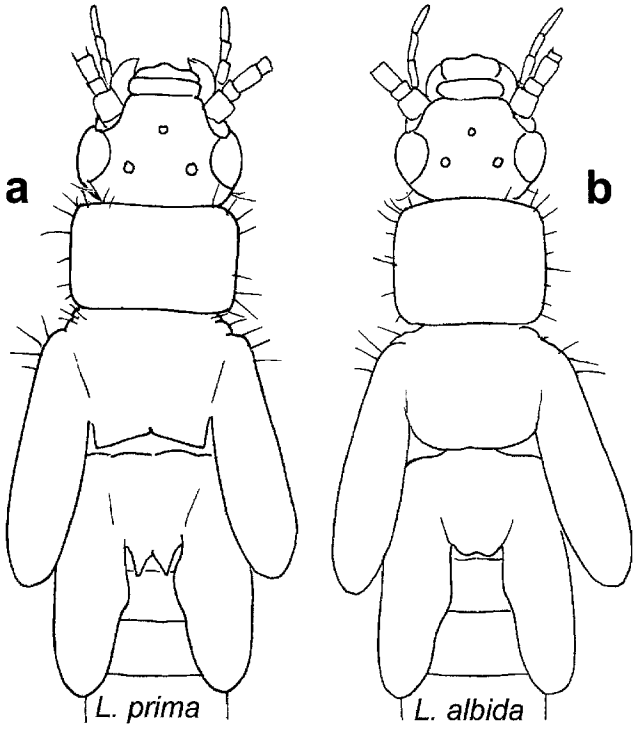

Fig. 35. (**a**) *Leuctra prima* and (**b**) *L. albida*, dorsal view of fore body.

  - Rear edge of thorax between wing-pads truncate or gently rounded (standard configuration, also in the 3 individual *Leuctra* species keyed above, as well as in the genera *Tyrrhenoleuctra* and *Pachyleuctra*) (Fig. 35b) ..... *fusca*–group

  This group includes a large share of species flying from late summer to autumn.

Notes on central European members of the *prima-hippopus-inermis*-group:

- Some members of the *prima*–subgroup (for example, *L. prima* KEMPNY, 1899, *L. autumnalis* AUBERT, 1948, *L. signifera* KEMPNY 1899, *L. pseudosignifera* AUBERT, 1954, probably also others) appear relatively hairy because hairs are stiff and tend to be well pigmented.
- *L. hippopus* KEMPNY, 1899 and the species of the *inermis*-subgroup (for example, *L. inermis* KEMPNY, 1899, *L. rauscheri* AUBERT, 1957, *L. handlirschi* KEMPNY, 1898, *L. teriolensis* KEMPNY, 1900) have paler, less easily noticed hairs but those on the abdominal segments are nevertheless about half as long as the segment length and well visible in profile.

Notes on central European members of the *fusca*-group: large group with many autumnal species.

- Some are normally shaped and normally pilose like *L. albida* KEMPNY, 1899 (Fig. 36b), *L. fusca* (L., 1758) and *L. digitata* KEMPNY, 1899 (Fig. 36a; the distinction of the latter two species after RAUŠER 1980 fails!);
- Many have short hairs and are slender (like *L. aurita* NAVÁS, 1919; Fig. 36c),

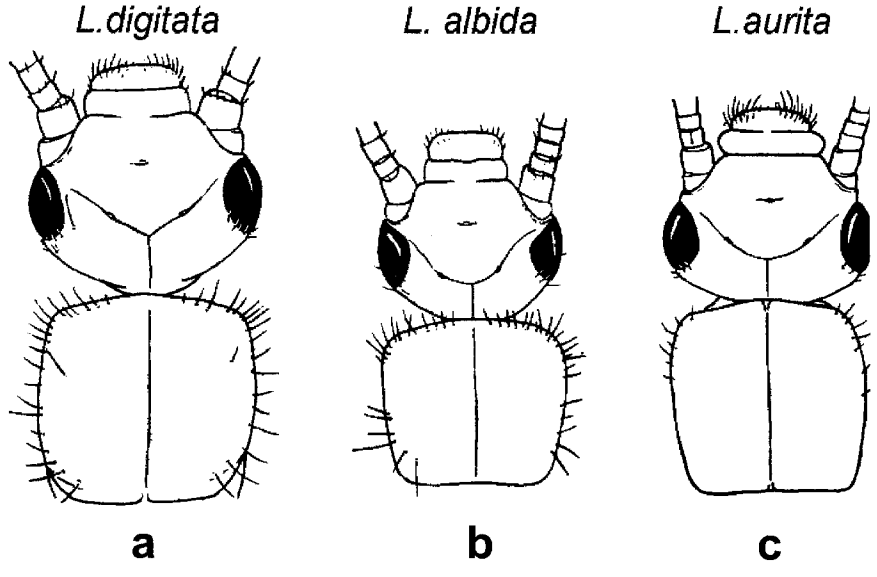

Fig. 36. Head and thorax of *Leuctra* spp. (from RAUŠER, 1980).

- Some are almost hairless, very slender and pale. The subterranean *L. major* BRINCK, 1949 and *L. leptogaster* AUBERT, 1949 are extremes.

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Taxonomic index

References in roman script are page numbers, those in *italics* are figure numbers.