

## THE LARVAE OF THE EUROPEAN AESHNIDAE (ANISOPTERA)

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The larvae or final instar exuviae of 19 spp. currently recorded from Europe and its environs are described and compared. A key, which could be used in the field to obtain reliable determination in the majority of spp., is included.

### INTRODUCTION

Most larvae/exuviae of the European species of the family Aeshnidae have been described separately, but so far keys have mainly been regional, i.e. northern European, or national in their coverage. The SE part of Europe, bordered and influenced by the Asian land bridge of Turkey and its adjacent islands, is less well documented. Although the area of distribution of species such as *Anax immaculifrons* is outside Europe, its presence is well established in two areas and possibly awaits discovery in others.

A field key has been constructed and this can be used with both larvae and exuviae *in situ* and therefore it will be particularly useful when dealing with scarce species or when constrained by restrictions on "collecting" in certain areas/sites. There are always a few specimens which defy the existing keys and this fact underlines the value of rearing out adults. This has been accomplished by myself with all species except *Anax parthenope*, *A. immaculifrons* and *Hemianax ephippiger*, in which cases accredited specimens have been examined and reliable literature used.

In literature it is not always clear whether references are to larvae or exuviae and in this respect remarks below can be assumed to apply to both unless stated otherwise.

The following descriptions are mainly for the species of *Aeshna*, as the other genera are quite easily separated. *Anaciaeschna isosceles* has been included alongside the genus *Aeshna*, as the larvae are very similar and the main separation fea-

ture (the long epiproct), is also present in specimens of *A. subarctica* and *A. mixta* (Figs 10, 17). The sequence of the generic listing is in accordance with DAVIES & TOBIN (1985).

#### COLOUR/MARKINGS

Most species have light and dark forms; with larvae this may be related to micro-habitat as variations in colour occur at the same site. Of all species included, *Aeshna grandis* shows the widest variety of colouration. The length of exposure to sunlight can interfere with the normal colour of exuviae (see SCHMIDT, 1936). All species of the Aeshnidae appear to have the "dazzle striping" (ROWE, 1987) in very early instars.

#### SIZE

Maximum/minimum published total lengths of final instars are quoted. There is considerable individual variation and overlapping between related species of larvae. Exuviae are also affected by weathering (SCHMIDT, 1936) and telescoping, so when one uses abdominal spine lengths in identification one should bear this in mind. Any use of this latter feature refers to the length a spine overlaps the margin of a posterior segment (Figs 8, 10, 11, 12, 15, 35, 40, 43).

#### HEAD

The shape of the head is used to separate the *Aeshna* from *Boyeria*, *Brachytron* and *Anax*. One species of *Aeshna*, *A. caerulea* has six-segmented antennae (Fig. 6); the others have seven, although segments 6 and 7 are sometimes difficult to distinguish (ASKEW, 1988). There are markings present in the ocellar region which separate *A. crenata* and *A. cyanea* larvae from others (Figs 13, 19). In the post-ocular region consistent markings (Figs 22, 23) can be used to separate *A. grandis*, a species which is otherwise problematical.

Two types of labium can be distinguished: those tapering to a narrow base (Figs 3, 45) and those which are more rectangular in outline. The former category includes *A. caerulea*, *A. cyanea*, *A. mixta* and *A. affinis*, whilst *A. juncea* and *A. subarctica* are examples of the latter. Other species show gradation between the two shapes.

#### SUPRACOXAL ARMATURE

Care has to be exercised in the objective use of this feature (ASKEW, 1988). However, it is distinct in species such as *A. isosceles* (Fig. 16), *A. mixta* and *A. affinis* (Fig. 2) and in *Caliaeschna* (Fig. 24), *Boyeria* (Fig. 29), *Anax*, *Hemianax*

(Fig. 36) and *Brachytron* (Fig. 34) and can be used as a secondary separation character.

#### LEGS

The shortness of the femur on the foreleg of *A. subarctica* is a useful character if specimens of *A. juncea* are available for comparison, (though as a rough guide the femur is always shorter than the distance from the centre of the ocellus to the outside of the eye in the former species). Banding on the legs is most marked in *A. cyanea* and *A. grandis*, whilst *A. juncea*, *A. caerulea* and *A. subarctica* show the least; individuals of other species show considerable variation between the two extremes.

#### ABDOMEN

The dorsal markings on each segment were divided into three areas by SCHMIDT (1936) with particular reference to *A. grandis*: (a) a central area where dark patches and flecking surround a pale median stripe; – (b) on each side of the above the medio-lateral area; – (c) outside the latter the lateral area.

The above markings and puncta are present in many of the following species (Figs. 1, 5, 12, 21, 47), though not with enough consistency to be used as a primary separation character, except in *A. viridis* (Fig. 21), which shows no colour pattern on its dorsal surface. The fleckings are processes on the surface of the abdomen which appear slightly darker. In *A. juncea* and *A. subarctica* the central area is usually flanked on either side by a pale stripe running as far as segment 7. *A. caerulea* has especially dark flecks in the central area on segments 7 and 8 (Fig. 5), this marking reaches segment 8 in *A. mixta*, whilst in *A. affinis* the central marking is extended onto segment 9 (Fig. 1). The species which has the greatest variety of markings is *A. grandis*. *B. pratense* has a small dorsal spine on segment 9 (Fig. 35) and *B. irene* has a cream triangular mark on segment 8.

#### LATERAL SPINES

Most of the species of *Aeshna* have spines on only 6-9 (*A. affinis* [Fig. 1], *A. cyanea*, *A. grandis*, *A. isosceles*, *A. mixta*, *A. serrata* [Figs 11, 12] and *A. viridis* [Fig. 21]), or on only 7-9 (*A. caerulea* [Fig. 5], *A. juncea* and *A. subarctica*). *A. crenata* (Fig. 15) has spines on segments 4-9. The other genera are: *B. irene* 5-9, *C. microstigma* 6-9, *Anax* and *Hemianax* 7-9 (but *A. immaculifrons* 6-9, Fig. 47).

Vestigial spines may be seen on an anterior segment in some individuals and it is not always possible to decide what constitutes a "spine" even when viewing in lateral aspect (Fig. 15). The length of a spine on segment 9 relative to segment 10 is affected by the amount of telescoping between segments (as already stated), but

may be useful when comparing *A. mixta* with related species.

#### ANAL APPENDAGES

The epiproct has a distal margin which is considered to be either concave (*A. affinis* [Fig. 1], *A. cyanea*, *A. isosceles* [Fig. 18] *A. mixta* [Fig. 4]), or bifid (*A. caerulea* [Fig 5], *A. crenata* [Fig. 14], *A. grandis*, *A. juncea*, *A. serrata* [Fig. 12] and *A. subarctica*). The dorsal keel of the epiproct however makes it difficult to decide whether it is as simple as this. The lateral points on the distal end of the epiproct of *A. crenata* (Fig. 14) are very long and unmistakable. *Caliaeschna* larvae (Figs 25, 26) have an epiproct with a single spine. *Boyeria* species have an acute angle between the side spines, *Brachytron pratense* (Fig. 35) has an almost straight distal margin with very small side spines, whilst species of *Anax* (Figs 42, 46), though similar in this respect to species of *Aeshna* species, can show considerable intraspecific variation.

The male projection provides a reliable separation character between *A. imperator* and *A. parthenope* and is noticeably nipple-shaped in *A. serrata* (Fig. 12), being less pronounced in related species.

The cerci are longest in two species: *A. isosceles* (Fig. 17) and *A. subarctica* (Fig. 10), but even in these two species there are gradations and the related species cannot always be separated from the above on this character. Furthermore, earlier instars of both species do not always have such long cerci. Most appendages are equal in length to segments 10 and 9, except for *A. crenata* (Fig. 15) where the appendages are equal to segments 10, 9 and 8. The cerci of *Caliaeschna* are sexually dimorphic, whereas females of *B. irene* have either long or short cerci.

#### SPECIES DESCRIPTIONS

These are arranged in genera: first the groups of related species of *Aeshna*, followed by the other genera. Names in brackets refer to similar species which may occur in the same habitat.

##### *AESHNA AFFINIS* VANDER LINDEN

Figures 1-2

[*A. mixta*]

*Material*. – 10 larvae, 8 final instar exuviae: Brenne and Pouilly sur Loire, France.

The mid to light brown colour of this larva is paler than that of *A. mixta*. Also, the overall body shape is generally more delicate, with a pronounced waist at the first three segments, which then swells out to segments 6 and 7, finally tapering to segments 8, 9 and 10 and the anal appendages (Fig. 1).

The head of *A. affinis* bears similar markings to *A. mixta*: the ocelli are highlighted, though some specimens have a small pale oval-shaped mark in front of the

anterior ocellus. At the back, there are also pale margins around the longitudinal post-occipital suture as in *A. mixta*.

The labium is different from *A. mixta* in being shorter (only  $3\frac{1}{2} \times$  longer than broad). Also unlike *A. mixta* there is no marked tooth on the distal margin of the labial palp.

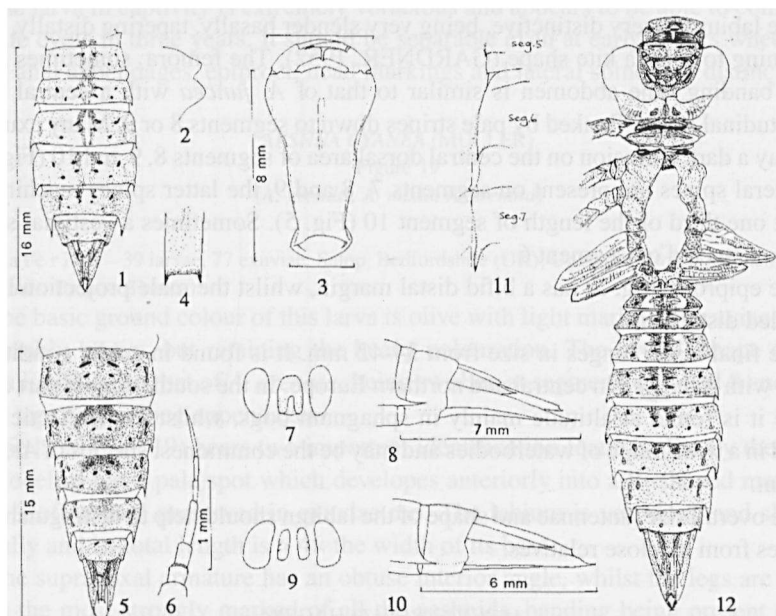
The supracoxal armature (Fig. 2) is similar to that of *A. mixta*, the lobes being very blunt and often difficult to detect.

The dorsal abdominal markings (Fig. 1) provide another difference, as the central dark band has a fine pale longitudinal line within it, whereas in *A. mixta* it does not appear to be a continuous line, but rather a series of dark blotches. These markings also are continued further down the abdomen, appearing as definite marks on segment 8 and sometimes continuing faintly onto segment 9.

Lateral spines are present on segments 6-9, the latter reaching about  $\frac{2}{3}$  length of segment 10.

The anal pyramid is similar to that of *A. mixta*, but the female ovipositor reaches approximately  $\frac{1}{2}$  way down seg. 10 in the final exuviae. The length of the final instar ranges from 29-38 mm.

The observed larval habitats were well weeded, sometimes temporary, waterbodies



Figs 1-12. Structure features of the European aeshnid larvae [in dorsal view, unless otherwise stated]: (Figs 1-2) *Aeshna affinis*: (1) abdomen; - (2) supracoxal armature. - (Figs 3-4) *Aeshna mixta*: (3) labium; - (4) distal margin of epiproct. - (Figs 5-6) *Aeshna caerulea*: (5) abdomen; - (6) RH antenna. - Figs (7-8) *Aeshna juncea*: (7) male genitalia, seg. 9; - (8) anal appendages, lateral view. - (Figs 9-10) *Aeshna subarctica*: (9) male genitalia, seg. 9; - (10) anal appendages, lateral view. - (Figs 11-12) *Aeshna serrata*: (11) segments 5-7 in dorso/lateral view; - (12) habitus.

in south and central Europe. Generally speaking, it is a scarce species, but may be locally abundant. Small larvae were obtained from central France and reared out in 1986. They were extremely aggressive feeders and consumed prey much larger than themselves, launching themselves towards food by jet propulsion, even emerging out of the water at times. Larvae were able to detect movements occurring over a metre away from their breeding tanks.

Some relatively small larvae (30 mm) produced adults of around 55 mm length, with a wingspan on average 10 mm less than normal.

*AESHNA CAERULEA* (STRÖM)

Figures 5-6

[*A. cyanea*, *A. juncea*, *A. subarctica*]

Material. – 17 larvae, 20 exuviae: Kevo (Finland), Silverflowe (Scotland).

The larva varies in colour from dark green to mid brown, whereas the exuviae is exclusively brown. The overall shape is delicate with a definite “waisting” at the first three segments. The head bears pale ocellar markings, but the antennae (Fig. 6) are unique amongst the European species of this genus, consisting of 6 rather than 7 segments, the sixth being extremely long and showing no sign of division.

The labium is very distinctive, being very slender basally, tapering distally, then widening to form a kite shape (GARDNER, 1952). The femora sometimes have faint banding. The abdomen is similar to that of *A. juncea* with a central dark longitudinal stripe flanked by pale stripes down to segments 8 or 9. Many exuviae display a dark suffusion on the central dorsal area of segments 8, 9 and 10 (Fig. 5).

Lateral spines are present on segments 7, 8 and 9, the latter spines reaching to about one third of the length of segment 10 (Fig. 5). Sometimes a vestigial spine can be detected on segment 6.

The epiproct (Fig. 5) has a bifid distal margin, whilst the male projection has a rounded distal edge.

The final instar ranges in size from 34-42 mm. It is found in acidic conditions often with *A. juncea* in central and northern Europe. In the southernmost part of its range it is found at altitude mainly in sphagnum bogs, whilst in the Arctic it is found in a wide range of waterbodies and may be the commonest species of *Aeshna* present.

The overall size, antennae and shape of the labium should help to distinguish this species from its close relatives.

*AESHNA CRENATA* HAGEN

Figures 13-15

[*A. grandis*]

Material. – 12 larvae, 21 exuviae: Jaala (Finland).

The colour of this rare NE European species is light tan, with pronounced fleckings

on the dorsal surface of the abdomen. This latter is distinctively cigar-shaped, being extremely slender at the 3rd and 4th segments, swelling out to the 7th segment and then tapering finally to the extremely long and slender anal appendages. Most diagnostic features of this species can be recognised even at early instars.

The head (Fig. 13) bears a distinctive pale bell-shaped mark, which extends forward from the anterior ocellus. Again this is present in early instars. The labium is very long and the hinge rests between the 2nd and 3rd pair of legs. The supracoxal armature has an internal angle which curves outwards to its points and all femora are all slightly banded.

Unlike all other European aeshnids, there are lateral spines present on segments 4-9 (Fig. 15), those on 4 being tiny, whilst those on 5 are clearly developed, even on early instars such as F-5. The anal pyramid is very long ( $\approx$  segments 8, 9 and 10 together). The epiproct (Fig. 14) is distinctive, having a distal margin which is deeply excavated.

*A. crenata* is the longest European *Aeshna* species, ranging in length from 49-54 mm. It appears to be mainly confined to forested sphagnum habitats in Russia and South Eastern Finland, where its distribution seems to be currently stable (Dr M. Hämäläinen, pers. comm.).

The larva in captivity is extremely voracious and appears to be able to complete its life cycle in three years. It should be separable even at early instars where the long anal appendages, epiproct, head markings and lateral spines are distinctive.

#### *AESHNA CYANEA* (MÜLLER)

Figure 19

[*A. grandis*, *A. mixta*, *A. crenata*]

**M a t e r i a l.** – 39 larvae, 77 exuviae: Salop, Bedfordshire (UK); Ugglarp Fultofta (Sweden); Jaala (Finland), Brenne (France).

The basic ground colour of this larva is olive with light marbling, exuviae being invariably brown, but retaining the heavy colouration. The overall shape of the larva is similar to that of *A. crenata*, being swollen at segments 6, 7 and 8 and also then tapering to long appendages.

The head (Fig. 19) bears two important identification features. Firstly the anterior ocellus has a pale spot which develops anteriorly into a W-shaped marking, this is often well preserved in exuviae too. The labium is very long and slender basally and its total length is  $> 4\times$  the width of its base.

The supracoxal armature has an obtuse interior angle, whilst the legs are probably the most strongly marked of all the aeshnids, banding being present on all femora and coxae. The dorsal abdominal pattern is also amongst the most marked of all (reminiscent of the Anactinae), the central longitudinal line being flanked by sinuous pale stripes. The darker areas lateral to these stripes have faint pale marbling continuing to the lateral margins.

Lateral spines are present on segments 6-9, those on 9 reaching to about halfway

down segment 10. The anal pyramid > length of segments 9 and 10 together. The distal margin of the epiproct is concave and the female ovipositor reaches the margin of the 9th sternite.

This large aeshnid has a final instar which ranges in size from 38-50 mm. It appears to inhabit a wide range of water bodies from eutrophic temporary pools to sphagnum bogs (though never common there) and is a pioneering colonizer of small garden ponds, where the larvae can be found in great numbers. It is rarely found at altitude and not inside the Arctic Circle.

The large size of the final instar, together with its head pattern, labium and banded legs should help distinguish it from similar species, whilst the supracoxal armature will distinguish it from *A. mixta*.

*AESHNA GRANDIS* (L.)

Figures 22, 22

[*A. viridis*, *A. serrata*, *A. crenata*]

**M a t e r i a l.** – 31 larvae, 74 exuviae: Shropshire, Bedfordshire (UK); Ugglarp, Furingstad (Sweden); Jaala, Luvia (Finland).

This is the most difficult of the European aeshnids to distinguish as its colouration, markings and spination are extremely varied throughout Europe. It has been recorded cohabiting with all of the other species of *Aeshna* in a variety of habitats across eastern and central Europe from Lapland almost to the Mediterranean coast.

Two main colour extremes occur: a purple/black, heavily marked and spinous type and another type which is more finely marked and less spiny. In England the darker form may be found amongst leaf litter, sometimes in semi-polluted habitat. The lighter form appears to be the commoner sort in northern Europe and is more likely to be confused with other species such as *A. viridis*. Between these two types exist several gradations of shade and pattern: SCHMIDT (1936) refers to "Fleckenform", "Streifenform" and the intermediate "Zwischenform".

The back of the head bears a curiously individual marking, on either side of the central longitudinal suture is an approximately circular process (Fig. 20). In this species it is always occupied by a small pale spot (Figs 20, 22), which is preserved in the exuviae too, but may be more difficult to see, owing to reflection or the transparency of the cuticle. It has been noted rarely in two other species (*A. crenata* and *A. isosceles*). The labium is broad and the legs have banding on the femora. There are definite lateral spines on segments 6-9 and often a vestigial spine may be present on segment 5.

The spine on segment 9 reaches halfway down segment 10. The distal margin of the epiproct is usually bifid.

The length of the final instar ranges from 38-46 mm.

The ubiquitous nature of this species and its variation mean that great care has to be taken with its identification, but the head marking can be seen by the naked eye and the combination of labium, leg rings and dorsal spines should be definitive.



*AESHNA JUNCEA* (L.)

Figures 7-8

[*A. caerulea*, *A. serrata*, *A. subarctica*]

**M a t e r i a l.** – 35 larvae, 54 final instar exuviae: Salop, New Forest (UK); Silverflowe, Wester Ross (Scotland); Eklingen (Sweden); Jaala, Kevo (Finland).

The colour of the larva ranges from dark green to mid-brown, the exuviae being always some shade of brown. The overall shape is more robust than *A. caerulea* and it has a less pronounced waist at the 3rd and 4th segments. The antennae have 7 segments and the head bears no obvious pattern apart from pale spots around the ocelli. The labium is very broad at the base, giving it a rectangular appearance and immediately distinguishing it from *A. caerulea*.

The supracoxal armature is not sufficiently different from that of closely related species for it to be a useful character and there is no apparent banding on the femora.

The abdomen has a dark central longitudinal tinge flanked by two pale stripes; these markings continue down to the 9th segment, which is normally unmarked. Lateral spines are present on segments 7-9, with a small spine sometimes present on segment 6. The spines on segment 9 reach to no more than half-way down segment 10 (Fig. 8).

CLAUSEN (1984) provides several useful characters for separation of *A. juncea* and *A. subarctica*. Males can be separated using the shape of the accessory genitalia on segment 9. In *A. juncea* (Fig. 7) the two halves are not divided and they are flat, not elevated as in *A. subarctica*. The main specific difference between the two species involves the length ratio of the cerci and paraprocts. As with many species there are individual variations, but in the majority of larvae the ratio is 0,5 in *A. juncea* (Fig. 8) and 0,6 in *A. subarctica* (Fig. 10). The shape of the labium (rectangular in this species and tapered in *A. caerulea*) is a relatively easy separation character, for these two species, which may cohabit.

The full grown larva ranges in length between 38-51 mm. It is found throughout Europe, but is most common in the northern area where it occupies a range of acidic habitats, often cohabiting with *A. caerulea* and *A. subarctica*, but elsewhere it may be found with species such as *A. mixta*, *A. cyanea*, *A. grandis*, *A. crenata* and *A. serrata*.

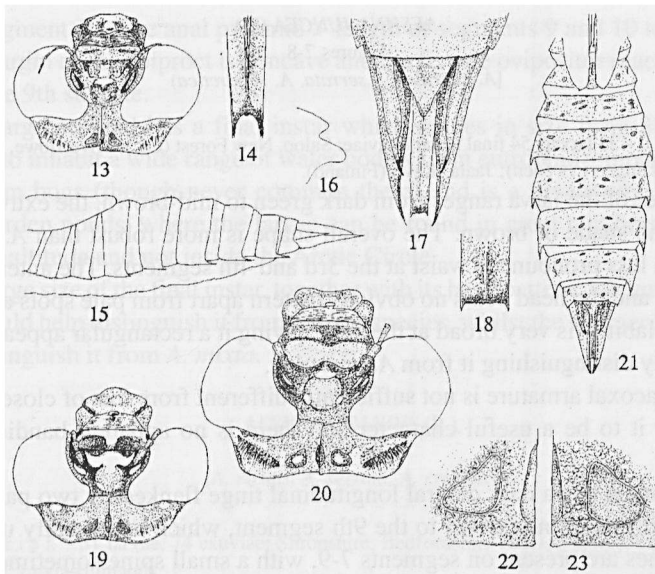
*AESHNA MIXTA* LATREILLE

Figures 3-4

[*A. affinis*, *A. cyanea*]

**M a t e r i a l.** – 15 larvae, 20 exuviae: Norfolk, Salop (UK), Brenne (France), Ugglarp (Sweden).

The colour of this species is variable, mainly mid brown, though some specimens are extremely dark, almost black, whilst others are a light brown. The shape of this small species is less bulbous than *A. affinis*, segments 8, 7 and 6 being of the



Figs 13-23. Structure features of the European aeshnid larvae [in dorsal view, unless otherwise stated]: (Figs 13-15) *Aeshna crenata*: (13) head in dorsal view; - (14) distal margin of epiproct; - (15) abdomen in lateral view. - (Figs 16-18) *Anaciaeshna isosceles*: (16) supracoxal armature; - (17) anal appendages; - (18) distal margin of epiproct. - (Fig. 19) *Aeshna cyanea*: head. - (Fig. 20) *Aeshna grandis*: head. - (Fig. 21) *Aeshna viridis*: abdomen. - (Fig. 22) *Aeshna grandis*: occipital process. - (Fig. 23) *Aeshna viridis*: occipital process.

same width and only tapering slightly to the basal segments.

The maximum width of the labium (Fig. 3)  $\approx 2\times$  the width of the basal hinge, whilst its maximum length =  $4\times$  the maximum width, producing an extremely narrow appearance. The movable hook bears a small tooth on its interior distal margin which is not present in *A. affinis*. Paired spots on either side of the central head suture have pale surrounds, whilst the supra coxal armature is as blunt as that of the previous species. The legs have faint rings confined to the femora.

Dark specimens of *A. mixta* have unclear abdominal patterns, but in normal specimens the pattern resembles that of other species of *Aeshna*: a darker central longitudinal stripe flanked by two pale stripes, but appearing finer and ending on segment 8. Segments 9 and 10 are unpatterned and pale coloured. Spines are present on segments 6-9, those on segment 9 being very long and generally reaching to the distal margin of segment 10. The female ovipositor does not reach much further than the base of segment 10. The distal margin of the epiproct (Fig. 4) is almost straight.

The published lengths of this species show a range between 30-40 mm. This large variation, plus a somewhat limited distribution in northern Europe possibly reflect its normal univoltine tendency (CORBET et al., 1960, p. 145), although specimens from Sweden have been reared out over a 2-year period by myself.

It is found in a variety of habitats ranging from slow flowing rivers to stagnant and even brackish water. In UK it appears to be extending its range northwards and westwards.

Its small size and supracoxal armature will separate it from most species, whilst the labium and lateral spines on segment 9 will distinguish it from *A. affinis*.

*AESHNA SERRATA* HAGEN

Figures 11-12

[*A. grandis*, *A. juncea*]

*Material*. – 11 larvae, 23 exuviae: Furingstad (Sweden); Luvia, Hanko (Finland).

The larvae are normally light brown in colour, whilst the exuviae are similar but paler. The final instar larva (Fig. 12) has a distinctive abdominal shape, being slender at the basal segments, swelling out to segment 7 then tapering to relatively long and fine anal appendages.

The head bears pale occipital patches, particularly noticeable around the processes on either side of the central suture line, but also on the basal margin of the eyes and on the lateral angles of the occiput. These are not present or are much duller in larvae or exuviae of *A. juncea*. The labium is long and heavy and the lateral distal angle of the movable hook is distinctly rounded. The legs are not banded, but bear noticeable longitudinal scars.

The abdomen (Fig. 12) is long and bears the normal central dorsal markings, occasionally flanked by two pale longitudinal stripes which fade on reaching segment 6. Some exuviae do not show these pale areas, but they may have faded due to exposure. Lateral spines are always clearly present on segments 6-9 (Fig. 12), but some individuals have a strong spine also on segment 5. Those on segment 9 reach halfway along segment 10. The anal appendages appear very long and pointed, but close examination and measurements of these alone cannot separate this larva from similar species. The male projection is always < 40% of the length of the epiproct and after tapering gradually from its base it suddenly curves inwards, producing a marked nipple at the end.

The length of this rare species ranges from 48-52 mm. It can be found in such varied habitats as acidic inland pools and brackish coastal lagoons. In Europe, it is recorded currently from Finland, Sweden, Estonia and Russia and is regarded by some authorities as a distinct species, *A. osiliensis* (Mierzejewski, 1913), the adults being slightly smaller than the nominal type.

The presence of definite spines on segment 6 should separate it from *A. juncea* and the abdominal shape, colour and markings from both the latter and *A. grandis*.

*AESHNA SUBARCTICA ELISABETHAE* DJAKONOV

Figures 9-10

[*A. caerulea*, *A. juncea*]

**M a t e r i a l.** – 15 larvae, 20 exuviae: Eklingen, Tagnatorp (Sweden); Jaala (Finland); Schleswig-Holstein (Germany).

The larva is generally of a dark colour: green, brown or almost black, reflecting the conditions in which it may be found, sphagnum bogs and the micro habitats therein, although some larvae and exuviae can be very pale.

No consistent head markings are apparent in this species and although the labium is extremely broad at the base it is not sufficiently distinct from that of *A. juncea*, which is also almost rectangular in outline.

The supracoxal armature is not diagnostic, but the fore femora of *A. subarctica* (<4 mm) are always shorter than those of *A. juncea* (>4 mm), (CLAUSEN et al, 1984).

The abdomen has the same longitudinal pattern as that of *A. juncea* and the location of abdominal spines is also the same as in that species, those on segment 9 reaching to no more than half way down segment 10 (Fig. 10). When compared with those of *A. juncea*, the male genitalia can be seen to be clearly separated into two elevated lobes (Fig. 9).

The anal pyramid (Fig. 10) provides the clearest means of separation, the cerci being consistently >60% of the length of the paraprocts in final instar specimens. The only other European aeshnid with a similar ratio is *A. isosceles* (Fig. 17), a species which is unlikely to be found in the same habitats.

*A. subarctica* varies in size from 37-42 mm, making it slightly smaller than *A. juncea*. It is confined to sphagnum bogs in northern and central Europe. It appears to be a particularly difficult species to rear in captivity and needs acidic conditions to be successful.

*AESHNA VIRIDIS* EVERSMANN

Figures 21, 23

[*A. grandis*, *A. isosceles*]

**M a t e r i a l.** – 13 larvae, 24 exuviae: Ugglarp (Sweden); Langelmaki (Finland).

Although the specific name probably only refers to the adult of this species, the larva too is invariably green, being primarily found amongst the seasonally floating plant *Stratiotes aloides*. The lack of dorsal abdominal markings is the most important separation feature, as cohabiting species are similarly coloured. The exuviae are a pale shade of either brown or grey.

The head has three markings which are visible in both larvae and exuviae. The anterior ocellus has a white line running laterally through it whilst the lateral ocelli have a “v” shaped marking behind them. The markings on either side of the rear central suture (Fig. 23) do not have a distinctive pale spot in either larva or exuviae.

Neither the labium nor the supracoxal armature appear distinctly different from those of *A. grandis* when a large number of specimens are examined.

The legs are not heavily banded as in *A. grandis* and the abdomen bears no markings apart from the normal *Aeshna* mid-dorsal processes. Also the abdomen appears unicolorous and without marbling of any sort. Lateral spines are present on segments 6-9, that on 9 reaching approximately halfway down segment 10.

The larval length ranges from 35-46 mm and its habitats are acid to neutral lowland waterbodies at low altitude, especially those with abundant populations of *Stratiotes aloides*.

The larva is identified by the lack of markings on abdomen and legs, plus the absence of the features shown by *A. grandis* and *A. isosceles*.

*ANACIAESCHNA ISOSCELES* (MÜLLER)

Figures 16-18

[*A. grandis*, *A. viridis*]

**Material.** – 13 larvae, 15 exuviae: Norfolk (UK); Ugglarp (Sweden); Albufuera (Majorca); Lake Volvi (Greece).

This species varies in colour from dark to pale brown, sometimes with shades of green, the exuviae being usually mid to pale brown. Its shape is rather bulky, the basal segments gradually widening to segment 6, 7 and 8 then tapering to the anal appendages.

Some individuals have a similar head marking to *A. grandis* (Fig. 22), though the pale spot in this species is located in the anterior part of the process. There is often a pale crescent-shaped mark located between the base of the antennae and the interior border of the eyes.

The supracoxal armature (Fig. 16) is distinctive, the anterior lobe being much shorter than the posterior lobe. The femora have faint banding. The abdominal markings consist of a very thin pale central stripe, flanked by a pair of darker parallel stripes, these latter having mid-segmental spots on segments 3-8. Outside these are a pair of paler stripes, then laterally the abdomen is darker. Spines are present on segments 6-9, those on 9 nearly reaching the apex of segment 10.

The distal margin of the epiproct (Fig. 18) is straighter than in other species. The cerci (Fig. 17) are very long, on average >60% the length of the paraprocts and this is noticeable in early instars. *A. subarctica*, which also shares this feature (Fig. 10) is found in entirely different habitats and the two species can be separated quite easily by the distinctive shapes of their supracoxal armatures.

The body length ranges from 35-46 mm; specimens bred in captivity appear on average to be much smaller. The south and central European habitats include fens, ditches, lakes and dykes at low altitude. Like *A. viridis* the larva of this species is often associated with *Stratiotes aloides*.

This species can be easily identified by the cerci, supracoxal armature and epiproct.

## ANAX IMMACULIFRONS RAMBUR

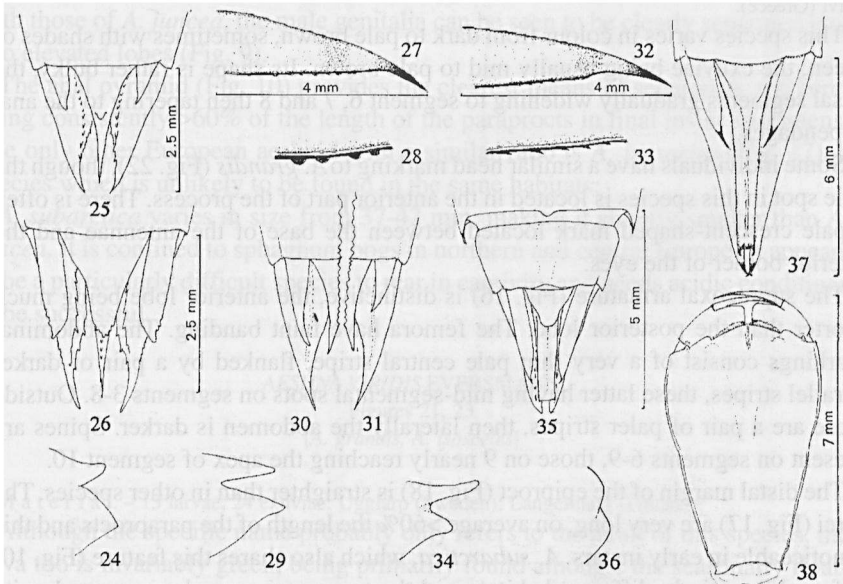
Figures 45-47

[*A. imperator*, *A. parthenope*, *H. ephipigger*]

**Material.** – 1 larva, 1 exuvia: Ootacamund (India) [20-XII-1922], F.C. Fraser leg.; Hoa Binh (Laos) [X-1916], R.V. de Salvaza leg.; both F.C. Fraser coll. NHM London.

The larva/exuvia (Fig. 47) appears similar in most respects to the other two European *Anax* species. Its general colouring is pale brown with slightly darker markings. The head appears more massive than that of the other two species (head max. width 11 mm, max. length 10 mm) and the frons protrudes further. The labium (Fig. 45) appears longer (max. width 7 mm; min. width 3 mm; total length 13.5 mm) with a very slim basal half to the prementum. The concave distal margin of the labial palpus has an angled outside corner and an internal long tooth. The distal margin of the prementum has a deeply excavated notch flanked by a pair of rounded lobes.

The supracoxal armature has an oblique angle between the large posterior lobe and the slender anterior lobe. The legs are long, with pronounced banding on the



Figs 24-38. Structure features of the European aeshnid larvae [in dorsal view, unless otherwise stated]: (Figs 24-26) *Caliaeschna microstigma*: (24) supracoxal armature; – (25) ♀ anal appendages; – (26) ♂ anal appendages. – (Figs 27-31) *Boyeria irene*: (27) internal margin of paraproct, ventral view; – (28) spines on paraproct, close up; – (29) supracoxal armature; – (30) cerci, long form; – (31) cerci, short form. – (Figs 32-33) *Boyeria cretensis*: (32) margin of paraproct, ventral view; – (33) spines on paraproct, close up. – (Figs 34-35) *Brachytron pratense*: (34) supracoxal armature; – (35) anal appendages. – (Figs 36-38) *Hemianax ephipigger*: (36) supracoxal armature; – (37) ♂ anal appendages; – (38) labium, ventral view.

distal parts of the femora. The abdomen is pale brown with normal aeshnid markings on segments 2-8, lateral scars on segments 3-9 and ventral punctae on segments 3-7. The dorsal surface of the abdomen is covered with fine setae which are set in rather large scale-like sockets. There are lateral spines on segments 6-9, in contrast to the other two above-mentioned species.

The anal appendages are almost as long as segments 8, 9 and 10 together. The female ovipositor reaches two-thirds of the way to the margin of segment 10. The epiproct (Fig. 46) is strongly keeled, has a mat of hairs basally and a deeply etched distal margin. The one final instar exuviae examined measured 55 mm total length.

The species was recorded from the island of Karpathos by Dr U. Norling in 1980 (G.S. Vick pers. comm.; cf. also BATTIN, 1990) and more recently from Rhodes (DUMONT, 1992). There is a distinct possibility of the species being recorded in other Aegean islands. In India it has been recorded from ponds and reservoirs, as well as the more typical European rheophilous habitats. Here the typical sites are rocky pools of small fast flowing streams, where the larvae have been found in gravel, sand and detritus deposits.

#### ANAX IMPERATOR LEACH

Figures 39-41

[*A. parthenope*, *A. immaculifrons*, *H. ephippiger*]

**M a t e r i a l.** – 26 larvae, 55 exuviae: Herefordshire, Warwickshire (UK); Ugglarp, Furingstad (Sweden); Brenne (France); Albufera (Majorca).

The general colour of this species varies from shades of brown through to green, the brown types often weakly marked and the latter generally strongly patterned. This genus is easily recognized by the shape of the eyes, as their lateral edges are elongated and are twice the length of the lateral edge of the occiput (Fig. 47). The bisection of the internal angle of the eye produces two very asymmetrical shapes.

The labium is long and slightly waisted, its maximum width is <70% of its length. The distal margin of the prementum is rounded and the moveable hooks are long and stout. The lateral lobes of the prementum are spinous and these spines are continued basally through a weakly defined line of scattered spines/setae (Fig. 41). The labial hinge rests between the 2nd and 3rd pair of legs.

The lobes of the supracoxal armature are blunt and produce an oblique angle in between. The femora are patterned, particularly in darker forms.

The centre of the dorsum has a thin pale line running down to segment 7. This is flanked by typical *Aeshna* markings, then laterally by pale sinuous stripes running longitudinally down to segment 8. Outside these are variable markings and stripes ending at segments 9 or 10, which are usually unicolourous. There are lateral spines on segments 7-9, that on segment 9 reaching to  $\frac{3}{4}$  segment 10. The anal appendages are longer than segments 9 + 10 together, the cerci are < $\frac{1}{2}$  length of the paraprocts. The male projection (Fig. 39)  $\approx \frac{1}{2}$  length of the cerci, its length  $\approx$  width of its base and its distal end is narrower than the distal end of the epiproct,

which is strongly keeled and glabrous. The female ovipositor (Fig. 40) reaches two-thirds of the way to the margin of segment 10.

The larvae of this species are found in rivers, lakes and ponds, even brackish marshes, but are less common at altitude. It is common in central and southern Europe where the larvae may be found in great numbers amongst water weed. Its size ranges from 45-56 mm.

*ANAX PARTHENOPE SELYS*

Figures 42-44

[*A. imperator*, *A. immaculifrons*, *H. ephippiger*]

*Material*. – 14 exuviae, 3 larvae: Adra (Spain).

Very similar to the above species, the body colour being very variable with similar patterning.

In males the projection (Fig. 42) is much shorter than the width of its base, and therefore  $<< \frac{1}{2}$  length of the cerci. The distal end of the projection is slightly wider than the distal end of the epiproct. The female ovipositor (Fig. 43) reaches at most halfway to the margin of segment 10.

The lateral lobes of the labium (Fig. 44) have a clearer set of small spines continuing in a line basally towards the hinge.

It is found in identical habitats to *A. imperator* (often co-occurring) but is only common in southern Europe and rarely commoner than the former species anywhere.

*HEMIANAX EPHIPPIGER* (BURMEISTER)

Figures 36-38

[*A. imperator*, *A. parthenope*, *A. immaculifrons*]

*Material*. – 3 ♂, ♀ exuviae, A.Wendler coll., no locality data; ♂ exuviae, Ukraine, S.N. Gorb leg., [R. Seidenbusch coll.]; 1 larva, Vom, Nigeria, R.M.Gambles leg., [G.S. Vick coll.].

The overall colour ranges from orange, pale brown through to greenish and there is a conspicuous marbling effect. The labium (Fig. 38) is a different overall shape from the species of *Anax*, being more convex on its lateral margins than concave. It is also rather short, the hinge resting no further than the 2nd pair of legs. The distal margin of the labial palpus is straight and the apical tooth is small, corresponding with a small notch in the apical margin of the prementum. The lobes of the supracoxal armature (Fig. 36) are very blunt with an oblique angle in between. The femora have dark markings on their distal margins.

The abdomen has a thin central light stripe flanked by darker sinuous stripes, then laterally a succession of lighter and darker sinuous stripes, which give the impression of marbling. This colour pattern may be continued onto segments 9 and 10, but is usually strongest on the first 8 segments. There are lateral spines on segments 7-9, that on segment 9 reaching at least as far as  $\frac{1}{2}$  segment 10.



The anal appendages (Fig. 37) are almost as long as segments 8, 9 and 10 combined, the cerci  $< \frac{1}{2}$  length of the paraprocts. The male projection is rather indistinct in this genus, and the female ovipositor reaches just over  $\frac{1}{2}$  segment 9.

The larva supposedly breeds in a variety of small standing water bodies, even of a temporary nature, although in Europe definite breeding has so far only been recorded from France, Italy and Sicily. It appears to be commoner in Eastern Europe where there is a strong migratory element to this population.

*BRACHYTRON PRATENSE* (MÜLLER)

Figures 34-35

*M a t e r i a l.* – 14 larvae, 12 exuviae: Caldecott (Wales); Somerset (UK); Galway (Eire); Dagstorpjans (Sweden).

Larvae of this species tend to range in colour from light tan (some with an almost orange tinge) through to near black. The head is distinctively shaped, possessing long lateral margins which taper markedly to the postocular lobes and produce a shape unique amongst European Aeshnidae. The eyes are also distinctively smaller than those of other European species in this family. The head is not strongly patterned either, bearing the usual highlights around the ocelli, antennal bases and the corners of the postocular lobes. The antennae are 7 segmented, segments 3, 6 and 7 being slightly longer than the remainder.

The labium is slender at the base, curving outwards distally to distinct lobes. The moveable hooks are long and there is a small tooth on the distal end of the labial palp.

The anterior lobe of the supracoxal armature (Fig. 34) is longer than the stouter posterior lobe. The lateral ridge of the prothorax ends in angular sides which are similar to the shape of the occiput. The larva when viewed sideways appears to be hunch-backed. The legs are not noticeably ringed and are rather short for this size of larva.

The abdomen is usually lightly marked with central spotting to segment 8. There is sometimes a central pale longitudinal line on segments 3, 4 and 5 which is flanked by two darkish stripes, dark smudges may also be central up to segment 6. The last three segments are keeled and segment 9 bears a tiny flattened dorsal spine (Fig. 35). There are lateral spines on segments 6-9, that on segment 9 reaching about one-third segment 10, some specimens bear a tiny lateral spine on segment 5.

The anal appendages (Fig. 35) are small  $<$  segments 9 + 10 together. The cerci reach over two-thirds the paraprocts which are only slightly longer than the epiproct. The male projection reaches halfway along the cerci and is distally rounded. The female ovipositor just reaches the margin of segment 10.

It is distributed over central and eastern Europe, with isolated pockets around the S and W fringes. It is found in a variety of habitats, from slow-moving waterbodies to the margins of large lakes, often amongst dense mats of detritus. The larva is also noted for its death-feigning habit. Its size ranges from 36.5-44 mm.

*CALIAESCHNA MICROSTIGMA* (SCHNEIDER)

Figures 24-26

*Material*. – 3 larvae, 20 exuviae: Platamonas, Dimitri, Delphi and Thassos (Greece).

The colour varies from dark brown, through grey shades to light tan, the exuviae retaining most of the colour, perhaps because it emerges in shady places. The antennae are small and 6-segmented, segment 3 being the longest (and often palest) followed in length by segment 6. The dorsal surface of the head is patterned with pale spots around the ocelli, the bases of the antennae and laterally on the rear margins of the eyes.

The labium is slightly wider distally than basally, on either side of the small median cleft is a flattened protrusion. The palps are developed distally into quite pointed ends and bear crenations on their internal margins. The hinge of the mentum usually rests between the second pair of legs.

The anterior lobe of the supracoxal armature (Fig. 24) is smaller than that of the posterior, and there is light banding on all femora and tibiae.

The abdomen bears a pale longitudinal central stripe confined to the anterior section of segments 1-7. This stripe is flanked by the normal aeshnid markings and then by alternate light and dark stripes. There are lateral spines on segments 6-9 (sometimes a vestigial spine on segment 5), those on segment 9  $\approx$  one-third segment 10.

The anal appendages are short  $\approx$  segments 9 + 10. Male and female are dimorphic, the male cerci and projection  $\approx$  two-thirds length of the paraprocts (Fig. 26), whereas the female cerci and "false projection" are much shorter, being  $\approx$  one-third the length of the paraprocts (Fig. 25). The internal margins of the paraprocts are spinous.

The length of this small species ranges between 30-35 mm. Small larvae of 7 mm were obtained in mid August and emerged the following May. It is a running water species of SE Europe and is found amongst detritus in highland streams and lowland rivers. Larvae and exuviae are most commonly found in shady areas.

*BOYERIA CRETENSIS* PETERS

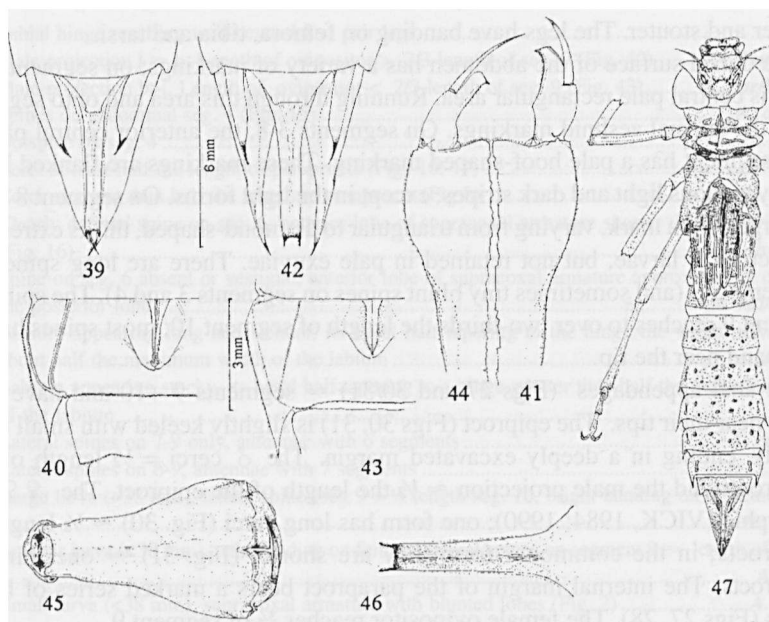
Figures 32-33

[*B. irene*]

*Material*. – 3 larvae, 1 exuvia: Mili/Rethymnon (Crete), R.G. Kemp leg. [4 Sept.].

This species, distinct from *B. irene*, was described only recently (PETERS, 1991). The larva resembles *B. irene* closely, but differs in the absence of spines on the internal margins of the paraprocts (Figs. 32, 33). One larva was reared by myself and on close examination its exuviae appears to have smaller, finer spines than those on *B. irene* (Fig. 33). It is possible that an investigation of a greater range of larvae/exuviae may show up other differences.

At present it is only known from Crete.



Figs 39-47. Structure features of the European aeshnid larvae [in dorsal view, unless otherwise stated]: (Figs 39-41) *Anax imperator*: (39) ♂ anal appendages; - (40) ovipositor, segment 9; - (41) labium, showing lateral setae. - (Figs 42-44) *Anax parthenope*: (42) ♂ anal appendages; - (43) ovipositor, segment 9; - (44) labium, showing lateral setae. - (Figs 45-47) *Anax immaculifrons*: (45) labium, ventral view; - (46) epiproct; - (47) habitus.

*BOYERIA IRENE* (FONSCOLOMBE)

Figures 27-31

[*B. cretensis*]

**Material.** - 18 larvae, 39 exuviae: Lot, Hérault (France); Marbella, Ronda (Spain); Morocco (no locality data).

The colour ranges from mid tan to very dark brown. The light forms have very little patterning on the abdomen and their exuviae are also very pale. The head has pale patterns around the bases of the antennae and on the ocelli and frons. The small central occipital processes have pale spots. The lateral margins of the occiput have sharply angled corners, often palely marked, no other European aeshnid having this shape. The antennae have 7 segments, the scape and pedicel being darker than the flagellum. Segment 3 is the longest.

The labium is  $\approx 4\times$  as long as wide, the width of the hinge being  $\approx \frac{1}{2}$  that of the distal lateral lobes. The moveable hook is long and narrow. The hinge rests between the 2nd pair of legs.

The mesepimeron bears a blunt spine one third of the way from the top, whilst the supra coxal armature (Fig. 29) has a long anterior spike, the posterior being

shorter and stouter. The legs have banding on femora, tibia and tarsi.

The dorsal surface of the abdomen has a variety of markings; on segments 2-4 there is central pale rectangular area. Running through this area and onto segment 8 are the normal aeshnid markings. On segments 3-8, the anterior central part of each segment has a pale hoof-shaped marking. These markings are flanked laterally by sinuous light and dark stripes, except in the light forms. On segment 8 there is a large cream mark, varying from triangular to diamond-shaped, this is extremely distinctive in larvae, but not retained in pale exuviae. There are long spines on segments 5-9 (and sometimes tiny blunt spines on segments 3 and 4). The spine on segment 9 reaches to over two-thirds the length of segment 10; most spines have a pale band near the tip.

The anal appendages (Figs 27 and 30/31)  $\approx$  segments 9 +10 and have pale bands near their tips. The epiproct (Figs 30, 31) is slightly keeled with small teeth distally, ending in a deeply excavated margin. The  $\delta$  cerci =  $\frac{1}{2}$  length of the paraprocts and the male projection  $\approx \frac{1}{2}$  the length of the epiproct. The  $\text{♀♀}$  are dimorphic (VICK, 1984; 1990); one form has long cerci (Fig. 30)  $\approx \frac{1}{2}$  length of paraprocts; in the commoner form they are shorter (Fig. 31)  $\approx$  one-third of paraprocts. The internal margin of the paraproct bears a marked series of blunt spines (Figs 27, 28). The female ovipositor reaches  $\frac{3}{4}$  of segment 9.

The size of this West Mediterranean species ranges from 37-40 mm. It inhabits a variety of moving water bodies from fast flowing hill streams to slow flowing large rivers. The larva is found among detritus and roots mainly in shaded areas. Exuviae can be found in great numbers on suitable vertical supports at heights ranging up to several metres above water level.

#### KEY TO THE LARVAE AND FINAL INSTAR EXUVIAE OF EUROPEAN AESHNIDAE

This key may be used with greatest success with final instar. Spines referred to are always lateral abdominal, unless otherwise stated.

- |   |  |                         |
|---|--|-------------------------|
| 1 | Epiproct ending in single point (Figs 25, 26) .....                    | <i>C. microstigma</i>   |
| – | Epiproct concave at end .....  | 2                       |
| 2 | Posterior corners of head angled and with tubercles .....              | 3                       |
| – | Posterior corners of head rounded and smooth (Fig. 20) .....           | 4                       |
| 3 | Lateral margins of paraprocts with blunt spines (Fig. 28) .....        | <i>B. irene</i>         |
| – | Lateral margins of paraprocts with fine spines (Fig. 33) .....         | <i>B. cretensis</i>     |
| 4 | Lateral margins of head tapering strongly to rear .....                | <i>B. pratense</i>      |
| – | Lateral margins of head approximately parallel (Figs 20, 47) .....     | 5                       |
| 5 | Bisection of internal angle of eye producing asymmetry (Fig. 20) ..... | 6                       |
| – | Bisection of internal angle of eye producing symmetry (Fig. 47) .....  | 9                       |
| 6 | Abdominal lateral spines on segs 6-9 (Fig. 47) .....                   | <i>A. immaculifrons</i> |
| – | Abdominal lateral spines on segs 7-9 .....                             | 7                       |
| 7 | Labial hinge inserted between 2nd pair legs .....                      | <i>H. ephippiger</i>    |

- Labial hinge reaching well beyond 2nd pair legs ..... 8
- 8 Male projection  $l \approx b$ . Length of ovipositor  $> 2/3$  length of seg. 9 (Fig. 40) ..... *A. imperator*  
Male projection  $b > l$ . Length of ovipositor  $< 2/3$  length of seg. 9 (Fig. 43) ..... *A. parthenope*
- 9 Spines on abdominal seg. 4 (Fig. 15) ..... *A. crenata*
- No spine on seg. 4 ..... 10
- 10 Cerci at least half the length of paraprocts (Figs 10, 17) ..... 11
- Cerci no more than half the length of paraprocts (Fig 8) ..... 12
- 11 Clearly defined spine on seg. 6, anterior lobe of supracoxal armature shorter than posterior lobe (Fig. 16) ..... *A. isosceles*
- Spine on seg. 6 absent or vestigial, anterior lobe of supracoxal armature approximately equal to the posterior lobe ..... *A. subarctica*
- 12 Labium appearing long and slender, its basal half tapering to the hinge the width of which is about half the maximum width of the labium ..... 13
- Labium appearing stocky, its basal half tapering to a hinge greater than half the maximum width of the labium ..... 15
- 13 Lateral spines on 7-9 only, antennae with 6 segments ..... *A. caerulea*  
Lateral spines on 6-9, antennae with 7 segments ..... 14
- 14 Large larva ( $>38$  mm), lateral spines seg 9 =  $1/2$  length seg. 10, bright banding on all femora ..... *A. cyanea*
- Smaller larva ( $<38$  mm), pale banding on femora, lateral spines on segment 9  $\approx$  length of seg. 10 ..... *A. mixta*
- 15 Small larva ( $<38$  mm), supracoxal armature with blunted lobes (Fig. 2) ..... *A. affinis*
- Larger larva ( $<38$  mm), supracoxal armature with pointed lobes ..... 16
- 16 Dorsal surface of abdomen unicolorous (green or brown) (Fig. 21) ..... *A. viridis*
- Dorsal surface not unicolorous and with markings ..... 17
- 17 Spine on seg. 6 absent or vestigial (at most  $1/3$  that on seg. 7), spine on seg. 9  $<< 1/2$  length seg. 10 ..... *A. juncea*
- Spine of seg. 6  $\approx 1/2$  that on seg. 7. Lateral spine on seg. 9 reaching to or beyond mid length seg. 10 ..... 18
- 18 Femora pale and unmarked. Head without pale centres to postocular eyespots (Figs 12, 23) ..... *A. serrata*
- Femora with variable banding present. Head with pale centres to postocular eyespots (Figs 20, 22) ..... *A. grandis*

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