



## Key to the larval stages of common Odonata of Hindu Kush Himalaya, with short notes on habitats and ecology

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**Author Contribution:** HN, RDTs and DNS conducted fieldworks and equally contributed in manuscript preparation. HN illustrated the specimens.

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**Abstract:** The order Odonata is one of the most widely studied groups among insects from the oriental region. They colonize in both stagnant and running water bodies of wide water quality. Hitherto, the existing literature on the Odonata contained numerous publications with coloured figures of adults, helpful for identification. Identification key with figures on larval stages, using their coloration as distinguishing characters are largely missing. The current work attempts to provide an identification key to aquatic larvae of the most common families of Zygoptera, Anisoptera and Anisozygoptera with colour illustrations. The specimens were collected from Nepal and India (northern part). Each family is represented by several examples to demonstrate the range of morphological variability. This key helps determination of aquatic larvae Odonata up to family level without enormous efforts in field and laboratory.

**Keywords:** Aquatic insect, damselfly, dragonfly, ecology, identification key, India, Nepal.

## INTRODUCTION

The modern order Odonata is highly diversified with 5,680–5,747 (accepted) extant species, 864 (accepted) extant subspecies and approximately 600 fossil species (Xylander & Günther 2003; Kalman et al. 2008; van Tol 2008). The highest species number is known from the Oriental region which has more than 1,000 species. From India, exactly 499 species were recorded until 2005 by Mitra and 463 species confirmed by Subramanian (2009). Among all the species and subspecies within this geographical limit, the figure or description is known only for 78 taxa (Mitra 2005). For Nepal the number of species and subspecies was previously 172 published by Vick (1989). Later Sharma (1998) listed 202 taxa and Kemp & Butler (2001) added a new species for the country. In Bhutan, Mitra (2006) has published an actualized Odonata list with 31 taxa, to which the occurrence of *Epiophlebia laidlawi* around Thimpu can be added (Brockhaus & Hartmann 2009).

The taxonomy and knowledge of odonates in the Indian subcontinent and in many other parts of the world is largely based on terrestrial adults. There has been an old tradition in publication of very high quality colour figures for each species since the 18th century (Malz & Schröder 1979). In recent years all known Odonata species from the Japanese Archipelago were published by Okudaira et al. (2005) giving colour figures of both the larvae and the adults.

Mitra (2003) has provided an updated list of the regional species

composition for the different ecoregions of the Indian subcontinent. It allows recognition of the local fauna and the possible presence of their aquatic larvae for the Himalayan region. In contrast, the distinction of aquatic odonates from the same territory is poorly known. Even the identification at the family level remains difficult for many Zygoptera (Superfamilies Coenagrionoidea, Lestoidea) and some Anisoptera (Libellulidae vs. Corduliidae).

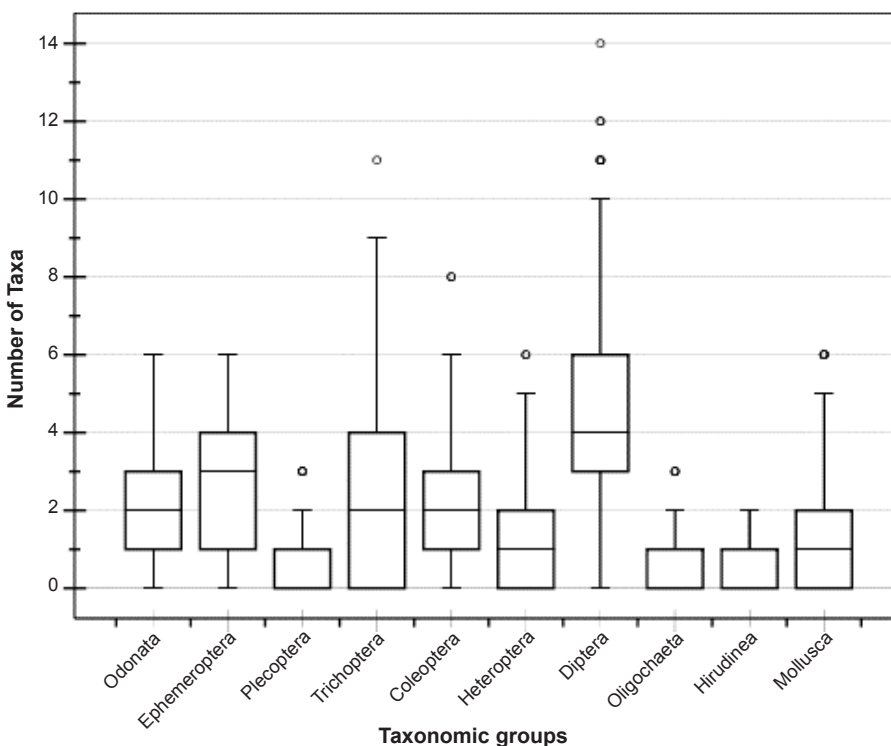
The classification of the order Odonata at the family level is a matter of controversy/ discussion. The number of families recognized by different authors varies largely. The 15 families in St. Quentin & Beier (1967), 27 families in Trueman & Rowe (2001), 56 families in Xylander & Günther (2003) demonstrate the different views. The present study follows the proposed system of Kalkman et al. (2008) with one addition.

The Odonata represents 7% among a total of 76,000 freshwater insect species of the world (Balian et al. 2008). Many species have small distributional ranges, and are habitat specialists; including inhabitants of alpine mountain bogs, seepage areas in tropical rain forests, and waterfalls (Kalkman et al. 2008). Larvae are mostly aquatic and predatory in nature. They feed on small odonates, oligochaetes, chironomids,

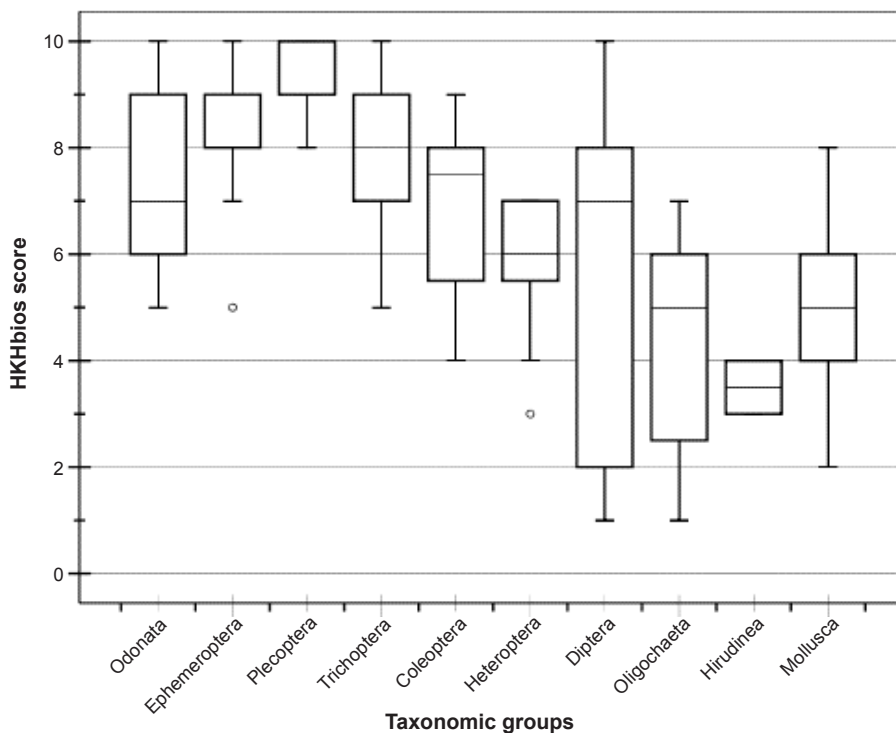
bettles, bugs, mayflies, molluscs, even tadpoles and small fishes, thus playing a major role in the aquatic ecosystem. The Odonata richness alone occupies a major component in freshwater macroinvertebrate assemblages. This aspect is clearly shown in Fig. 1 based on data sets of 250 macroinvertebrate samples from various studies (Shah 2007; Tachamo 2007; Neseemann 2009; Tachamo 2010).

The order Odonata is an ideal model taxon for the investigation of the impact of environmental warming and climate change due to its tropical evolutionary history and adaptations to temperate climates (Hassall & Thompson 2008). Its assemblages are also considered as surrogates for the insect community structure in water bodies, being capable of indicating changes in the biological integrity of these ecosystems (Silva et al. 2010). This can be proven from the newly developed HKHbios scoring (Ofenböck et al. 2010) list for the Hindu Kush Himalayan river system (Fig. 2). The Odonata at family level alone occupy about 11% of the scoring list with tolerance scores ranging from 5 to 10.

The objective of the present study is to fill the gap in the knowledge of the odonata larvae and to provide a pictorial catalogue to help in their identification. Here 31 examples from recent collections are presented to



**Figure 1. Number of taxa in different taxonomic groups based on 250 macroinvertebrate samples data. Whiskor and Box plots: □ indicates 25–75<sup>th</sup> percentile range; - indicates median; o indicates outliers (both graphs)**

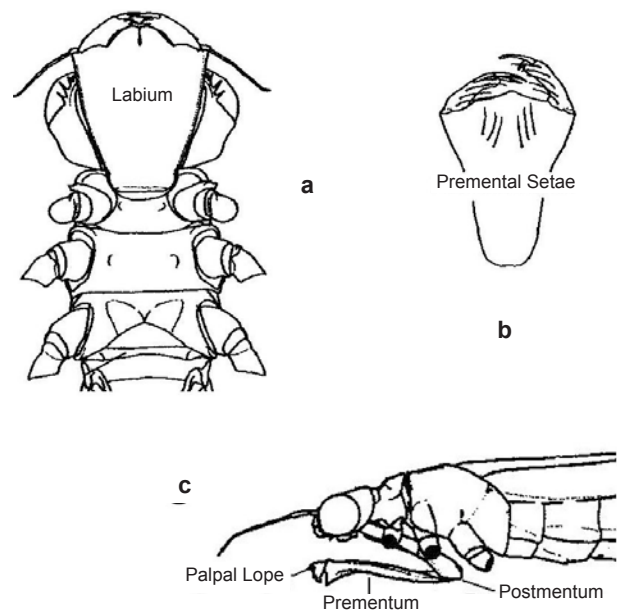


**Figure 2. Taxa Tolerance scores of macroinvertebrates in HKHbios Scoring list (Ofenböck et al. 2010) for different taxonomic groups. HKHbios list consists of 139 families from different taxonomic groups for Hindu Kush Himalaya.**

give their morphological characters as well as live colour. Colour was studied in living materials.

#### Identification characters of odonata larvae

Srivastava (1990) highlighted that the aquatic phase of the life cycle comprises eggs, pro-larval and larval stages, and 70–95 % of the whole life span is passed in water. Larvae undergo approximately 10–20 molts (mostly 11–14), over a period of three months (e.g. some Libellulidae) and about 6–10 years (e.g. Epiophlebiidae) depending on the species. One characteristic shared by all Odonata larvae is the conspicuous grasping labium (mask) (Fig. 3 a–c), used for capturing the prey. At rest stage, the labium is held folded underneath the head. During prey-capture, the labium is shot rapidly forward and the prey is grasped with paired hand-like lateral lobes (palps). Form, size and number of mental setae can be used for family or even genus identification but requires a microscope. Even from the above characters and with mask retracted, identification of larvae to suborder and family is very easy, based on several other features. These are namely the apices of abdomen, number and form of caudal gills, presence of abdominal gills, form, size and number of segments of antennae, presence of teeth along the anterior margin of the lateral lobes (palps) of labium (mask) and anal



**Figure 3 a–c. Head with labium of Damselfly larvae a - ventral view of Euphaeidae; b - dorsal view of labium of Coenagrionidae showing the premental setae; c - lateral view showing the resting position of labium.**

pyramid with length relationship of epiproct, paraprocts and cerci (Fig. 4 a–b).

The identification of larvae (nymphs) even to genus, is often difficult because of the fact that morphological differences are so slight (Pennak 1978,

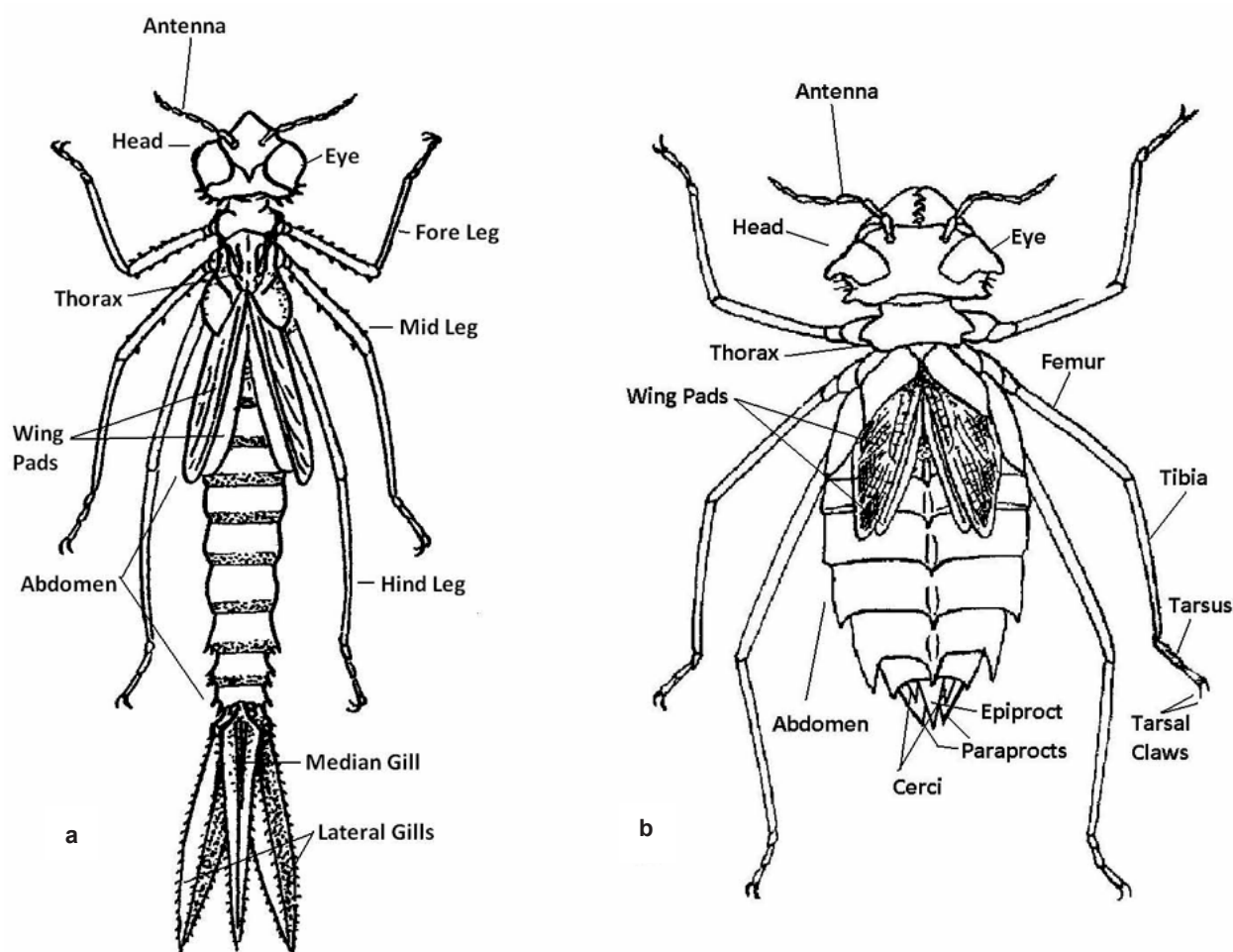


Figure 4 a–b. Odonata Morphology [figs. modified from Fraser 1919b (pl. XXXII fig. 3, pl. XXXVI, fig. 3)]. a - dorsal view of Damselfly larva Protoneuridae: *Disparoneura* spec.; b - dorsal view of Dragonfly larva Libellulidae: *Tramea* spec.

p. 557). Therefore, keys must be used with great care.

The identification of the collected and figured specimens was mainly based on descriptions given for the Odonata fauna of Japan (Kawai 2005; Okudaira et al. 2005), Malaysia (Yule & Hoi Sen 2004), and a few available publications from the western Himalayan region (Kumar 1973; Mitra 2005). The identification result reached in the present study remains mostly at family level. Only in a few cases the genus or species level could be reached.

## MATERIALS AND METHODS

### Study area

The study was carried out in various parts of Nepal and the northern part of India (Fig. 5) between 2005

and 2009. The climate in the region varies from humid sub-tropical to temperate with hot summers from March to early June, the monsoon season from mid-June to September and winter from November to February. There is a dominance of monsoon rainfall pattern with maximum precipitation in the summer. The region is one of the most fertile and densely populated regions of the world.

All the illustrated specimens are with the authors' personal collection.

### Illustrated catalogue

#### Zygotera: Chlorocyphidae

The medium-sized larvae (Fig. 6) have two forceps-like caudal gills which are triangular in cross section. They inhabit unpolluted, fast running streams and rivers (Fraser 1919a; Kumar & Prasad 1977).



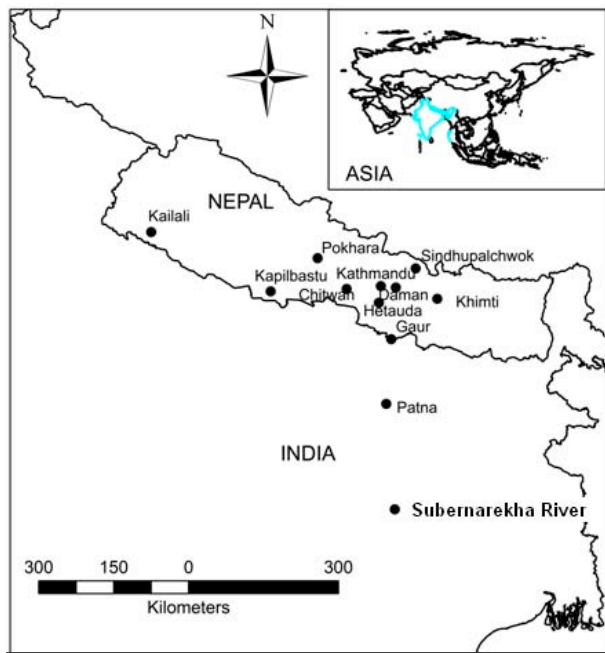


Figure 5. Major study sites in Nepal and India.

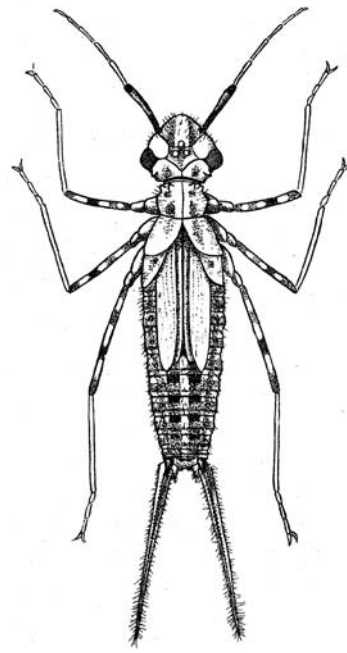


Figure 6. Chlorocyphidae [fig. taken from Fraser 1919a (fig. No. XXIII), *Libellago* sp. (syn. *Micromerus*), length unknown]

Chlorocyphidae occur from tropical Africa to Australia with the highest diversity in the Oriental region (Kalkman et al. 2008). The family is represented with 21 species in India (Subramanian 2009) and five have been recorded from Nepal (Sharma 1998) based on adults.

### Euphaeidae

The larvae (Image 1 a–b) are medium-sized to

large and robust with stonefly-like, flattened body form. They have three very large caudal gills that are saccoid. In addition, there are filamentous gills on the underside of abdominal segments II–VIII that are light grey-blue and un-pigmented (Image 1b). These characters allow easy identification of the family in the field.

Euphaeidae (and some related families) are distributed from the Mediterranean in the west to Japan

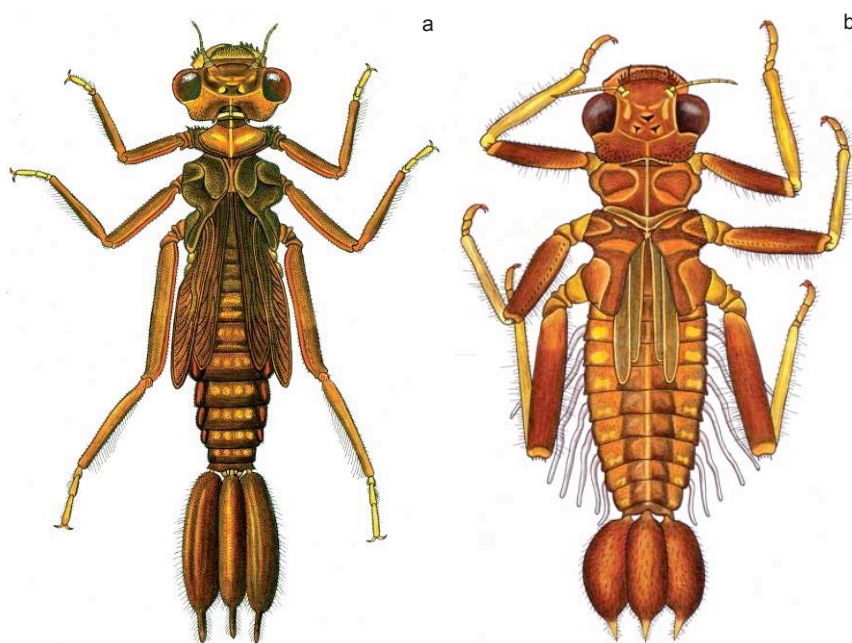


Image 1 a–b. Euphaeidae - Habitat: a - Khimti Khola, central Nepal, length 29.3mm; b - Yangi Khola, Pokhara, western Nepal. Length 21mm.

in the east. These pollution-sensitive larvae are highly specialized on lotic microhabitats. They are locally common in fast running streams and smaller rivers of the Himalayan middle mountains. They prefer unpolluted waters with low organic load. Usually they are found on the underside of large stones in high water current of riffles and rapids together with large stoneflies of the family Perlidae. Earlier Euphaeidae were often united with other similar forms as families Polythoridae and Epallagidae (Xylander & Günther 2003).

### Calopterygidae

The family is also known as broad-winged Damselflies (Image 2). The larvae of the family has a shorter middle gill than lateral gills that are triangular in cross section without visible veins. Prementum is diamond shaped with deep median cleft. Palpal lobes are deprived of setae. First segment of antenna is longer than or equal to the combined length of the remaining antennal segments. The body size ranges between 30–40 mm.

The family has cosmopolitan distribution and contains 171 species worldwide. They are most often found at the edge of streams with slow flowing water. In the study area, they were clinging to root masses and overhung on twigs.

### Synlestidae

The caudal gills of Synlestidae (Image 3) are short, broad and leaf like rounded, with oval apices and a smaller median lobe. Prementum or palps do not hold any setae. The mentum is deeply cleft. The palpal lobes have a long moveable hook and two robust spines. The adults are large, metallic green or bronze-black damselflies inhabiting in forested streams. A distinct 'breaking joint' or area of weakness occurs at the base of each caudal gill. In our study, Synlestidae occurred in pristine rocky mountain streams at an elevation of 1600m.

### Amphipterygidae (including: Philogangidae)

The deeply pigmented aquatic larvae (Image 4) are typical running water species which have a flattened body and bear long 7-segmented antennae. They may be larger than other damselflies and have a stonefly-like appearance. The palpal lobes of the labium have three spines and one movable hook. Their long gills are of



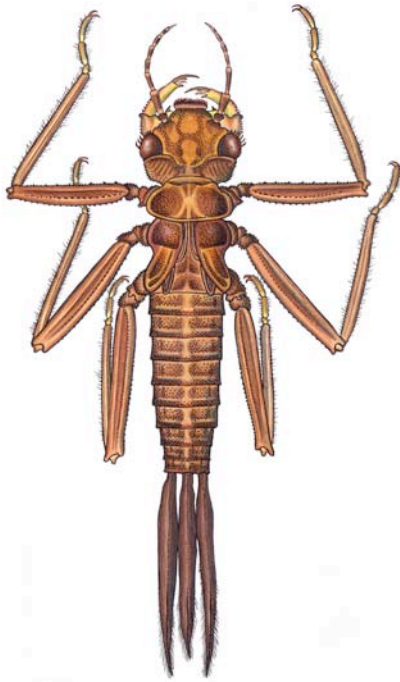
**Image 2. Calopterygidae -**  
Habitat: Sano Khahare Khola,  
Maghi gau, central Nepal.  
Length 38mm.



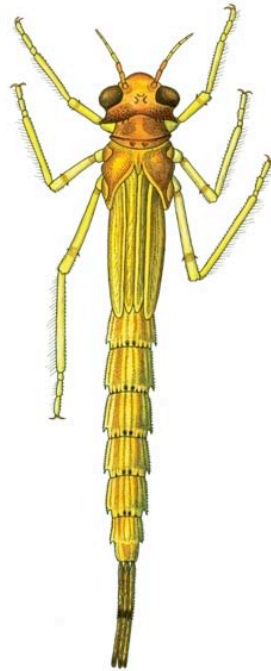
**Image 3.**  
Synlestidae -  
Habitat: Bagmati  
River, Kathmandu,  
central Nepal.  
Length 36.5mm.

saccoid type. They are rare in the Himalayan region with a few scattered records from Nepal (Kemp & Butler 2001) and northeastern India from Darjeeling to Assam and Meghalaya (Prasad & Varshney 1995).

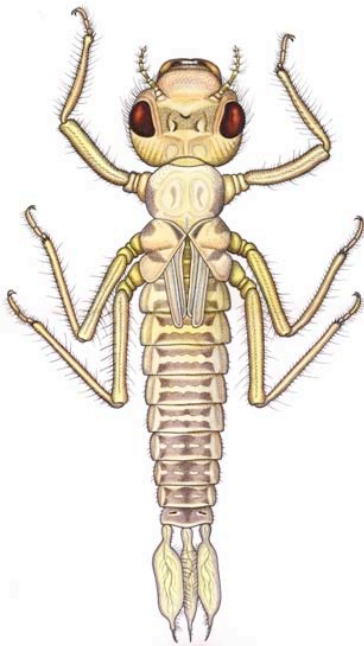
This family includes around 10–12 species of 4–5 genera in the tropical and oriental region. They share generally plesiomorphic characters and might be an ancient relict line within the Zygoptera (Dudgeon 1999; Kalkman



**Image 4.**  
**Amphipterygidae**  
**Habitat: Poyang,**  
**China. length**  
**24.5mm.**



**Image 6. Protoneuridae -**  
**Habitat: Ghate Khola (Inlet of**  
**fishpond), Hetauda, central**  
**Nepal. Length: 13mm.**



**Image 5.**  
**Platystictidae -**  
**Habitat: Jakeshwori**  
**Khola, Melamchi,**  
**central Nepal.**  
**Length 15mm.**

et al. 2008, 2010). The genus *Philoganga* is often separated as subfamily or family (Subramanian 2009).

### **Platystictidae**

The larvae of the Platystictidae family (Image 5) possess more or less saccoid gills as in Euphaeidae, but do not bear any abdominal gills. The palpal lobes of the labium consist one spine and one movable hook. The colour pattern of the body is pale and somewhat

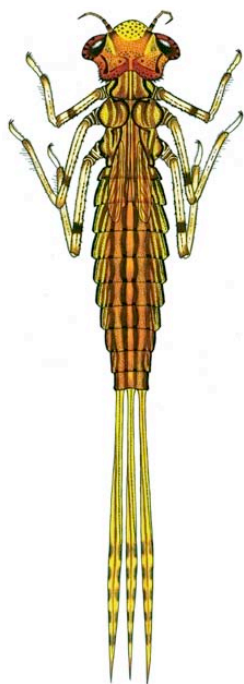
spindly with large bulbous eyes.

The Platystictidae are widespread in South Asia to Southeast Asia (New Guinea) and are also known from central America and the northern part of South America. The larvae are found in small forested streams. Around 191–213 species are known worldwide (Kalkman et al. 2008; van Tol 2008).

### **Protoneuridae**

The larvae of this family (Image 6) have two-segmented leaf-like caudal gills of similar shape and length. The gills are clearly divided into a thickened dark proximal portion and a thin, paler distal part. The anterolateral margins of the labial mentum are fringed with tiny teeth. One premental seta is situated on either side of the midline of the mentum. There are three setae on the palpal lobes. This family has delicate aquatic larvae with flattened bodies and relatively long antennae; the long, slender legs are fringed with setae. The posterior margin of the head forms two lateral horn-like extensions, whereas it is smoothly rounded in Coenagrionidae.

Protoneuridae have a wide distribution in tropical and subtropical zones but they are insufficiently known and not generally recognized as family by traditional odonatology. Protoneuridae inhabit in a narrow range of slowly running and stagnant waters. The most abundant fauna is found in wetlands and lentic zones



**Image 7. Platycnemididae -**  
**Habitat: Jagadishpur Reservoir,**  
**Lumbini, central Nepal. Length**  
**15mm.**

of rivers and streams in lowlands and plains. In the study area, they occurred numerously together with Coenagrionidae in submerged macrophytes of ponds, reservoirs and lakes. The general color appearance of the observed larval forms is uniform light yellow brown. The identification of genus- or species level is almost impossible due to the high number of taxa with completely unknown larvae.

### **Platycnemididae**

The caudal gills of the larvae are very long, their length is approximately the same as the abdomen with apices somewhat pointed or attenuated and inconspicuous tracheal branching (Image 7). The gills are not usually clearly divided into proximal and distal portions. The third segment of antenna is slightly longer than the second. The anterolateral margins of the labial mentum are not toothed.

The records of larvae in the study area are rare. The family occurs at elevations ranging from about 200m to 1900m. The figured specimen (Image 7) was found in the littoral section of Jagadishpur reservoir (197m).

### **Coenagrionidae (Synonym: Agrionidae)**

The larvae have leaf-like caudal gills of similar shape and length. The gills are not usually distinctly divided into proximal and distal portions. The caudal gills are shorter than the abdomen, with rounded apices

and conspicuous tracheal branching. The anterolateral margins of the labial mentum are not toothed and 3-5 premental setae are usually situated on either side of the midline of the mentum. The third segment of antenna is shorter than the second.

This family has the highest species number among all Zygoptera with 1,080 taxa and a worldwide distribution. Coenagrionidae (Image 8a–d) inhabit a wide range of running and stagnant waters; the most diversified fauna is found in wetlands and lentic zones of rivers and streams. In the study area, they occurred numerously together with Libellulidae in submerged macrophytes of ponds, reservoirs and lakes. The general color appearance included light yellow brown forms, dark striped forms, and bright green to dark brown forms. The distinction between Coenagrionidae and Protoneuridae is very easy based on the form of head and color but the identification of genus or species level is almost impossible due to the high number of taxa with completely unknown larvae.

### **Anisoptera: Gomphidae**

The general body shape of Gomphidae (Image 9 a–b) is compact, and elongate with an ovate dorso-ventrally flattened abdomen. The legs and often the whole larval body is covered with various types of hairs, setae, and spines. The antennae are four-segmented with the third segment enlarged. The tarsi of the first two pairs of legs are two-segmented. The labial mentum is more or less quadrate and the anterior margin of labial mentum is never cleft.

The larvae mostly inhabit running waters and are highly diversified in lowlands at floodplains of large rivers. Worldwide there are more than 966 species known. All Gomphidae are burrowers in sediment. The larvae process various morphological adaptations to different sediment types. Despite their burrowing lifestyle some Gomphidae are very good swimmers too.

The larval body of sand and silt (Psammopelal, Pelal) burrower is covered with fine hairs. Living specimens have attracting light greenish colour (Image 9a). They occur in moderately polluted water bodies. In case of fine gravel (akal) burrower, only the legs are covered with fine hairs. The third antenna segment is broadened spooned-shaped (Image 9b). Living specimens have yellow-orange brownish colour. They occur in non/slightly and moderately polluted river



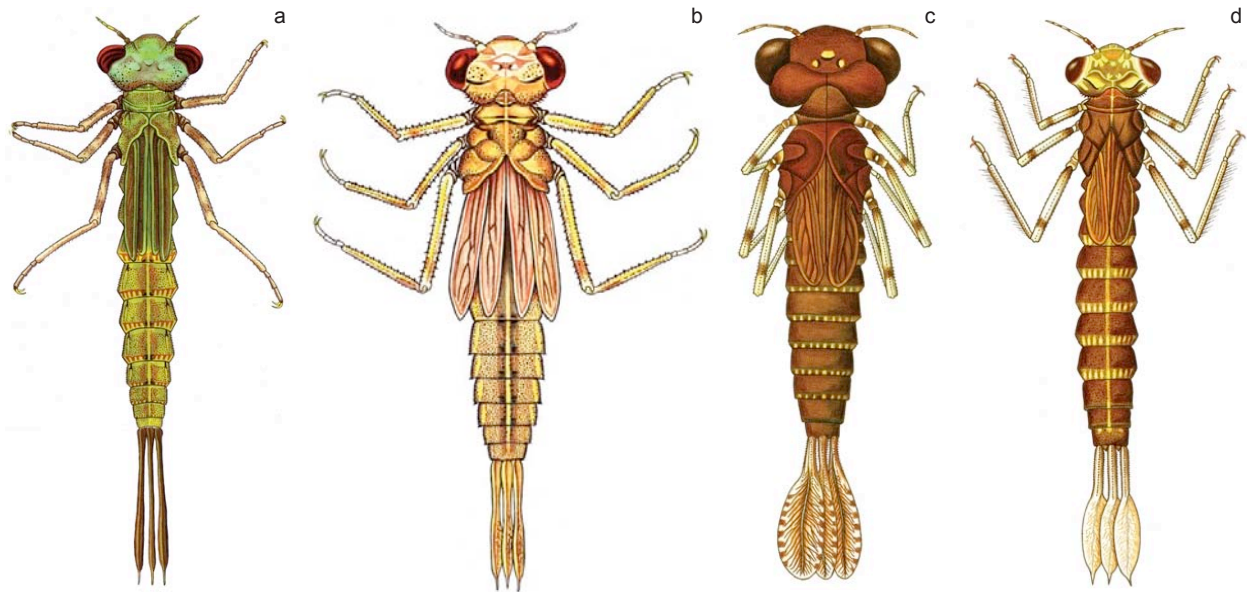


Image 8 a–d: Coenagrionidae – Habitat: a & b - Dhobi Khola near Kathmandu University, Dhulikhel, central Nepal; c - Ghodaghodi Tal, Kailali, far western Nepal; d - Ghate Khola (Inlet of fishpond), Hetauda, central Nepal. Length: (a) 18.2mm; (b) 12.5mm; (c) 14.5mm; (d) 13mm.

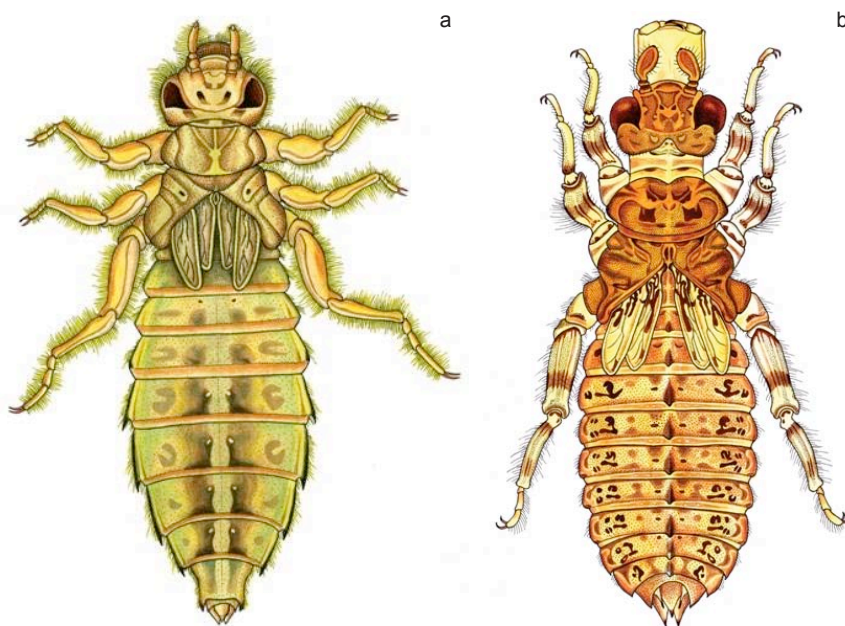


Image 9 a–b. Gomphidae - Habitat: (a) Ganga River, right bank at Ghandi Ghat, Patna (Bihar) Northern India; (b) Bijayapur Khola, Pokhara, western Nepal. Length: (a) 21mm; (b) 18mm.

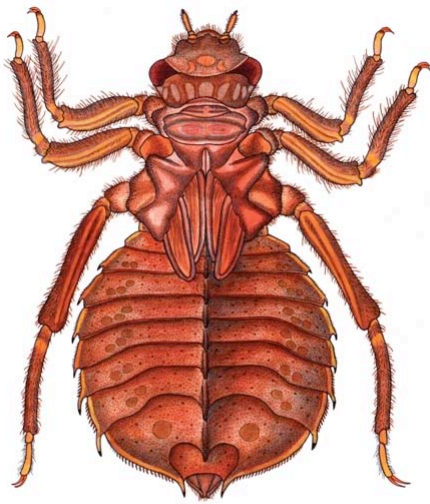
stretches. The figured specimen (Image 9b) was found in the same habitat of *Aphelocheirus* spp. (Heteroptera: Nepomorpha: Aphelocheiridae).

### Lindeniinae

This subfamily (Prasad & Varshney 1995, p. 403) or family (Hawking & Theischinger 1999, p. 25) (Image 10) comprises the genera *Sieboldius*, *Ictinogomphus* and *Gomphidia* in Asia and Australia. Kalkman et al., (2008) does not include Lindeniinae (or Lindeniidae)

as a separate taxon. The larvae are very large and robust with circular flattened abdomen. Previously they were placed into the family Gomphidae, but differ in several characters and life style. The labium is enlarged and much broader than in Gomphidae. The colour of the body is dark ochre-brown.

Lindeniinae larvae are not sediment-inhabiting; they are exclusive climbers on submerged macrophytes. They colonize large stagnant water bodies and slowly running rivers from lowlands up to 800m. Larva



**Image 10.**  
Lindeniinae -  
Habitat: Phewa  
Lake wetland,  
Pokhara,  
western  
Nepal. Length:  
20.5mm.

was found climbing on submerged macrophytes in a lentic zone of Metapotamon-type (large river). They were recorded in a moderately polluted water body. It is locally abundant in floating macrophytes, found in Nepal (Phewa Tal wetlands, Begnas Tal effluent) and India (Jharkhand, upper Subernarekha River and Maharashtra, Tahoba wetland), preferring *Eichhornia crassipes* as substrate.

Lindeniidae were already separated from the majority of Gomphidae on subfamily level as Hageniinae by several authors (St. Quentin & Beier 1968, p. 8). More recent publications raise them to family level (Xylander & Günther 2003, p. 141).

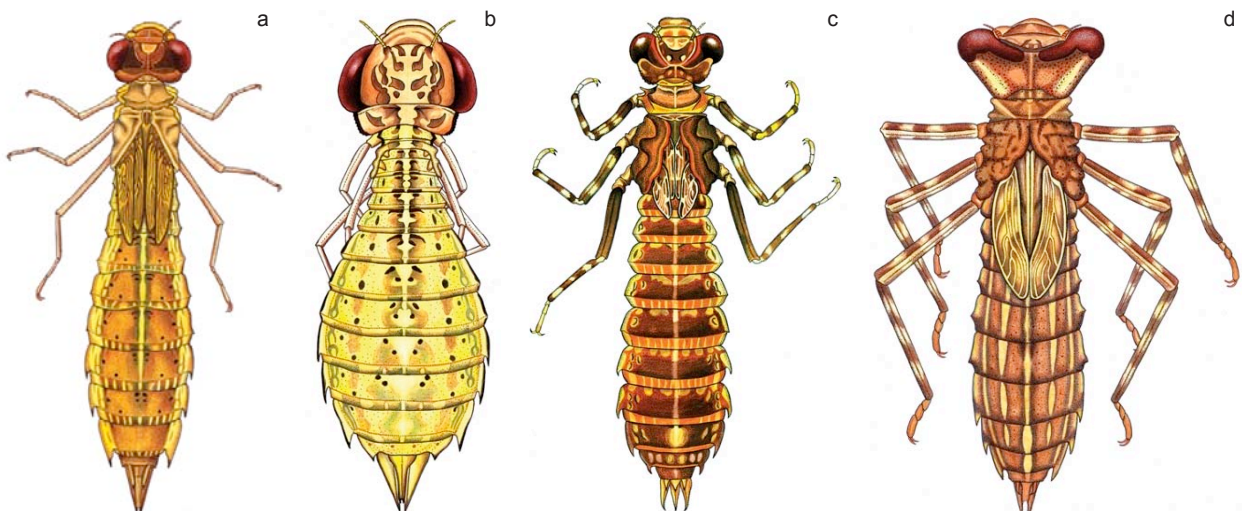
## Aeshnidae

Aeshnidae larvae (Image 11 a–d) are the largest among Odonata reaching more than 5cm length. The larvae are rather elongated with a robust, cylindrical abdomen and very large eyes. The antennae are six or seven-segmented and filamentous. The tarsi of all legs have three segments. The labial mentum is widest in the distal portion and narrowing towards the posterior part with a cleft in the anterior margin. The body surface of the larvae is smooth, without any hairs, setae or bristles. The larval colour display a wide range from light yellow, bright green, ochre brown to dark brownish often with segmentally arranged dark patterns on the dorsal side of the abdomen.

Within the family Aeshnidae, the subfamily Anactinae is mainly confined to the Ethiopian and Oriental regions with range extension of some species into the temperate Palearctic. In the Indian subcontinent, they are found sporadically in various undisturbed, natural, slightly and moderately polluted waters. They are nowhere abundant or common and only small numbers of individuals were observed.

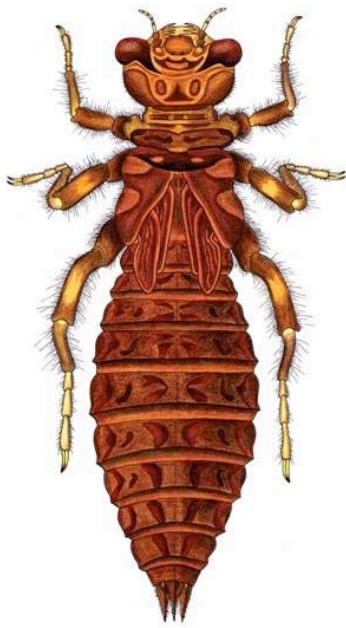
## Cordulegastridae

The body of Cordulegastridae larvae (Image 12) is elongate and covered with bristles or tufts of setae. The distal margin of the palpal lobes of labium is with large irregular teeth which interlock with those on the corresponding lobe. The anterior margin of the mentum is cleft. The colour appearance is dominated

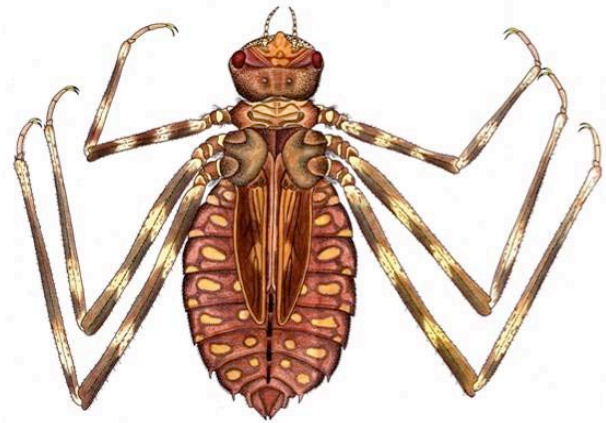


**Image 11 a–d.** Aeshnidae - Habitat: a - Gaur municipality pond, Rautahat, central Nepal; b - Punpun River, Gaurichak, Patna, northern India; c - Khimti Khola, central Nepal; d - Punyamata Khola, Nagarkot hill, central Nepal. Length (a) 53mm; (b) 10.3mm; (c) 30.5mm; (d) 26.5mm





**Image 12.**  
Cordulegastridae -  
Habitat: Pengul Khola,  
Sindhupalanchwok,  
central Nepal.  
Length: 33.5 mm.



**Image 13. Macromiidae** - Habitat: Mahadev Khola,  
Bhaktapur, central Nepal. Length: 23.5mm.

by a dark brown background with some blackish markings, regularly arranged on the dorsal side of the abdominal segments.

The family has a limited distribution range in the Palearctic and Oriental regions. The larvae are crawlers on sand and muddy sediments of fast running cool streams and rivers, especially in the Himalaya. They usually lay half buried in the surface sediment layer and wait for prey. The larvae are pollution-sensitive and demand highly oxygenated water. They are not common and were recorded during the present study only from the upper stretches of small rivers and streams of natural forests above 1500m.

### Macromiidae

The legs of Macromiidae (Image 13) are very long, giving the larvae a “spidery” appearance. The abdomen is depressed and more or less circular in outline. On the head, a small “horn” is present between the antennal bases. The labium bears rather long, regular teeth along the distal margins of the palpal lobes.

The family has a worldwide distribution but their occurrence is restricted in the tropical, subtropical and warm temperate zones except South America. There are approximately 120 species known. They prefer running water with low organic input and are found in slightly to moderately polluted stretches. A few *Macromia* and *Epophthalmia* species are recorded from northern India and Nepal (Sharma 1998; Mitra

2003). The Macromiidae are recently raised to family level, previously they were placed as subfamily Epophthalmiinae into family Corduliidae.

They are frequently recorded from the upper regions of undisturbed forest streams in the Himalayan middle mountains from 800 to 1970 m. The figured specimen might belong to *Macromia moorei moorei*, which is spread widely over the northern Indian subcontinent. The larvae occur on coarse-grained sand or gravel substrate (Psammal, Akal) deposited behind or under large stones.

### Corduliidae

The larvae of Corduliidae (Image 14 a–b) resemble Libellulidae, but their size is usually larger and the body is more firm than the latter ones. Their legs are rather short and the apex of the femur does not extend beyond abdominal segment VIII. The abdomen is not markedly depressed or circular in outline. The cerci are generally more than one-half as long as paraprocts.

The total number of species is 255 worldwide; in Asia the family is less represented. Historically, there was no clear distinction between the three families Libellulidae, Corduliidae and Macromiidae. They all were placed into a single family Libellulidae. More recently fundamental characters of the anal pyramid allow distinguishing larvae. In Corduliidae, the length of cerci exceeds always more than half as long as epiproct, whereas in Libellulidae the length of cerci is less than half as long as epiproct (Okudaira et al. 2005, p. 360). They were rarely collected in the study area from slowly running stretches of stream and river

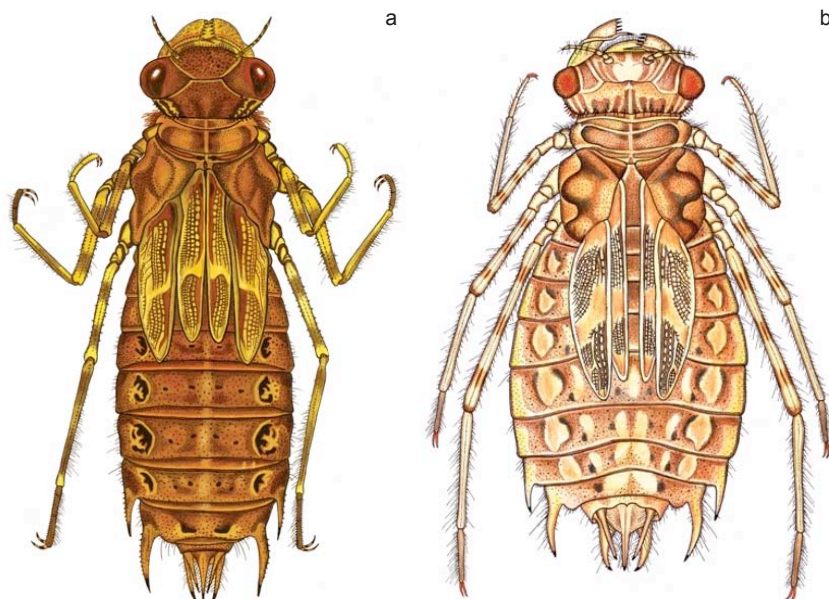


Image 14 a–b: Corduliidae - Habitat:  
 a - Dhobi Khola near Kathmandu  
 University, Dhulikhel, central Nepal;  
 b - Ghate Khola (Inlet of fishpond),  
 Hetauda, central Nepal.  
 Length: (a) 26.3mm; (b) 22mm.

with moderate to heavy pollution. It is not possible to recognize and separate them in the field from Libellulidae; proper identification can be only done in a laboratory with a microscope.

#### Libellulidae

The larvae (Image 15 a–g) are minute to medium-sized and have a delicate comparatively soft body. Their legs are rather short and the apex of the femur does not extend beyond abdominal segment VIII. The abdomen is not markedly depressed or circular in outline. The cerci generally are not more than one-half as long as paraprocts.

The family Libellulidae, the largest family of Anisoptera has a cosmopolitan distribution with more than 970–1,012 described species. The larvae are very similar in appearance and shape to Corduliidae but differ by their anal pyramid. In Libellulidae, the length of the cerci is less than half as long as epiproct. Body colour of the different species may cover a wide range from bright yellow, light greenish to dark brown. Larvae are usually very abundant in all types of stagnant waters and are able to colonize successfully even in small water bodies with low oxygen where other odonates cannot survive.

#### Anisozygoptera: Epiophlebiidae

The larvae are somewhat slender and elongate; with a slight petiolation at the base of the wing pad. The minute and very short antennae are with five

segments. The larval body is very hard and firm covered with tubercles, but lacking any bristles. The family is extremely rare with isolated discontinuous relict distribution in Japan and the Himalaya only. The family is certainly recorded from Mesozoic onwards (Nel & Jarzembowski 1996).

There are only two extant species, regarded as 'living fossils'. *Epiophlebia superstes* are recorded only from Japan while *Epiophlebia laidlawi* are recorded from the Himalayan regions of Bhutan, India and Nepal. The life cycle of the *Epiophlebia superstes* is better known, including adults, terrestrial phase, and egg deposition; adults of *E. laidlawi* are not yet found. The larvae are limited on natural upper regions of fast running forest streams with good water quality. Small larvae prefer rapids and riffles with embedded stream bottom; they are highly pollution-sensitive and live only in Epirhithron- to Metarhithron-type of biocoenotic zone (Neseemann et al. 2008, 2011).

The young larvae (Image 16a) differ markedly in dorsal colour, having dark pigmentation only on abdominal segments 2 to 5, and 9. Large larvae have generally brownish or nearly blackish appearance with dorsal metameric pattern on abdomen (Image 16b). The distinguishing of male and female individuals by the presence of ovipositor is only possible for larger larvae from 8mm body length onwards (Neseemann et al. 2008, 2011).



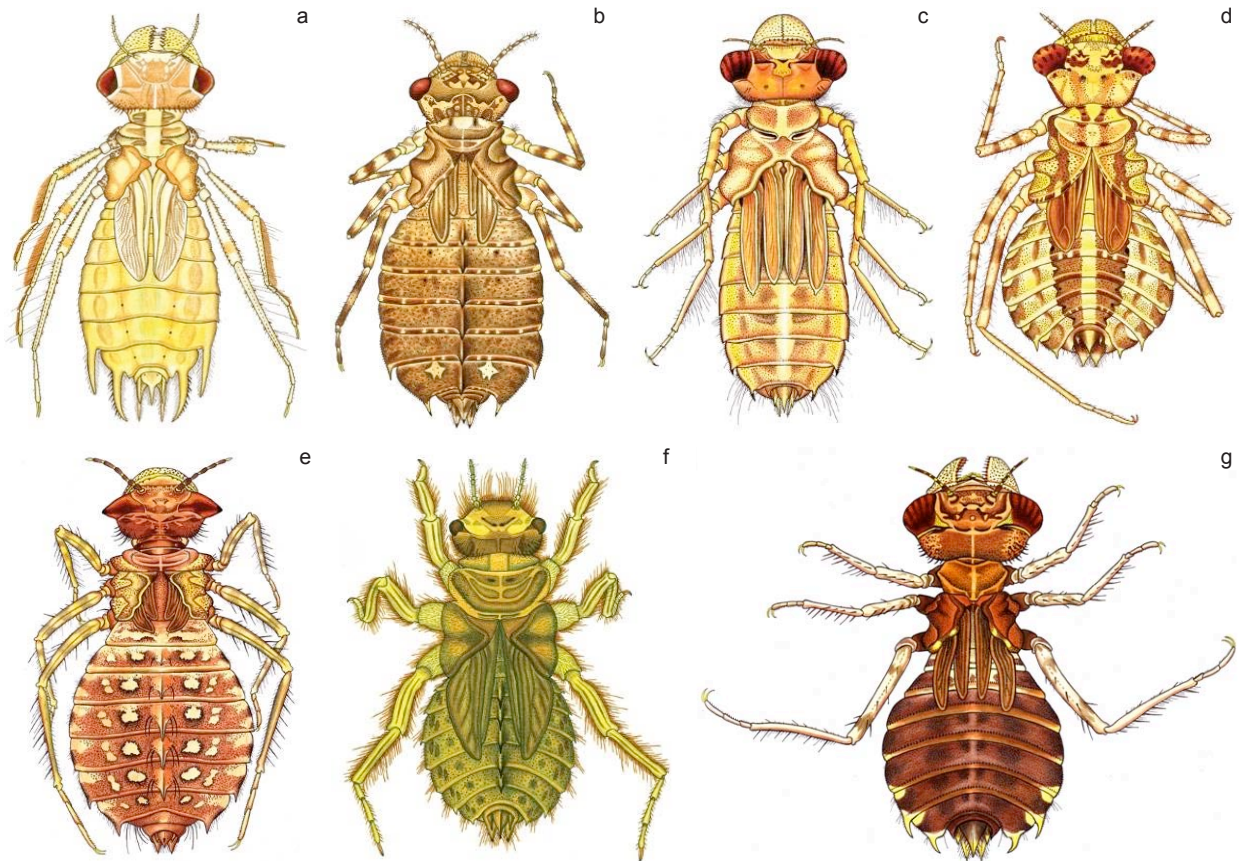


Image 15 a–g. Libellulidae - Habitat: a - Cha Khola (irrigation channel), Kuntabesi, central Nepal; b - Nagdaha pond, Lalitpur, central Nepal; c - Kumhrar park, “Bivalvia” pond, Patna, northern India; d - Taudaha Lake, Kirtipur, central Nepal; e - Kumhrar park, “Phoenix” pond, Patna, northern India; f & g - spring pools in Kathmandu University, Dhulikhel, central Nepal. Length (a) 24mm; (b) 11.5mm; (c) 12.2mm; (d) 12.5mm; (e) 13.8mm; (f) 18mm; (g) 18mm.

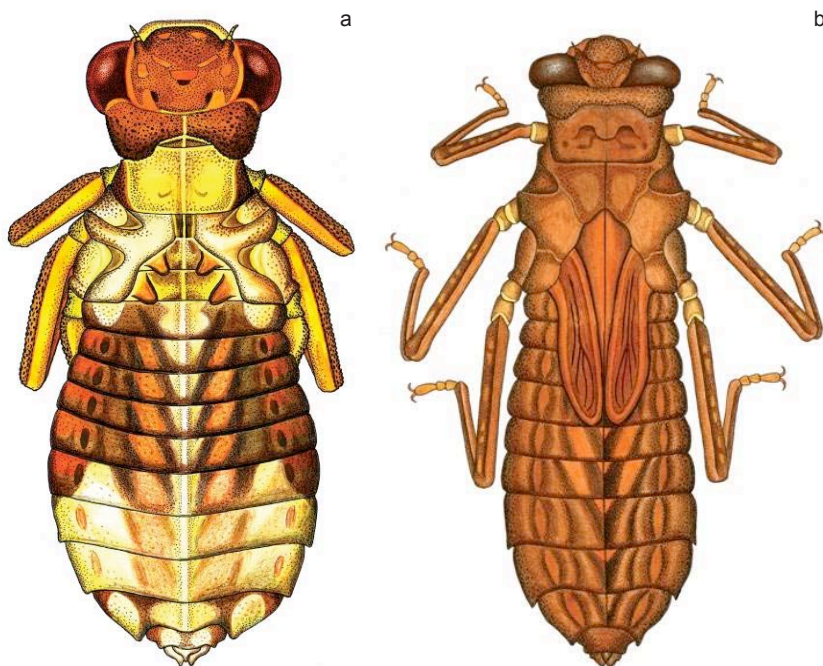
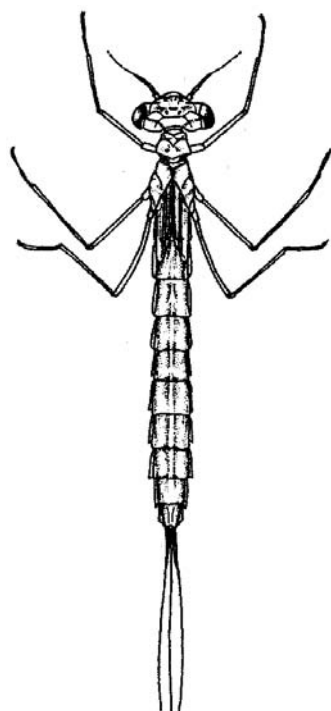


Image 16 a–b. Epiophlebiidae (*Epiophlebia laidlawi*) - Habitat: a - Sim; b - Simbhanjyang Khola, Daman, central Nepal. Length: (a) 8.6mm; (b) 23mm.



**Figure 7. Lestidae [fig. taken: Kawai 1985: 62 (fig. no. 3a), *Lestes* sp. (length unknown)]**

## TAXONOMIC KEY

The order Odonata can be divided into two distinct groups or suborders: Damselflies (Zygoptera) and Dragonflies (Anisoptera).

Damselflies larvae are usually more slender than dragonflies and their abdomen terminates in three caudal filaments (gills) resembling leaves. Dragonflies larvae are much more robust with an abdomen terminating in five points consisting of a pair of cerci, a pair of paraprocts, and a single epiproct. In both damselflies and dragonflies, the shape of the lower lip (labium) can be a diagnostic character for separating families. The shape of antennal segments is also an important character in identification of odonates.

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### Key to Odonata suborders

1. Larvae slender, head wider than thorax and abdomen; abdomen terminating in three long caudal leaf-or sac-like gills (these gills are fragile and are sometimes broken off and lost)... Zygoptera (Damselflies)
2. Abdomen rather short and stout, lacking caudal gills; head usually narrower than thorax and abdomen; five short stiff, pointed appendages at tip of abdomen ending in five points; the three largest of which form an 'anal pyramid' .....Anisoptera (Dragonflies)
3. Larvae stout, elongate with a slight petiolation at the base of the wing pad; antennae with five segments; body covered with tubercles, but lacking bristles, body firm; extremely rare and restricted in the Himalayas (Nepal, India and Bhutan).....Anisozygoptera (Relict Dragonflies): one family with one species: Epiophlebiidae (*Epiophlebia laidlawi*) (Image 16 a&b)

### Key to Zygoptera Families

1. Two forceps-like caudal gills (the median gill is minute) which are triangular in cross section..... Chlorocyphidae (Fig. 6)
  - Three caudal gills that are sac-, leaf-, or blade-like.....2
2. Filamentous gills on the underside of abdominal segments II-VIII.....Euphaeidae (Image 1 a-b)
  - No filamentous gills on the underside of abdominal segments II-VIII .....3
3. First antennal segment longer than the combined length of subsequent segments; anterior margin has a well-developed median cleft ..... Calopterygidae (Image 2)
  - First antennal segment much shorter than the combined length of subsequent segments.....4
4. Labium distinctly spoon-shaped and strongly tapered posteriorly .....Lestidae (Fig. 7)
  - Labium quadrate or more or less triangular in shape, with palpal lobes bearing moveable hooks or spines at the tips, and lacks setae on the mentum or palpal lobes.....5
  - Labium with setae on the mentum or palpal lobes.....8
5. Gills leaf-like with rounded apices.....Synlestidae (Image 3)
  - Gills more or less saccoid.....6
6. Delicate aquatic larvae with flattened bodies and relatively long antennae; long, slender legs fringed with setae..... 7
7. Larvae may be large and deeply pigmented; palpal lobes of the labium with three spines and one movable hook .....Amphipterygidae (including: Philogangidae) (Image 4)
  - Pale, somewhat spindly larvae with large bulbous eyes; palpal lobes of the labium with a single spine and one movable hook.....Platystictidae (Image 5)
8. Gills clearly divided into a thickened dark proximal portion and a thin, paler distal part; one premental seta is situated on either side of the midline of the mentum; anterolateral margins of the labial mentum fringed with tiny teeth .....Protoneuridae (Image 6)
  - Gills not usually clearly divided into proximal and distal portions; anterolateral margins of the labial mentum are not toothed; usually more than one premental seta on either side of the midline of the mentum..... 9
9. Caudal gills long (approximately the same length as the abdomen); third segment of antenna longer than the second.....Platycnemididae (Image 7)
  - Caudal gills shorter than the abdomen; third segment of antenna shorter than the second; 3-5 premental setae are usually situated on either side of the midline of the mentum..... Coenagrionidae (Image 8 a-d)

### Key to Anisoptera Families

1. Labial mentum or palpal lobes more or less flat; without setae on the mentum or (usually) the palpal lobes ..... 2
  - Labial mentum or palpal lobes are mask- or bowl-shaped; setae usually occur on the mentum and are always present on the palpal lobes .....3
2. Antennae four-segmented, with the 3rd segment enlarged; tarsi of the first two pairs of legs are two-segmented; labial mentum more or less quadrate; anterior margin of labial mentum is never cleft,
  - A. With elongated abdomen, burrowing in substrate .....Gomphidae (Image 9 a-b)
  - B. With circular and widened abdomen, climbing on macrophytes.....Lindeniinae (Image 10)
    - Antennae six or seven-segmented and filamentous; tarsi of all legs have three segments; labial mentum widest in the distal portion and narrowing towards the posterior with a cleft in the anterior margin..... Aeshnidae (Image 11 a-d)
3. Body elongate and covered with bristles or tufts of setae; distal margin of the palpal lobes of the labium with large irregular teeth; anterior margin of the mentum is cleft.....Cordulegastridae (Image 12)
  - Body short and stout; anterior margin of the mentum is cleft.....4
4. Legs very long giving the larvae a 'spidery' appearance; abdomen depressed and more or less circular in outline; a small 'horn' may be present between the antennal bases..... Macromiidae (Image 13)
  - Legs rather short; abdomen not markedly depressed or circular in outline ..... 5
5. Cerci generally more than one-half as long as paraprocts .....Corduliidae (Image 14 a-b)
  - Cerci generally not more than one-half as long as paraprocts ..... Libellulidae (Image 15 a-g)

*Montana* (Selys) (Zygoptera: Amphipterygidae). *Notulae Odonatologicae* 5(7): 85–96.

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