Odonata, Dragonflies and Damselflies

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Introduction

Life cycles and phenology

Odonata are hemimetabolous insects with egg, larval and adult stages. In North Europe all species deposit their eggs into, or in the immediate vicinity of freshwater or brackish habitats in which the larvae complete their development.

Dragonflies are basically warm-adapted insects, and that applies also to the northern species. It appears that very little larval development takes place at a water temperature below app. 10°C. The life-cycle duration of North European Odonata varies from one to more than five years, and is often flexibly adapted to local conditions. Emergence of the adults begins about mid-May in the south, and continues well into August. Specimens emerging after mid-August probably fail to reproduce, because sexual maturity is not reached until one or more weeks later, depending on weather and species. During the maturation period dragonflies can be found foraging far from any water. Some species, e.g. *Libellula quadrimaculata,* are known to migrate long distances. These migrations are probably triggered by a combination of specific weather conditions, high density of larvae before emergence, and possibly also endoparasites (Corbet 1962). Dragonfly migrations are not uncommon and occur in the area yearly.

The life-cycles can be roughly classified according to the overwintering stages, which are also interrelated with adult phenology (Norling 1984c).

(1) Obligatory univoltine species with a fixed overwintering diapause stage.
 (a) Overwintering as adults.
 (b) Overwintering as eggs.
(2) Overwintering is possible in several or most larval instars, sometimes in the egg stage as well. Life-cycle and phenology are very flexible and adaptable to local conditions.

Knowledge of the life-cycle patterns are often of some help in the identification of larvae.

Overwintering in the adult stage (**type 1a**) is rare, and in North Europe it occurs only in *Sympecma fusca*. This species breeds during the spring. The new generation appears late in the summer and enters a state of reproductive diapause.

Type 1b, obligatory one-year development with overwintering eggs, characterises members of the genera *Lestes* and *Sympetrum* and also, at least in Scandinavia, *Aeshna mixta*. They are typically late-flying (July–September), but species adapted to temporary waters, most notably *Lestes dryas*, can sometimes be on the wing already in early June in southern Sweden. These species do not reproduce in the coldest areas, but may migrate. A couple of *Sympetrum* species, *S. vulgatum* and *S. striolatum*, can possibly overwinter as small larvae in the southernmost part of North Europe, and the latter is reported to do so in Britain (Corbet *et al.* 1960). Otherwise, larvae of type 1 species are of course absent from late autumn and winter samples.

Most species belong to the flexible **type 2** life cycle. The flexibility increases their ability to adapt to different conditions. *Coenagrion hastulatum* in southern Sweden usually develops in one year, but may require four years in the north. And, on top of that, there is nearly always a variation within the populations. There is for instance always some two-year development going on in the south Swedish *C. hastulatum* populations (Norling 1984a).

The flexibility also includes different phenological patterns in the adults, variations that are governed by the last overwintering stages and the speed of larval development. This variation is predominantly interspecific. It is relatively easy to recognise a group of **early breeders**. In these species most specimens usually spend their last winter in the final larval instar, which they reach during the season before emergence. This accumulation in the final instar gives rise to a well synchronised peak of early emergence, often followed by some stragglers. Some well-known examples are species of *Leucorrhinia*, *Libellula*, *Cordulia*, *Erythromma*, *Pyrrhosoma*, and *Coenagrion armatum* (e.g. Corbet 1962, Norling 1984c). Other *Coenagrion* species are less typical, except in the north.

Late breeding type 2 species are less distinct. There are some that have a long flight season, starting early and ending late with no particular preference, e.g. *Ischnura elegans* and *Enallagma cyathigerum*. Among the most typical late-breeding type 2 species are those of *Aeshna* (except *A. mixta*, which is type 1).
These type 2 groups are not distinct, and their phenologies change with latitude. The short season in the northernmost parts of the area makes all species appear as "early breeders" (Norling 1984c).

Late breeding species often also lay overwintering diapause eggs. This egg diapause can be obligatory, as in *Aeshna*, or facultative, e.g. in *Somatochlora*, where eggs that are laid early may develop rapidly without delay, at least in Central Europe (Robert 1959).

Both the inter- and intraspecific flexibility of the

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type 2 life cycles is largely governed by the positioning and intensity of different responses to photoperiod among the later instars. These responses act via diapause phenomena, and can be modified by temperature conditions (e.g. Norling 1984c). They are further discussed under "rearing".

Habitats

The Odonata are distributed over the entire world, and although there are Odonata in most bodies of water on all continents except Antarctica, the vast majority of species are tropical. In North Europe the 59 recorded species inhabit many different habitats, from bog pools above the tree-line in the Scandes down to artificial agricultural ponds in densely populated areas. Most species breed in standing water, although a small number of rheophilic species are present in the area. Slowly running waters and stagnant backwaters of rivers and creeks will also attract species found in standing waters. Only some *Sympetrum* and *Lestes* species will breed in temporary waters. In the saline waters of the west coast, dragonflies occur only in the brackish waters of estuaries and in rock-pools filled with a mixture of seawater and rainwater. Many species can also breed in the brackish coastal waters of the Baltic Sea.

Small, nutrient rich, fish-free and non-acidic lakes and ponds usually have the largest number of dragonfly species. Up to 20 different species coexisting in one such lake is not uncommon in the south, although eutrophication in agricultural and densely populated areas tends to reduce the number substantially.

The habitat preferences of dragonflies are dependent on many factors, one of them being the plant communities of the breeding waters. Some species, in particular those that deposit their eggs into plant tissue have a preference for one or a few particular plant species. However, the relationship is probably more complex than that, since it would seem that egg-laying females choose waters, or indeed parts of waters, with a particular composition of plants, some of which do not act as egg-laying substrates (cf. e.g. Buchwald 1992, House 1991).

Water chemistry, e.g. acidity, does not seem to influence the larvae directly, and affects distribution mainly via the mature female and other animal and plant species. Some dragonfly species are dominant invertebrates in acid waters poor in nutrients (Henriksson 1992), and are probably of great importance in the local food chain.

Most species prefer dense vegetation in and around their breeding waters, but a few species, e.g. *Ischnura pumilio* and *Libellula depressa*, actually prefer "disturbed" habitats, such as pools in sand-pits, quarries and newly dug ditches.

Trophic relationships

Both adults and larvae are strictly predatory, consuming every living prey of suitable size they can get hold of. Newly hatched instar II larvae feed on unicellular organisms, protists or monerans, but as soon as they reach a sufficient size, i.e. after one or two more moults, they start eating small crustaceans, a food source that also seems to be important for much larger specimens, at least in bog pools (Henriksson 1992).

Larger larvae eat a variety of water organisms, ranging from small crustaceans via various mosquito larvae to small vertebrates, e.g. larvae of frogs and newts. Most species – but in particular the larger anisopterans – are cannibalistic at least in dense populations. However, even large larvae prefer prey items that are smaller than themselves unless they are very starved.

Large dragonfly larvae are sometimes top predators in fish-free lakes and ponds. They do, however, have some rivals to that position in the large dytiscid beetles and their larvae. In other ecosystems odonate larvae are eaten e.g. by fish, dytiscids and newts. In warmer areas dragonfly larvae in large numbers have been reported to cause damage in fish-farms but this has not been reported from North Europe.

Adults and most larvae hunt by sight. Therefore moving prey items are most readily detected and attacked. Some larvae dwell in the bottom substrate, and they are in addition highly dependent on tactile stimuli, mainly through the antennae, to catch their prey.

The adults hunt in flight. They consume a variety of other insects, mostly Diptera and Hymenoptera. Anything small enough to be handled is considered a possible meal. Adults are normally not cannibalistic, but some species occasionally consume other, smaller dragonflies.

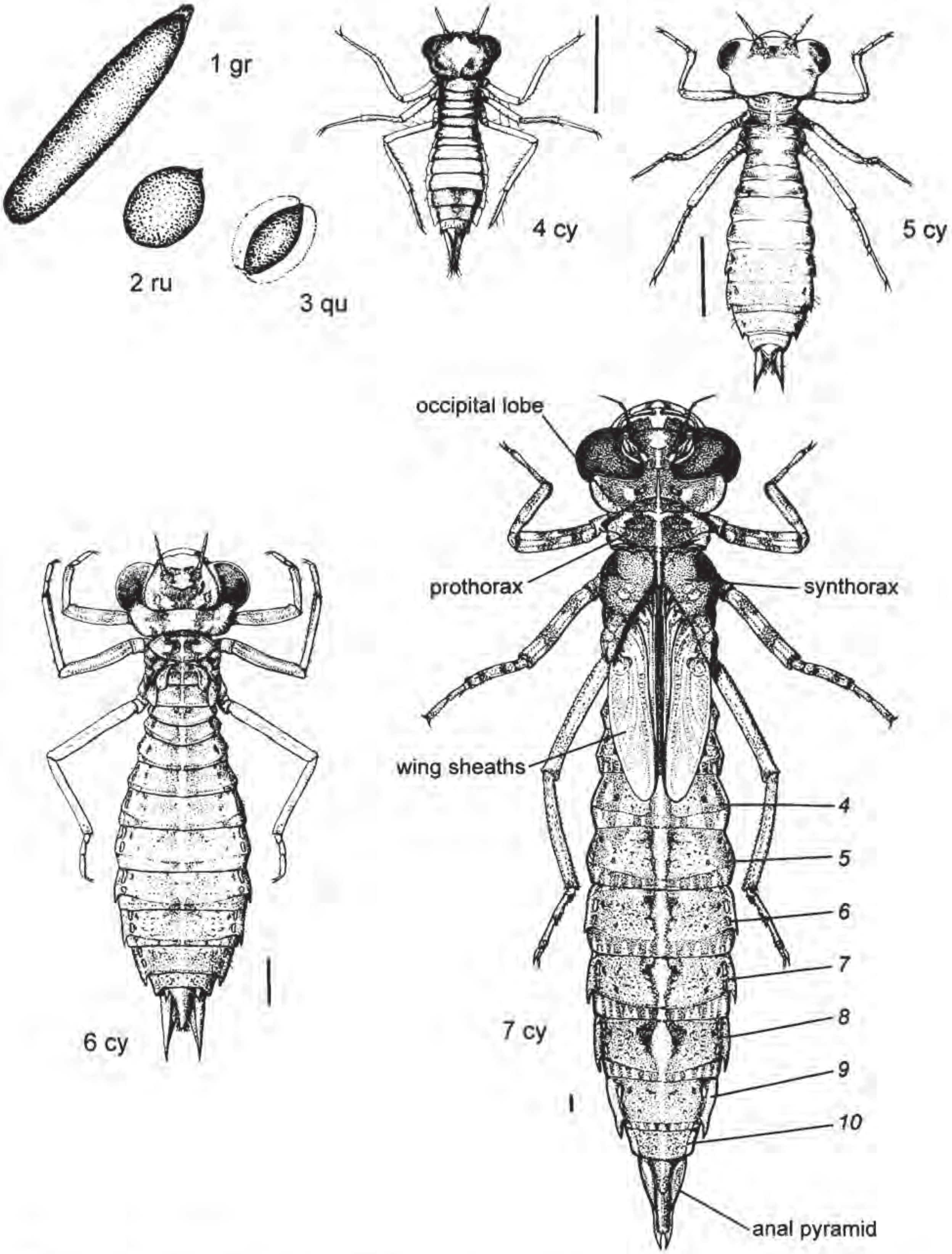
Fungal infections kill off a large number of eggs, and fish may also consume them at deposition (along with the female, see below).

Fish is perhaps the principal enemy of dragonfly larvae, and their occurrence can affect the distribution of some species (Henriksson 1992, but cf. Johansson & Samuelsson 1994).

Adult dragonflies are eaten by birds. The most critical moment in the life-cycle is the emergence, when they are susceptible not only to bird predation, but also fall victim to frogs, fish and some invertebrates. Water-mites of the genus *Arrhenurus* are common parasites on adult dragonflies. The mite larvae attack the dragonflies when they emerge, positioning themselves in the soft tissue between the abdominal tergites and sternites. On damselflies they are often present on the thorax as well. It does not seem as though the mite larvae actually kill their hosts, but they may weaken them and thus make them more susceptible to predation from birds or fish (Åbro 1982). Adults of small species are frequently caught in spider's webs. Egg-laying females are often eaten by fish. This is common both in species that dip their abdomens into the water to deposit their eggs, and in damselflies that climb down into the water to deposit eggs into the stem of a water plant.

State of knowledge

The eggs of the Odonata have only recently been examined ultrastructurally (e.g. Becnel & Dunkle 1990, Trueman



Figs 1-7. Odonata, egg (1-3) and larva (4-7). -1. *Aeshna grandis*, length 1.25 mm. -2. *Leucorrhinia rubicunda* without exochorionic jelly, length 0.42 mm. -3. *Libellula quadrimaculata* with exochorionic jelly, length (excluding jelly) 0.38 mm. -4-7. *Aeshna cyanea*, development (scale bar 1 mm), del. G. Marklund. -4. Instar II. -5-6. Intermediate instars. -7. Final instar. Figs 1-3 redrawn from Sahlén (1985).

1991, Sahlén 1994a & b). Although differences exist between taxa, a general key for odonate eggs is of little use since eggs are most easily obtained from live females or from aquatic plants into which they have just oviposited. However some patterns of oviposition into plants are species-specific and eggs in water-plants can sometimes be determined to the correct species (e.g. Robert 1959). The egg is the least well-known stage of the Odonata.

With few exceptions, larvae of Odonata in North Europe can be determined to the species level in the late instars, but it is sometimes considered to be difficult. Many species can be identified in a wide range of instars, and some even in all instars (excluding the prolarva). However, the ability to identify earlier instars is mostly the property of experienced odonatologists, and cannot, as a rule, be learnt from the literature.

It seems, for example, that *Aeshna*-larvae have a general reputation of being difficult to determine. However, this is a genus where many species can be told apart in all instars, at least if the larvae are alive or well preserved. The difficulties may correlate with the high number of species that often are morphologically close to each other, and, particularly, with the different appearance of younger larvae compared to the final instars, for which most keys are made.

There are several keys to European odonate larvae. They rarely allow reasonably accurate identification of other instars than the two or three last ones, which means that most larvae in a random sample often cannot be identified with their help.

The larval keys hitherto used in this area are Askew (1988), Bellmann (1993), Carchini (1984), Gardner (1954, reprinted in Corbet *et al.* 1960, and Hammond 1983), Sahlén (1985, 1996), Valle (1943), and for exuviae Heidemann & Seidenbusch (1993). None of these cover all species extant in the area.

Good treatises with diagnostic characters for species in some genera can be found elsewhere, e.g. Ander (1926), and Schmidt (1936a-c). The adults are relatively easy to identify even in the field, and with the exception of a few species, a skilled observer can tell them apart without having to capture them. Many keys are available, both traditional and pictorial. Sandhall (1986), Sahlén (1985, 1996), Askew (1988) and Bellmann (1993) are but a few of the many books available.

Morphology

Eggs

Dragonfly eggs are whitish when deposited, changing to various shades of yellow, brown and black within a few hours. Two egg-types are present in the area, namely: (1) the elongated *endophytic* type (Fig. 1) deposited into living or decaying plant material in or just above the water, and (2) the roundish-oval *exophytic* type (Figs 2, 3) deposited freely into water or wet mud by dipping of the tip of the abdomen. *Cordulegaster boltoni* and also some corduliids deposit their exophytic eggs into the bottom sediment in shallow places. Exophytic eggs may sometimes aggregate when deposited on the same spot but only one species in the region regularly deposit eggs in large masses. Eggs of the corduliid *Epitheca bimaculata* are deposited in long strands much like those of the common toad (*Bufo bufo*), only much smaller. More than 2000 eggs may be present in one such strand.

Endophytic eggs are believed to be the archaic type. They are characterised by a thicker and more complex eggshell along with a larger number of micropylar openings. Exophytic eggs have a simpler eggshell, the outer layer (exochorion) of which is often transformed into a jelly layer consisting of thin proteinous threads that expand many times when in contact with water. The jelly layer gives extra protection and camouflage. The number of micropyles in exophytic eggs is often only two.

Larvae

The number of larval instars during development is high and variable, normally within the range of 10–15, and varies even within each population. The increase in head width between instars is often a factor of 1.15-1.25. Therefore, development is highly gradual, and instars can be specifically identified only late and early in development.

The first instar is named prolarva. With its aberrant pupa-like shape it is specifically adapted to leave the egg, and in endophytic species the surrounding plant tissue. After the few minutes this takes, the prolarva immediately moults into instar II (Fig. 4). This instar is adapted to a normal larval life, and is accordingly of a more normal appearance.

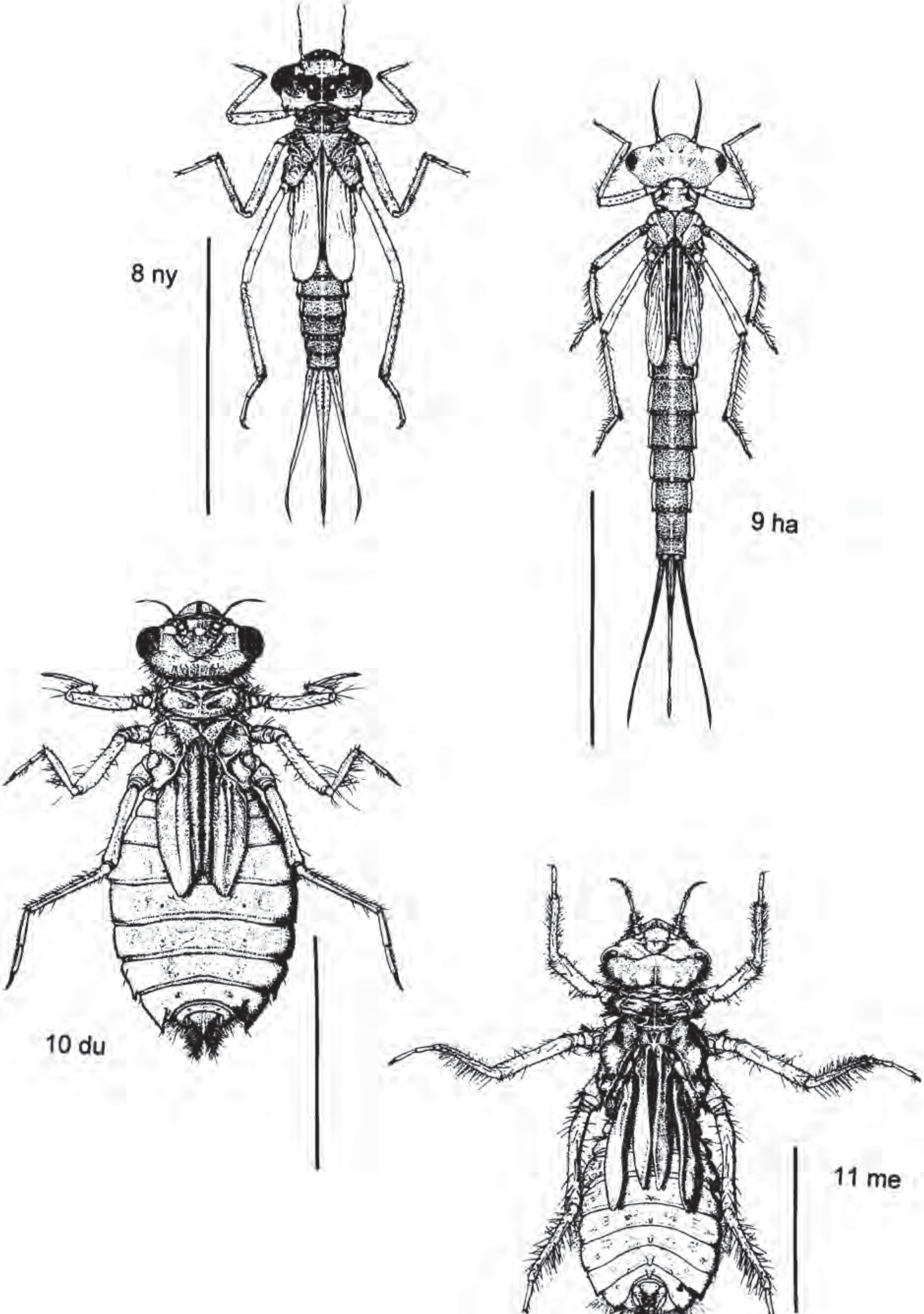
Also during subsequent development the proportions and shape of the larva changes as different structures and body parts grow with different rates (allometric growth). Typical adult features, such as wing sheaths, show this pattern particularly well. The gross ontogenetic changes in *Aeshna cyanea* are illustrated in Figs 4–7.

Due to this accelerated acquirement of adult features in late larval life, the final instar (F, Figs 7-11) is easily recognised by the large wing-sheaths or -pads, which as a crude rule of thumb are at least as long as the head width. The two preceding instars, F-1 and F-2, can usually also be recognised with the help of size (head width) and wing-pad length, but this requires some experience.

The proximity to the adult stage can make the F-instar somewhat atypical in comparison to the middle instars. The newly hatched instar II larva is likewise slightly aberrant, but this instar is not covered in the key.

When emergence approaches during the final instar, metamorphosis takes place. Metamorphosis is the process where larval structures break down, and the adult is formed within the larval cuticle. During this period profound changes occur within the larva, which alter its appearance in important respects (see below for details).

Cuticle. The larval cuticle is usually dull and provided with setae (hairs or spines with a basal articulation) of various size and shape. It is often roughened by small elevated, sometimes dark setal bases, bearing minute setae, only discernible as such at high magnification. At the



Figs 8-11. Odonata, habitus of larva, final instar. -8. *Pyrrhosoma nymphula*. -9. *Coenagrion hastulatum*. -10. *Leucorrhinia dubia*. -11. *Somatochlora metallica*. Del. G. Marklund, scale bar 10 mm.

borders of the chitinous plates (sclerites), setae are often larger and shaped like long hairs, spine-like bristles or short, stout conical structures. The sclerite itself can also be drawn out into spines. This is often seen in the abdominal dorsal plates (tergites, see below), where taxonomically important spines may be present mid-dorsally and at the posterior corners (Fig. 16).

The places where muscles attach to the cuticle (muscle scars) are often prominent, e.g. on head (Fig. 12) and abdomen. They are distinguished by their smooth surface (no setae; cf. Fig. 155, right side of prothorax), and often by a darker pigmentation (e.g. the small spots in Fig. 134).

The visible pigment of larvae resides both in the cuticle, in the underlying epidermis, and in other subcuticular structures such as tracheae. The ground colour of specimens, brownish or greenish, is also dependent on the body fluid. The greenish colour always disappears in conservation. The cuticular pigment is the most permanent, and remains in exuviae and decomposed larvae.

Head. The head morphology in Odonata larvae is highly characteristic. It is shaped by their roles as visual/tactile predators, with compound eyes and antennae in different species developed according to their relative roles in detecting prey. Strongly visual predators with large eyes are found in Lestidae and Aeshnidae (cf. Figs 27, 113).

In younger larvae the eyes are always widely separated and approximately rounded, and their relative size increases progressively during development (allometric growth). In Anisoptera, where the adult eyes usually meet dorsally, the gradual formation of this dorsal part is seen in late instars as probably non-functional dorsomedially extended areas of the larval eyes, often sharply delimited from the functional larval eye and usually with a different texture (Fig. 12).

During the last instar, the final formation of the adult eye is visible through the larval cuticle, in Aeshnidae as a pigmented black area expanding from the medial extended part of the eye, encroaching on the muscle-scars behind it, hiding other larval features and finally meeting medially. In Libellulidae and Corduliidae it is a dark line expanding from the eye rim, enclosing an initially light adult tissue, which later turns darker (reddish or brownish) (Fig. 12). These features are omitted from the illustrations in the key, since they are variable distracters without diagnostic value, and can conceal larval features.

The larval ocelli are less well developed (Fig. 12), and are best detected by means of their pigment (e.g. Fig. 185). The pigmentation, however, is often missing in early instars (Fig. 172).

The antennae are usually filamentous (Fig. 13; cf. also Figs 19 & 100, for more aberrant types). The first two segments, scapus and pedicellus, nearly always have a larger diameter than segment 3, the flagellum. The latter segment normally consists of up to 5 annuli, which lack their own separate musculature. The annuli are therefore not considered to be separate true segments. The annuli increase in number during early development.

The mouth-parts are biting, and the labium is uniquely modified as a prey-capturing device of great taxonomic importance. Its two main parts, the distal prementum and the proximal postmentum, are at rest folded below the head as a mask (Fig. 13). The labial palps at the end of the prementum are modified to seize and hold the prey. The mask is thrown forwards by an increase in the pressure of the body fluid produced by abdominal muscles. Hence the mask is often extended due to the increased internal pressure in poorly preserved larvae.

There are two basic types of masks, flat and spoon-shaped. The flat type, found in aeshnids and gomphids, is well designed for catching large, free prey and have palps with strong movable hooks (e.g. Figs 106, 142). The spoon-shaped type occurs in the primarily bottom-dwelling Cordulegastridae, Corduliidae and Libellulidae. The large triangular palps comprise the anterior end of the spoon, and have smaller movable hooks (Figs 13, 197). The prementa of the zygopteran families often fall somewhere between these two types (Fig. 15). In most zygopteran types, and in the anisopteran spoon-shaped type, the prey is further enclosed by large setae along the dorsal edge of the palps and on the prementum (Fig. 15).

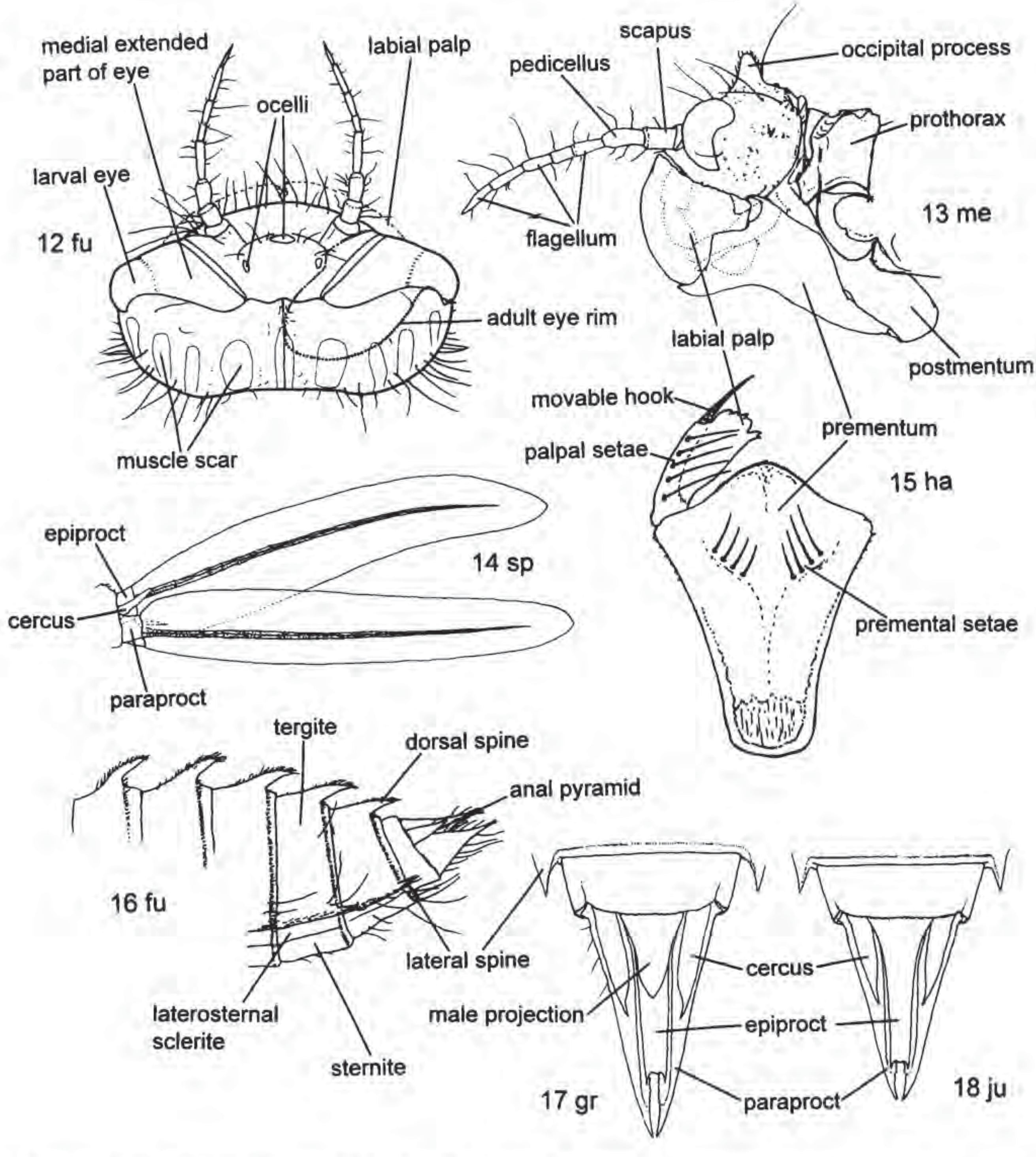
During late metamorphosis, a few days before emergence, the tissues in the prementum are withdrawn.

Thorax. The development of the powerful adult flight apparatus strongly transforms the thorax during the larval stage. Initially the three thoracic segments are similar to each other, and in dorsal view also to the first abdominal ones (e.g. Figs 4, 5). The sides (pleurites) of the wing-bearing meso- and metathorax (thoracic segments 2 and 3, together called ptero- or synthorax), and the initially almost invisible wing-buds or -sheaths, rapidly increase in size at the end of larval life (Figs 6, 7). In contrast to e.g. Ephemeroptera and Plecoptera, the wing-sheaths lie inverted, folded with the underside turned upwards. They usually cover the small tergites in the last two instars. Prior to emergence the wing-sheaths swell, which is a certain sign that emergence will follow within 1–3 weeks.

The legs and the prothorax (thoracic segment 1) show less dramatic transformations.

Abdomen. The abdomen has 10 segments. The typical abdominal segment consists of a dorsal plate (tergite) and a ventral plate (sternite), connected to those of adjacent segments by soft intersegmental cuticle (Fig. 16). In the Zygoptera the tergite and sternite are connected laterally by a pleural area of soft cuticle, that can be reduced to a thin suture. In Anisoptera there are two additional lateral rows of ventral sclerites (Fig. 16), the laterosternal sclerites (or spiracular sclerites, sometimes also called pleurites). There are sometimes two pairs of laterosternal sclerites, the larger spiracular, and a smaller triangular sclerite (Fig. 238). In late instars of anisopteran larvae, the first abdominal segment is very small and easily overlooked. In the posterior end of the abdomen the lateral margins of the tergites often bear lateral spines. Dorsal spines can occur on some or even most segments.

The abdomen often has a pigment pattern of great diagnostic value, however, the pattern is sometimes very different in larvae of different sizes. Some of the dark



Figs 12-18. Odonata, larval morphology. -12. *Libellula fulva*, final instar (F) near emergence, head, dorsal view. -13. *Somatochlora metallica*, younger larva (head width 2.2 mm), head and prothorax, lateral view. Mouth-parts hidden by prementum and palps are indicated with broken lines.-14. *Lestes sponsa*, N:Ø, 3.8 mm, F; caudal gills, lateral view. -15. *Coenagrion hastulatum*, (F), prementum in dorsal view. -16. *Libellula fulva*, (F), abdomen, lateral view. -17-18. *Aeshna*, (F), anal pyramid, dorsal view. -17. *A. grandis*, male. -18. *A. juncea*, female. Del. U. Norling. Fig. 15 redrawn from Sahlén (1985).

markings occur at muscular attachments (muscle scars, see above).

Ventrally on segment 9 the genital area can be seen in later instars, especially if it is accompanied by an ovipositor. In males the accessory copulatory organ on the second and third sternite can be discerned.

Segment 10 consists of a single annular sclerite, and bears 5 abdominal appendages surrounding the anus. In Anisoptera they form the so called anal pyramid (Figs 16–18), where the epiproct and the paraprocts are present in all instars and can close the anus. The cerci are more peripheral and appear and grow progressively during ontogeny, thus having no constant size relationship with the other appendages. In Anisoptera, the cerci form the lateral anal appendages of the adult, whereas the unpaired inferior appendage of the male adult (still above the anus) develops from the basal part of the larval epiproct. In the final instar of male larvae it shows a distinctive bulge (male projection, Fig. 17). Sometimes even the final instar cerci can show traces of their future adult shape. The paraprocts are reduced to valve-like structures in the anisopteran adult.

In the Zygoptera the epiproct and paraprocts bear large caudal tracheal gills (Fig. 14). These probably serve as a combination of respiratory organs, sensory structures, and tail fins for swimming (cf. Norling 1982: 377). The relative importance of these functions varies between species and probably also between instars. The gills are often divided by a node (Fig. 39 and e.g. 68, 72, 75), and are of great taxonomic importance. Unfortunately, they are easily lost at a pre-formed zone of weakness.

At emergence the tissues of the gills are left behind in the exuviae, while the male inferior anal appendages develop in the paraproct bases. The larval cerci, precursors of the paired adult superior appendages, are small (Fig. 14). The epiproct is reduced in the zygopteran adult.

Parts of the tracheal system are often seen through the cuticle, because of the dark pigment often deposited in the tracheal cells, and in living specimens also due to their air content. The closed spiracles can be seen, often as small dark spots, in the pleural or laterosternal area of most segments (e.g. Fig. 243).

Adults

Wings and abdomen of newly emerged dragonflies are soft, and the characteristic colours are not yet present. Such teneral individuals should not be handled since they are easily damaged. When dried they usually loose both their shape and what little colour they have. The shape of the long, slender body and large wings is very characteristic. Body length varies from 22 up to 85 mm. The wing span ranges from 25 to 115 mm. Colours are highly variable and may differ between males and females. Metallic colours arise from reflections in thin layers of the cuticle, while other colours arise from pigment in the cells. Colours change with age and in the males of some species a bluish or white waxy substance is secreted from the cuticle, covering other colours of the body. Such secretion is called pruinescence.

Head. All Zygoptera have compound eyes on the sides of the head, thus giving the entire head the appearance of a small hammer (Figs 316, 317). The antennae are small, and the ocelli usually conspicuous on a small elevated triangle on the forehead. Anisopterans have much larger compound eyes which in most species dominate the entire head (Figs 318, 319). Frons is prominent in these species, forming a sharp-angled forehead. A small occipital triangle (Fig. 322) is present behind the eyes, which meet on top of the head in all families but Gomphidae. The eyes are frequently cleaned with brushes of hairs on the insides of the protarsi. The mouth-parts are biting.

Thorax. Prothorax is separate from the two last segments. These are fused, forming the wide synthorax and containing the well developed flight muscles (Fig. 323). The legs are designed for clinging or sitting, not for walking. The shape of the prothorax and the colour markings on the front and sides of the synthorax are often used for identification. Many species of Zygoptera have a thin light-coloured line anteriorly on the side of the synthorax (cf. Fig. 323). This shoulder-line is sometimes diagnostic.

Wings. Anisoptera have narrow fore wings and wider hind wings, whereas the slender Zygoptera have fore and hind wings of the same size and shape (Figs 316-319). The wings are moved by direct muscles, rendering them very movable and making dragonflies excellent fliers. The wings of most species have a pterostigma near the wing tip. The only exception is the family Calopterygidae where the females instead have a conspicuous white spot at the same location. The wing venation, colour and presence or absence of wing-spots are important diagnostic characters. The shape and size of the discoidal cell (Zygoptera) or the wing triangle (Anisoptera) is often used to separate families, while the coloration of the cells adjacent to the membranula (a parchment-like section in the posterior basal corner of the wing) is used to distinguish certain species.

Abdomen. The abdomen is long and slender with 10 visible segments (Figs 322, 323). Abdominal coloration as well as shape and size of anal appendages are important characteristics. The male accessory genitalia located under segments 2 and 3 (Figs 223, 350, 352) serve as diagnostic characters in some closely related species. Females primarily have a well developed ovipositor for insertion of the eggs into plant tissues (Figs 324, 351, 353). In Anisoptera, some groups may lack ovipositor altogether (Gomphidae, Corduliidae and Libellulidae) or have a reduced ovipositor (as in Cordulegastridae). In the three former families, a secondary ovipositor is sometimes present. Basically this is a secondarily enlarged vulvar scale (Figs 355, 366), shaped to allow oviposition in different soft substrata. Vulvar scales are used as diagnostic characters in many species.

Methods

Collecting

Larvae are best collected with a handnet with fine meshes (approx. 1 mm) mounted on a sturdy metal frame and securely attached to a suitable, rigid rod. Netting should be carried out in such a way that the plants as well as the bottom material is disturbed and the larvae washed out into free water. Most larvae are found among dense vegetation close to the shoreline, but some species live deep down at the bottom, and others burrow into sand and detritus in running water. When collecting plant-dwellers in some places it may be best to leave the bottom material undisturbed, as it may clog the net, making it impossible to find anything in the mess.

Sorting is best performed by emptying the contents of the net into a light-coloured flat bowl containing some water. A pair of soft forceps can be used to catch the larvae. Very young larvae can be caught using a pipette or a small sieve. Live larvae are best transported in small vials with a little water and some plant tissue to offer means of climbing. Large larvae are cannibalistic and best transported singly, or at most together with equally sized specimens, which are less likely to eat each other.

Adults are collected with a handnet. The opening of the net should be fairly large (approx. 0.4–0.5 m), and for the fast-flying Anisoptera a telescopic rod, expandable to a length of several meters might be useful. Live adults are best put into small paper envelopes folded from thin paper. The wings should be folded above their backs, and the envelopes transported in a rigid box to prevent squashing.

Both adults and larvae can be collected using various kinds of traps. For adults, the window trap is the most useful, but it should be used with caution, since the entire local population of patrolling males can sometimes end up being caught. For larvae traps with inverted cones in cylinders can give a sample of the more active species, but neither small larvae nor such species that live submerged in the bottom sediments can be sampled this way.

Rearing

Rearing is a useful method for identifying larvae for which this or any other key proves inadequate. Rearing also serves as a simple method to get acquainted with the shape and appearances of smaller larvae. As the larvae grow, their cast-off skins can be collected and stored for future reference.

Eggs can readily be obtained by catching an egg-laying female and either dip the tip of her abdomen into a vial of water (exophytic species) or place her in a small plastic container lined with wet tissue paper for about one day (endophytic species). Eggs are then deposited into the tissue and can easily be picked out.

Some eggs hatch within a few weeks whereas others enter a state of diapause and require several months to hatch (see below). In most species the pigmentation of the larval eyes are visible through the eggshell during the later stages of embryonic development. The developmental arrest in diapause can occur about half-way to hatching (e.g. *Aeshna*) or in a very late stage (e.g. *Lestes*). The emerging prolarva is seldom seen, and the instar II larva is thus the first stage to be observed.

Larvae are dependent on an adequate food supply. Very small larvae are first fed small drops of protists and monerans obtained from a hey infusion. As the larvae grow they can be given minute crustaceans, e.g. cladocerans and copepods, small mosquito larvae and successively larger prey. If the larvae tend to leave half-eaten prey items in the water, a change of water on a regular basis is necessary.

For species living in running water it may be necessary to increase the oxygen content of the water by means of a simple aquarium air pump, but otherwise dragonfly larvae have very small demands. Small larvae may be kept together in a large container, but as they grow it is better to rear them individually in small pots with only a few centimetres of water and some plant material for climbing or hiding. As the larvae get close to emergence, i.e. when the wing-sheaths become swollen, a sufficiently large stick or twig should be added in order to allow the larvae to leave the water and provide a suitable substratum for its final moulting.

The moulting interval varies depending on species, temperature, nourishment, and diapause phenomena. Normally at summer temperatures, the interval is about 1–3 weeks, in the final instar 2–5 weeks. At least in later instars, larvae do not feed when a moult is approaching. However, if larvae do not eat, or eat very little for longer periods (often best seen by the few faecal pellets they leave), and do not moult, they have probably entered a state of diapause (life-cycles of type 2). In nature this serves to bring the life-cycle, in particular emergence, in harmony with the seasons (see Life cycles and phenology), and is largely governed by day-length.

In the simplest case, it is a pure hibernation diapause, serving to ensure that the cold season is encountered in a suitable state, and it is induced and maintained by short days (often c. 13–14 hours or less, depending on latitude). This situation typically occurs in small and medium-sized larvae from northern species and populations, and is simply terminated by longer days. In populations from the northernmost parts of Scandinavia, continuous light may be required; otherwise c. 20 hr is suitable.

The more complex series of photoperiodic responses, serving to regulate the time of emergence, can be more troublesome in rearing. The first step is a long-day induced delay in development, occurring in late instars. It is often most notable in the penultimate instar, but can also include a few earlier instars in late-flying species (e.g. *Aeshna*), in particular in the south. In the other extreme, it can be entirely confined to the final instar in early breeding species, in particular in northern populations (e.g. *Leucorrhinia*). This long-day diapause is a frequent complication when trying to rear larvae collected during late summer.

This state is terminated by exposure to shorter days, when some moulting may, or may not occur during the transition, before a short-day diapause is induced. After an exposure of c. 3 weeks or more to short days (preferably 12 hr or less), which is often sufficient to simulate a winter even at room temperature, re-exposure to long days normally leads to a terminal burst of growth. This rapidly leads to emergence, provided that the larvae are in a sufficiently late instar at the transition. Otherwise they (re)enter the long-day diapause. The number of late instars sensitive to this short-day–long-day transition correlate with phenology. In early fliers the transition may have to take place in the final instar, in southern populations of late fliers also several preceding instars may be sensitive. Large larvae collected from September onwards are already "short-day treated", and exhibit this "terminal" reaction when placed in long-day conditions. Material collected during the spring gives the best results.

High temperature may counteract the hibernation diapause, and facilitate the terminal burst, allowing larvae of smaller size to react. See Norling (1984c) for more detailed information on this subject.

Preparation and conservation

Adults are killed with ethyl-acetate or simply put into the freezer. Specimens without metallic colours will become dark and dull if they are dried. Colours are adequately preserved if the newly killed specimens, still placed in paper envelopes with their wings folded over their backs, are submerged for about 24 hr in pure acetone. This readily available liquid will extract both water and fat from the bodies and thus prevent the deterioration of pigments caused by fermentation processes. Putting live specimens into acetone would result in strangely bent abdomens if they are not straightened immediately after death. After the acetone-treatment, the animals should be kept in their triangles until they are completely dry. Adults are therefore not mounted on insect pins but rather kept in transparent envelopes of cellophane or plastic with a white paper sheet as background (allowing ample room for various data to be written on them).

Larvae are killed either in the fixative or by immersion into hot water. One should always be aware of osmotic processes that can alter the appearance of the specimens. It is recommended to puncture the thick cuticle with a thin needle several times for larvae of all sizes. For fixation a mixture of 80% alcohol and some formaldehyde will give the best results. Most important, avoid diluting the fixative by putting too many larvae in the same small vial. Larvae can be transferred to 70–80% alcohol after about one day in the fixative. Protect the specimens from light and store them in tight containers. Change the alcohol if evaporation has occurred. Dried out larvae are very difficult to examine, as are soft, swollen and partly decomposed specimens that have been fixed in too weak fixative.

Freeze-drying techniques are also available and should work well on both adults and larvae. Bottom-dwelling larvae should, however, be cleaned before drying to prevent them from being covered by a layer of dried mud. Caudal gills may change their appearance if dried.

On the illustrations

Most drawings are originals for this key, and prepared from Scandinavian material. With the exception of the habitus illustrations by Görel Marklund, the great majority of the drawings of larvae were originally made by Ulf Norling and prepared for publication by Göran Sahlén. The equipment used was a Wild M5 stereo microscope with a line drawing mirror. Transmitted light was occasionally used to see fine hairs, and the specimens were fixed in a cradle that could be tilted in all directions in order to achieve a consistent orientation. The lateral displacement of the image during refocusing was compensated with the help of a mechanical stage. In these illustrations the number of hairs/setae is often reduced so as not to obscure other features. The drawings of adults are mostly adapted from Sahlén (1985, 1996).

On the plates, the figure number is followed by the first two letters of the species name so as to improve the perception ergonomics. To facilitate identification of abdominal structures, segment numbers are shown in italics where this information is relevant.

For each original illustration by Ulf Norling the following information is presented in the figure legends: (1) species name, (2) origin (country: province) according to the list below, (3) head width, and (4) instar if final (F) or penultimate (F-1). Countries are coded as: (D) Denmark, (N) Norway, (S) Sweden, and (F) Finland. Provinces are coded as: D: (EJ) East Jutland, (NEZ) North East Zealand, (B) Bornholm; N: (Ø) Østfold, (MR) Møre og Romsdal, (F) Finnmark;
S: (Sk) Skåne, (Ha) Halland, (Go) Gotland, (Sm) Småland, (Ög) Östergötland, (Vg) Västergötland, (Sö) Södermanland, (Up) Uppland, (Vs) Västmanland, (Dr) Dalarna, (Me) Medelpad, (Ån) Ångermanland, (Vb) Västerbotten, (Nb) Norrbotten; F: (Kb) Karelia borealis, (Ob) Ostrobothnia borealis. Maps showing the location of these provinces are found e.g. in any volume of Fauna Entomologica Scandinavica.

Keys for larvae

Some comments

The present key is a somewhat preliminary attempt to allow identification of smaller larvae of at least most of the species. However, the very first instars are not included. The lower size-limits for the various taxa are given in the key. The increased size range has necessitated some additional complexity in the keys, but we hope that the advantages outweigh the problems.

Part of the keys are unfortunately based on a very limited material, sometimes single specimens, specimens in a bad condition, or material from only one locality. Variation is thus likely to be underestimated. The *Lestes* and *Sympetrum* keys are mainly based on information from the literature.

Thus, this key to larvae is version 1.0, and other bugs than Odonata may appear in it. When using it, it is important to remember the aforesaid limitations and possible pitfalls (see also below). Even when failing, it should at least be a help towards acquiring the experience required for a correct determination of odonate larvae.

Problems in identification

It has already been stated that odonate larvae change their appearance during development (differentiation, allometric growth, changes in some pigment patterns). In addition, the high and variable number of instars make these changes virtually continuous. This makes it difficult to construct and use a key dealing with many instars.

Here, characters are often presented for the final instar, and for one, sometimes two, specified sizes of smaller specimens, defined by the head width.

When working with larger samples, or a series of samples originating from the same locality but collected on different dates, it is always best to start with the sample containing the largest specimens, where the species are easiest to tell apart, and then work downwards in size or backwards in time towards the smaller specimens. The gradual ontogenetic changes often allow identifications that would otherwise be very uncertain.

Size-dependent or not, most characters are not fool-proof but subject to various limitations. Be careful to consider all characters given in the key, and the following comments to some of the characters, before the key is used.

Shape of head changes during ontogeny. The illustrations of smaller larvae may represent most pre-final instars better than those of the final instar. Particularly the appearance of the posterior margin can be strongly affected by the orientation of the head. The orientation of the illustrations is described at appropriate places in the key or figure legends. Deformations during preservation occur. The contour of the eyes in the illustrations are drawn from the larval cuticular sutures. Eye pigmentation is shown in some figures only (see end of "pigment patterns" for comments).
Shape of prementum is a most useful and easily observed character, but some people seem to find it difficult to perceive the more subtle differences. Ontogenetic changes are usually moderate, but some individual variation does occur. A frequent problem is inflation from osmotic processes during preservation. This renders the character useless unless the organ is deflated, which may require heating in KOH. In the illustrations the prementum is normally viewed from below *in situ*, oriented with its articulations to postmentum and palps in the same plane.
Large setae on prementum and palps. The number of these setae is used as an important character in most keys. However, this number is size-dependent and changes during ontogeny, and also shows a great deal of individual variation. When encountered in the key this should be borne in mind, in particular when it comes into conflict with other characters.

The bases of the palpal setae are mostly easy to see anterodorsally without disturbing the natural position of the prementum (cf. Figs 58, 59), whereas the premental setae may require some manipulation to observe.
Dorsal and lateral spines on abdomen are useful characters, but are subject to variation in their size and occurrence, both ontogenetically and between specimens. It is often hard to tell if there is a spine or not. The difference between a bulge and a spine can be very arbitrary. Specimens should be cleaned and examined at fair magnification, both to reveal small hidden spines and to dismiss spine-like dirty tufts of setae. For cleaning, good quality synthetic brushes for water-colours with their rather stiff and finely tipped hairs are often excellent.
Proportions of caudal appendages in Anisoptera are strongly affected by allometric growth. The relative length of cerci increases strongly during ontogeny, and is thus useful only in comparison between similar-sized specimens.
Caudal gills in Zygoptera are easily lost – and regenerated. Regenerated gills are useless as characters when they are small, and they are often still atypical when they almost have attained their correct size. There is also a great deal of normal individual variation, e.g. in shape, pigmentation and tracheal pattern. Inflation from osmotic processes during preservation can be a problem. Gills in final instar exuviae retain their epidermal pigment and tracheae and can be used, but those from earlier instars are but empty sacs.
Pigment patterns are often highly specific but can be difficult to use, especially on exuviae, larvae close to emergence, poorly preserved, bleached or totally black specimens. The patterns are often subject to ontogenetic changes, compounded by complexity and individual variation. As already mentioned, pigment occurs both in the cuticle, in the epidermis and in other tissues such as tracheae. The latter non-cuticular pigment may disperse after poor preservation. The formation of adult tissues during metamorphosis obliterates the non-cuticular pigment characters, and usually obscures the cuticular patterns.

Key to suborders for larvae

1. Larva long and slender with a cylindrical abdomen terminating in three, usually flattened caudal gills (Figs 8, 9, 14) .... **Zygoptera**
- Larva shorter and more robust. Abdomen not cylindrical, terminating in the short, pointed appendages, known as the anal pyramid (Figs 4–7, 10, 11) ..... **Anisoptera**

Key to families for larvae

Zygoptera

1. First antennal segment extremely elongated, making up about half of the antenna (Fig. 19), in the earliest instars less. Prementum with wide and deep median cleft (Fig. 25). Vegetation dwellers in running waters .... **Calopterygidae** *(Calopteryx)*
- First antennal segment normal, no more than a fraction of the total length (Fig. 26). Prementum without (e.g. Fig. 32), or with a very small and closed median cleft (Figs 26, 27) 2
2. Prementum with a short and closed median cleft (Figs 26, 27). Labial palps deeply divided, with the movable hook dorsally provided with setae (Fig. 28). Prementum of the more common species extremely narrow. Vegetation dwellers in still waters .... **Lestidae**

- Prementum without median cleft (Figs 15, 32, 67). Labial palps only with shallow indentations. Movable hook without setae. No species with extremely narrow prementum 3
3. Prothorax with distinct dorsal bulges. Head with a distinctive angular shape (Figs 31, 32). Gills variegated with long, drawn out and hairy tip (Figs 33, 34). Prementum usually with no more than 2+2 large setae, often placed in a single straight transverse row, and palps usually with 3 setae. Small larvae (at least below a head width of c. 2 mm) with rounded dorsal bulges on the anterior abdominal segments very similar to those of *Onychogomphus* (Fig. 102). A running water species .... **Platycnemididae** *(Platycnemis pennipes)*
- No bulges on prothorax (Fig. 35). Head and gills lacking this combination of characters (however, check Figs 35–37). Gills in small specimens may on some occasions be somewhat similar to Fig. 34 (cf. Figs 38, 51). Large and medium-sized larvae (> c. 1.5 mm head width) usually with more than 2+2 premental, and 3 palpal setae, however, 1+1 premental setae is normal in one species. The premental setae are typically placed in two separated oblique rows, at least in late instars (Fig. 15). No dorsal bulges on abdomen. Mostly vegetation dwellers in still water or slow streams .... **Coenagrionidae**

Anisoptera

1. Prementum flat, only covering the underside of the head at rest (Figs 106, 112). Labial palps narrow 2
- Prementum spoon-shaped with triangular palps, reaching almost up to the base of the antennae at rest (Figs 13, 197) 3
2. Antenna with no more than 4 "segments"; "segment" 3 extremely elongated (Fig. 108). Digging bottom-dwellers in streams or lake shores .... **Gomphidae**
- Antenna with more than 4 "segments" except in very small larvae; segments of normal appearance (Fig. 111). Generally vegetation dwellers in still water or slow streams .... **Aeshnidae**
3. Distal margin of labial palps irregularly and deeply indented (Fig. 197). Apex of prementum bifid. The larva dwells in the bottom material of running waters, often in small woodland streams .... **Cordulegastridae** *(Cordulegaster boltoni)*
- Distal margin of labial palps regularly serrated (Figs 198–200). Apex of prementum not bifid 4
4. The compound length of the first 2 antennal segments is shorter than the distance between the median line and the antennal base (e.g. Fig. 248). In small larvae (c. 2 mm head width) of some species these measurements can be about equal, or even slightly reversed (e.g. Fig. 280). Serrations at distal margins of palps usually shallow and relatively symmetrical (Fig. 200). If one of these characters is ambiguous (e.g. Fig. 199), the other is not (Figs 260, 264). Cerci in the final instar often less than half, at most 60% of the length of the paraprocts (Figs 262, 263 and 254, 255 resp.; note that even penultimate instar Corduliidae are in this range; Figs 244, 245). Bottom- or vegetation-dwellers, mostly in still water .... **Libellulidae**
- The compound length of the 2 first antennal segments is greater than the distance between the median line and the antennal base (Fig. 209, at least as in Fig. 242). In small larvae the difference between these measurements is particularly great (e.g. Fig. 213). Serrations at distal margins of palps deep and asymmetrical (Fig. 198; if the serrations of the two palps are interlocking, as in life, the asymmetry is hidden when they are seen from the front). Cerci in the final instar more than 60% of the length of the paraprocts, at least as in Figs 203, 204. Bottom-dwellers in still waters or streams .... **Corduliidae**

Keys to species for larvae

Calopterygidae

1. The processes behind the eyes (occipital processes), are large and rather pointed (best seen in dorsolateral view; Figs 19–21). First antennal segment in the final instar is slightly more than half (c. 53%) the total length of the antenna (Fig 19). In smaller larvae the first antennal segment is shorter. It is half the total length at a head width of c. 2 mm, and less in still smaller specimens (Figs 20, 21). Caudal gills often with a single light band. In vegetation, typically in faster running, woodland streams .... *Calopteryx virgo*

Note. Some specimens may have shorter distal parts of one or both antennae, with fewer joints than usual. These may have been damaged earlier in life. Be careful to use the longest antenna, or look at the ratio between the first and second segments in figs 19–24.

- The occipital processes are less developed and blunter (Figs 22–24). First antennal segment in the final instar is closer to 2/3 than than half (c. 62%) of the total length of the antenna (Fig. 22). In larvae of 1.3 mm head width it is still slightly more than half the antennal length (Fig. 24). Caudal gills often with two light bands. Typically in slow streams in open country .... *C. splendens*

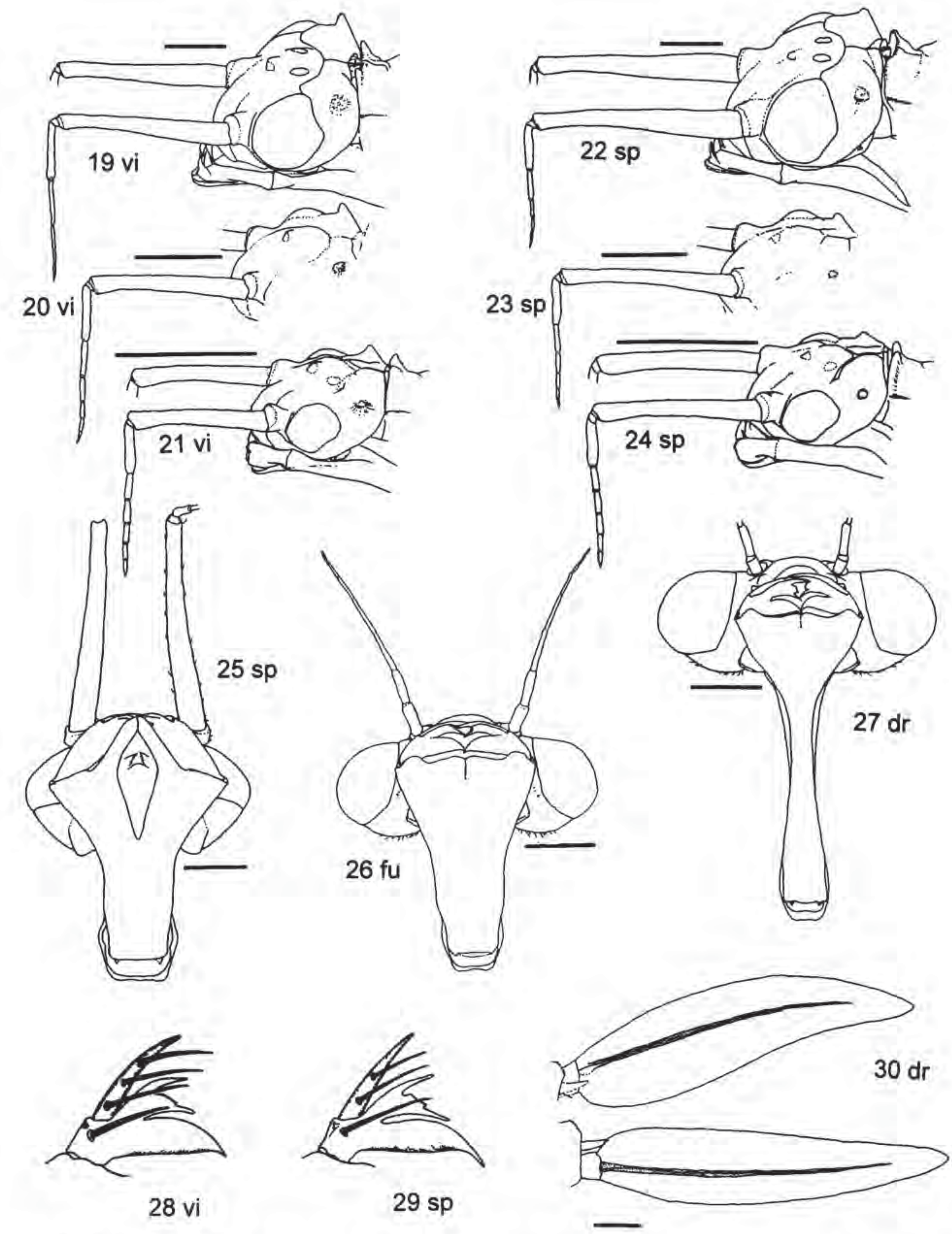
Lestidae

[This key is partly based on information in literature (Sahlén 1996) and applies primarily to the final instar.]

1. Proximal part of prementum of normal appearance, not shaped like a handle (Fig. 26). Southern species .... *Sympecma fusca*
- Proximal part of prementum extremely long and narrow, shaped like a handle (Fig. 27) *(Lestes)* 2
2. Caudal gills almost parallel-sided (Fig. 14) 3
- Caudal gills distinctly tapering towards the apex (Fig. 30). Often in semi-permanent waters, sometimes common .... *L. dryas*

Note. The migrant *L. barbarus* which has not been found as a larva in the area has similar caudal gills and will key out here. See Heidemann & Seidenbusch (1993) for more information.

3. Movable hook with three long setae (Fig. 28). A rare, southern species .... *L. virens*



Figs 19-30. Calopterygidae and Lestidae, larva. -19-24. Head in dorsolateral view. -19-21. *Calopteryx virgo*. -19. S:Me, 3.6 mm, F. -20. S:Me, 2.0 mm. -21. D:EJ, 1.3 mm. -22-24. *C. splendens*. -22. D:EJ, 3.8 mm, F. -23. D:EJ, 2.1 mm. -24. D:EJ, 1.3 mm. -25-27. Labium *in situ*, ventral view. -25. *C. splendens*, D:EJ, 3.8 mm, F. -26. *Sympecma fusca*, S:Ög, 3.7 mm, F. -27. *Lestes dryas*, S:Up, 3.9 mm, F. -28-29. Labial palp, dorsal view, -28. *L. virens*. -29. *L. sponsa*. -30. *Lestes dryas*, S:Up, 3.9 mm, F. caudal gills, lateral view. Del. U. Norling. Figs 28-29 redrawn from Sahlén (1985).

Note. In North Europe as ssp. *vestalis*; larva not seen by the authors.

- Movable hook with no more than two setae (Fig. 29). Very common in most still waters .... *L. sponsa*

Platycnemididae

Only one species in North Europe; see key to families.

Coenagrionidae

[If not specified, *"smaller larvae"* refers to specimens with a head width of about 1.3 mm. In the figure plates the orientation of heads in dorsal view is not consistent; see figure legends.]

1. Larva of compact, stocky build with angular occipital lobes (Figs 8, 35, 36). Caudal gills wide and pointed, lacking node and provided with characteristic markings (Figs 37, 38). Sometimes very dark. In both streams and ponds .... *Pyrrhosoma nymphula*

- Slender larva with rounded occipital lobes (e.g. Figs 9, 87; cf. also 57, 58, 62; the exact appearance is dependent on orientation). Gills with different combination of characters 2

2. Caudal gills nodate, with three distal dark areas (Fig. 39), except in very small and sometimes medium-sized larvae (Fig. 40). Underside of abdomen with a series of median dark spots, best seen in small larvae (Fig. 43; they tend to disperse in poorly preserved specimens, and become obscured when emergence is approaching). Posterior end of sternites on anterior abdomen and metathorax with distinct wide and stout setae (Figs 41, 42; in larvae of < 1.3 mm head width they are extremely few and can probably be absent). Common and rather widespread in lakes and open ponds with floating vegetation .... *Erythromma najas*

- Gills with no more than two distal dark areas. No ventral median spots. Setae on posterior end of sternites absent or insignificant, except sometimes in posterior abdomen 3

3. No more than three dark rings on femora. Small, short setae near the posteromedial lower margin of the eyes (e.g. Fig. 67). These setae are, however, very small or absent in small larvae of most species (e.g. Fig. 92). Normally more than 2+2 large premental setae (head width > 1.3 mm). Gills not matching the description below 4

- Four, often incomplete dark rings on femora, and a characteristic pattern on thorax (Figs 44, 45; probably reduced in pale specimens). No short setae below the eyes, but thin hairs (Figs 46–48; hairs not shown). Prementum short and wide, rarely with more than 1+1 large setae. Gills rarely of more than 3 mm length, with characteristic dark spots and ending in a short, drawn out tip, longer in younger larvae (Figs 49–52). Node indistinct and oblique. Small (no more than 13 mm long), extremely rare species ..... *Nehalennia speciosa*

4. A dark spot present in the soft cuticle between the base of each wing-pad and the pleurites (Fig. 53). Gills pointed and lanceolate, final instar larvae with a very oblique and indistinct node, often discernible only at the margins, where the setae change in appearance and density (arrows in Fig. 54), in dark specimens sometimes accompanied by dark markings (Fig. 55). Node in medium-sized larvae less oblique and even more indistinct. Small larvae with long gills without visible node (Fig. 56). Back of head (dorsal area only) without prominent dark spots (cf. Fig. 87, where they are present). Medial dark extensions of eye pigmentation usually present, at least ventrally (Fig. 57), except in the smallest larvae. Body pigmentation usually with good contrast and a well visible dark distal ring on the femora. Prementum short and wide. Distinct angle between eye and occipital lobe at back of eyes (Fig. 58). Labial palps distally without small spine (Fig. 59 as compared to 63). Common in the south, in still waters and in brackish water in the Baltic Sea area .... *Ischnura elegans*

Notes. The *dark spots* mainly consist of pigment situated around tracheae below the soft cuticle between the wing-pads and the pleurites. When this cuticle is folded under the pleurites, the spots are seen through the latter, but often less distinctly. These spots may also be hard to see, or even absent, in a) small larvae (< c. 1.4 mm head width) and b) very pale or very dark larvae and c) poorly preserved larvae, where the pigmented tissue disperses. In larvae approaching emergence, the underlying adult tissues may sport somewhat similar spots also in other species. *Erythromma najas* may have a dark bulge on the basal part of the wing-pad itself in late instars.

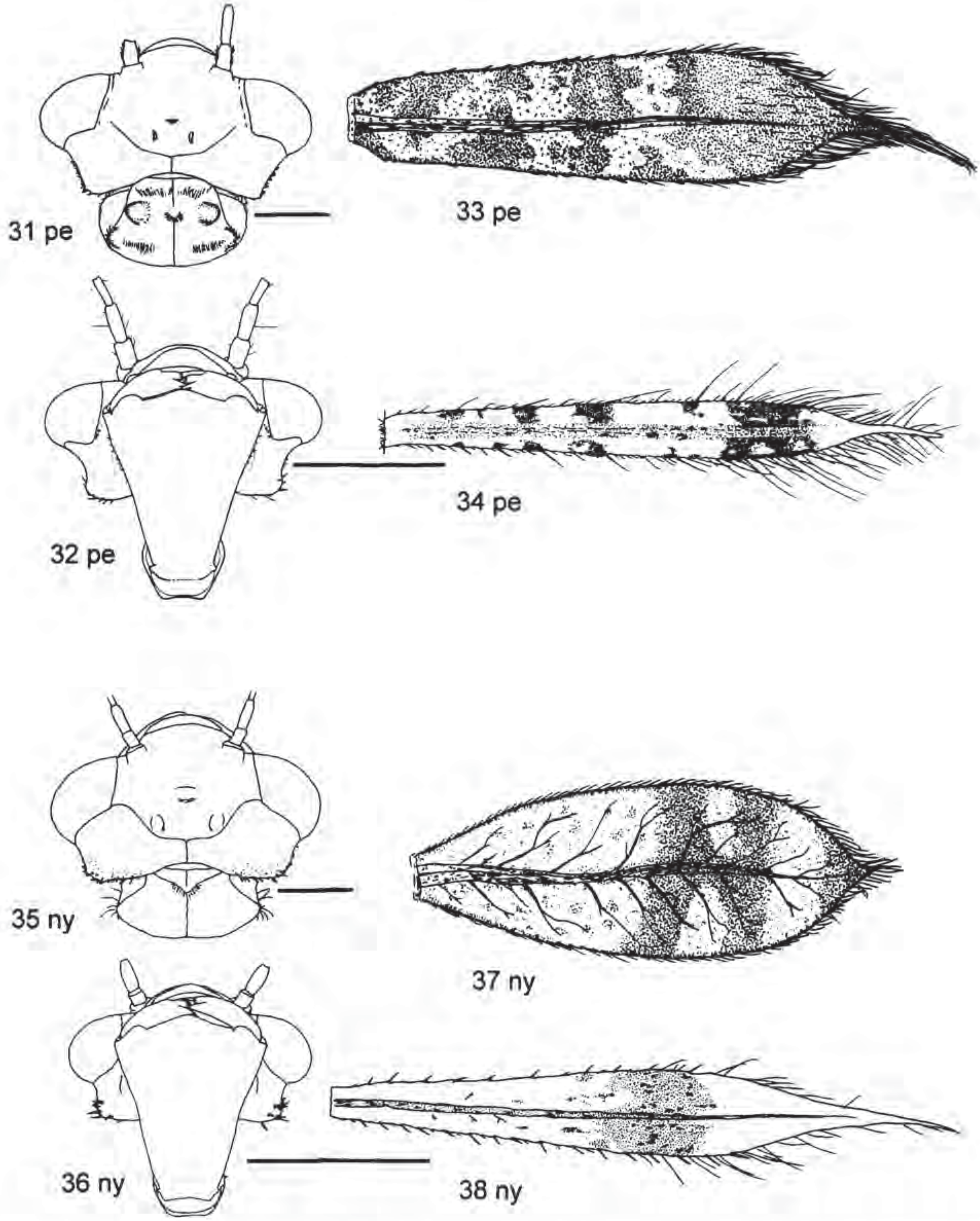
The *extended eye pigmentation* is present in many species, e.g. *E. najas* and *C. pulchellum* (Figs 66, 67). In larvae approaching emergence the extensions disappear as the dark adult eye-tissue expands towards the medial eye rim. Be careful here!.

We have not seen any larvae of *Ischnura pumilio*, a rare species, belonging to disturbed waters with scarce vegetation, coastal in the south and east. According to Heidemann & Seidenbusch (1993) it is less pigmented and has weaker contrasts, e.g. the dark ring on the femora is absent or hardly visible. No known records of presence or absence of spots at the wing-pads or dark eye extensions. The gill node is more proximal than in *elegans*, often reaching no further than 1/3 of the length of the gill. The tip is more extended, and the tracheation is less dense and less branched.

- No such dark spots at the wing-pads (see notes above and below). Gills in the latest instars usually not lanceolate and pointed, and they have a mostly distinct node that is perpendicular or moderately oblique (e.g. Figs 68, 75). However, the gills may also be lanceolate with a slightly indistinct node (Figs 60, 61), which mostly applies also to small larvae (e.g. Fig. 72). The gill node is generally absent in very small larvae (< 1.3 mm head width; cf. Fig. 79) 5

Note. Very weak spots at the wing-pads have been observed in a large *E. cyathigerum*. *I. pumilio* mentioned in the note above may also key out here.

5. Back of head (dorsal area only) without dark spots even in larger larvae. Gills lanceolate and pointed, often with 1–3 dark bands at or parallel to the indistinct node (Figs 60, 61; node shown with arrows). The bands disappear or taper before reaching the gill margins. When visible, the node in prefinal instars is more distal and less oblique. Small larvae have long gills without node (Fig. 64). Labial palps with a small spine at the most distal seta (Fig. 63). Pigmentation often pale. No medial eye extensions. Small larvae are very similar to *Ischnura elegans*, but they are paler, have a more elongated prementum, and a slightly different head shape (Figs 62, 65; the difference in prementum is often greater than shown here). Often in still waters with a fairly large open surface .... *Enallagma cyathigerum*



Figs 31-38. Platycnemididae and Coenagrionidae, larva. -31-34. *Platycnemis pennipes*. -31. Head, dorsal view, somewhat tilted forwards (antennal base and posterior rim straight behind it in level) (S:Vs, 3.6 mm, F). -32. Labium *in situ*, ventral view (S:Sk, 1.9 mm). -33-34. Left caudal gill. -33. F. -34. S:Sk, 1.9 mm. -35-38. *Pyrrhosoma nymphula*. -35. Head, dorsal view, projection as in Fig. 31 (S:Sk, 3.6 mm, F). -36. Labium *in situ*, ventral view (S:Sk, 1.3 mm). -37-38. Left caudal gill. -37. F. -38. S:Sk, 1.3 mm. Del. U. Norling. Figs 33 & 37 redrawn from Sahlén (1985).

Note. The spines on the labial palps seem to be a reliable character of this species, even in quite small larvae. However, such small and transparent features are notoriously difficult to see with an ordinary stereo microscope. Therefore, observing them in small larvae requires great care and high-quality equipment, not least concerning illumination. Attempts to observe the spines in silhouette sometimes give a false impression that they are present also in other species.

- Back of head (dorsal area) in larger larvae with black spots (at bases of very short setae; Fig. 87). These are, however, indistinct or absent in small larvae. Labial palps without small spine at the most distal seta (as in Fig. 59). Gill node usually distinct, except in small larvae (< c. 1.3 mm head width). The gills are often shorter relative to the body than in *Enallagma* or *Ischnura*. Gills neither evenly lanceolate nor acutely pointed in large larvae, but often so in smaller specimens *(Coenagrion)* 6

6. Dark medial extensions of eye pigment (see note at couplet 4) usually present (Figs 66, 67, 71; often absent in smaller specimens). Gill node in larger larvae clearly oblique and curved (Fig. 68), but it is less distinct than in other *Coenagrion*, and can in rare cases be hard to see. There is frequently a wide, diffuse transverse band near or at the node, often divided in two areas by a constriction in the middle, and a large diffuse darker area near the apex. The shape and proportions of the gill can vary somewhat. Smaller larvae have relatively wide, pointed gills (Figs 70, 72), with one or two dark areas: always one distally and often one proximal to the node. The latter area may be expanded over most of the proximal part of the gill. The node in small larvae may be straight and perpendicular. Head in pre-final instars distinctly concave behind the eyes (see arrows in Fig. 69). Femora with two distinct bands. Width of prementum intermediate (Figs 67, 69, 71). Common in lakes, ponds and marshes ..... *C. pulchellum* & *puella*

Note. These species cannot be reliably separated. The description refers primarily to *pulchellum*; *puella* often has more pointed gills and weaker pigmentation, and is usually green in life.

- No dark medial eye extensions (dark extensions may, however, be present ventrally, Fig. 76). Gill node distinct, perpendicular, straight or moderately curved. In small larvae the developing node may, however, be oblique, seemingly by chance (e.g. Figs 77, 86) 7

7. Prementum of short, wide and straight-sided appearance, length c. 65% of head width in larger larvae and 70 % in smaller ones (e.g. Figs 74, 78, 81, 85). Gills widest distally in larger larvae (e.g. Figs 75, 82) 8

- Prementum more elongate, often with incurved sides, length c. 70% of head width in larger larvae and 75% in smaller ones (e.g. Figs 88, 92, 94). Gills often more parallel-sided in larger larvae (Figs 89, 95) 9

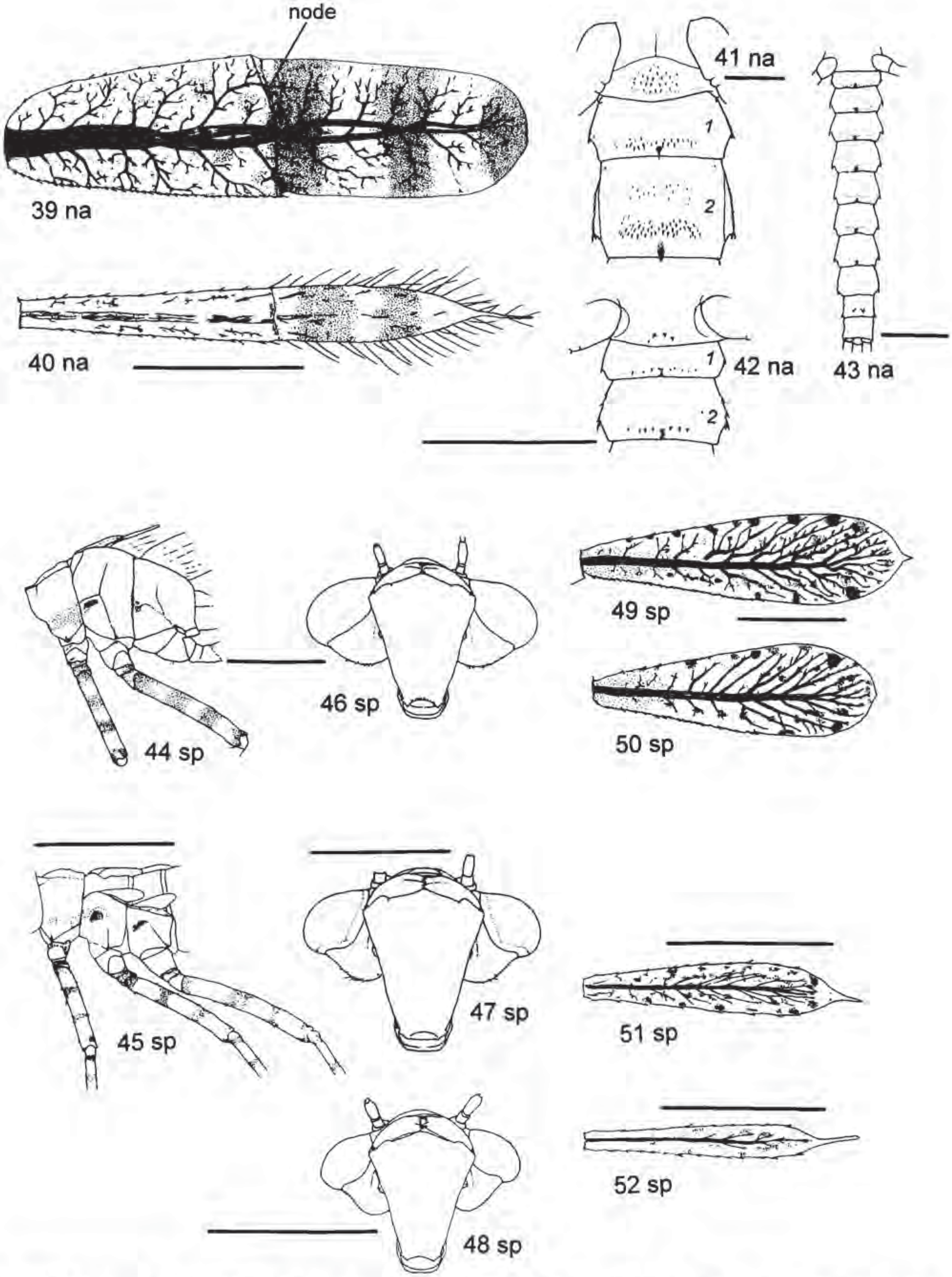
8. Gills uniformly light and transparent, with coarse tracheation (Figs 75, 77, 79, 80). Node relatively distal in late instars (Figs 75, 77). Larger larvae with continuous longitudinal dark bands behind the likewise dark antennal bases, provided their general pigmentation is not too weak (Fig. 73, cf. *hastulatum*, Fig. 87). Head concave behind the eyes in small and medium-sized larvae (Figs 76, 78, see arrow; cf. Fig. 74). Medial eye extensions often present ventrally (Fig. 76). Small northern species, common in acid bogs and small lakes .... *C. johanssoni*

- Gills in late instars usually with darker (cuticular) pigmentation proximally of the node and along the margins of the distal part (Fig. 82). Tracheal branches dense and more often longitudinally slanted than in the other species. Node often slightly curved. Small larvae have relatively wide gills with distally placed nodes (compared to the following two species) and an indistict dark area of epidermal pigment over the nodes (Fig. 86). In medium-sized larvae this area becomes more distal, and may conceal that the cuticle of the distal area is lighter than in the proximal area (Fig. 84; see note). Head typically more rounded, less concave and spiny behind the eyes in small and medium-sized larvae (Fig. 85; Fig. 83 is not comparable with Fig. 76, which shows an older larva, but rather with Fig. 78). Also the final instar has an unusually rounded head (Fig. 81). No continuous bands are ever present behind the antennae. The larvae are often darkly pigmented compared to other species at the same locality. Often in waters with abundant emergent vegetation. Widespread in the area .... *C. armatum*

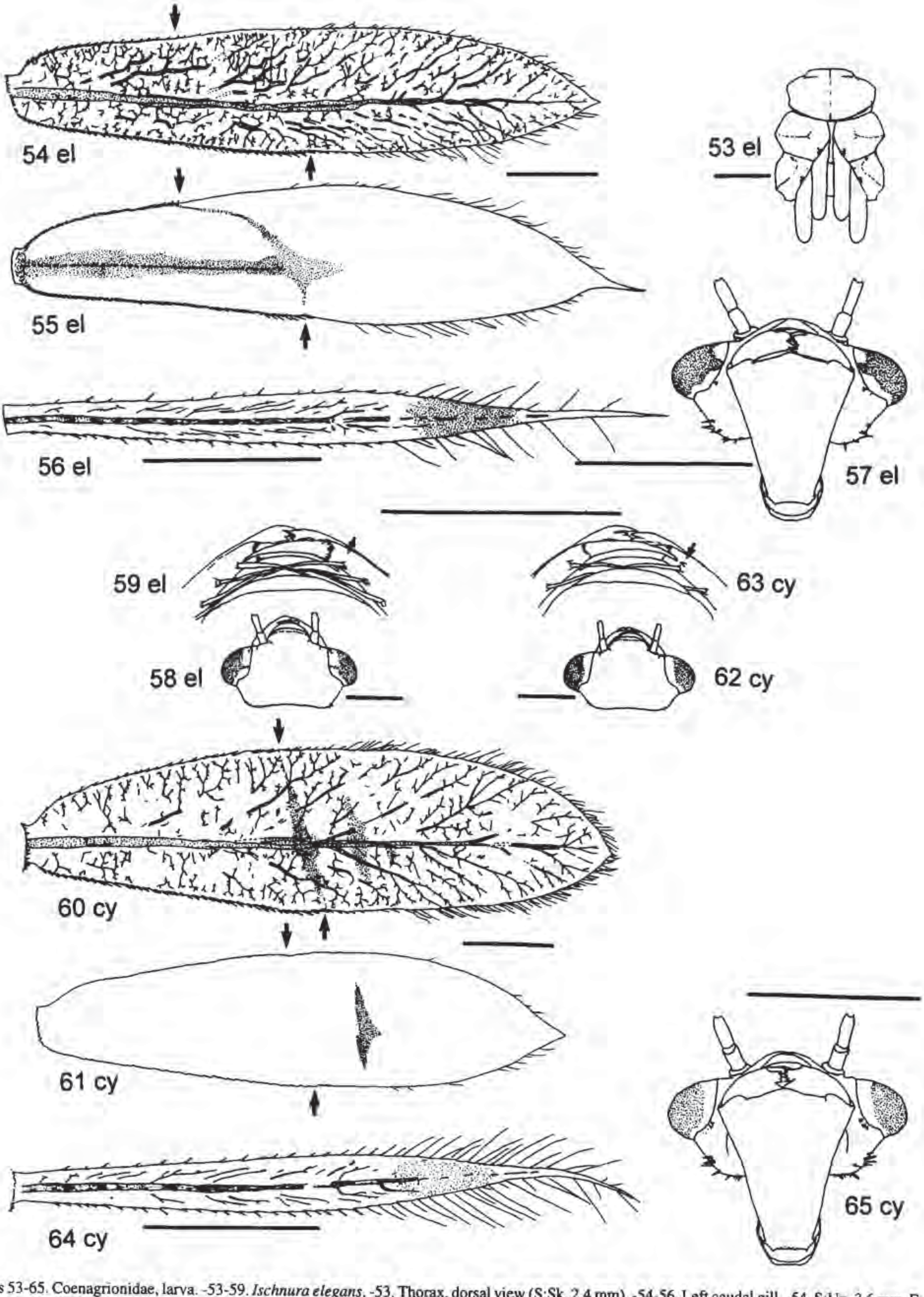
Note. Cuticular pigment, as in the proximal area of the caudal gills, is brownish and even, whereas epidermal pigment, as in the distal area, is often sligthly "mottled" and often acquires a weak violet tinge in preserved material.

9. Late instars with extremely distinct node, forming a dark sclerotized articulation at the margins (Fig. 89). Sometimes 1 or 2, rarely 3 narrow darker bands are present distally of and parallel to the node (such bands have once been observed also in *armatum*). Pigmentation of tracheae usually uneven, giving the gills a "mottled" appearance. Smaller larvae have very narrow gills with relatively proximal nodes (Figs 91, 93). An indistinct dark area is normally (head width >1.3 mm) entirely confined to the post-nodal area. Head "slender" and distinctly concave behind the eyes, and in small and medium-sized specimens conspicuously spiny on the occipital lobes (Figs 90, 92). Sides of prementum always incurved. Dark bands of femora nearly always distinct. Common and very widespread species, found in many habitats and often dominant in acid bogs ....
.... *C. hastulatum*

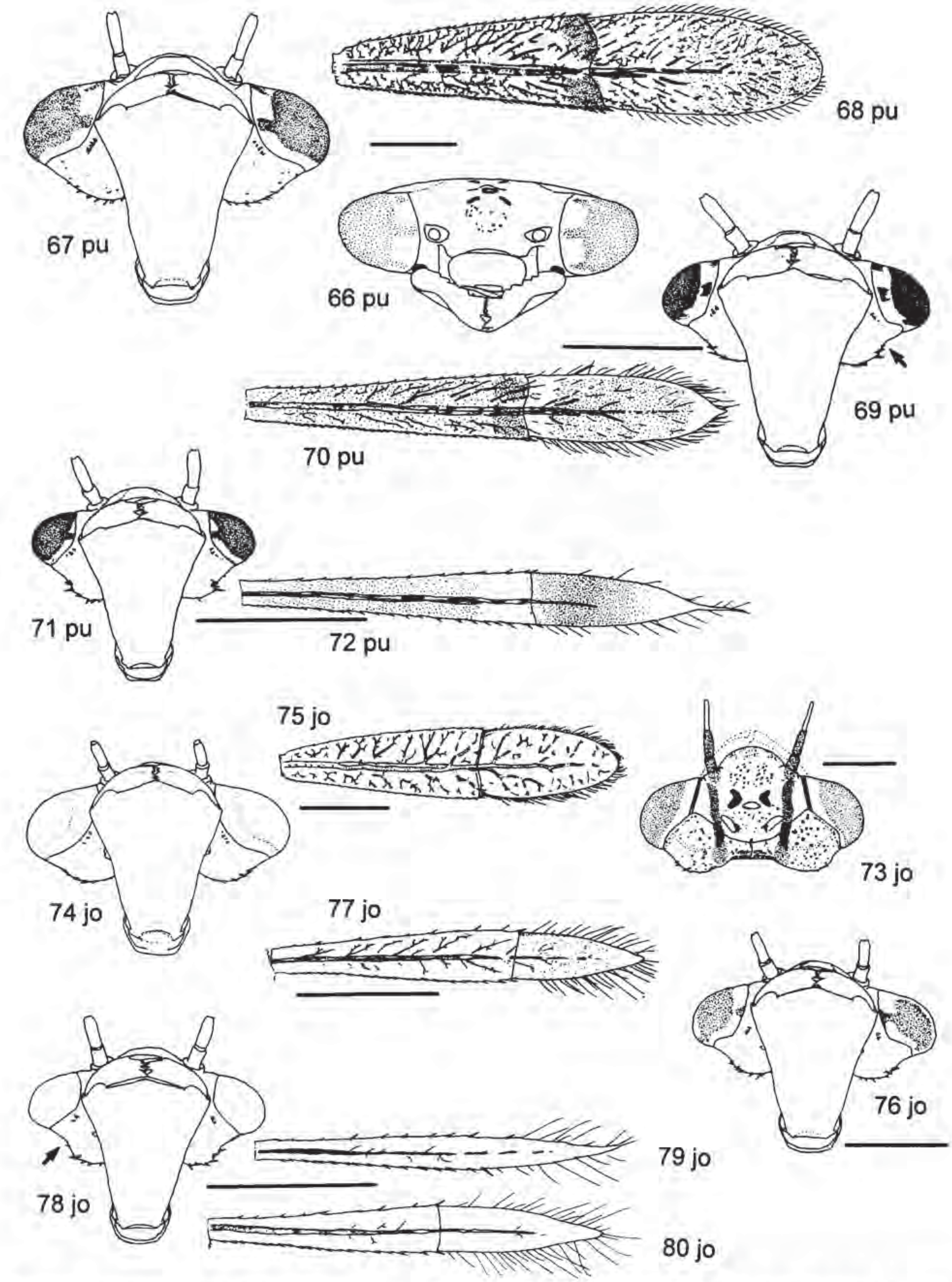
- Late instars have lightly pigmented, transparent gills with (relatively) less distinct nodes and no accompanying dark bands (Fig. 95; gill apex often less rounded than shown here). Pigmentation of tracheae more even. Small larvae with somewhat wider gills, the dark area reaching forward of the node (Fig. 99). This area is dissipating and moving behind the node during ontogeny (Fig. 97). Head typicaly more rounded and less concave behind the eyes (Figs 94, 96, 98), in smaller larvae also less spiny (Fig. 98). Large specimens seem to have somewhat less incurved premental margins, giving a triangular and "intermediately wide" impression. Larvae usually lighter and more transparent than other species at the same locality. The dark ring near the apex of the



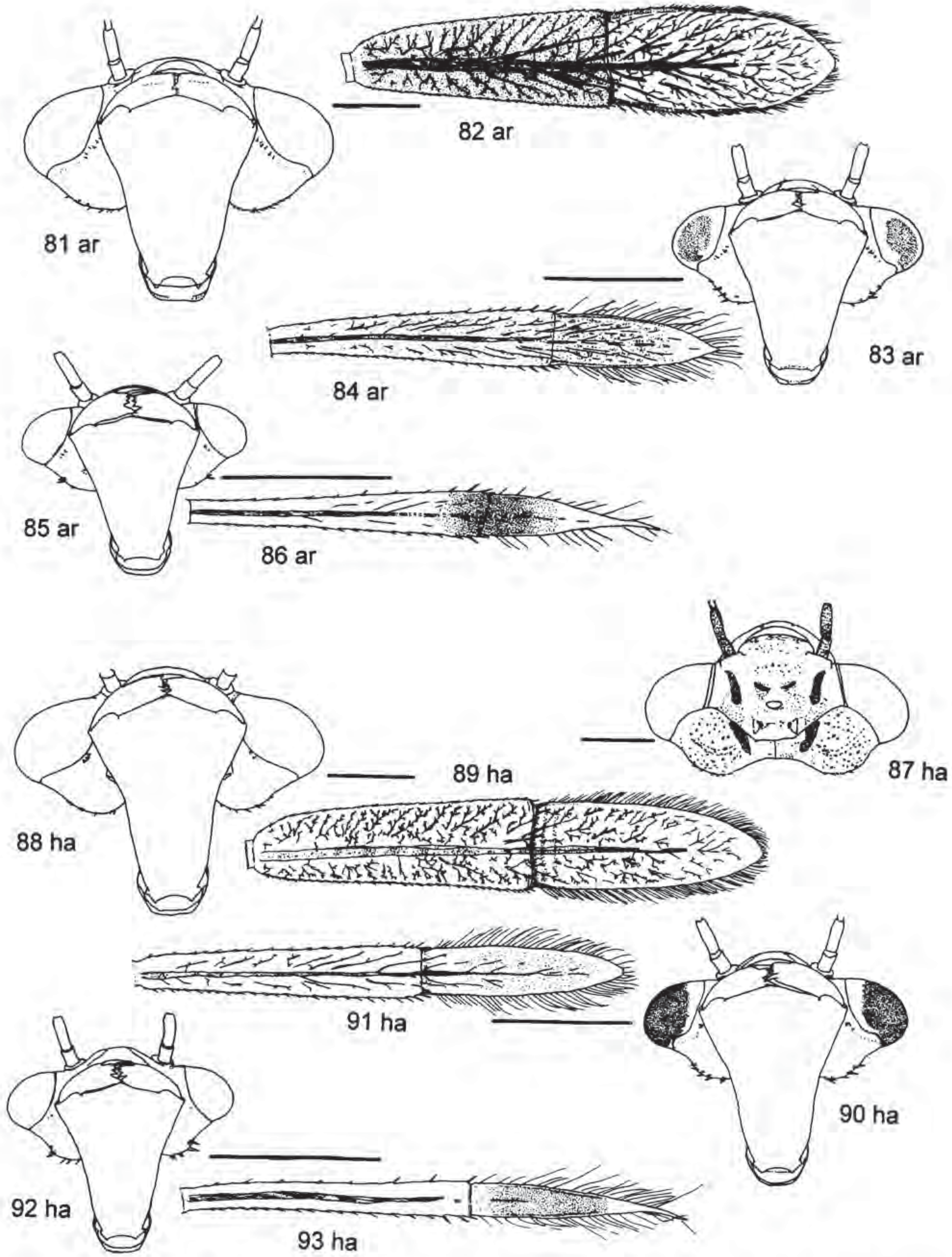
Figs 39-52. Coenagrionidae, larva. -39-43. *Erythromma najas*. -39-40. Left caudal gill. -39. F. -40. S:Sk, 1.3 mm. -41-42. Last thoracic and first 2 abdominal segments, ventral view. -41. S:Sk, 3.7 mm, F-1. -42. S:Sk, 1.4 mm. -43. Abdomen, ventral view (S:Sk, 1.4 mm). -44-52. *Nehalennia speciosa*, D:NEZ. -44-45. Thorax, dorsolateral view. -44. 2.6 mm, F. -45. 1.3 mm. -46-48. Labium *in situ*, ventral view. -46. 2.7 mm, F. -47. 1.7 mm. -48. 1.2 mm. -49-50, 52. Left caudal gill. -49. 2.5 mm, F. -50. 2.5 mm, F. -51. Median caudal gill (loose), 1.6 or 1.3 mm. -52. 1.2 mm. Del U. Norling. Fig. 39 redrawn from Sahlén (1985).



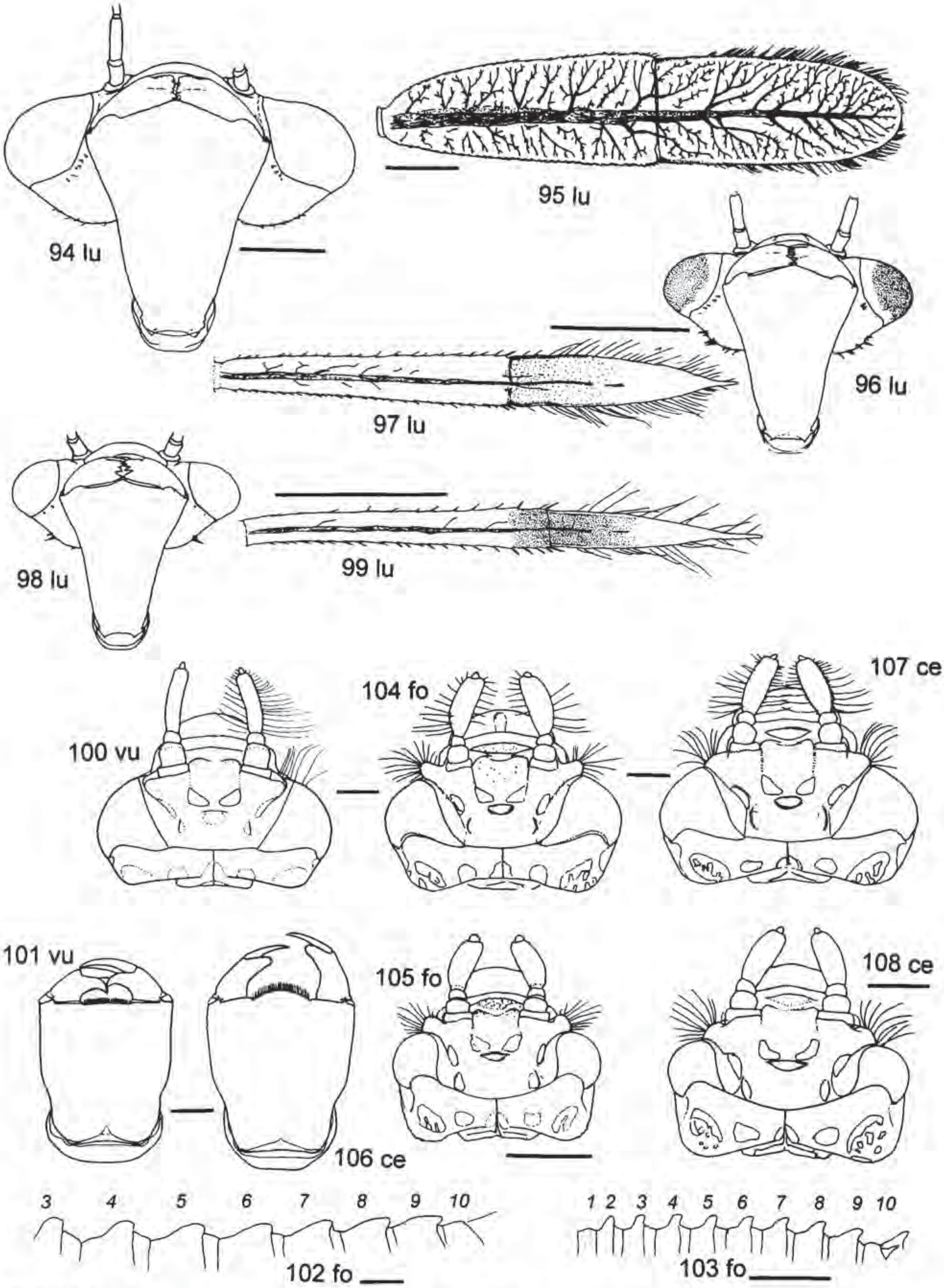
Figs 53-65. Coenagrionidae, larva. -53-59. *Ischnura elegans*. -53. Thorax, dorsal view (S:Sk, 2.4 mm). -54-56. Left caudal gill. -54. S:Up, 3.6 mm, F. -55. S:Up, 3.6 mm, F; tracheae not shown. -56. S:Sk, 1.3 mm. -57. Labium *in situ*, ventral view (S:Sk, 1.3 mm). -58. Head, dorsal view (antennal base and median posterior rim in level) (S:Sk, 2.3 mm). -59. Detail of fig. 58, same projection. -60-65. *Enallagma cyathigerum*. -60-61. Left caudal gill. -60. S:Up, 3.8 mm, F. -61. S:Up, 3.6 mm, F; tracheae not shown. -62. Head, dorsal view, projection as in fig. 58 (S:Ög, 2.3 mm). -63. Detail of fig. 62, same projection:. -64. Left caudal gill (S:Sk, 1.4 mm). -65. Labium *in situ*, ventral view (S:Sk, 1.4 mm). Del. U. Norling.



Figs 66-80. Coenagrionidae, larva. -66. Head, frontal view. -67, 69, 71, 74, 76, 78. Labium *in situ*, ventral view. -68, 70, 72, 75, 77, 79, 80. Left caudal gill. -66-72. *Coenagrion pulchellum/puella*, probably *pulchellum*. -66-68. S:Sk, 3.5 mm, F. -69-70. S:Sk, 1.9 mm. -71-72. S:Sk, 1.3 mm. -73-80. *C. johanssoni*. -73. Head, dorsal view, projection as in Fig. 31 (S:Vb, 3.1 mm, F). -74-75. S:Vb, 3.1 mm, F. -76. S:Vb, 2.4 mm, F-1, possibly F-2. -77. S:Vb, 1.8 mm. -78. S:Vb, 1.3 mm. -79. S:Vb, 1.3 mm; possibly regenerated. -80. S:Vb, 1.4 mm. Del. U. Norling.



Figs 81-93. Coenagrionidae, larva. -81, 83, 85, 88, 90, 92. Labium *in situ*, ventral view. -82, 84, 86, 89, 91, 93. Left caudal gill. -81-86. *Coenagrion armatum*. -81-82. S:Vb, 3.6 mm, F. -83-84. S:Vb, 1.8 mm. -85-86. S:Vb, 1.3 mm. -87-93. *C. hastulatum*. -87. Head with unusually distinct markings, dorsal view, somewhat tilted forwards (projection as in Fig. 31) (S:Vb, 3.6 mm, F). -88-89. S:Vb, 3.6 mm, F, different specimens. -90-91. S:Sk, 1.9 mm. -92-93. S:Up, 1.3 mm. Del. U. Norling.



Figs 94-108. Coenagrionidae (94-99) and Gomphidae (100-108), larva. -94-99. *Coenagrion lunulatum*. -94, 96, 98. Labium *in situ*, ventral view. -95, 97, 99. Left caudal gill. -94. S:Vb, 4.0 mm, F. -95. S:Vb, 4.1 mm, F. - 96-97. S:Up, 1.8 mm. -98-99. S:Up, 1.3 mm. -100, 104-105, 107-108. Head, dorsal view. -101, 106. Labium, ventral view. -100-101. *Gomphus vulgatissimus*, S:Sk, 5.6 mm, F. -102-105. *Onychogomphus forcipatus*. -102-103. Dorsal abdomen, lateral view. -102. S:Me, 5.5 mm, F. -103. S: Me, 1.4 mm. -104. S: Me, 5.5 mm, F. -105. S: Me, 2.4 mm. -106-108. *Ophiogomphus cecilia*. -106-107. F:Ob, 6.1 mm, F. -108. S:Nb, 3.9 mm; somewhat tilted forwards. Del. U. Norling.

femur is often very indistinct. Darker specimens are sometimes unpleasantly similar to *hastulatum*. Widespread and generally rare, but may be locally common. Seems to occur in a wide range of still waters ... . *C. lunulatum*

Gomphidae

[In the illustrations the orientation of heads in dorsal view is not consistent, but this is not relevant for the key.]

1. Larva very flattened dorsally, without dorsal spines. Inner lobe of labial palp pointed and hook-shaped (Fig. 101). Third elongated antennal "segment" not club-shaped (Fig. 100). In slow running streams or the wave zone in lakes .... *Gomphus vulgatissimus*
- Larva less flat. Blunt dorsal spines or bulges always present, often better developed in younger larvae than in older ones (Figs 102, 103). Inner lobe of labial palp blunt and approximately straight (Fig. 106). Third "segment" of antenna distinctly club-shaped (Figs 104, 107) 2
2. Front of head between eye and antenna protruding, covered with numerous long hairs (Figs 104, 105). Often in stony, woodland streams .... *Onychogomphus forcipatus*
- Front of head between eye and antenna not protruding (Figs 107, 108). Dorsal spines somewhat better developed than in the preceding species. Rare eastern species .... *Ophiogomphus cecilia*

Aeshnidae

This key should work reasonably well for specimens down to a head width of c. 3 mm, sometimes less. "*Smaller larvae*" in the key primarily refers to a head width about 3.5 mm; the material used for illustrations lies between 3.2 and 3.8 mm.

When using the key it is particularly important not to base a determination on a single key character, especially not when the differences between alternatives are subtle. Some key characters are not as clear-cut as one would wish, and it is therefore often necessary to explore different alternatives. In order to facilitate comparisons between different parts of this rather cumbersome key, morphological keywords are highlighted in italics.

Please also consider the following comments on limitations in the characters used:

Shape of head. This is an important character. The illustrations of "small larvae" are probably reasonably representative for most pre-final instars, except the earliest ones (cf. Figs 4–7). The final instar is often somewhat different. The illustrations in dorsal view show the head with the *antennal bases* at the same level as the median *posterior margin* of the head. In this position the head is slightly raised compared to the probable resting position. Be careful not to make comparisons with the head viewed more from behind, since such a change of angle greatly changes the appearance of the posterior margin. The illustrations in ventral view are oriented after the prementum, and the orientation of the head can thus vary somewhat.

Shape of prementum. This is a most useful character for later instars, but it is subject to deformations and some variation. Differences between species are often very subtle.

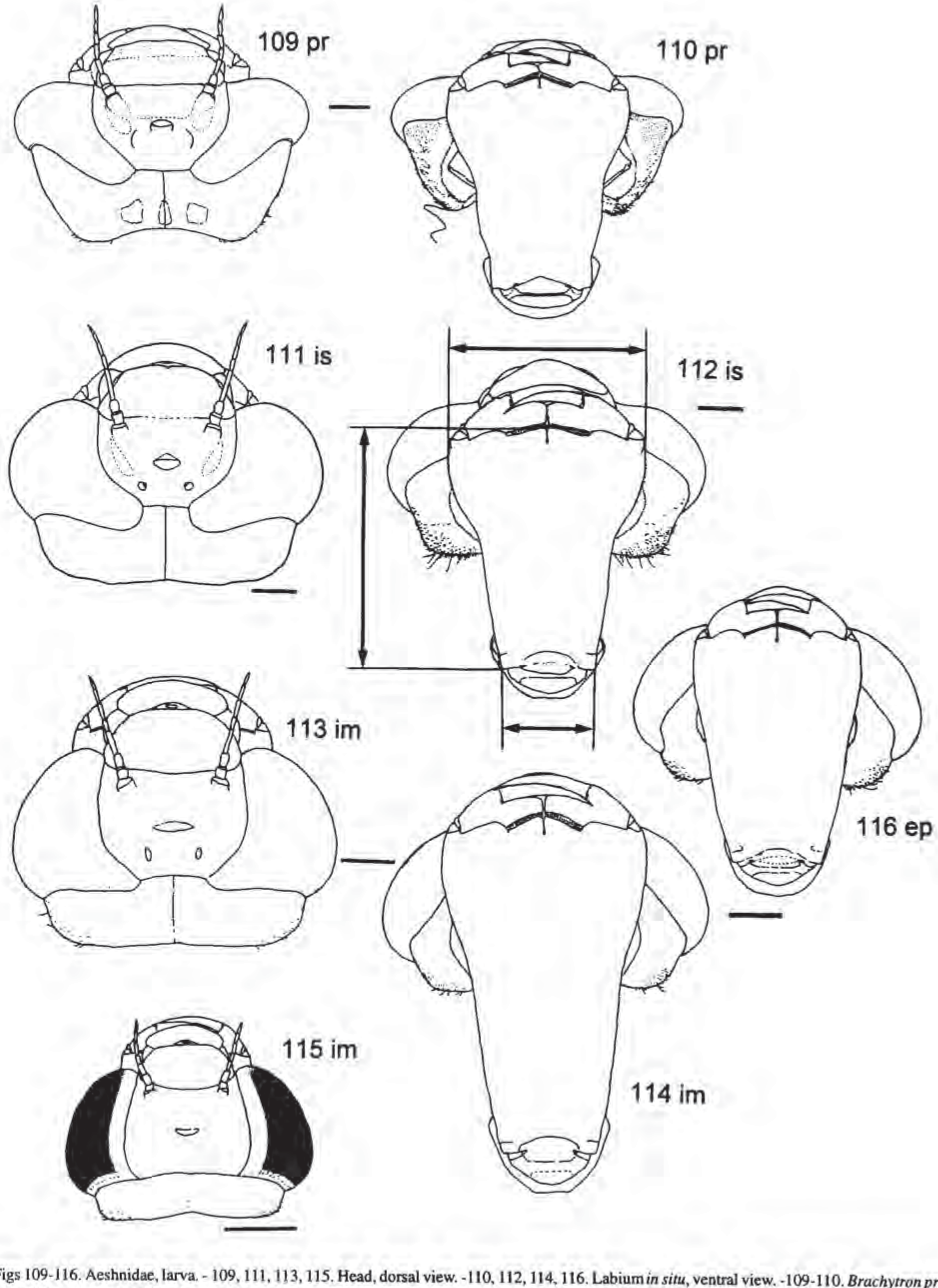
Pigment of ocelli. The ocelli are usually seen as three clear windows in the cuticular pigment of the head. The ocellar pigment is visible at the borders of these windows (e.g. Fig. 180). The pigment belongs to the sense-organs themselves, and may disperse in poorly preserved specimens. There is a great deal of variation, and smaller larvae are often more poorly pigmented.

Lateral abdominal spines. The spine on segment 6 is an important key character that can be used in the present size-range; however, variation may produce some overlap in extreme specimens. The spine on segment 9, e.g. compared to the length of segment 10, is really useful only in late instars, and the perception of its length is dependent on the distension of the abdomen.

The anal pyramid is routinely illustrated, but the illustrations should be used with care, since they show one specimen only. The tip of the epiproct is subject to variation and damage. Remember that the relative length of the anal appendages, in particular the cerci, is useful only for comparison between similar-sized specimens.

Abdominal pigment pattern. The illustrations show normally to lightly pigmented specimens. Very dark larvae may sometimes be almost devoid of pattern, or the contrasts can be enhanced, and dark areas otherwise not present may appear. Most of the patterns lie in the cuticle, which is very even and "grainless". The muscle-scars are mostly seen as pigmented spots or areas. The epidermal pigment below the cuticle is usually consisting of irregular, often branching patches, visible at low magnification. This is very distinctly seen in light areas of the abdomen in most species (Fig. 7, but it is never symmetrical as shown here), whereas other species are "fine-grained" or may almost lack such pigment.

1. *Eyes* very large, with great extension longitudinally and the greatest width far back. Lateral *occipital margin* of head is relatively short (Figs 113–116) (*Anax & Hemianax*) 12
- *Eyes* smaller, of different shape, with the greatest width farther forwards (at least as in Fig. 111). Lateral margin of *occipital area* more prominent relative to that of the eye 2
2. *Eyes* relatively small and strongly directed forwards (Figs 109, 110). *Occipital margin* longer than the lateral eye margin. *Abdomen* posteriorly almost triangular in cross-section, with a blunt dorsal spine on segment 9. Very sluggish larva, normally feigning death when collected. Often in small, nutrient-rich waters .... *Brachytron pratense*
- *Eyes* and *occipital area* of intermediate size and shape (Figs 111, 112). *Abdomen* semicircular in cross-section, with no dorsal spine on segment 9. Usually active when collected 3
3. Lateral *occipital margin* well set-off from the contours of the eyes and almost longitudinally parallel (Fig. 119,



Figs 109-116. Aeshnidae, larva. - 109, 111, 113, 115. Head, dorsal view. -110, 112, 114, 116. Labium *in situ*, ventral view. -109-110. *Brachytron pratense*, S:Up, 8.1 mm, F. -111-112. *Anaciaescna isosceles*, S:Go, 8.8 mm, F. -113-115. *Anax imperator*, Italy:Sardinia. -113-114. 7.4 mm, F-1. -115. 3.3 mm. -116. *Hemianax ephippiger*, D:B, 6.5 mm, F-1; head somewhat deformed (theoretically, this specimen could be *Anax parthenope*). Del. U. Norling.

arrow). Final instar larvae are least typical, but have an unusually convex posterior margin with the posterior corners well rounded (Fig. 111) and not protruding posteriorly as in *A. cyanea* (Figs 7, 139, but Fig. 7 is not very proportional). *Cerci* long and slender, in the final instar about 2/3 of the paraprocts (Fig. 117) as in *A. subarctica*, in the penultimate instar still >1/2 of the paraprocts. *Epiproct* usually with a shallow fork. Lateral abdominal *spines* on segment 6 relatively well developed (Figs 118, 122). Pigmentation of *ocelli* often poorly developed as in *A. grandis*, often completely absent in smaller larvae (Figs 111 and 119, respectively). The lateral ocelli are more often pigmented than the median one (cf. the reverse condition in *A. grandis*). *Prementum* wide anteriorly (>2/3 of length, as defined in Fig. 112), strongly narrowing towards the base (Figs 112, 120). Abdominal *pigmentation* relatively even (Fig. 123), with little patchy epidermal pigment. Dark larvae exhibit more contrast-rich pigmentation. In small larvae the small dark lateral spots (muscle scars) are usually conspicuous. Small darker larvae have a wide *transverse* light band behind the thorax (Fig. 124). Southern species, common on Gotland ...*Anaciaeshna isosceles*

- *Occipital margins* distinctly narrowing behind the eyes. In doubtful cases, the posterior corners are strongly protruding posteriorly, i.e. almost the whole posterior margin of the head is strongly concave (cf. Fig. 139) (*Aeshna*) 4

4. *Prementum* long and narrow (Figs 125, 136, 145). This character grows less clear-cut with decreasing size of the larvae (Figs 130, 149). Width at basal articulation (between the most posterior corners, cf. Figs 112, 126) about 1/3 or less of its total length (may approach 40% in some small larvae, Fig. 130), and usually not more than half the maximum width. Maximum width usually 2/3 of length. Small larvae never have any light *transverse band* behind the thorax 5

- *Prementum* of wider appearance, at least as in Figs 169, 173. Width at basal articulation c. 40% or more of total length, and usually slightly more than half of maximum width. Maximum width 3/4 or more of length, or at least closer to this value than to 2/3. Small larvae of some species have a light *transverse band* behind thorax (as in Figs 179, 184) 7

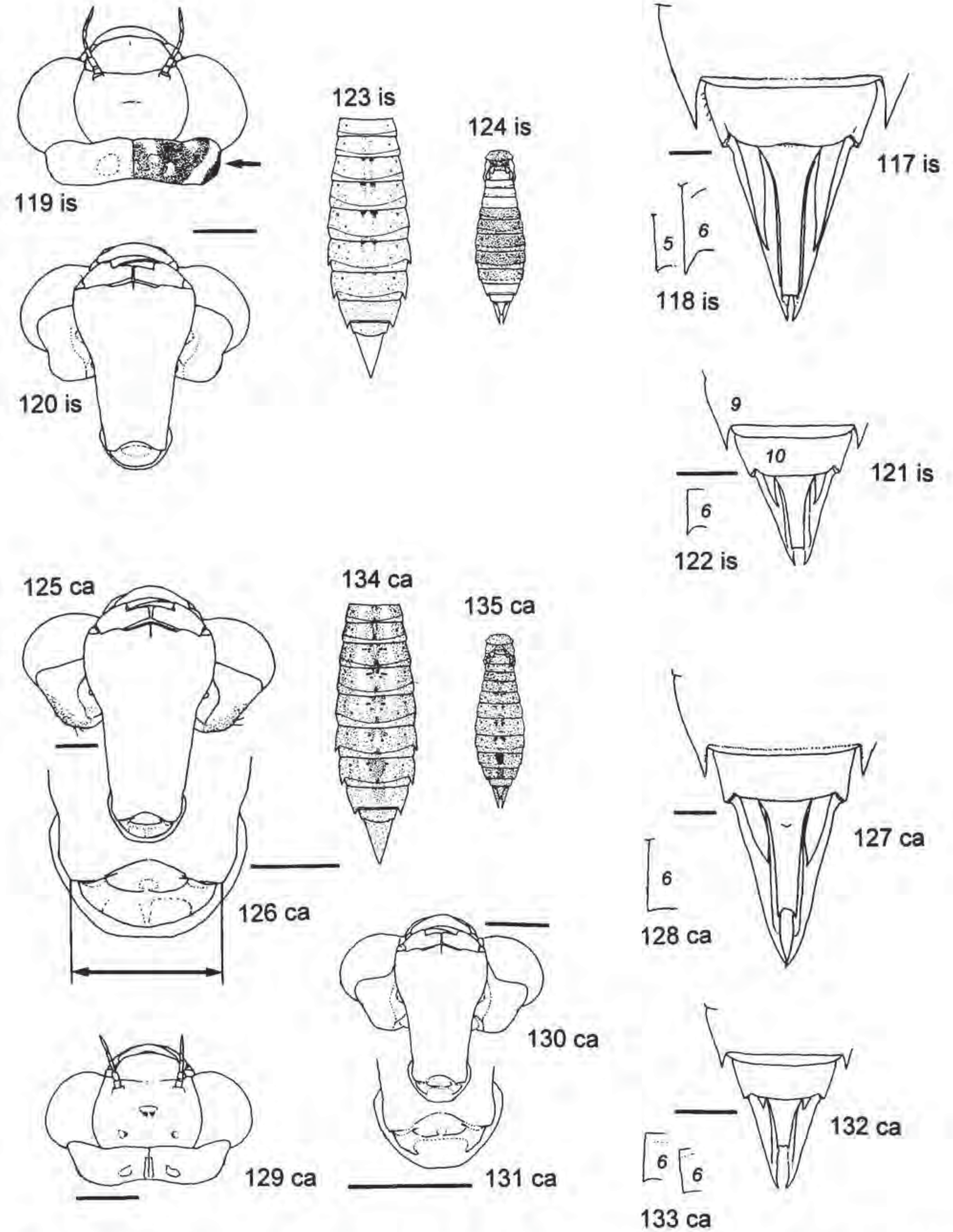
5. Lateral abdominal *spines* on segment 6 vestigial or absent (Figs 128, 133). Lateral abdominal spines on segment 9 relatively small, about half as long as segment 10 in late instars (Fig. 127, cf. 132). Basal part of *prementum*, at least in larger larvae, angled in two steps (Figs 126, 131). Greatest width of prementum some distance behind the palps, and its "waist" situated so far back that the area anterior to it, including palps, is about circular (Figs 125, 130; contrasting to *A. mixta* only). *Pigmentation* of low contrast, patchy epidermal pigment not apparent, typically with a diffuse darker triangle on abdominal segment 8, and often also with a darker unpaired posterior median area in the preceding segments (Fig. 134; somewhat similar to *grandis*, Figs 177, 178). In small larvae pigmentation is more even (Fig. 135; dark areas exaggerated), in the first instars almost uniformly greyish brown, which is diagnostic for the species. In late instars the tip of the *epiproct* is moderately forked (Fig. 127), and the *cerci* are in the final instar less than half the length of the paraprocts. The *occipital lobes* are rounded, and the head medially emarginated (even when seen slightly anterodorsally) (Fig. 129). Small species of mainly northern distribution, mostly encountered in bog-pools . *A. caerulea*

- Lateral abdominal *spines* on segment 6 distinct (at least as in Figs 138, 141, 147, 151; ambiguities may, however, arise), on segment 9 moderate to long, usually more than half the length of segment 10 in the final instar (Figs 137, 146). Base of *prementum* different, with a single, often sharp angle. *Pigmentation* of abdomen without medial unpaired dark areas. *Occipital* area usually different. *Cerci* in the final instar about half as long as the paraprocts. Tip of epiproct often shallowly forked (Fig. 137). Larvae often very active when collected 6

6. *Prementum* with very narrow basal section, reminiscent of a handle (Figs 136, 140). The greatest width lies somewhat behind the palps, and the "waist" is situated so far back that the area anterior to it, including palps, is about circular. Head relatively narrow compared to the rest of the body, with prominent *occipital lobes*. Posterior margin well emarginated, even when seen somewhat anteriorly (Fig. 139). Lateral abdominal *spines* on segment 9 moderately long (Fig. 137). The dorsal abdominal *pigmentation* (except in some very dark specimens) dominated by two central stripes separated by a thin light stripe. The latter is widening to triangular areas in more posterior segments, that on segment 7 (lightest) or sometimes 8 (widest) often being the most notable, the former visible even in dark specimens (Fig. 7; see also the somewhat similar *osiliensis*, Fig. 186). Most late instars can be present throughout the year due to a 2–4 year development. Common in small, shaded waters in the southern parts of the area .... *A. cyanea*

- *Prementum* widening more gradually (Figs 145, 149). The greatest width is near the palps, and the "waist" is situated so far forwards that the area anterior to it (including palps) is not circular in appearance and shorter than wide. Head with less prominent *occipital area*, blending well with the eyes. Posterior margin not very emarginated when seen slightly anteriorly (Fig. 148; the final instar is somewhat similar to *caerulea* as in Fig. 129). Lateral abdominal *spines* on segment 9 often as long as segment 10 in late instars (Fig. 146, cf. small larva in Fig. 150). Dorsal abdominal *pigmentation* often with small spots as prominent features. Larvae absent between September and April in Scandinavia due to univoltinism and obligatory egg diapause. Small species of southern distribution .... *A. mixta*

7. Lateral abdominal *spines* on segment 6 rudimentary or absent (Figs 154, 158, 162, 166). *Prementum* short and wide, even at the base, and in late instars parallel-sided for a short distance in the middle (Figs 152, 160;



Figs 117-135. Aeshnidae, larva. -117, 121, 127, 132. Anal pyramid. -118, 122, 128, 133. Lateral abdominal spines, lateral view. -119, 129. Head, dorsal view. -120, 125, 130. Labium *in situ*, ventral view. -123-124, 134-135. Schematic presentation of abdominal pigmentation. -117-124. *Anaciaeschna isosceles*. -117-118. S:Go, 8.8 mm, F. -119-122. S:Sk, 3.7 mm. -123. Light specimen, S:Go, F. -124. Dark specimen, S:Sk, 2.4 mm. -125-135. *Aeshna caerulea*. -125-128. N:F, 7.2 mm, F. -126. Detail of fig. 125. -129. N:F, 3.4 mm. -130-132. N:F, 3.3 mm. -131. Detail of fig. 130. -133. N:F, 3.4 and 3.3 mm. -134. N:F, F. -135. N:F, 3.4 mm. Del. U. Norling.

alternatives often ambiguous). Small larvae may have a less typical prementum (Fig. 156), but they have an unmistakable longitudinal *striping* (Fig. 159) with 6 continuous dark stripes. Abdomen also in late instars more or less striped, the median pair of stripes reaching segment 9 (Fig. 167; in contrast to e.g. *osiliensis*, Fig. 186) 8

- Lateral abdominal *spines* on segment 6 present (Figs 171, 175, 189, 193). *Prementum* usually more intermediate in shape, or short and wide, but usually not as clearly parallel-sided in the middle (e.g. Figs 142, 187, 194). Abdomen usually not as distinctly *striped*. Small larvae do never have the 6 continuous stripes of Fig. 159 ... 9

8. *Prementum* wide anteriorly (posterior width about 60% of maximum width), but widest some distance behind the palps (Figs 152, 156). *Cuticle* never shiny, the dorsal muscle-scars on prothorax stand out well through their more even surface, an effect caused by the absence of the dark setal bases roughening the rest of the prothorax (Fig. 155). In small larvae the anterior part of the abdomen is totally dull. Legs long and slender. *Cerci* of "normal" length, about half as long as the paraprocts in the final instar (Fig. 153, cf. small larva in Fig. 157). Widespread and very common in many habitats, often dominant in bogs and woodland pools .... *A. juncea*

- *Prementum* more narrow anteriorly (posterior width > 60% of maximum width, Figs 160, 164), still widening towards the palps in late instars. *Cuticle* shiny, partly because the roughening setal bases are few, or even absent at some places. The dorsal muscle-scars on prothorax are therefore less contrasting (Fig. 163; setal bases are only present near the lateral margin in late instars, but a fine wrinkling can often be seen). In small larvae the anterior part of the abdomen has a fatty, mirror-like smoothness. Legs short and thick. *Cerci* large, about 2/3 of the paraprocts in the final instar (Fig. 161, cf. small larva in Fig. 165). Widespread in floating *Sphagnum* or *Drepanocladus* mats or in *Sphagnum* borders of bog-pools .... *A. subarctica*

9. Distinct lateral abdominal *spines* present on segment 5 (Fig. 144). Prementum short and wide (Fig. 142). Anal pyramid long, *epiproct* deeply forked, even in smaller specimens (Fig. 143). Large, very rare eastern species .... *A. crenata*

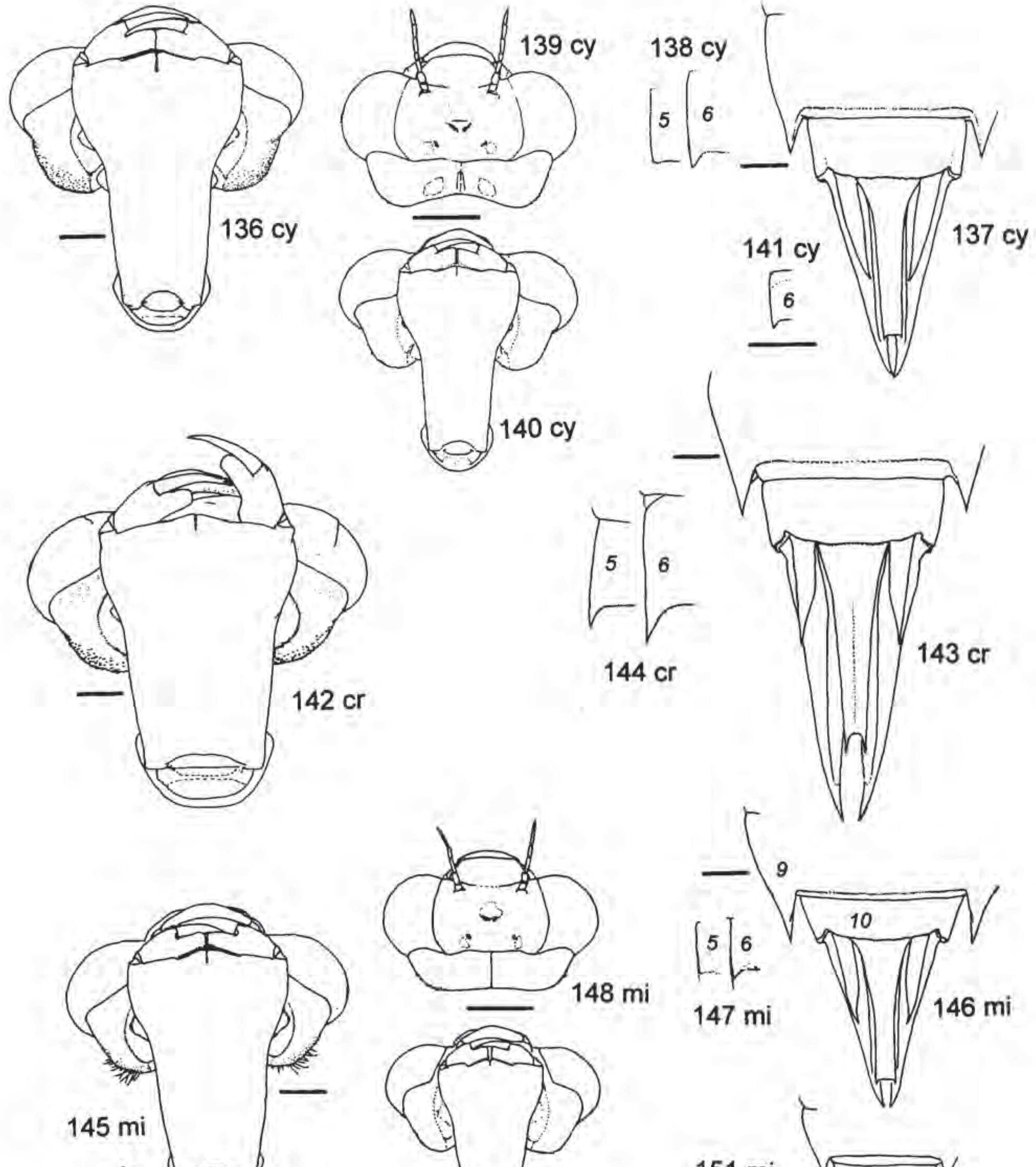
- Lateral abdominal *spines* absent on segment 5. Anal pyramid normal, tip of *epiproct* moderately forked (e.g. Fig. 170). Small larvae often with a light *transverse band* behind thorax 10

10. *Ocelli* with no or little pigmentation, often limited to the median ocellus (Figs 168, 172). *Occipital lobes* straight-margined and somewhat sharp-angled. *Pigmentation* patterns very variable, but nearly always rich in contrasts (Figs 172, 174, 176–179). On segment 8, there is usually a conspicuous dark triangle, which, however, can be absent or broken up, e.g. in very light specimens. In the preceding segments there are typically a posterior dark, unpaired median area. There are two main types of abdominal pattern, one striped, and one spotted (Figs 177, 178, respectively). Very light specimens still have some distinct dark markings in the anterior part of the abdomen, but the general contrast is less pronounced, not as in Figs 174 and 176–178. In the lighter areas there is a very distinct patchy epidermal pigmentation, which looks speckled even at low magnification, as in most *Aeshna* species (see Fig. 7). Colour in life usually brown, sometimes green. Small larvae typically have a light *transverse band* behind the thorax (Fig. 179). The band often shows dark markings of various extension, and can be entirely absent. The dark area posterior to the band is not uniform, and usually shows both lighter and darker parts. *Prementum*, in comparison with other similar species, is somewhat more elongate, narrower at the base, and has a more distinct "waist" (Fig. 169). Widespread and common in waters with large open surfaces or with open surroundings .... *A. grandis*

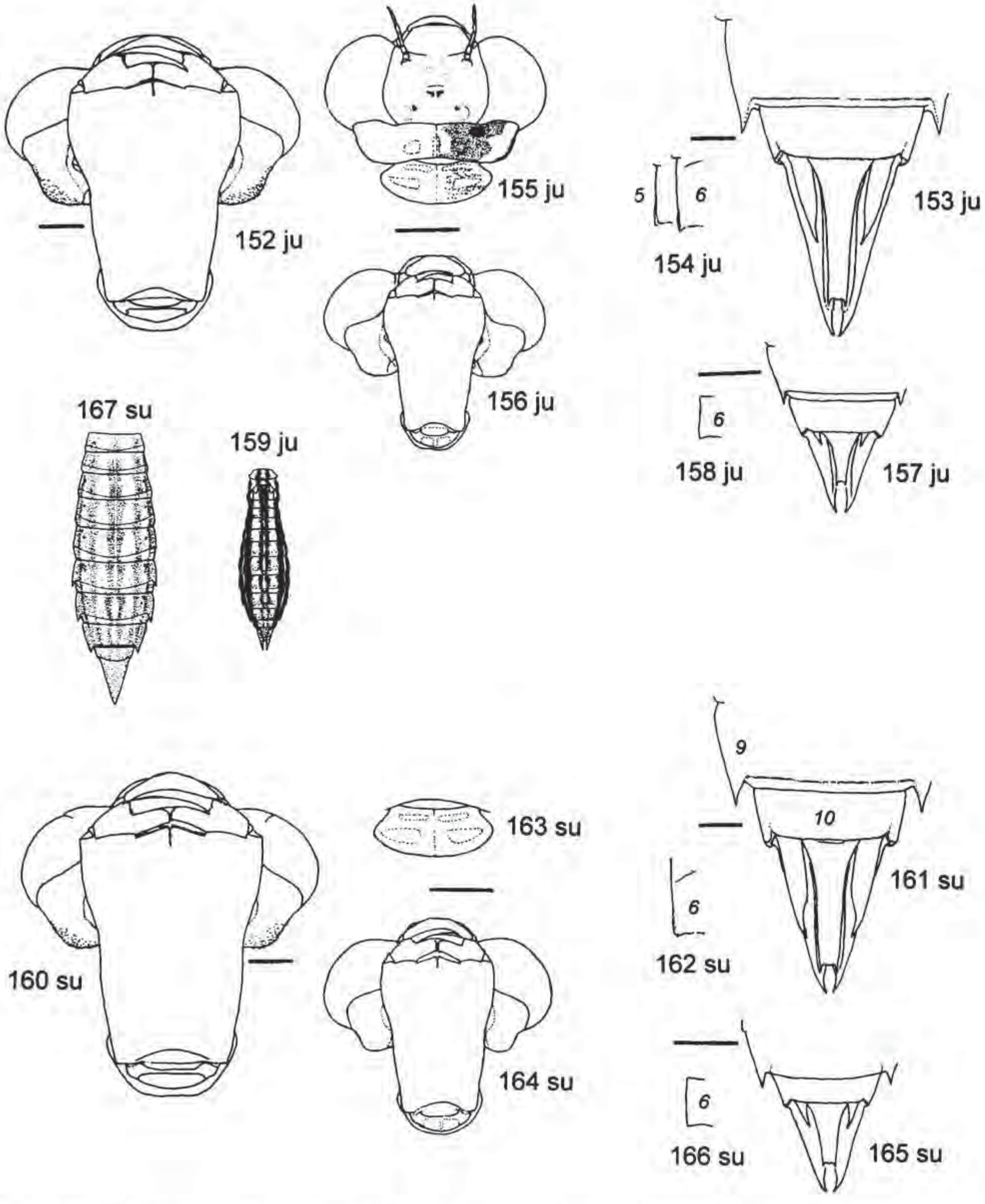
- *Ocelli* mostly with normal pigmentation (Figs 180, 181, 185, 190). Head with at least slightly more rounded occipital lobes. *Pigmentation* of low or moderate contrast. The triangle on segment 8 is absent or broken and hardly more prominent than on other segments. No unpaired medial dark areas on the preceding abdominal segments (e.g. Figs 183, 186). Small larvae of these species may also have a light *transverse band*. *Prementum* typically somewhat wider and/or less narrowing towards the base (Figs 187, 194). The "waist" is often less pronounced 11

11. *Pigmentation* very even, almost featureless (Figs 182, 183), with little or fine-grained epidermal pigmentation. Colour generally greenish in life. Only a few slightly darker pigmented spots (muscle scars) occur. *Ocellar* pigmentation may be weak in smaller larvae, but is normally stronger than in *grandis* (Figs 180, 181). Young larvae, if not extremely light-coloured, have a light *transverse band* behind the thorax, but both this band and the dark area behind it are virtually featureless (Fig. 184). *Prementum* is normally somewhat shorter and more evenly tapering than in *grandis* and *osiliensis* (Fig. 194). Morphologically close to *grandis* (Figs 194, 195) but readily distinguished by its uniform and constant pigment pattern. In waters with *Stratiotes aloïdes*, where it can be locally common ..... *A. viridis*

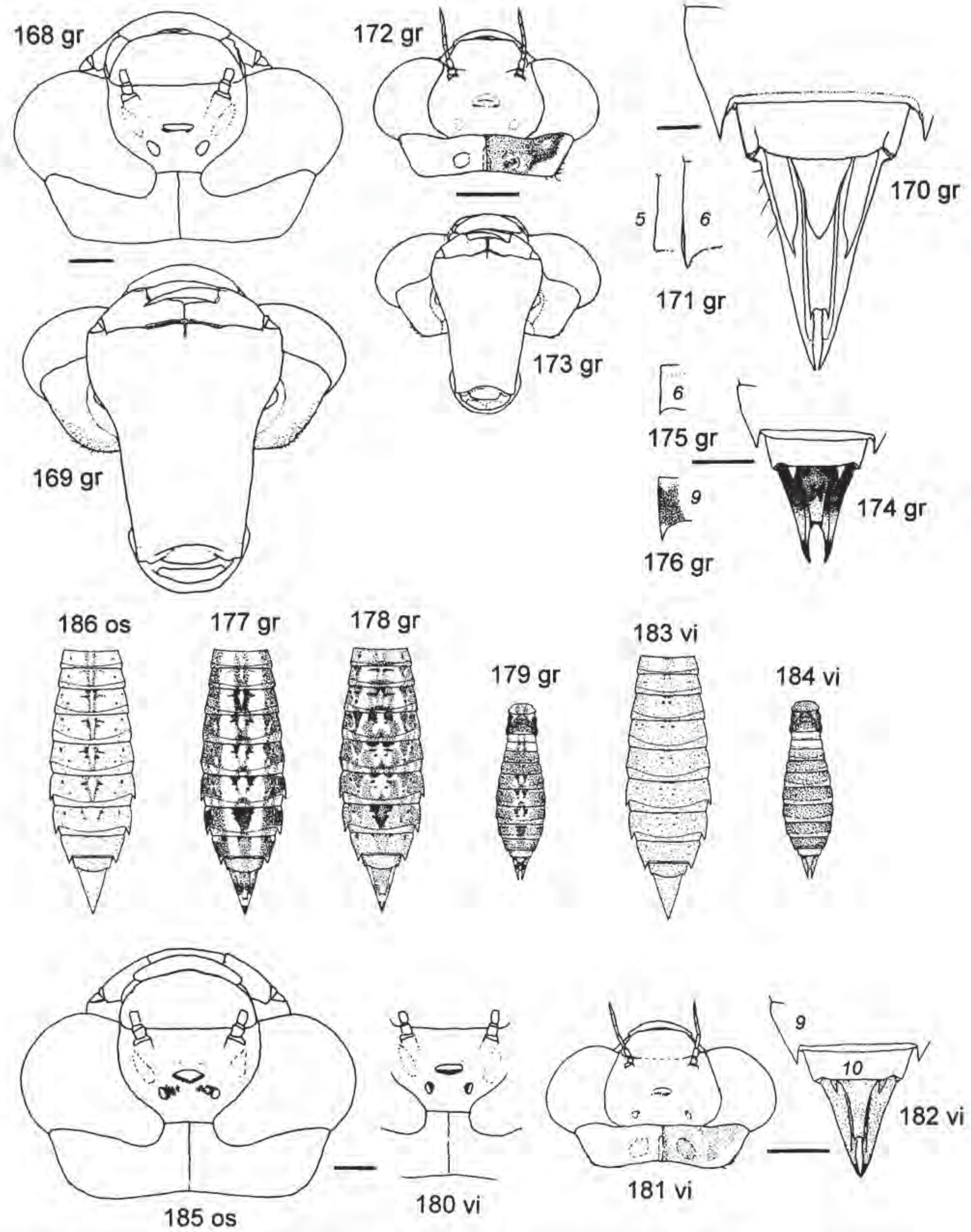
- Abdominal *pigmentation* consisting of two medial dark bands, not reaching segment 9 (Fig. 186; cf. *juncea* and *subarctica*, Fig. 167, which sometimes may be otherwise similar). Young larvae, if dark enough, often with a less distinct light *transverse band* behind the thorax. The area behind this band is relatively uniform, but not as featureless as in *viridis*. The pigment pattern may remind of *cyanea* in that the median light stripe produces a particularly eye-catching light-coloured triangular spot on segment 7. The *occipital lobes* are well rounded, and *ocellar* pigmentation is well developed (Figs 185, 190). Morphologically similar to *grandis* (Figs 187, 188, 191, 192). A large species confined to brackish waters in Sweden and Finland, and some eutrophic lakes rich in *Phragmites* and *Typha* in south-central Sweden .... *A. osiliensis*



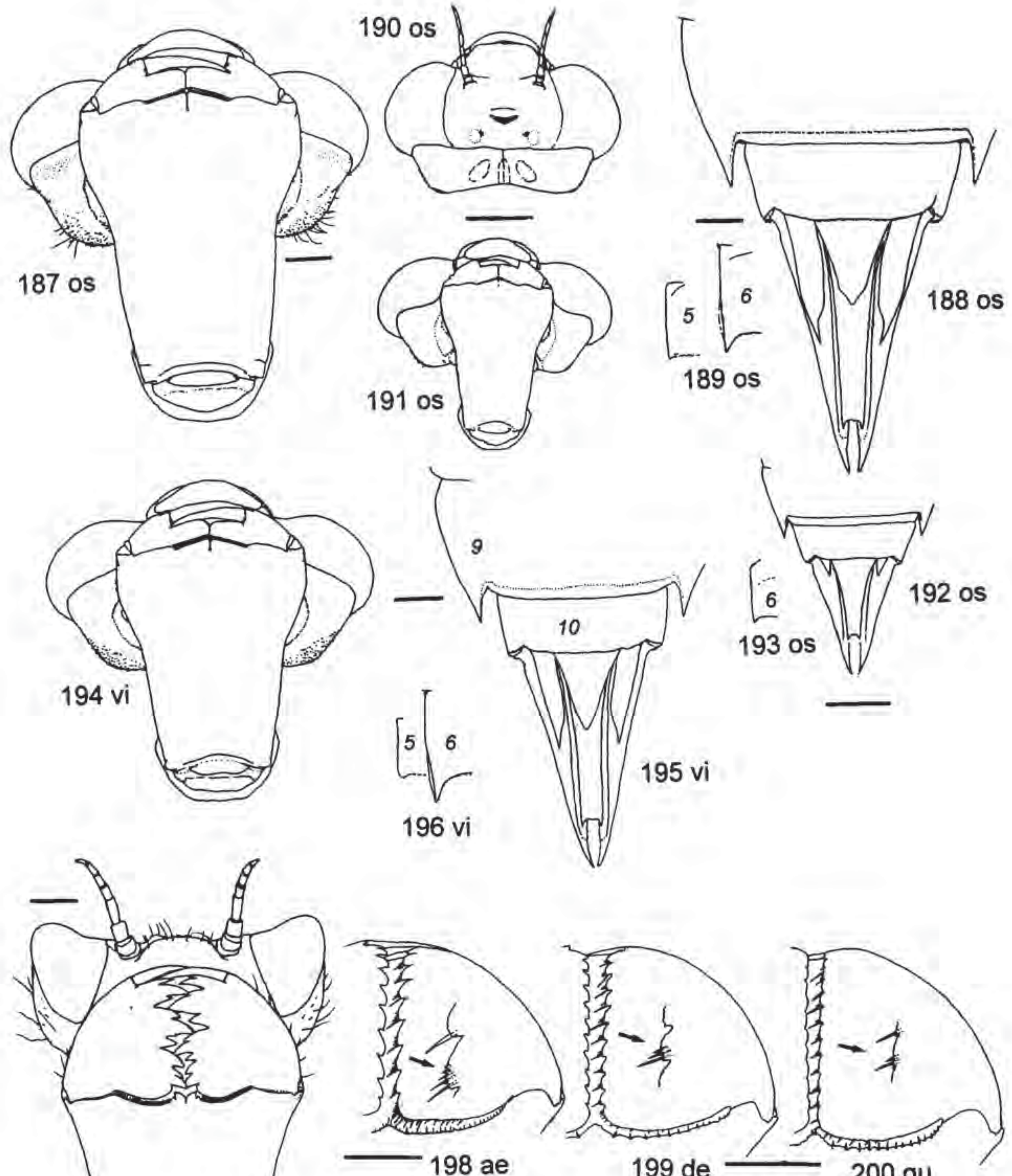
Figs 136-151. *Aeshna*, larva. -136, 140, 142, 145, 149. Labium *in situ*, ventral view. -137, 143, 146, 150. Anal pyramid. -138, 141, 144, 147, 151. Lateral abdominal spines, lateral view. -139, 148. Head, dorsal view. -136-141. *Aeshna cyanea*, S:Ög. -136-138. 7.8 mm, F. -139-141. 3.5 mm. -142-144. *A. crenata*, F:Kb, 10.0 mm, F, exuvium. -145-151. *A. mixta*, S:Sk. -145-147. 7.5 mm, F. -147. Segments 5-6. -148-151. 3.2 mm. Del. U. Norling.



Figs 152-167. *Aeshna*, larva. -152, 156, 160, 164. Labium *in situ*, ventral view. -153, 157, 161, 165. Anal pyramid. -154, 158, 162, 166. Lateral abdominal spines, lateral view. -155. Head and prothorax, dorsal view. -159, 167. Schematic presentation of abdominal pigmentation. -163. Prothorax, dorsal view. - 152-159. *Aeshna juncea*. -152-154. S:Ög, 8.1 mm, F. -155-159. S:Up, 3.4 mm. -160-167. *A. subarctica*. -160. S:Sk, 8.2 mm, F, exuvium. -161-162. S:Sm, 8.0 mm, F. -163-166. S:Sö, 3.5 mm. -167. S:Sm, F. Del. U. Norling.



Figs 168-186. *Aeshna*, larva. -168, 172, 181, 185. Head, dorsal view. -169, 173. Labium *in situ*, ventral view. -170, 174, 182. Anal pyramid. -171, 175-176. Lateral abdominal spines, lateral view. -177-179, 183-184, 186. Schematic presentation of abdominal pigmentation. -168-179. *Aeshna grandis*. -168-171. S:Up, 9.1 mm, F. -172-176. S:Sm, 3.6 mm. -177. S:Dr, F-1. -178. S:Dr, F. -179. S:Ög, 3.3 mm. -180-184. *A. viridis*, S:Up. -180. Ocelli, S:Up, 8.8 mm, F. -181-182. 3.6 mm. -183. F. -184. 3.6 mm. -185-186. *A. osiliensis*. - 185. S:Up, 9.3 mm, F. -186. S:Ög, F, lightly pigmented specimen. Del. U. Norling.



Figs 187-200. Anisoptera, larva. -187, 191, 194. Labium *in situ*, ventral view. -188, 192, 195. Anal pyramid. -189, 193, 196. Lateral abdominal spines, lateral view. -190. Head, dorsal view. -187-193. *Aeshna osiliensis*, S:Ög. -187-189. 9.4 mm, F. -190-193. 3.5 mm. -194-196. *A. viridis*, S:Up, 8.8 mm. -197. *Cordulegaster boltoni*, labium *in situ*, anteroventral view (S:Vg, 6.3 mm, F-1). -198-200. Labial palp with detail, anteroventral view. -198. *Cordulia aenea*, S:Sm, 4.8 mm, F-1. -199. *Libellula depressa*, S:Ög, 4.22 mm, F-1. -200. *Libellula quadrimaculata*, S:Up, 4.5 mm, F-2?. Del. U. Norling.

12. *Prementum* long and narrow (Fig. 114). Essentially a Central European species, very rare in the extreme southwest .... *Anax imperator*
- *Prementum* shorter, almost oval (Fig. 116). Rare immigrant .... *Hemianax ephippiger*

Cordulegastridae

Only one species in North Europe; see key to families.

Corduliidae

["*Smaller larvae*" refers to specimens of c. 2 mm head width. In the figure plates, the heads in dorsal view are drawn with the median ocellus at the same level as the posterior margin of the head.]

1. Dorsal spines on abdomen present (e.g. Figs 210, 219), except sometimes in smaller larvae (head width < c. 3–4 mm, Fig. 215). Lateral spines always present on abdominal segment 9. Abdominal segments with only a few long hairs (Figs 210, 215; for clarity of other features, the number of hairs actually drawn is reduced) 2

Note. Dorsal abdominal spines are generally absent in the very first instars, which, however, are not included in this key. The distinction between "spine" and "no spine" is greatly assisted by cleaning the larvae.

- Dorsal spines on abdomen always absent (e.g. Figs 232, 244). Lateral spines on abdominal segment 9 usually absent, the sole exception being a species of extreme northern distribution, living in and above the subalpine birch forest (Figs 232, 233). Generally hairy larvae with numerous long hairs on each abdominal segment (the number of hairs in the illustrations is reduced) 5

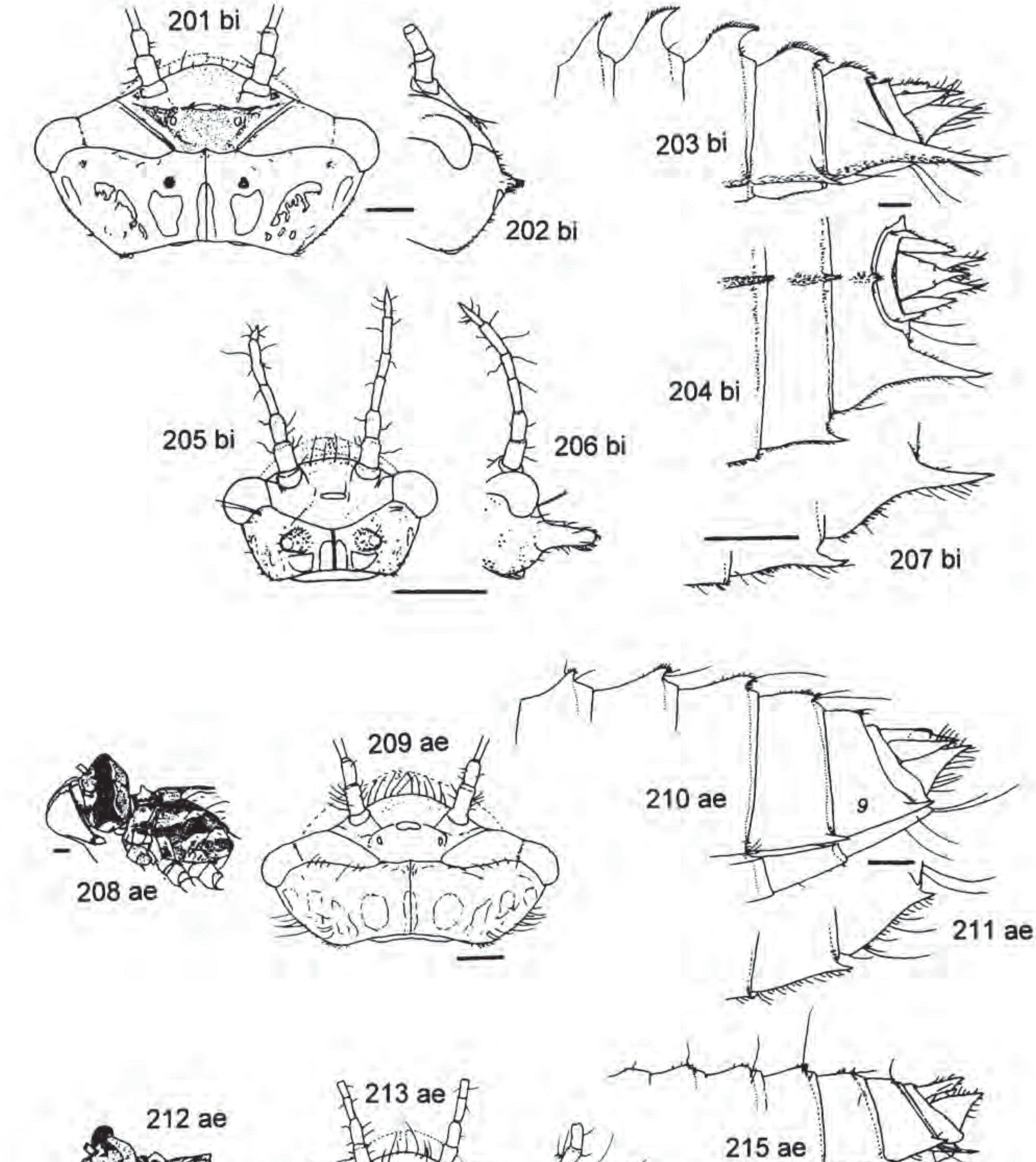
2. Lateral spines on abdominal segment 9 very large, reaching about as far as the paraprocts. Dorsal spines very large (Figs 203, 204, 207). Abdomen large, wide and relatively flat. Distinct occipital processes on the head present in all instars (Figs 201, 202, 205, 206), larger than in other corduliid species when similar-sized instars are compared. Large rare species found in mesotrophic lakes. Larvae often live at a greater depth than other species .... *Epitheca bimaculata*
- Lateral and dorsal spines shorter. Occipital processes on the head can be absent down to a head-width of c. 2 mm, but are sometimes rudimentary in the final instar and distinct in all pre-final instars (Figs 217, 218, 221, 222; such processes are always present in the very first instars) 3

3. Dorsal abdominal spines of moderate or small size on segments 3–8, and at most a small bulge on 9 (Fig. 210); however, these spines are vestigial or absent in smaller larvae (head width < 3–4 mm; Fig. 215). Distinct lateral spines on segments 8–9 (Figs 211, 216). Abdomen relatively flat, with the widest point closer to the posterior end. Ground color often light, with distinctly contrasting pigmentation, e.g. stripes on the thorax, and a transverse dark band comprising the eyes and the area between (Fig. 208). Pigment pattern in smaller larvae somewhat different (Fig. 212). Long-legged, slender, "spidery" appearance. Occipital processes absent in specimens with a head width above c 1.5–2 mm (Fig. 214). In small larvae the occipital margin behind the eyes is straight and slanted (Fig. 213). Widespread and common in many types of standing waters .... *Cordulia aenea*
- The dorsal abdominal spines are generally larger, and a distinct one is present also on segment 9 (Figs 219, 223, 225, 229). They are discernible on some segments even at a head width of c. 1–1.2 mm. The abdomen is more parallel-sided and less flat. Often darker, more compact larvae with a less contrasting pigment pattern, which can, however, be reminiscent of that in *C. aenea*. Occipital processes absent or present. Occipital margin more rounded in smaller larvae (e.g. Fig. 221) 4

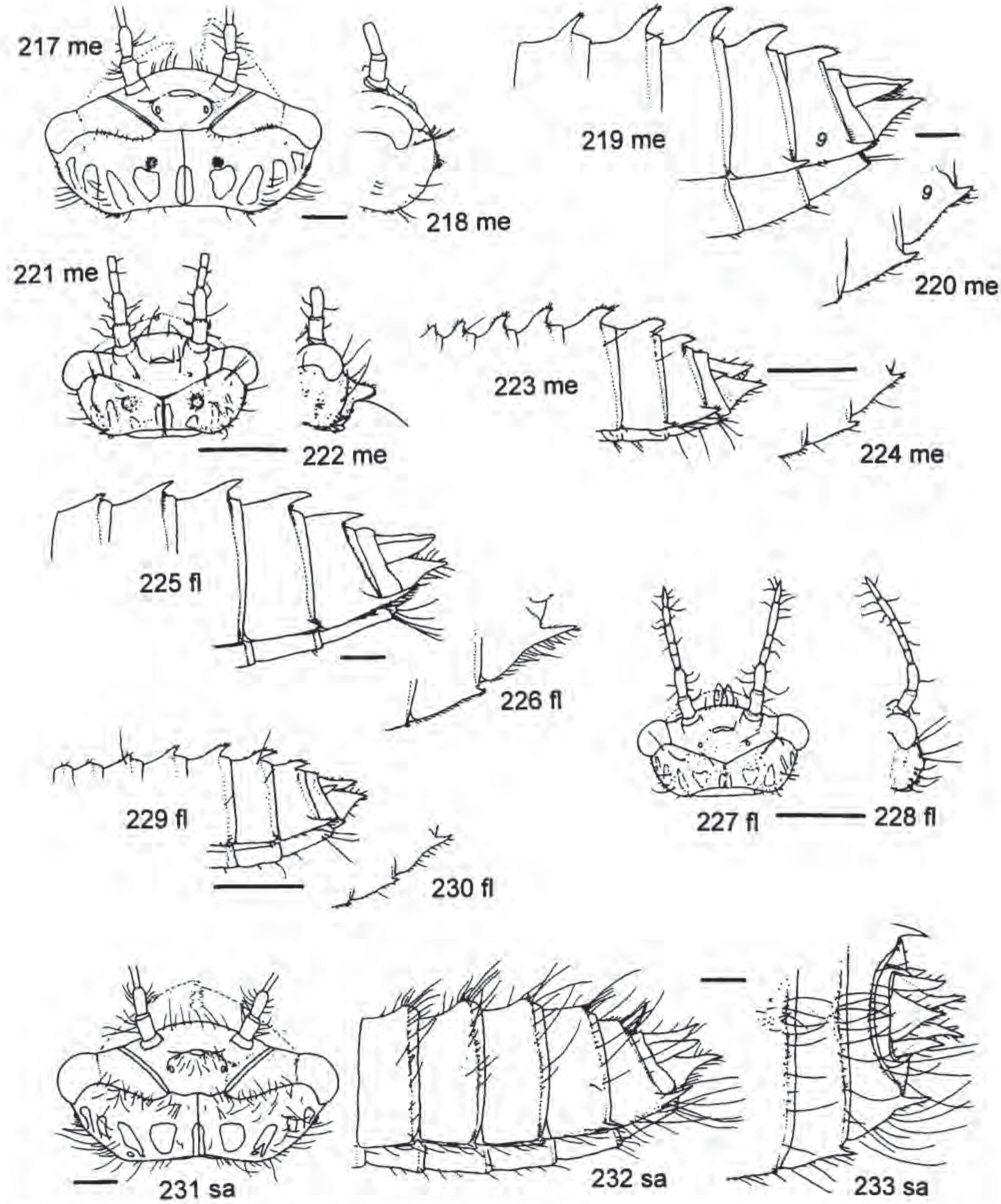
4. Occipital processes distinct in pre-final instars (Figs 221, 222), and present as slight elevations with tufts of short, mostly downlying hair in the final instar (Figs 217, 218). Lateral abdominal spines on segment 9 short, of similar size as those on segment 8 (Figs 220, 224). Widespread and common, often found in streams and not too small standing waters .... *Somatochlora metallica*
- Occipital processes are absent above a head width of c. 1.5–2 mm (Figs 227, 228), but a few hairs may be present at the corresponding place. Lateral abdominal spines on segment 9 distinctly longer than those on segment 8 (Figs 226, 230), a condition discernible even at a head width of c. 1 mm. In many different types of water, bogs and marshes. Not commonly encountered as a larva .... *S. flavomaculata*

5. No lateral abdominal spines. Small larvae (head width 2 mm) without occipital processes 6
- Lateral abdominal spines present on segments 8–9 (Figs 232, 233, 236). Small larvae (head width < c. 3mm) with small occipital processes (Figs 234, 235). Otherwise morphologically close to *S. alpestris*, as described below. An extremely northern species found only in tundra bog-pools at or above the arctic tree-line .... *S. sahlbergi*

6. Paraprocts short, with small, well set-off tips, abruptly curved outwards when seen in dorsal or dorsolateral view (Figs 239–241). In caudal view paraprocts and epiprocts look like plates, together sealing off the end of the abdomen, with the small tips protruding at the center. Two laterosternal sclerites on segment 7 as on most other abdominal segments (Fig. 238; an unusual condition in the genus). Abdomen with long hairs at the posterior margins of the segments and partly with shorter hairs on the surface, particularly apparent when seen dry (Figs 239, 240; the short hairs are only partially shown). The eye margin of the final instar normally shows an angle to the occipital area (Fig. 237). Widespread, but absent in the extreme south. In bog-pools. .... *S. arctica*
- Paraprocts longer, smoothly curved outwards when seen in dorsal or dorsolateral view as in most other *Somatochlora* species (Figs 244, 245, 247). Laterosternal sclerites on segment 7 fused (Fig. 243). Abdomen with very long hairs at the posterior margins of



Figs 201-216. Corduliidae, larva. -201, 205, 209, 213. Head, dorsal view. -202, 206, 214. Dorsal part of head, lateral view. -203, 210, 215. Abdomen, lateral view. -204. Tip of abdomen, dorsal view. -207, 211, 216. Left lateral abdominal spines, dorsal view. -208, 212. Head and thorax, dorsolateral view. -201-207. *Epitheca bimaculata*, S:Sk. -201-204. 7.5 mm, F. -205-207. 2.3 mm. -208-216. *Cordulia aenea*. -208-211. S:Ög, 6.5 mm, F. -212-216. D:EJ, 2.3 mm. Del. U. Norling.



Figs 217-233. *Somatochlora*, larva. -217, 221, 227, 231. Head, dorsal view. -218, 222, 228. Dorsal part of head, lateral view. -219, 223, 225, 229, 232. Abdomen, lateral view. -220, 224, 226, 230. Left lateral abdominal spines, dorsal view. -233. Tip of abdomen, dorsal view. -217-224. *Somatochlora metallica*. -217-220. S:Vs, 6.3 mm, F. -221-224. S:Ån, 2.2 mm. -225-230. *S. flavomaculata*, S:Up. -225-226. 6.5 mm, F. -227-230. 1.9 mm. -231-233. *S. sahlbergi*, N:F. -231. 6.4 mm, F. -232-233. 6.2 mm, F. Del. U. Norling.

the segments, but the hairs on the surface are generally shorter than in *arctica* (Figs 244, 245; this character is useful in larger larvae only). The eye margin of the final instar more smoothly blending with the occipital area (Fig. 242; cf. however the small larva in Fig. 246). Northern and high-altitude species found in bog-pools .... *S. alpestris*

Libellulidae

[*"Smaller larvae"* refers to specimens of c. 2 mm head width. In the figure plates, the heads in dorsal view are drawn with the median ocellus at the same level as the posterior margin of the head.]

1. Eyes small in comparison with the occipital area, the lateral projection of the eye margin comprising less than half of the length of the head (e.g. Fig. 248; 269 and 256 are showing the extremes of variation). The eyes are often breaking the outline of the head, and may be raised over the central part of the head when seen obliquely from behind (e.g. Fig. 261). The functional larval eye is well delimited from the medially extended part in late instars (e.g. Fig. 269). Dorsal area of head, except eyes, with numerous hairs of varying size, fewer in smaller larvae. Lateral abdominal spines small to moderate, no larger than in Fig. 251. Generally hairy, bottom-dwelling species, hence often dirty and requiring cleaning 2

- Eyes large; the ocular area at least as large as the occipital area, the lateral projection of the eye margin usually comprising more than half of the length of the head (Figs 285–287, 311). The large eyes give the head a smooth contour and are not or only insignificantly raised above the central part of the head (Figs 298, 312). Dorsal area of head, except eyes, with few hairs. Lateral abdominal spines moderate to large, no smaller than in Figs 305, 310. Vegetation-dwellers with few long hairs 6

2. Abdomen with dorsal spines on segments 7–8; however, the one on segment 8 may be small and scale-like, or even absent (Figs 262, 266). If so, the lateral spines on segment 9 of larger larvae are very small (Fig. 263). Most of the dorsal spines seem to be present in small larvae (head width 2 mm or even less), but in such specimens they can be hard to see (Figs 258, 266). Occipital margins behind the eyes can sometimes be parallel and longitudinal in late instars (Fig. 260), but not in smaller larvae (Figs 256, 264) *(Libellula)* 3

- Abdomen without dorsal spines on segments 7–8; however, a small one may sometimes be present on segment 7. Dorsal spines may lack entirely, especially in smaller larvae. Occipital margins behind the eyes approximately longitudinally parallel both in large and small larvae (Figs 269, 273, 276, 280) *(Orthetrum)* 5

3. Abdomen with large dorsal spines, also present on segment 9 (Figs 250, 251). Normally no more than 4–5 palpal setae in the final instar. Premental setae in groups, the usually 3+3 large setae separated from the smaller ones by gaps. Eyes not raised above the ocellar area (Fig. 249). Smaller larvae have not been studied by the authors. Rare southern species. In small lakes and slow streams .... *L. fulva*

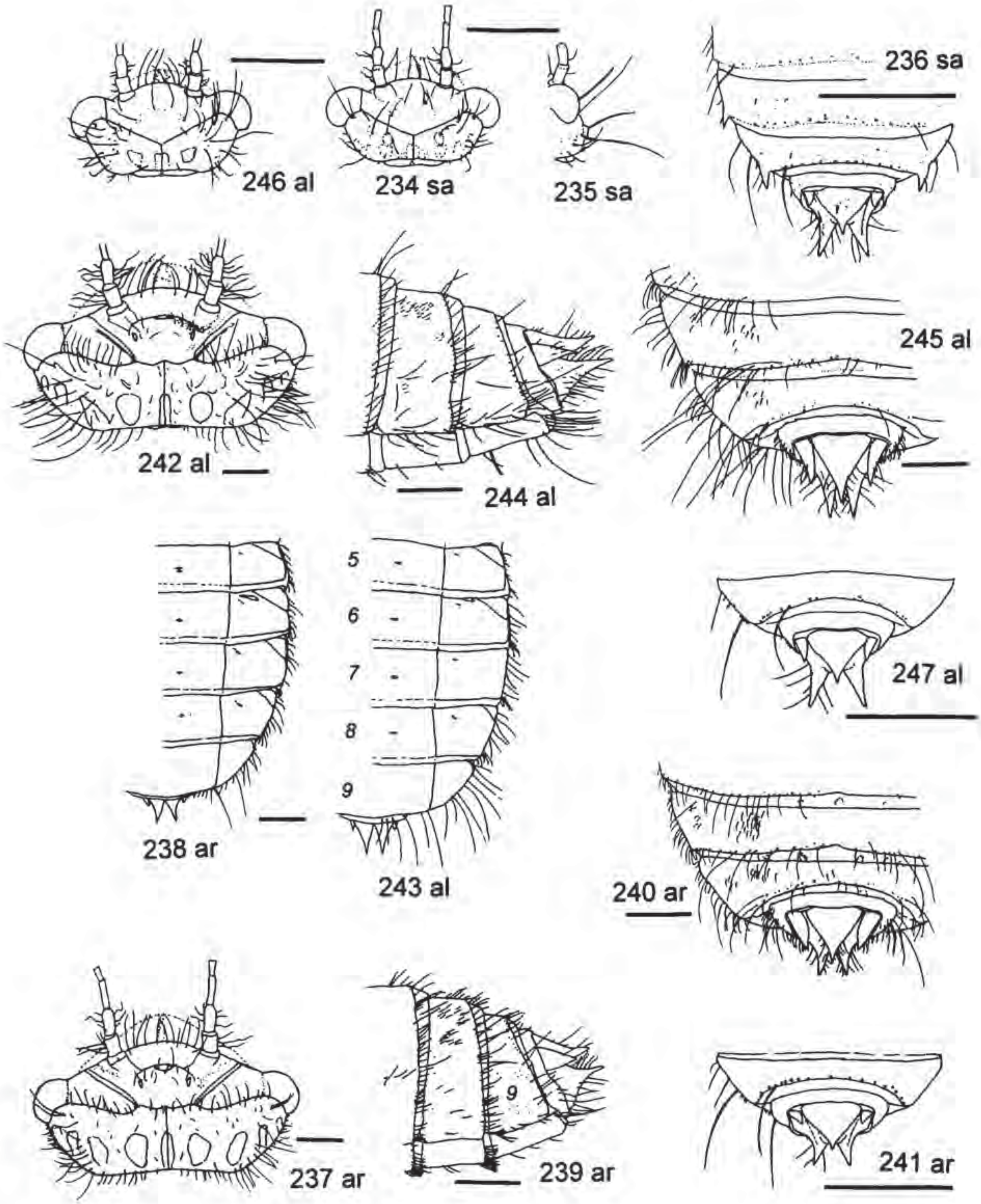
- Abdomen with rather small dorsal spines, not present on segment 9 (e.g. Fig. 254). Normally not less than 7 palpal setae in late instars; often 5–7 in small larvae. Premental setae in two continuous rows with medially diminishing size. Eyes sometimes raised above the ocellar area (Fig. 261) 4

4. Eyes not raised above the ocellar area when seen dorsocaudally so as to align the ocellar bulge with the anterior margin of the head (Fig. 253). Small larvae (head width 2 mm), however, have somewhat raised eyes (Fig. 257), the posterior margin of which appears relatively slightly and evenly curved in dorsal view (Fig. 256). Occipital area always narrowing behind the eyes (Fig. 252). Distinct lateral abdominal spines on segments 8–9 (Figs 254, 255, 259). Body hairs not dark. Cerci more than half the length of the paraprocts in the final instar. Pigmentation of low contrast, the abdomen of small larvae being almost uniformly greyish brown (preserved specimens) with a small light area dorsally in segments 1–4. Widespread and very common in most kinds of still waters .... *L. quadrimaculata*

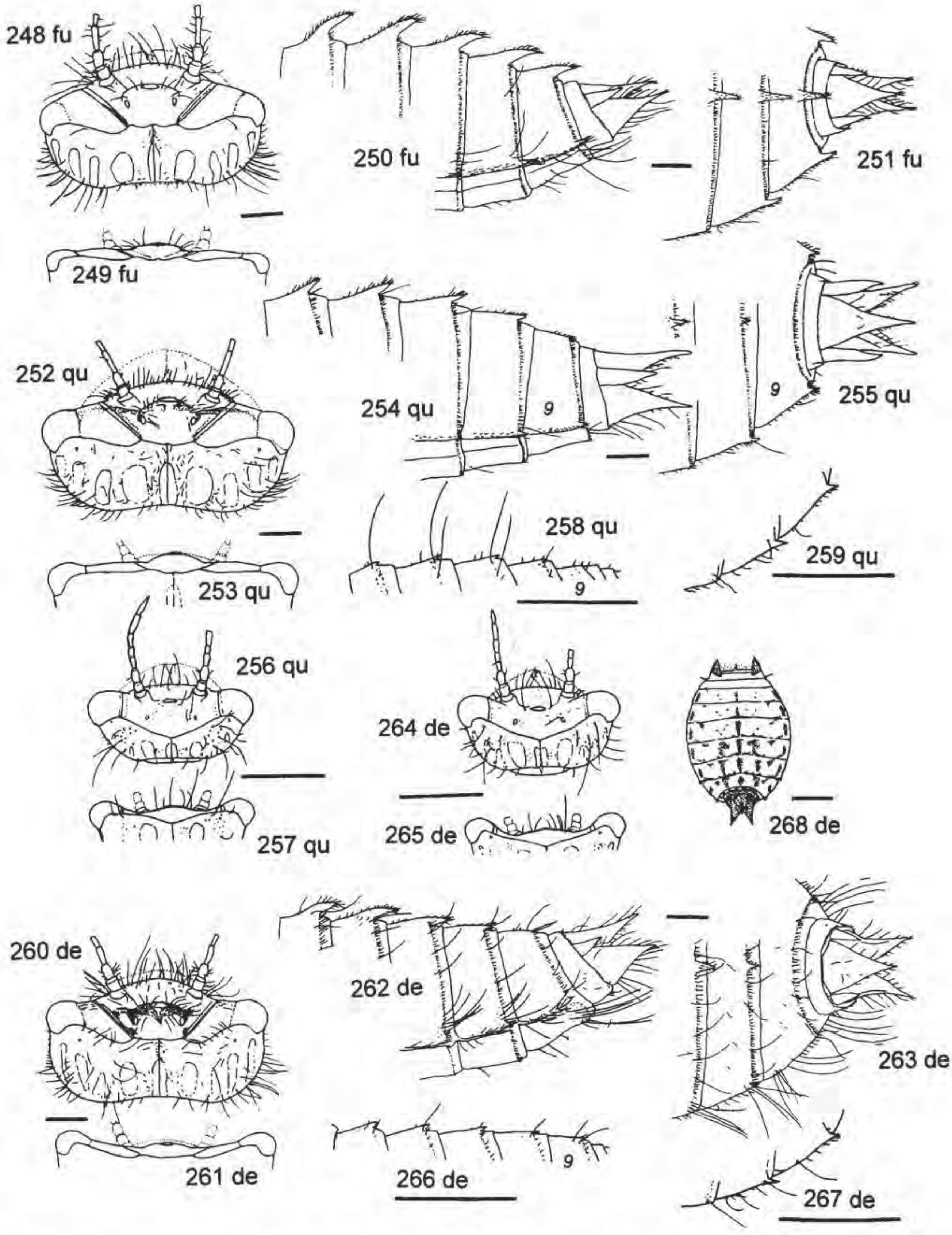
- Eyes raised above the ocellar area when seen dorsocaudally (Figs 261, 265), especially in small larvae where it makes their posterior margin appear strongly curved or even sinuous in dorsal view (Fig. 264). Occipital margins behind the eyes parallel or even widening posteriorly in the latest 3-4 instars, but not in larvae of < 0.3 mm head width (Figs 260, 264). Lateral abdominal spines very small in late instars, in particular on segment 9 (Figs 262, 263), but apparently distinct in small larvae (Fig. 267). Cerci less than half the the length of the paraprocts in the final instar. Body often with numerous thin black hairs. Pigmentation often of high contrast, in particular in small larvae, the abdominal pattern (Fig. 268) then showing 7 rows of spots, where the median one and, when present, the secondmost lateral one, are the most diagnostic. A local species, often in small ponds and ditches .... *L. depressa*

5. Eyes somewhat raised above the ocellar area in dorsocaudal view (ocellar area and anterior margin of the head aligned; Fig. 270), still more in small larvae (Fig. 274). Usually 6–7 large palpal setae, frequently 5–6 in small larvae (Fig. 275). Dorsal abdominal spines present up to segment 6 (Fig. 271), but often absent or indistinct in small larvae. Lateral spines distinct (Fig. 272). Paraprocts more than twice the length of the cerci in the final instar. Pigmentation more even than in the rather similar *L. depressa*, but not as even as *L. quadrimaculata*. In lakes in the southern parts of the area .... *O. cancellatum*

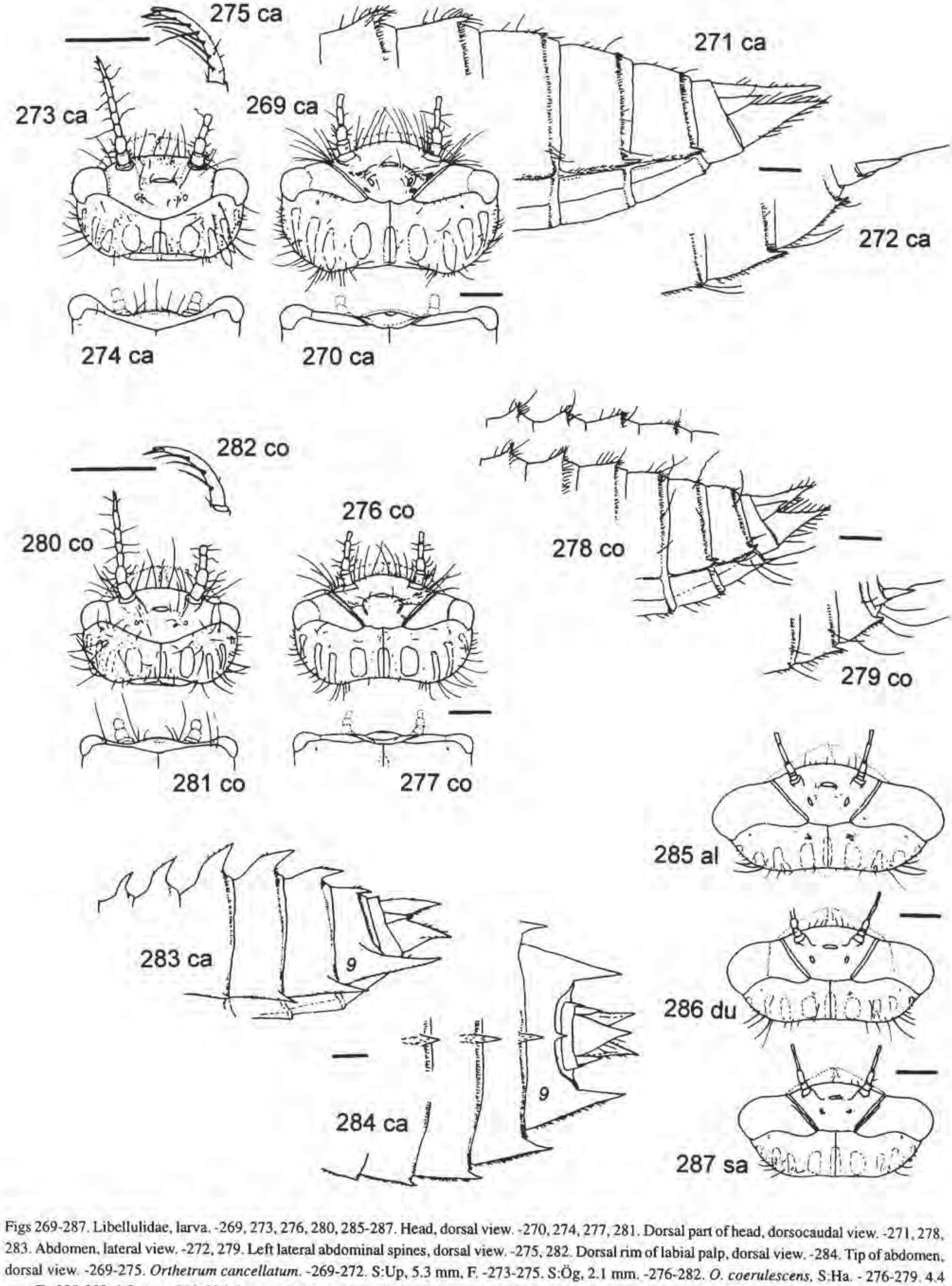
- Eyes not raised above the ocellar area in dorsocaudal view (Fig. 277), not even in small larvae (Fig. 281; applies to still smaller larvae). Usually 3–4 large palpal setae, often 3 in small larvae (Fig. 282). Dorsal spines



Figs 234-247. *Somatochlora*, larva. -234, 237, 242. Head, dorsal view. -235. Dorsal part of head, lateral view. -236, 240-241, 245, 247. Tip of abdomen, dorsal view. -238, 243. Abdomen, ventral view. -239, 244. Tip of abdomen, lateral view. -234-236. *Somatochlora sahlbergi*, N:F, 1.9 mm. - 237-241. *S. arctica*, N:MR. -237. 5.9 mm, F. -238-240. 4.8 mm, F-1. -241. 1.8 mm. -242-247. *S. alpestris*. -242. N:F, 6.1 mm, F. -243-245. N:MR, 4.8 mm, F-1. -246-247. N:F, 1.9 mm. Most hairs on these specimens are not shown. Del. U. Norling.



Figs 248-268. *Libellula*, larva. -248, 252, 256, 260, 264. Head, dorsal view. -249, 253, 257, 261, 265. Dorsal part of head, dorsocaudal view. -250, 254, 262. Abdomen, lateral view. -251, 255, 263. Tip of abdomen, dorsal view. -258, 266. Dorsal part of abdomen, lateral view (segments 5-10). -259, 267. Left lateral abdominal spines, dorsal view. -268. Abdomen, dorsal view. -248-251. *Libellula fulva*, D:EJ, 5.6 mm, F. -252-259. *L. quadrimaculata*. -252-255. S:Up, 6.2 mm, F. -256-259. S:Ög, 2.0. -260-268. *L. depressa*, S:Ög. -260-263. 5.5 mm, F. -264-268. 2.0 mm. Del. U. Norling.



Figs 269-287. Libellulidae, larva. -269, 273, 276, 280, 285-287. Head, dorsal view. -270, 274, 277, 281. Dorsal part of head, dorsocaudal view. -271, 278, 283. Abdomen, lateral view. -272, 279. Left lateral abdominal spines, dorsal view. -275, 282. Dorsal rim of labial palp, dorsal view. -284. Tip of abdomen, dorsal view. -269-275. *Orthetrum cancellatum*. -269-272. S:Up, 5.3 mm, F. -273-275. S:Ög, 2.1 mm. -276-282. *O. coerulescens*, S:Ha. - 276-279. 4.4 mm, F. -280-282. 1.9 mm. -283-284. *Leucorrhinia caudalis*, S:Up, 5.8 mm, F. -285. *L. albifrons*, S:Up, 5.7 mm, F. -286. *L. dubia*, S:Dr, 5.1 mm, F. -287. *Sympetrum sanguineum*, S:Sk, 4.8 mm, F. Del. U. Norling.

on abdomen can sometimes reach as far as segment 7, but may also be entirely absent (Fig. 278), which is the normal condition in small larvae. Paraprocts about twice as long as cerci in the final instar. Small species, in streams and sometimes small lakes ... *O. coerulescens*

6. Eyes somewhat slanted backwards, occupying a significantly bigger part of the longitudinal axis of the head than the occipital area (Fig. 285; less typical in 286; small larva 297, 298). This is best seen in the posterior margin and in the anteriolateral curvature of the eye. Bigger larvae usually with significant pigmented areas on underside of abdomen (e.g. Fig. 306; the pattern can vary). Most instars, except the first ones, can be found throughout the year because of a life-cycle duration of 2 or more years *(Leucorrhinia)* 7

Note. Small larvae of all *Leucorrhinia* species have not been studied. The characters should work at least down to 3 mm head width.

- Eyes directed more forwards, and the occipital area more protruding posteriorly (Figs 287, 311). Pigment on the underside of abdomen, if present, usually not covering large areas but concentrated to small spots, much as in Fig. 310. Larvae are normally absent from September to March, because of univoltinism and overwintering in the egg stage *(Sympetrum)* 12

Note. The *Sympetrum* key is made from information in the literature (Heidemann & Seidenbusch 1993, Sahlén 1996) and applies to the final instar only.

7. Lateral abdominal spines present on segment 7 (and 8–9), and dorsal abdominal spines up to segment 9. Most spines very large (Figs 283, 284). Large species with wide abdomen. Typically in woodland waters with abundant floating vegetation .... *L. caudalis*

- Lateral abdominal spines present on segments 8–9 only, and dorsal abdominal spines at most up to segment 8 (e.g. Figs 290, 304) 8

8. Dorsal abdominal spines present up to segment 8 9

- Dorsal abdominal spines at most present up to segment 7 10

9. Lateral abdominal spines long, dorsal spines mostly large, the one on segment 7 much bigger than that on 8 (Figs 288, 289). Dorsal pigmentation of abdomen with only few small eye-catching spots, ventral pigmentation often absent, or consisting of transverse bands. Often in shallow waters with floating vegetation .... *L. albifrons*

- Lateral abdominal spines shorter, dorsal spines generally of moderate size, the spine on segment 7 only slightly larger than that on segment 8 (Figs 290, 291). Dorsal pigmentation of abdomen often displaying numerous small spots (Fig. 292); ventral pigmentation, when present, also here with a tendency towards transverse bands, somewhat similar to Fig. 306. The posterior laterosternal spot of this figure is, however, often less prominent. Large southeastern species, locally common .... *L. pectoralis*

10. Lateral abdominal spines long, dorsal spines mostly large, even that on segment 7 (Figs 288, 289). Ventral pigmentation of abdomen often absent, or consisting of wide transverse bands instead of distinct longitudinal rows. Eyes very distinctly slanted backwards as seen in the anterolateral curvature (Fig. 285). Often in shallow waters with floating vegetation .... *L. albifrons*

- Lateral abdominal spines usually shorter, but somewhat varying in length. Dorsal spines usually smaller, sometimes absent (Figs 295, 304). Segment 7 without or with a small spine (Fig. 295). Ventral pigmentation of abdomen variable, often forming 3 longitudinal bands, but also transverse bands (in the latter case the abdominal spines are small). Eyes somewhat less slanting posteriorly (Fig. 286) 11

11. Ventral pigmentation of abdomen rarely absent, except in small larvae, and is always forming 3 distinct longitudinal rows. The pattern on each segment in the lateral rows has a light, oblique gap, opening posterolaterally (Figs 300–302). When reduced, as in light or small larvae, a posteromedial spot remains in the lateral row. These extends farther forwards than the paired spots remaining in the median row (Fig. 303). Even this reduced pattern is highly diagnostic for the species. Dorsal abdominal spines (at least in larger specimens) nearly always reach segment 5 (Figs 293, 294, 299; spines here may be very small), but rarely as far as segment 7 (Figs 295, 296). Long lateral spines do not necessarily correlate with well developed dorsal ones. Small widespread species, often very abundant in acid waters with *Sphagnum* .... *L. dubia*

- Ventral pigmentation of abdomen varying in extension, from absence to almost complete blackness (Fig. 308). It may form 3 distinct longitudinal rows, but then the segmental pattern in the lateral rows has a gap with a transverse direction (Fig. 307). There is a strong tendency of the rows to merge laterally (Fig. 306). When reduced, as in light or small larvae, the lateral rows tend to disappear, while the paired spots in the median row still remain (Fig. 310). This reduced pattern is not very diagnostic, since it can be found even in other genera. Species generally with smaller and/or fewer abdominal spines (Figs 304, 305). Dorsal abdominal spines are sometimes entirely absent. They are seldom present farther back than segment 4, but may reach segment 6. Common and widespread, but rare or absent in the west. Often in acid waters, coexisting with *dubia*, but also in less extreme habitats .... *L. rubicunda*

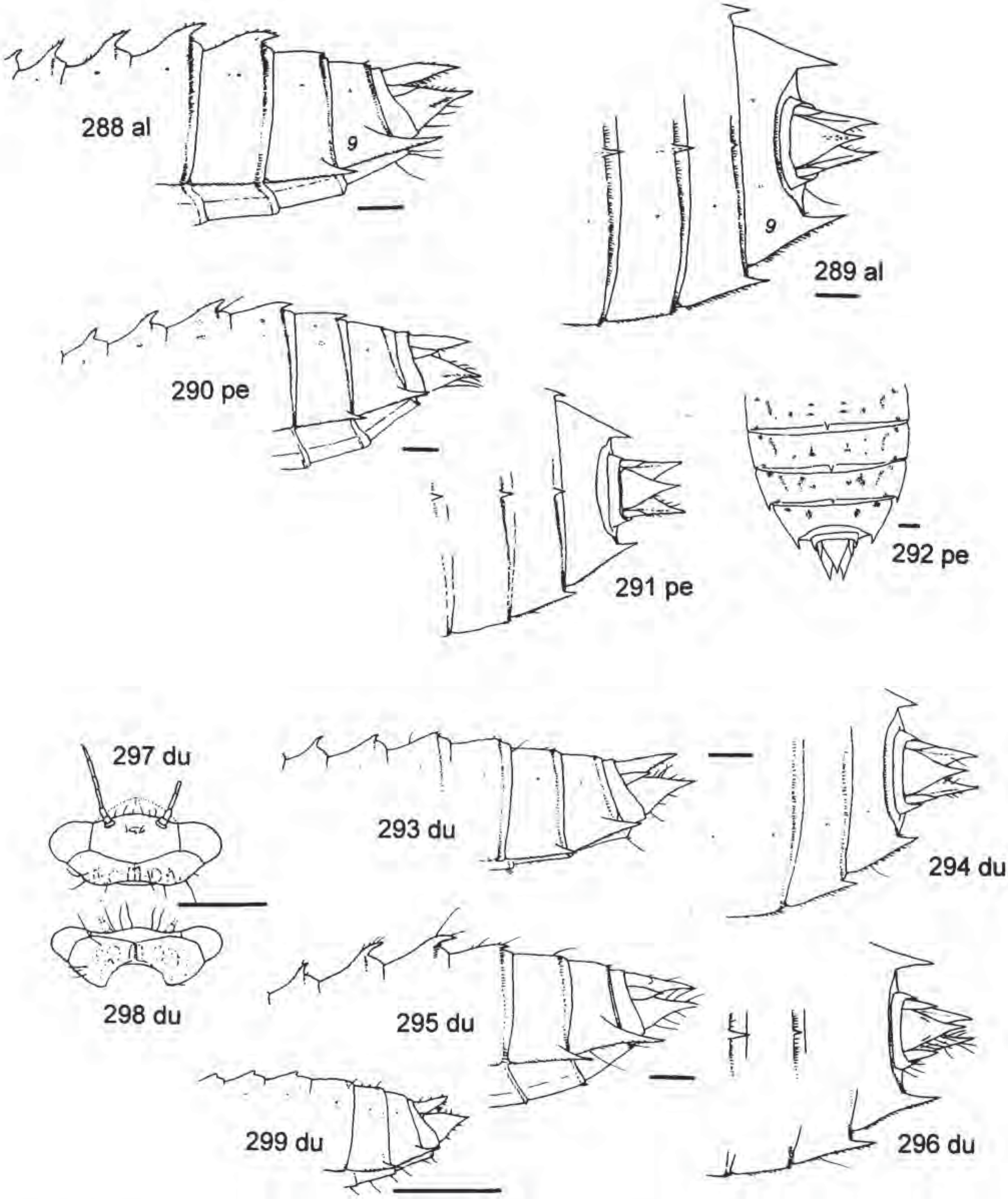
12. Lateral spine on abdominal segment 9 with its inner side about, or nearly half as long as the outside of the spine and the rest of the segment taken together (Fig. 313) 13

- Lateral spine on abdominal segment 9 with its inner side distinctly less than half as long as its outside and the rest of the segment taken together (Fig. 314) 15

13. A series of dense hairs form a "comb" on at least one of the abdominal sternites 7 or 8, at least in the middle region (Fig. 315) 14

- No "comb" present on these abdominal sternites (sometimes a few hairs may be present on segment 8). Common species in all kinds of still waters .... *S. vulgatum*

14. Dorsal spine on abdominal segment 8 small, not reaching back to segment 9. Lateral spines on segment



Figs 288-299. *Leucorrhinia*, larva. -288, 290, 293, 295, 299. Abdomen, lateral view. -289, 291-292, 294, 296. Tip of abdomen, dorsal view. -297. Head, dorsal view. -298. Dorsal part of head, dorsocaudal view. -288-289. *Leucorrhinia albifrons*, S:Up, 5.7 mm, F. -290-292. *L. pectoralis*, S:Sk. -290-291. 6.0 mm, F. -292. 6.2 mm, F. -293-299. *L. dubia*. -293-294. S:Up, 5.2 mm, F. -295-296. N:F, 5.0 mm, F. -297-299. S:Sk, 1.9 mm. Del. U. Norling.

8 more than one third of the total length of the segment. Not common, seems to prefer coastal areas .... *S. striolatum*

- Dorsal spine on abdominal segment 8 bigger, reaching back over a small part of segment 9. Lateral spines on segment 8 at most one third of the total length of the segment. Common in many types of standing waters. .... *S. sanguineum*

15. Lateral spines on abdominal segment 8 bigger; app. 1/3 of the length of the entire segment. Dorsal spine present on segment 8. Common in many types of stagnant waters .... *S. flaveolum*

- Lateral spines on abdominal segment 8 smaller; app. 1/4 of the length of the entire segment. Dorsal spines up to segment 7, sometimes a small one on segment 8. Widespread small species, common in bog pools and forest tarns .... *S. danae*

Keys for adults

Identification of adult dragonflies using this key is dependent on either live specimens or specimens that have been dried after immersion into acetone to preserve the colours (see Preparation and conservation). Newly emerged specimens are too fragile to be handled and should therefore not be examined until they have hardened, which may necessitate keeping them alive for a few hours up to one day in small jars. For more help with identification see e.g. Sandhall (1987) that includes both colour photos of all species as well as good drawings.

Key to suborders for adults

1. Fore and hind wings of about the same size and shape (Figs 316, 317). Often small and slender insects with "hammer-shaped" heads. Weak fliers .... **Zygoptera**

- Hind wings with broader base than fore wings (Figs 318, 319). Often large, robust insects with eyes covering both sides and top of head. Strong and fast fliers .... **Anisoptera**

Key to families for adults

Zygoptera

1. Pterostigma absent, or in females replaced by a white spot. Wings unstalked (Fig. 316) and tinted blue, brown or green. Body colour metallic blue (males) or green or brown (females). Fairly large insects with a "butterfly-like" flight. Normally found near running waters .... **Calopterygidae** *(Calopteryx)*

- Pterostigma present. Wings stalked (Figs 317, 320) and hyaline. Smaller insects 2

2. Pterostigma rectangular, about twice as long as broad. Wing cells often 5-sided (cf. Fig. 320) .... **Lestidae**

- Pterostigma rhomboid, of with approximately equal length and width. Wing cells often 4-sided (Fig. 320) 3

3. Discoidal cell trapezoid (Fig. 320) ... **Coenagrionidae**

- Discoidal cell rectangular (cf. Fig. 320). A running water species, seldom present in lakes apart from near their inlets and outlets .... **Platycnemididae** *(Platycnemis pennipes)*

Anisoptera

1. Triangles of fore and hind wings of roughly the same size and shape (Fig. 321) 2

- Triangles of fore and hind wings differing in size and shape (Figs 319, 368) 4

2. Small wing area in front of triangle with cross-veins (Fig. 321) .... **Aeshnidae**

- Area in front of triangle without cross-veins 3

3. Eyes meeting on top of head. A running water species, often present in large numbers at woodland streams, but also at larger rivers .... **Cordulegastridae** *(Cordulegaster boltoni)*

- Eyes not meeting on top of head. Species associated with running water, but also occasionally present in lakes. .... **Gomphidae**

4. Distal margin of compound eyes with a small incision (Fig. 325). Body colour often metallic (green, copper, black or brown) .... **Corduliidae**

- No incision in distal margin of compound eyes (Fig. 326). Body colour never metallic .... **Libellulidae**

Keys to species for adults

Calopterygidae

1. Male with blue wings (teneral males with blue-green wings), except a small transparent area near the base. Female with brown wings. At many different types of streams .... *Calopteryx virgo*

- Male with a broad blue transverse band on wings (Fig. 316). Female with green wings. Prefers slow streams in open country .... *C. splendens*

Lestidae

1. Discoidal cell of fore and hind wings of about the same size and shape. All species have some metallic colours, males often with a bluish pruinescence. June to September *(Lestes)* 2

- Discoidal cell of fore wing shorter and narrower than that of the hind wing. (July) August to May. A southern species overwintering as an adult. Body colour mostly brown and bronze .... *Sympecma fusca*

2. Neck region of head completely dark 3

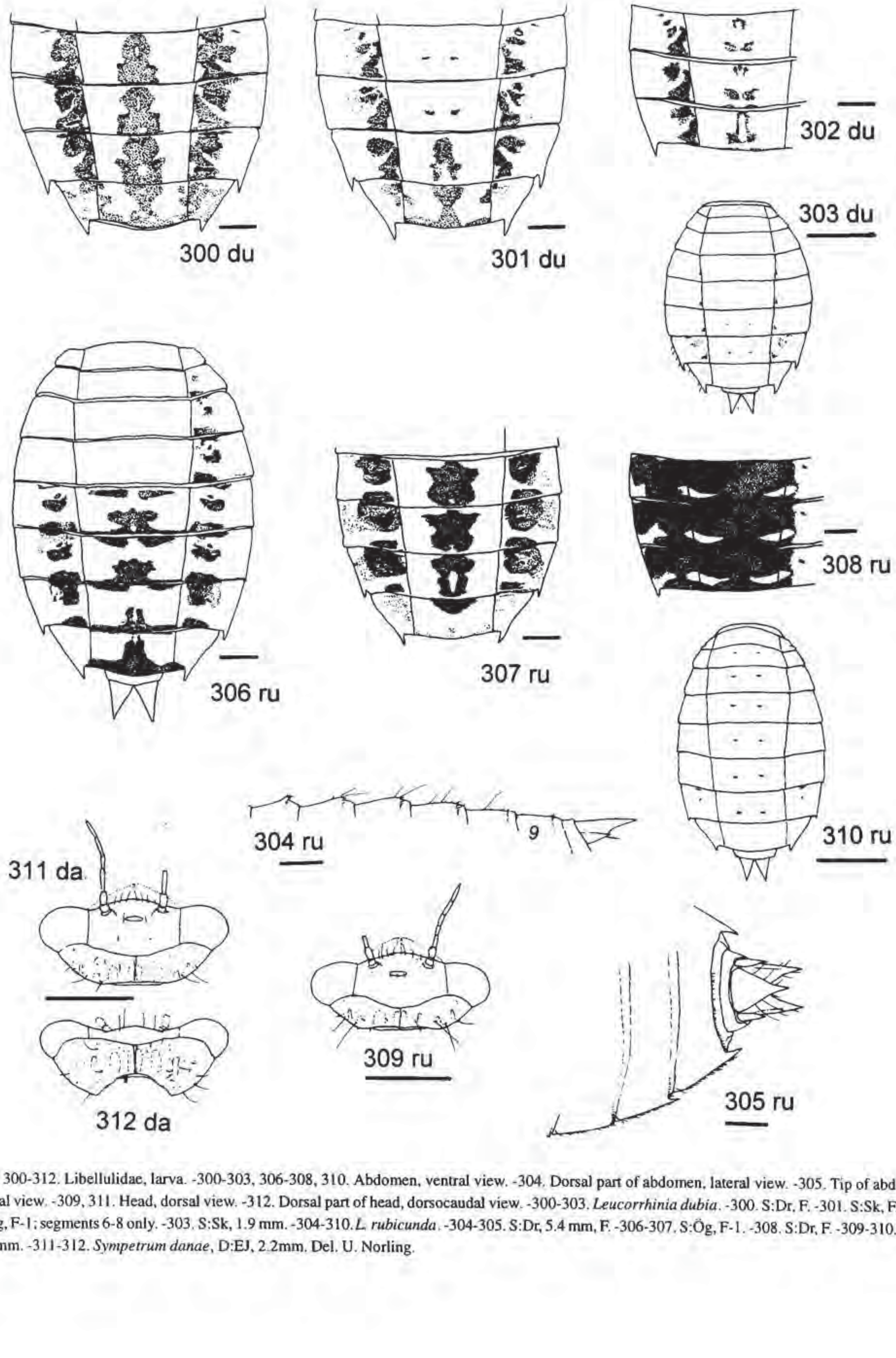
- Neck region of head yellowish 4

3. Lower anal appendages of male straight (Fig. 327). Prothorax of female with a dark patch dorsally (Fig. 328). Common in most stagnant waters...... *L. sponsa*

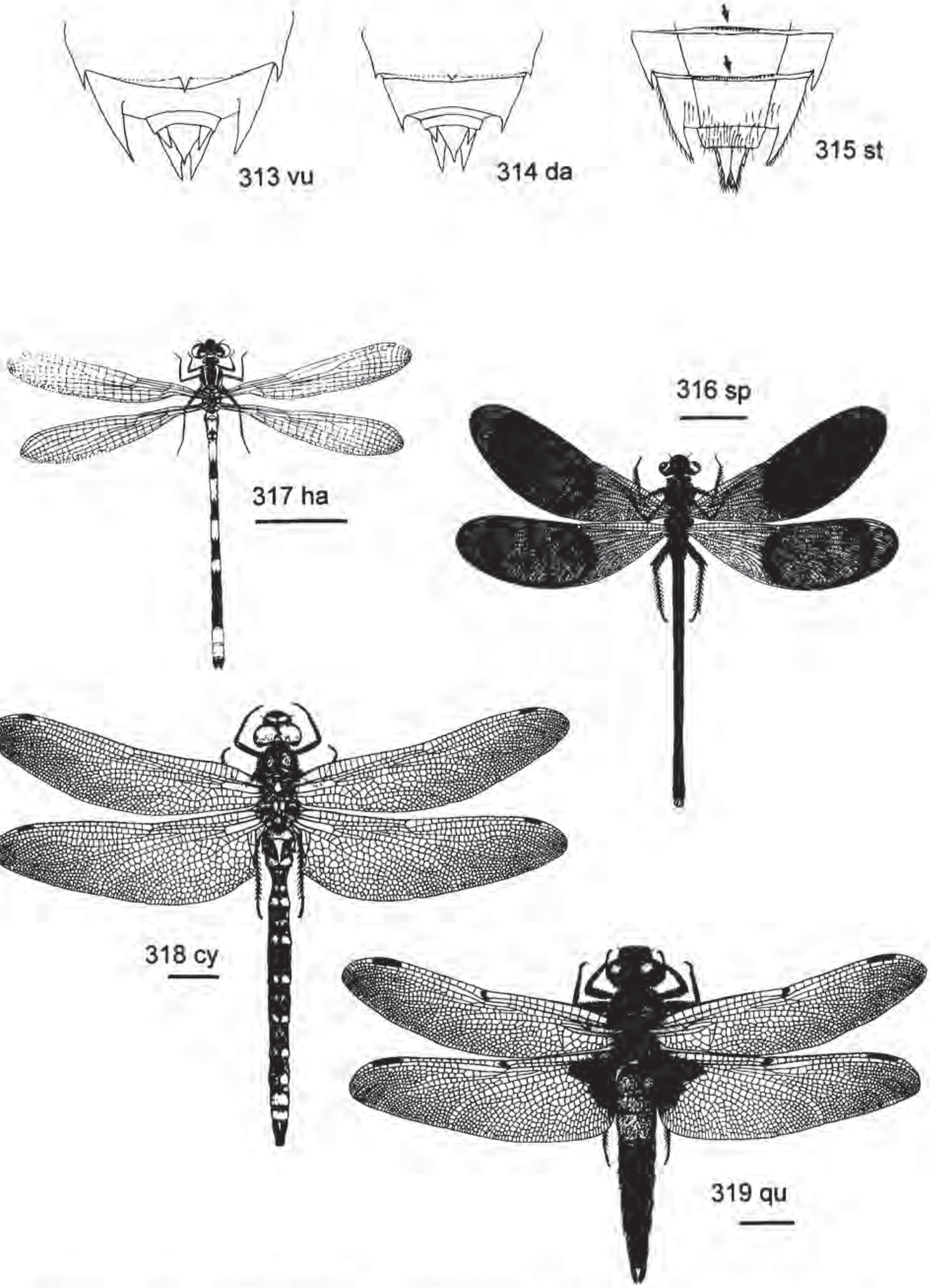
- Lower anal appendages of male widened and curved inwards (Fig. 329). Prothorax of female with dark patches dorsally and laterally (Fig. 330). Often in semi-permanent waters but may choose any type of lake .... *L. dryas*

4. Synthorax golden green. Legs black with yellow lines. Pterostigma dark. Male anal appendages as in Fig. 331. A southern species, rather uncommon .... *L. virens*

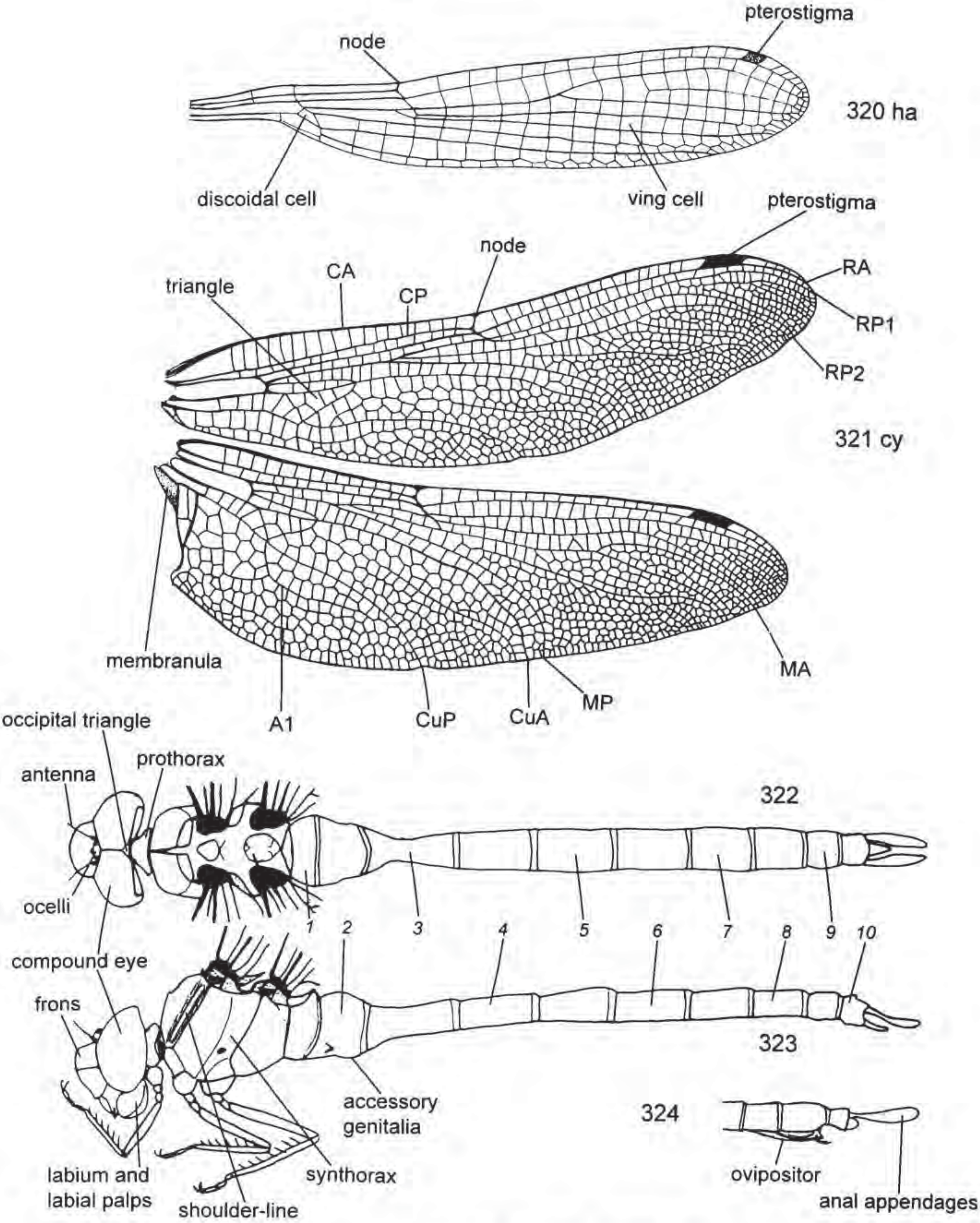
- Synthorax bronze-coloured. Legs mainly brown and yellow. Pterostigma dark with outer third a yellowish white. Anal appendages of male as in Fig. 332. A rare



Figs 300-312. Libellulidae, larva. -300-303, 306-308, 310. Abdomen, ventral view. -304. Dorsal part of abdomen, lateral view. -305. Tip of abdomen, dorsal view. -309, 311. Head, dorsal view. -312. Dorsal part of head, dorsocaudal view. -300-303. *Leucorrhinia dubia*. -300. S:Dr, F. -301. S:Sk, F. -302. S:Ög, F-1; segments 6-8 only. -303. S:Sk, 1.9 mm. -304-310. *L. rubicunda*. -304-305. S:Dr, 5.4 mm, F. -306-307. S:Ög, F-1. -308. S:Dr, F. -309-310. D:EJ, 2.1 mm. -311-312. *Sympetrum danae*, D:EJ, 2.2mm. Del. U. Norling.



Figs 313-319. Odonata, larva (313-315) and adult (316-319). -313-315 Tip of abdomen. -313. *Sympetrum vulgatum*, dorsal view. -314. *S. danae*, dorsal view. - 315. *S. striolatum*, ventral view, arrows indicate "combs" on sternites. -316-319. Dorsal habitus, scale bar 10 mm, del. G. Marklund. -316. *Calopteryx splendens*. -317. *Coenagrion hastulatum*. -318. *Aeshna cyanea*. -319. *Libellula quadrimaculata*. Figs 313-315 redrawn from Heidemann & Seidenbusch (1993).



Figs 320-324. Odonata, adult morphology. -320. *Coenagrion hastulatum*, fore wing. -321-324. *Aeshna*. -321. *A. cyanea*, wings. -322-323. Body in dorsal (322) and lateral view (323). -324. Tip of abdomen, lateral view. Figs 322-323 redrawn from Sandhall (1986), 324 from Sahlén (1986).

migrant found only a few times in the south .... *L. barbarus*

Platycnemididae

Only one species in North Europe; see key to families.

Coenagrionidae

1. Top of head, including neck-region, dark with no colour markings 2
- Top of head including neck-region dark with conspicuous colour markings (spots or lines) on a dark background 3
2. Body colour red, brown and black. No blue markings. A local species at streams and ponds .... *Pyrrhosoma nymphula*
- No red markings on synthorax or abdomen. Large species, often at lakes with sea-lilies .... *Erythromma najas*

Note. Some aberrant females of *Erythromma najas* have coloured spots on their necks, and would key out as *Coenagrion*. However, *Erythromma* always has two rows of cells between wing-veins C and RA outside the pterostigma (Fig. 333), as opposed to the single row of cells in *Coenagrion* (Fig. 334)

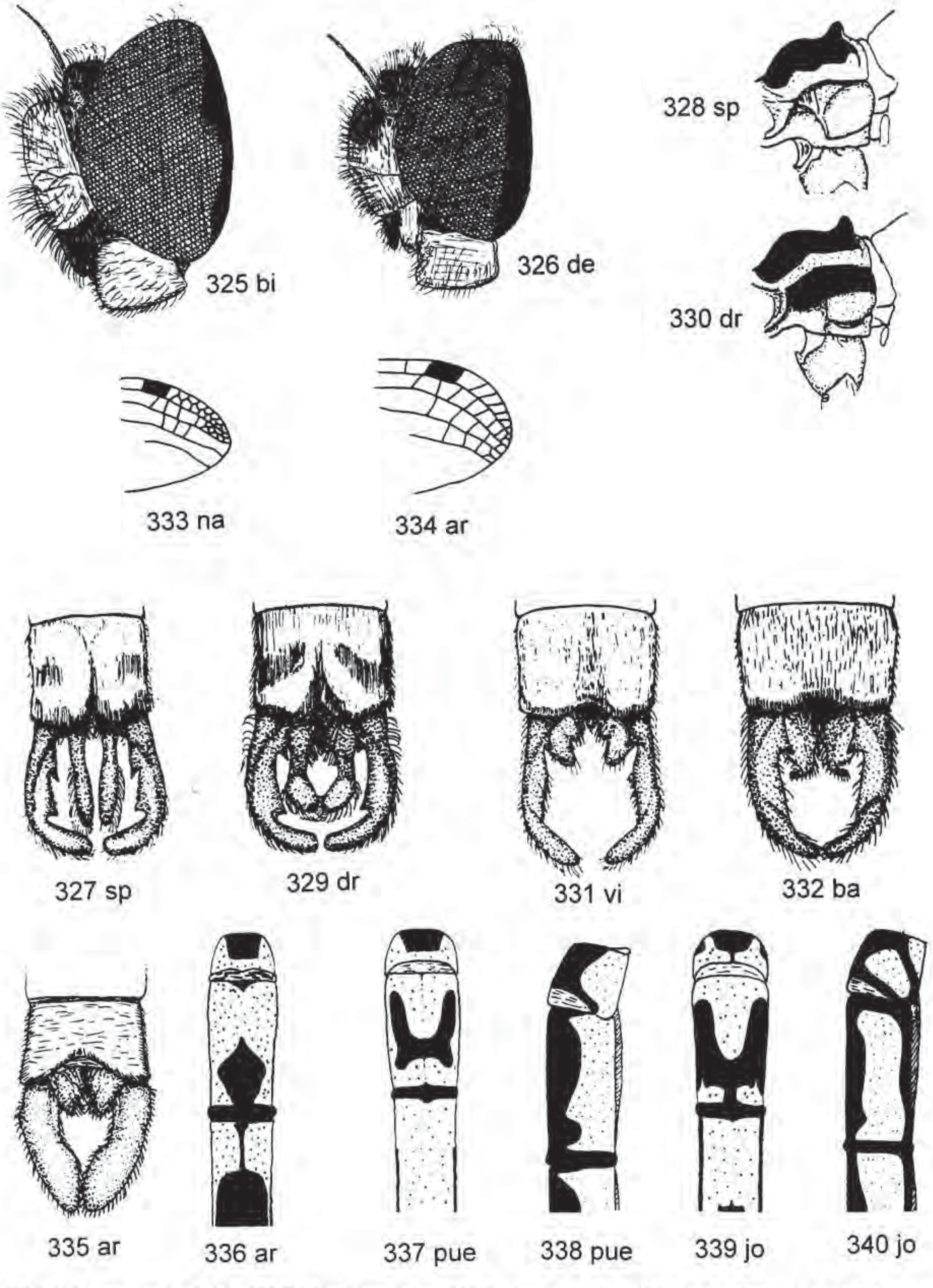
3. A thin blue line runs along the neck of the head. In specimens that have been dried without preserving body colours, this line is virtually invisible. A very rare and very small species (wing length only 12–15.5 mm) with a southern and eastern distribution. Difficult to find except by sweeping the vegetation with a net .... *Nehalennia speciosa*
- Back of head with two light-coloured spots, sometimes united by a thin line 4
4. Round spots on the back of the head *(Ischnura)* 5
- Triangular spots on the back of the head 6
5. Abdominal segment 8 with a coloured marking dorsally. Common in the south at stagnant inland and brackish waters .... *I. elegans*
- Abdominal segment 8 without coloured marking dorsally. A rare species in the south and east, associated with "disturbed" habitats, such as lime-stone quarries and sand pits; often in small numbers coexisting with numerous *elegans* .... *I. pumilio*
6. Light-coloured shoulder-line on synthorax normally at least as wide as the dark lateral line adjacent to it. Abdominal segment 8 of female ventrally with a small, sharp spine (this spine may be blunt in some specimens). Often in stagnant, open waters .... *Enallagma cyathigerum*

Note. In some areas this species may be darker than average, thus reducing the width of the shoulder line. In this case the black marking dorsally on abdominal segment 2 in the male is diagnostic (Fig. 347). Dark specimens may be very small.

- Light-coloured shoulder-line on synthorax narrow, sometimes interrupted or missing entirely. Abdominal segment 8 of female without small, spine-like projection ventrally *(Coenagrion)* 7
7. Lower anal appendages of male large, longer than abdominal segment 10, slightly bent inwards (Fig. 335). Body colour yellow or green and black. Female abdominal segment 2 dorsally with a black rhomboid marking at the posterior border (Fig. 336). Often at vegetation-rich waters. A rather local and very early species .... *C. armatum*
- Lower anal appendages of male of the same size as upper appendages. Female abdominal segment 2 different. Most females have two colour morphs, one with bluish colour on the sides of the abdomen and one with yellow (green) or grey 8
8. Posterior margin of prothorax slightly angled when viewed from above (Fig. 341, side view Fig. 342). Mature male somewhat greenish blue and black. The most common and widespread species of the genus, found in all kinds of ponds and marshes, often in great numbers .... *C. hastulatum*
- Posterior margin of prothorax different (sometimes with 3 separate lobes) 9
9. Central lobe of prothorax large and conspicuous (Figs 343–346) 10
- Prothorax without distinct lobes (similar to Fig. 342 in side view) 11
10. Central lobe of prothorax clearly angled when viewed from the side (Fig. 344). Male blue and black, ventral side conspicuously yellowish-green. Generally rare, but locally common at a wide range of small waters .... *C. lunulatum*
- Central lobe of prothorax almost straight when viewed from the side (Fig. 346). Male dark blue and black. Common at many lakes and ponds but also slow rivers .... *C. pulchellum*
11. Male abdominal segment 2 with a U-shaped black marking dorsally that does not reach the posterior margin of the segment (Fig. 337). Mature males slightly blue-grey. Abdominal segment 2 of female black dorsally (Fig 338). Ventral side of abdomen not black. Common at lakes and ponds but also slow rivers .... *C. puella*
- Male abdominal segment 2 with a U-shaped black marking dorsally that reaches the posterior margin of the segment (Fig. 339). Mature males black, blue and yellow. Abdominal segment 2 of female black dorsally and laterally (Fig. 340). Ventral side of abdomen black. A small, northern species, common at bogs and small oligotrophic lakes .... *C. johanssoni*

Aeshnidae

1. Hind wing with a distinct saffron spot at the base. Body colour brown with a triangular yellow marking dorsally at the base of the abdomen. Southern species .... *Anaciaeshna isosceles*
- Hind wing without such saffron spot 2
2. Abdomen densely pubescent. Found mainly near small, nutrient-rich stagnant waters, but also at slow-running rivers and occasionally at oligotrophic lakes .... *Brachytron pratense*
- Abdomen not pubescent with the exception of some thin hairs on the first segments 3
3. Wing vein RP_2 sharply curved towards vein RP_1 beneath pterostigma (Fig. 348, arrow) 4
- Vein RP_2 not sharply curved *(Aeshna)* 5
4. Sides of abdomen with a thin, distinct longitudinal ridge (Fig. 349; arrow). Synthorax green. Abdomen blue in



Figs 325-340. Odonata, details of adult. -325-326. Head, lateral view. -325. *Epitheca bimaculata*. -326. *Libellula depressa*. -327-328. *Lestes sponsa*. -327. Male anal appendages, dorsally. -328. Female prothorax, laterally. -329-330. *L. dryas*. -329. Male anal appendages, dorsally. -330. Female prothorax, laterally. -331-332. Male anal appendages, dorsally. -331. *L. virens*,. -332. *L. barbarus*. -333-334. Tip of wing in females. -333. *Erythromma najas*. -334. *Coenagrion armatum*. -335. *Coenagrion armatum*, male anal appendages, dorsally. -336-340. Base of abdomen. -336. *C. armatum*, female. -337-338. *C. puella*. -337. Male, dorsally. -338. Female, laterally. -339-340. *C. johanssoni*. -339. Male, dorsally. -340. Female, laterally. Drawn to different scales. Redrawn from Sahlén (1985, 1996).

males, green in females (both with a black dorsal line). Thus far a rare species occurring only in the south-west. Might be expanding northwards .... *Anax imperator*

- Sides of abdomen without a ridge. Body colour light brown. Abdominal segment 2 blue in the male. A migrant species which might be found in the entire area, mostly in the autumn .... *Hemianax ephippiger*

5. Eyes meeting for a distance no longer than the length of the occipital triangle. A small species, common in the north, missing in the extreme south. Prefers boggy areas .... *A. caerulea*

- Eyes meeting for a distance longer than the length of the occipital triangle 6

6. Front of synthorax entirely dark, or with two thin, sometimes interrupted, light-coloured bands 7

- Front of synthorax with two broad, green or yellowish-green bands 12

7. Frons with a sometimes indistinct T-shaped, brown marking dorsally. Wings uniformly brown. Ground colour of body brown. Very common species found at any water with open surroundings, often in large numbers .... *A. grandis*

- Frons with a distinct T-shaped, black marking dorsally. Wings not uniformly brown. Ground colour of body black or very dark brown 8

8. Wing with CA dark. A small southern species. Flight season very late, extending into November ... *A. mixta*

- Wing with CA light-coloured or yellowish brown 9

9. Coloured markings of abdomen relatively large and sometimes fusing. Indistinct white spots often present dorsally on abdominal segments 4–6 (these markings are very diagnostic since they are not present in any other member of the family). A large species confined to brackish waters in Sweden and Finland, and some inland eutrophic lakes in south-central Sweden. Locally common .... *A. osiliensis*

- Coloured markings of abdomen smaller; rarely fusing. No indistinct spots present 10

10. Upper anal appendages of male dentate dorsally. Anal appendages of female with pointed tips. A very large and rare eastern species at small oligotrophic lakes in forested areas .... *A. crenata*

- Upper anal appendages of male not dentate dorsally. Anal appendages of female with rounded tips 11

11. Synthorax laterally with 2 light-coloured bands, and between them a small spot of the same colour (spot sometimes missing). Accessory genitalia as in Fig. 350. Ovipositor as in Fig. 351 – note the size-variation of the appendages. One of the most widespread and common species in the area .... *A. juncea*

- Synthorax laterally with 3 light-coloured spots between the 2 bands; sometimes fusing, forming a third band. Accessory genitalia as in Fig. 352. Ovipositor as in Fig. 353. At bogs or lakes with floating *Sphagnum* or *Drepanocladus* moss .... *A. subarctica*

12. Sides of synthorax uniformly green. A rather uncommon species, often associated with waters supporting a population of *Stratiotes aloïdes* .... *A. viridis*

- Sides of synthorax green and black. A species common in small, shady waters but also in streams .. *A. cyanea*

Gomphidae

1. Head and synthorax green. Eastern species. Rare and local .... *Ophiogomphus cecilia*

- Head and synthorax yellow and black 2

2. Upper anal appendages of male rather straight (Fig. 354). Vulvar scale of female with a narrow incision posteriorly reaching at most half-way into the scale (Fig. 355). At slow running streams or lake shores. Rather uncommon .... *Gomphus vulgatissimus*

- Upper anal appendages of male sharply bent towards each other (Fig. 356). Vulvar scale of female with a very deep incision posteriorly which almost cleaves it (Fig. 357). At stony woodland streams or at more rapid sections of other streams. Canbe very common .... *Onychogomphus forcipatus*

Cordulegastridae

Only one species in North Europe; see key to families.

Corduliidae

1. Hind wing with a dark spot at the base. Triangle in fore wing almost equilateral. Body colour never metallic. A rare species associated with mesotrophic lakes. Often seen patrolling high above the water.......................... .... *Epitheca bimaculata*

- Hind wing without dark spot. Triangle in fore wing different. Body colour metallic green, copper or shiny black 2

2. Frons entirely metallic green or copper-coloured. Male anal appendages as in Fig. 358. Present in a wide range of habitats, mostly standing waters .... *Cordulia aenea*

- Frons metallic green or copper with yellow markings laterally (Figs 364, 365) *(Somatochlora)* 3

3. Yellow markings on frons almost meeting (Fig. 365). Male anal appendages as in Fig. 359. Present in a wide range of habitats, often running waters and larger bodies of standing waters .... *S. metallica*

- Yellow markings confined to lateral parts of frons (Fig. 364) 4

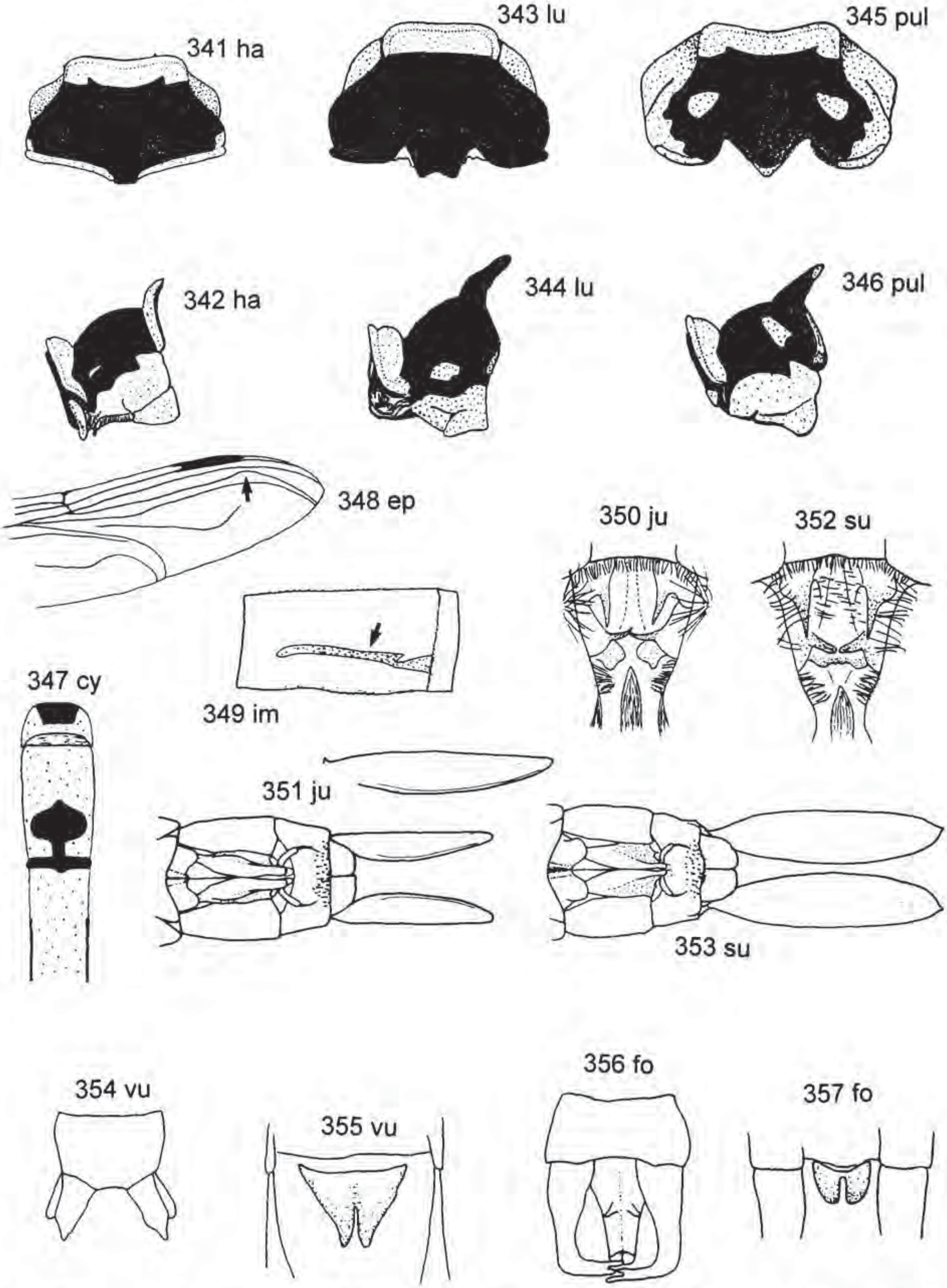
4. Yellow markings present on sides of synthorax and most abdominal segments. Male anal appendages as in Fig. 360. Often seen at bogs and in adjacent forest but also in other habitats .... *S. flavomaculata*

- Yellow markings absent on synthorax but sometimes present at the base of the abdomen 5

5. Upper anal appendages of male as in Fig. 361. Abdomen of female with 2 yellow spots dorsally on segment 3. At bogs or patrolling in forest .... *S. arctica*

- Upper anal appendages of male more sharply bent inwards (Figs 362, 363). Abdomen of female without yellow spots (narrow white areas may be present) 6

6. Anal appendages of male as in Fig. 362. Vulvar scale of female with at most a small notch at the apex (Fig. 366). A northern species found at bogs or small tarns .... *S. alpestris*



Figs 341-357. Odonata, details of adult. -341, 343, 345. Prothorax dorsally. -342, 344, 346. Prothorax laterally. -341-342. *Coenagrion hastulatum*. -343-344. *C. lunulatum*. -345-346. *C. pulchellum*. -347. *Enallagma cyathigerum*, male, base of abdomen, dorsally. -348. *Hemianax ephippiger*, wing venation. -349. *Anax imperator*, lateral ridge on abdominal segment 6. -350, 352. Male accessory genitalia ventrally. - 351, 353. Female ovipositor and abdominal appendages ventrally. -350-351. *Aeshna juncea*, the variation in size of the anal appendages is shown in Fig. 351. -352-353. *A. subarctica*. -354, 356. Male abdominal appendages, dorsally. - 355, 357. Female vulvar scale, ventrally. -354-355. *Gomphus vulgatissimus*. -356-357. *Onychogomphus forcipatus*. Drawn to different scales. Redrawn from Sahlén (1985, 1996), Sandhall (1986) and originals by G. Sahlén.

- Anal appendages of male as in Fig. 363. Vulvar scale of female with a deep incision at the apex (Fig. 367). A rare species found only at tundra bog-pools at or above the arctic tree-line .... *S. sahlbergi*

Libellulidae

1. Frons white, or nearly so. Hind wing always with a dark spot at the base. Species usually found early in the season *(Leucorrhinia)* 2
- Frons differently coloured. Hind wing sometimes with a dark spot near the base. Both early and late species 6
2. Anal appendages completely or partly white. Males without red markings. Mature males often pruinescent 3
- Anal appendages black. Males with red markings, never pruinescent 4
3. Labial palps partly white. Male pterostigma black. Often at shallow waters with abundant floating vegetation .. .. *L. albifrons*
- Labial palps black. Male pterostigma white. At waters with abundant floating vegetation often in woodlands .... *L. caudalis*
4. Fore wing at the base with a dark spot that covers most of the wing cell adjacent to the membranula. The smallest species of the genus. Very common at acid waters with *Sphagnum* moss .... *L. dubia*
- Fore wing at the base with a dark spot that covers only a small portion of the wing cell adjacent to the membranula 5
5. Abdominal segment 7 with a yellow spot dorsally. A large species, found at vegetation-rich waters in the south and east. Locally common .... *L. pectoralis*

Note. The yellow spot may be difficult to use in very young females where all light markings on the body appear to be yellow. In this case the shape of the spot is diagnostic. In other *Leucorrhinia* the spot is longer than wide, but in this species it is about as long as wide.

- Dorsal spot on abdominal segment 7 red or brown, not yellow. Similar to and often coexisting with *L. dubia* in acid waters. Very common .... *L. rubicunda*
6. Wing with RP_2 and/or CuA somewhat winding (Fig. 319). Large species, often with wide abdomens. Males often with blue pruinescence. Wings hyaline or with dark spots at the bases 7
- Wing with RP_2 and/or CuA not or just slightly winding (Fig. 368). Small, thin-bodied, often red. Commonly found in open areas from July onwards. Wings never with dark spots but sometimes with orange spots *(Sympetrum)* 11
7. Wings with dark markings at bases *(Libellula)* 8
- Wings without dark markings *(Orthetrum)* 10
8. Wings with dark markings at the nodes and at bases on hind wings. Mature male without pruinescence. Common at all kinds of stagnant waters and slow rivers .... *L. quadrimaculata*
- Wings with dark markings only at the bases 9
9. Dark markings on fore wings reaching triangle. Mature male with blue pruinescence. Locally occurring at many different habitats, often small ponds and newly dug ditches. Never in great numbers .... *L. depressa*
- Dark markings on fore wings not reaching triangle. Mature male with blue pruinescence. A rare, southern species at running and standing waters .... *L. fulva*
10. Pterostigma yellow. At streams, sometimes at small lakes .... *O. coerulescens*
- Pterostigma dark. At lakes and at the Baltic sea coast . ... *O. cancellatum*
11. Legs dark with a light-coloured line laterally 12
- Legs completely black 14
12. Hind wing with a large orange spot at the base. Common at many different types of standing water. Earliest species in the genus (June onwards) .... *S. flaveolum*

Note. In some rare cases this spot may be reduced in size but it still covers a larger proportion of the wing than in the following two species.

- Hind wing without a large spot 13
13. Frons with a short black line on top, between antennae (Fig. 369). Fairly uncommon species. Seems to prefer coastal areas .... *S. striolatum*
- Black line of frons reaching down the sides along the margin of the eyes (Fig. 370). Common at all kinds of standing waters .... *S. vulgatum*
14. Upper anal appendages of male black. Vulvar scale of female pointing downwards. Front of synthorax brown with a clearly triangular, black section in the centre. Mature male black. Smallest species in the genus, particularly common at bog pools and forest tarns .... *S. danae*
- Upper anal appendages of male yellowish. Vulvar scale of female pointing backwards, pressed to the underside of the abdomen. Front side of synthorax brown with a thin, black line in the centre. Common at many types of lakes and slowly running waters ..... *S. sanguineum*

Acknowledgements

It would not have been possible to produce this key without material kindly provided by a number of colleagues.

The contributions of Hans Olsvik, Norway, have been of particular impact. He kindly put a unique material from northern Norway at our disposal, among other things containing all the northern *Somatochlora* species in various sizes. He also sent a large material from southern Norway, the full utilisation of which our deadline did not permit. He also unselfishly let us benefit from his eminent collecting skills during common excursions elsewhere.

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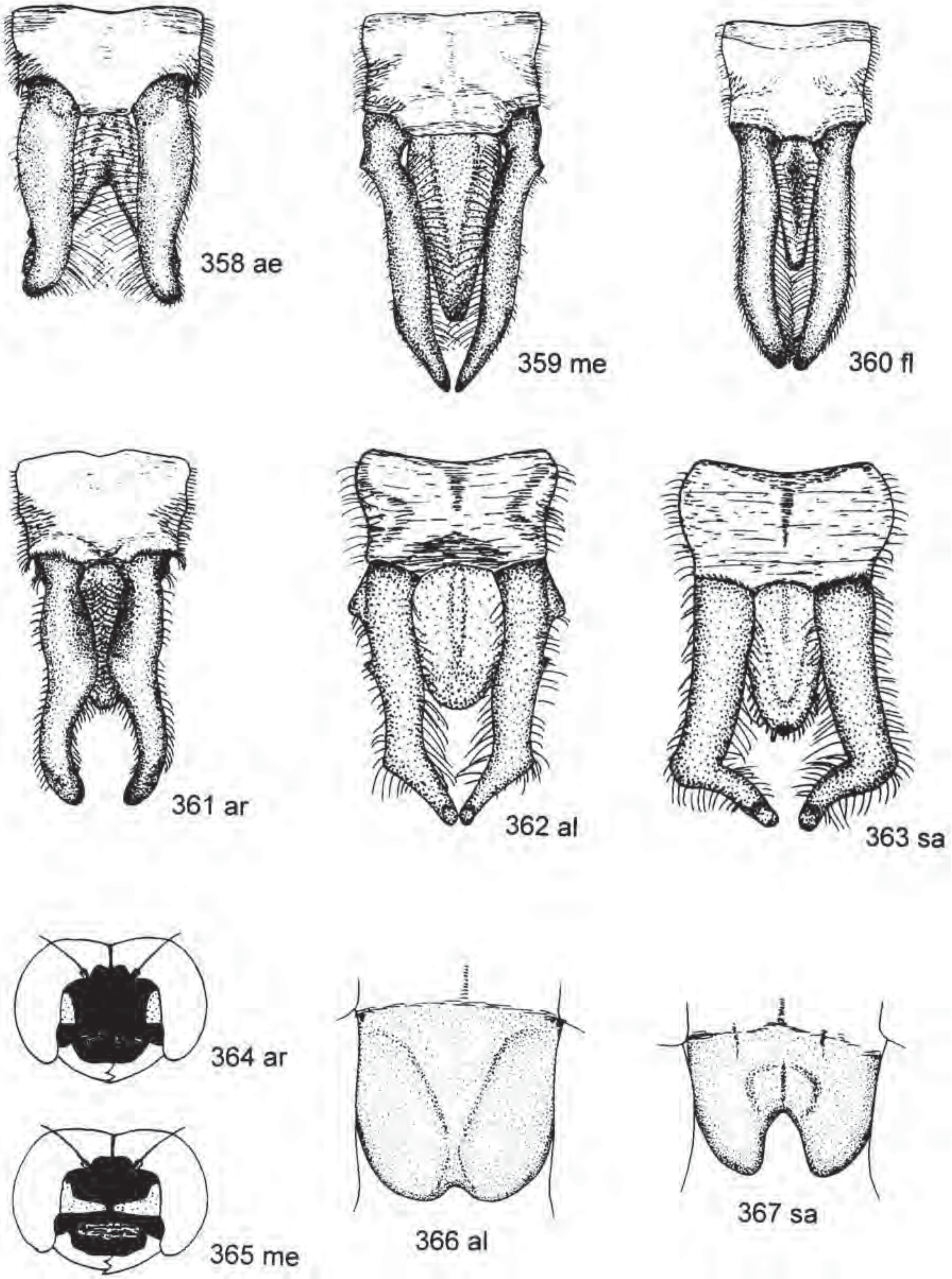
Anders Nilsson, Sweden, also lent us some northern material, in particular *Ophiogomphus cecilia*. He also showed great patience while putting up with the perpetual delays in our work with the key.



Figs 358-367. Corduliidae, details of adult. -358-363. Male abdominal appendages, dorsally. -358. *Cordulia aenea*. -359. *Somatochlora metallica*. -360. *S. flavomaculata*. -361. *S. arctica*. -362. *S. alpestris*. -363. *S. sahlbergi*. -364-365. Head anteriorly. -364. *S. arctica*. -365. *S. metallica*. -366-367. Female vulvar scale, ventrally. -366. *S. alpestris*. -367. *S. sahlbergi*. Drawn to different scales. Redrawn from Sahlén (1985, 1996).

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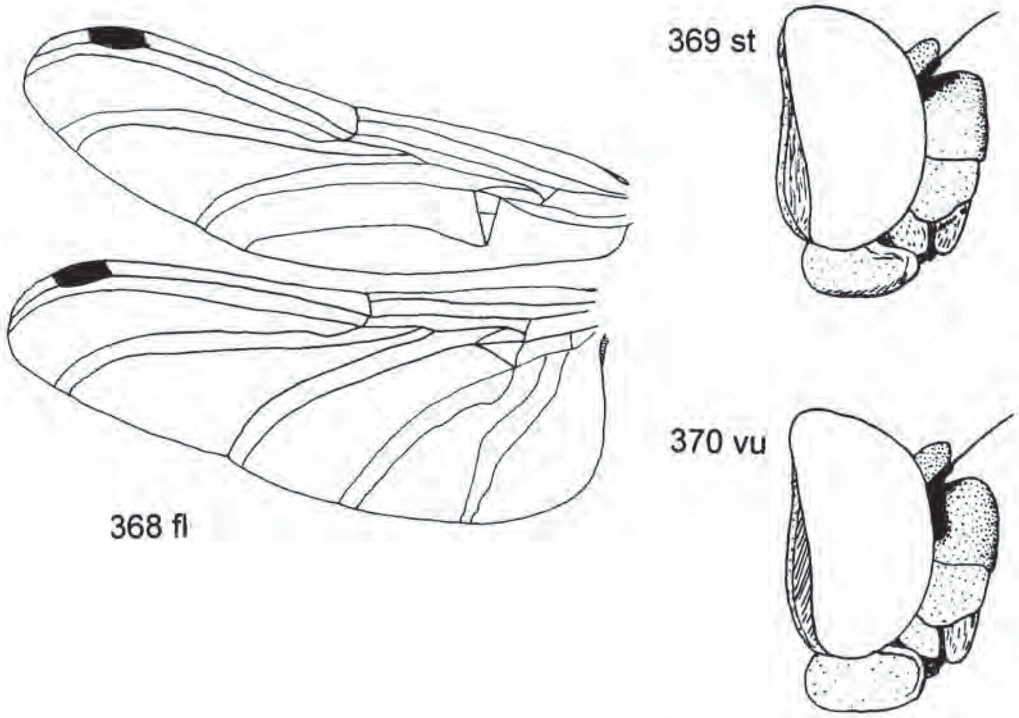

Figs 368-370. *Sympetrum*, details of adult. -368. *Sympetrum flaveolum*, wing venation. -369-370. Head laterally. -369. *S. striolatum*. -370. *S. vulgatum*. Drawn to different scales. Redrawn from Sahlén (1985, 1996) and original by G. Sahlén.

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Check list

[Parts of North Europe coded as: D= Denmark, N= Norway, S= Sweden, F= Finland, K= Fennoscandian parts of Russia, I= Iceland; no records are known from Faroes or Svalbard. Small, dark specimens of *Sympetrum striolatum* from western N and Åland in F are sometimes referred to as *Sympetrum nigrescens* Lucas, 1912, but the taxonomic status of this form is not clear.]

Zygoptera

Calopterygidae

Calopteryx virgo (Linné, 1758) .... DNSFK
C. splendens (Harris, 1789) .... DNSFK

Lestidae

Lestes sponsa (Hansemann, 1823) .... DNSFK
L. dryas (Kirby, 1890) .... DNSFK
L. virens vestalis (Rambur, 1841) .... DS
L. barbarus (Fabricius, 1798) .... DS
Sympecma fusca (Vander Linden, 1839) .... S

Platycnemididae

Platycnemis pennipes (Pallas, 1771) .... DNSFK

Coenagrionidae

Pyrrhosoma nymphula (Sulzer, 1776) .... DNSFK
Erythromma najas (Hansemann, 1823) .... DNSFK
Coenagrion armatum (Charpentier, 1840) .... DNSFK
C. hastulatum (Charpentier, 1825) .... DNSFK
C. lunulatum (Charpentier, 1840) .... DNSFK
C. pulchellum (Vander Linden, 1823) .... DNSFK
C. puella (Linné, 1758) .... DNSFK
C. johanssoni (Wallengren, 1894) .... NSFK
Enallagma cyathigerum (Charpentier, 1840) .... DNSFK
Ischnura elegans (Vander Linden, 1823) .... DNSFK
I. pumilio (Charpentier, 1825) .... DSF
Nehalennia speciosa (Charpentier, 1840) .... DSF

Anisoptera

Aeshnidae

Aeshna caerulea (Ström, 1783) .... NSFK
A. juncea (Linné, 1758) .... DNSFK
A. subarctica Walker, 1908 .... DNSFK
A. grandis (Linné, 1758) .... DNSFK
A. viridis Eversmann, 1836 .... DSFK

A. osiliensis Mierzejewski, 1913 .... (N)SF
(*serrata* Hagen, 1856)
A. crenata Hagen, 1856 .... FK
A. cyanea (Müller, 1764) .... DNSFK
A. mixta Latreille, 1805 .... DS
Anaciaeschna isosceles (Müller, 1767) .... DS
Brachytron pratense (Müller,1764) .... DNS
Hemianax ephippiger (Burmeister, 1839) .... D(N)SI
Anax imperator Leach, 1815 .... D

Gomphidae
Gomphus vulgatissimus (Linné, 1758) .... DNSFK
Onychogomphus forcipatus (Linné, 1758) .... DNSFK
Ophiogomphus cecilia (Fourcroy, 1785) .... DSF
[*serpentinus* (Charpentier, 1825)]

Corduleagstridae
Cordulegaster boltoni (Donovan, 1807) .... DNSFK

Corduliidae
Cordulia aenea (Linné, 1758) .... DNSFK
Somatochlora metallica (Vander Linden, 1825) .... DNSFK
S. arctica (Zetterstedt, 1840) .... DNSFK
S. alpestris (Selys, 1840) .... NSF
S. flavomaculata (Vander Linden, 1825) .... DNSF
S. sahlbergi Trybom, 1889 .... NSF
Epitheca bimaculata (Charpentier, 1825) .... DNSF

Libellulidae
Leucorrhinia dubia (Vander Linden, 1825) .... DNSFK
L. albifrons (Burmeister, 1839) .... DNSFK
L. caudalis (Charpentier, 1840) .... DNSFK
L. rubicunda (Linné, 1758) .... DNSFK
L. pectoralis (Charpentier, 1825) .... DNSFK
Libellula depressa Linné, 1758 .... DNSFK
L. fulva Müller, 1764 .... DSF
L. quadrimaculata Linné, 1758 .... DNSFK
Orthetrum cancellatum (Linné, 1758) .... DNSFK
O. coerulescens (Fabricius, 1798) .... DNSFK
Sympetrum striolatum (Charpentier, 1840) .... DNSFK
S. vulgatum (Linné, 1758) .... DNSFK
S. flaveolum (Linné, 1758) .... DNSFK
S. danae (Sulzer, 1776) .... DNSFK
S. sanguineum (Müller, 1764) .... DNSFK