Javier Oscoz · David Galicia
Rafael Miranda *Editors*

Identification Guide of Freshwater Macroinvertebrates of Spain

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Preface

Freshwater ecosystems are of key importance, since water is a natural resource that exerts vast ecological influences over all the other ecosystems. Furthermore, fluvial systems are considered basic and fundamental indicators of the conservation status of the environment in general because the state of the water is the (integral) consequence of all that occurs within a given river basin. To put it in a different way, the disturbances and transformations that the environment suffers end up affecting the state of the freshwater ecosystems, as these are the final sewers of those disturbances. Therefore, the ecological status of the water ultimately portrays the status and quality of the entire adjacent ecosystem. The capital importance of freshwater ecosystems leads to the notion of water as heritage. As such, it needs to be protected and defended, promoting the sustainable use of water and improving water quality as much as possible.

As a result of the European Commission's concern on the status of continental waters, and as a clear reflection of the notion of water as heritage to be conserved, in the year 2000 the Water Framework Directive (2000/60/CE) was enacted. Its goal is to establish a framework to protect water and the different aquatic ecosystems by requiring the Member States to achieve good ecological status in all their waters by 2015.

Like all ecosystems, freshwater ecosystems undergo physical, chemical and energy changes, both of natural and anthropogenic origin. These disturbances affect the organisms living in them and those who utilize their resources. Therefore, evaluating these changes has become a very important task to better understand aquatic systems. The study and analysis of the ecological status of these ecosystems in relation to their conservation status and water quality is thus a fundamental tool for a more efficient and rational management of their resources; that is, a management that does not threaten the ecosystem.

The present key for the identification of Spanish freshwater macroinvertebrates aims to facilitate the job of those who go to great lengths to identify macroinvertebrates to then determine biotic indices. All of us who have contributed to this work hope to have achieved this goal.

Acknowledgments This monograph is the result of the project entitled "Study and Description of Macroinvertebrate Populations of the Ebro Basin and Comparison among Spanish Basins in the Water Framework Directive", financed by the Ebro Hydrographic Confederation of the Ministry of Environment, Rural and Marine Affairs of the Spanish Government and supervised by Dr. Concha Durán, manager of the Water Quality Service of this institution. María Díez-León translated into English our confusingly written Spanish paragraphs; without her help and friendship this book could not have been possible. Our colleagues in the Department of Zoology and Ecology of the University of Navarra encouraged us to take this initiative and supported us through its completion. Finally, we are especially grateful to Jose Antonio Salinas (Franky), eminent researcher, precursor, teacher and friend, who introduced us into the amazing world of macroinvertebrates.

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1 Why, Where and How: An Identification Guide of Macroinvertebrates

Abstract

This chapter provides a general introduction to the identification of macroinvertebrates, with particular emphasis on the management of river systems and the correct identification of these animals in field surveys. Subsequently, the study area and taxonomic groups considered are defined and delimited. Technical considerations about photographic methods are also included at the end of the chapter.

Introduction

Although the status of the ecosystems has traditionally been analysed using physicochemical parameters, in later years there has been a trend to complement their use with biological indicators such as diatoms, macrophytes, macroinvertebrates or fish (e.g. Oliveira and Cortes 2006; Oscoz et al. 2007; Hermoso et al. 2010). Communities of living organisms reflect the physicochemical conditions in a given ecosystem, and they also provide information across time (as opposed to one-point-in-time sampling) about the status of the waters. The Water Framework Directive (Directive 2000/60/CE) establishes groups of biological indicators belonging to phytoplankton, macrophytes, phytobenthonic organisms, invertebrate benthic fauna (benthonic macroinvertebrates) and ichtyofauna, which ultimately determine the ecological status of a particular body of water.

Within the biological indicators, macroinvertebrates are one of the most employed groups of organisms. They have a series of advantages as bioindicators that can be summarised as follows (Platts et al. 1983; Metcalfe-Smith 1994): (1) most have limited mobility and thus reflect the local characteristics of the sampled area; (2) they generally have long enough life cycles and therefore their characteristics are the result of a relatively recent past, including sporadic episodes difficult to detect with chemical or microbiological analyses; (3) they can be found in most aquatic habitats, where they are abundant and relatively easy to capture; (4) sampling has minimal impact on the resident biota; (5) their taxonomy is relatively well defined; (6) they have different sensitivity to different pollutants, reacting rapidly with gradual responses; (7) because different groups of animals and trophic levels are included, the probability of one of these organisms reacting in the face of an environmental change is high; and (8) taxonomical determination to family level is a reliable indicator of environmental conditions (Graça et al. 1995; Olsgard et al. 1998).

Macroinvertebrates in a broad sense are those invertebrates big enough that can be observed without magnifying lenses (Platts et al. 1983), usually under 500 μm (Cummins 1992). More precisely, freshwater macroinvertebrates can be defined as those invertebrate organisms that live in aquatic habitats at some point in their life cycle and that are trapped by mesh with a gauge between 200 and 500 μm (Rosenberg and Resh 1993).

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This includes many species from different phyla, such as annelids, molluscs, plathelminthes, nematodes and arthropods (mainly insects). Most of these species are associated with surfaces of the bottom of rivers or other stable surfaces, instead of being species that swim freely most of the time. Due to that tendency to inhabit bottoms, they are usually referred to as benthic macroinvertebrates (Hauer and Resh 1996).

In the last few years, several Spanish studies using macroinvertebrates have been carried out with several purposes, such as the development of quality indices (e.g. García de Jalón and González del Tánago 1986; Alba-Tercedor and Sánchez-1988; Benito and Puig 1999), the study of the quality and ecological status of the environment (e.g. Zamora-Munoz and Alba-Tercedor 1996; García-Criado et al. 1999; Alba-Tercedor et al. 2002; Martínez Mas et al. 2004; Oscoz et al. 2007, 2008a), and several different studies on macroinvertebrate ecology (e.g. Vivas et al. 2002; Oscoz et al. 2006, 2008b; Leunda et al. 2008, 2009). Despite these efforts, there are few published works on identification keys of Spanish macroinvertebrates, and those published either refer to just a portion of the territory or to a specific macroinvertebrate group (e.g. Nieser et al. 1994; Puig 1999; Tierno De Figueroa et al. 2003; González and Cobo 2006; Rueda Sevilla and Hernández Villar 2009). Therefore, general keys of different countries have been traditionally used to identify Spanish macroinvertebrates (e.g. Macan 1975; Tachet et al. 1984, 2000; Sansoni 1988). However, sometimes these foreign keys might not be sufficient to correctly determine Spanish fauna. This book is intended to attend this need and provide a useful tool for the different macroinvertebrate studies that are carried out in Spain.

In short, it is not the aim of this book to be a zoological treaty, nor has any taxonomic claim, or aims to add new information on the biology or the ecology of the taxa covered. This book is, simply, a working tool explicitly designed to facilitate the identification of the Spanish macroinvertebrates and the posterior computing of biotic indices.

Methods and Materials

In order to meet the goals we set out for this book, two well differentiated tasks needed to be carried out: (i) to compile and prepare a complete reference collection of the macroinvertebrates present in Spain; (ii) to describe those specimens in detail and to produce the corresponding keys.

Description of the Study Area

As it has already been mentioned, our study area comprises the region of Spain and more specifically, the network that each Hydrographic Confederation has established within its boundaries for the sampling and follow-up of the ecological quality of its waters. According to the Red List of the International Union for Conservation of Nature, Spain is the European country with the most diversity of species, and consequently, the country with the most endemisms and threatened species (IUCN 2010). The peculiar biogeographical situation of the Iberian Peninsula and the consequent climatic diversity are the two main causes of this high biological diversity. All these particular characteristics make of Spain an especially interesting place from a biological point of view.

Study Area and Macroinvertebrate Taxa Considered

In Spain, Limnology represents one of the most important scientific disciplines within the fields of Animal Biology and Ecology. There are numerous groups of scientifically prosper researchers focusing on different groups of macroinvertebrates; all these scientists are heirs to the school started by illustrious scientific minds, whose most international and prominent figure has unquestionably been Ramón Margalef.

The high scientific production in this field greatly complicates the search of an updated reference list. One must not forget that talking about macroinvertebrates is talking about a great amount of different taxa, with experts in each taxon arguing about their taxonomy, in many cases with no few controversies. With the aim to unify criteria, the *Ministerio de Medio Ambiente, Rural y Marino de España* (Ministry of Environment, Rural and Marine Affairs, a.k.a. MARM) has compiled a database unifying the information gathered in water quality sampling of all the Spanish hydrographic basins. Thus, there is an official, centralised and coordinated source of information that provides records of the biological quality of Spanish continental waters that go back almost 20 years. From a scientific point of view, this information might not be as precise as it could be desired, since the taxonomic depth of the water quality samplings is different than that used by the experts. However, for management purposes and for the aim of the present work, that information is extraordinarily useful.

Therefore, the present work is based on the MARM database, which gathers records of macroinvertebrates registered in water quality samplings since the early 1990s of the twentieth century, with a geographic range that covers all the Spanish territory. The original taxonomical lists have been adjusted to the taxonomic levels commonly used in the evaluation of the quality of waters, observing the taxonomical hierarchy established in databases such as *Fauna Ibérica* and *Fauna Europaea*. In this way the book contains 146 taxa belonging to the following phyla: Porifera, Cnidaria, Bryozoa, Plathelminthes, Nematoda, Nematomorpha, Annelida, Mollusca and Arthropoda. Given the nature of the primary source of information, the range of macroinvertebrate fauna covered has the same bias that water quality samplings have, both in the proportion of the different groups found as well as in their taxonomic detail. Almost all the included taxa correspond to the taxonomical level of family, and they are mostly insects. Others, let it be due to a lack of knowledge (e.g. nematods or acari) or because they are unfortunately well known (e.g. the zebra mussel or the American river crawfish), are consigned to the extremes of the taxonomical scale.

Reference Collection

A large proportion of the collected taxa were already part of the collections of the Museum of Zoology of the University of Navarra. However, it has been necessary to resort to other organisms or particular collections to complete the digital collection. We are sincerely grateful to Rafael Araujo (*Museo Nacional de Ciencias Naturales*, National Museum of Natural Sciences, MNCN), Javier Ignacio Sánchez (MNCN), Ana Pujante (*Laboratorios Tecnológicos De Levante*), Jose Luís Moreno (University of Castilla la Mancha), Josefina Garrido (University of Vigo), Mª Angels Puig (*Centro de Estudios Avanzados de Blanes*, Center for Advanced Studies of Blanes, *CSIC*), Miguel Alonso (URS Corporation), Enrique Baquero and Enrique Beruete (University of Navarra).

Image Capture and Processing

A fundamental aspect of this book that we have particularly tended to is the illustrations that accompany the text. These illustrations have been created according to the standards of taxonomic photography (Ariño and Galicia 2005; Ariño et al. 2005). From the first instances, this work has had a practical focus, using key steps to identify specimens which are supported by rich graphic information so the reader can see on paper what he or she might be observing under the microscope.

Photographs were taken with a stereo microscope (Leica MZ6) equipped with a digital camera (Leica DFC420). The optical equipment included two achromatic lenses 0.32× and 1×, thus providing a magnification range from 2× to 40× with an effective field of view of 3 mm to 60 mm wide. This magnification range allowed us to cover almost entirely the wide range of sizes that the different macroinvertebrate taxa can have. Photographs of specimens bigger than 50–60 mm were taken with a reflex digital camera (Nikon D-90) along with a macro zoom lens (Nikon AF 70–180 mm f/4.5–5.6). Lighting was administered through a cold light source (Leica CLS 150X) with optical fiber outputs and a diascopic base. This system allows us to take photographs of both light and dark fields, as required for specimens that are not very chitinous. In the case of the photographs taken with the reflex digital camera, full-spectrum fluorescent lamps (5,500°K) were used (Ariño and Galicia 2005).

It is not easy to obtain on paper a photographic image equivalent to direct observation under the microscope; this level of quality has required the use of a macro photography technique based on multiple images. Depth of field is one of the greatest problems in macro photography and there are several methods oriented to reduce its harmful effect on the quality of a photo. Among them, extended depth of field techniques (based on multiple images of the same object) provide the best results because theoretically they get photographs with no out of focus areas. This is especially suitable for our study because of the size of the specimens and the detail required for adequate taxa description. Therefore, each photograph is a digitally processed image from an array or stack of images taken at different focal planes. All the structures of specimens photographed in this way are focused simultaneously. Obviously, this notably increases the effort required to get each illustration: in the end, more than 8,500 photographs were processed to get around 900 images, most of which have been used for the plates that accompany the texts in this book. All the files have been stored in the image server of the Department of Zoology and Ecology of the University of Navarra.

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2 Identification Keys

Abstract

Identification keys of the most important taxonomic groups of benthic invertebrates recorded in Spanish watersheds are displayed. Some non-Iberian taxa are included, with the aim to facilitate correct taxonomic classification. Identification keys are accompanied by a series of plates. These plates include photographs of the most important taxonomic groups, with more or less detail, to facilitate group identification.

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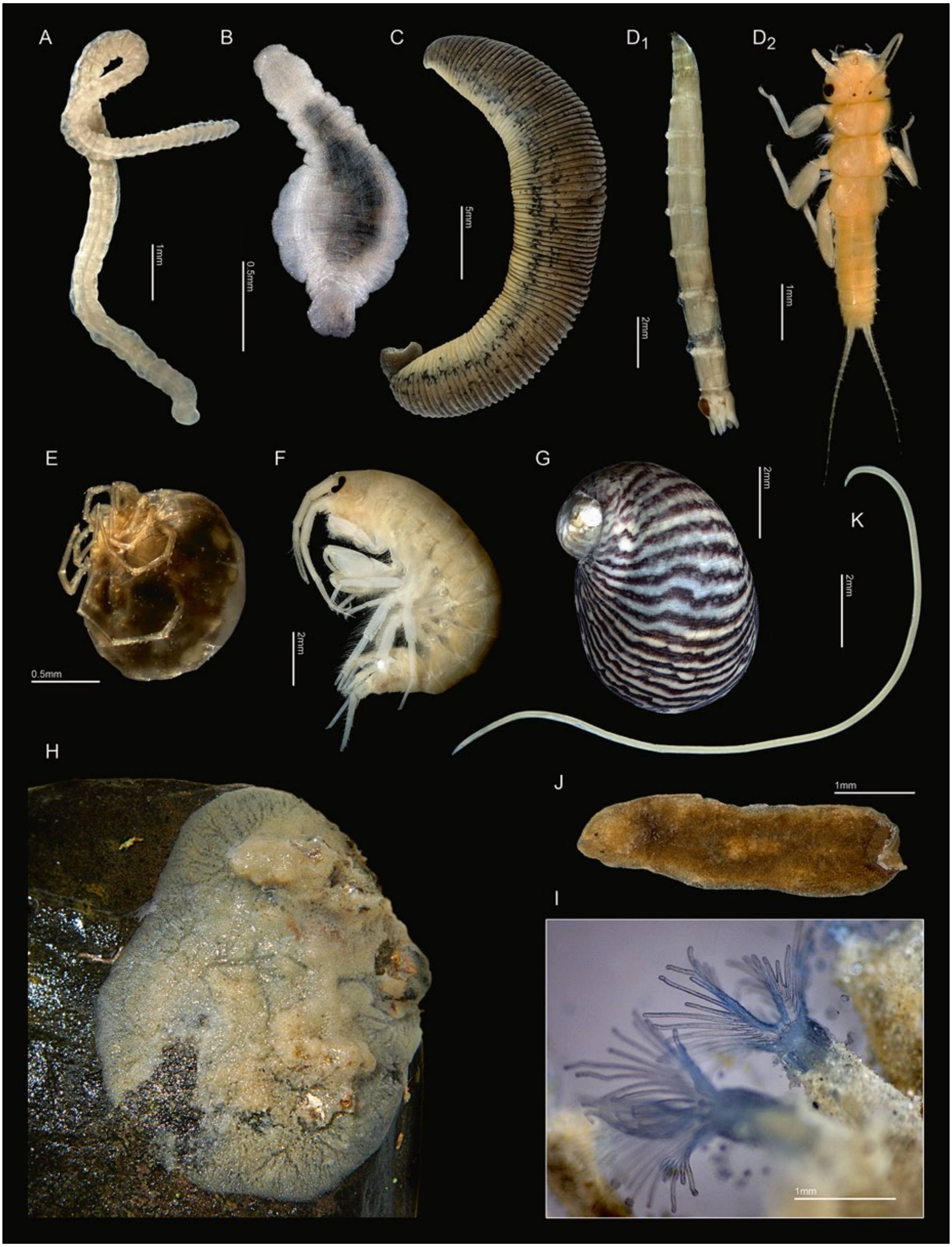

Fig. 2.1 Key Illustrations: Major Groups. (**a**) Oligochaeta; (**b**) Branchiobdellidae; (**c**) Hirudinea, Haemopidae; (**d**) Insecta: Rhagionidae ($\mathbf{d}_1$), Perlidae ($\mathbf{d}_2$); (**e**) Hydrachnidia (Hydracarina); (**f**) Crustacea, Gammaridae; (**g**) Mollusca, Neritidae; (**h**) Porifera, Spongillidae; (**i**) Bryozoa; (**j**) Turbellaria, Dugesiidae; (**k**) Nematoda

Key 1 Major Groups

1. Animal with segmented legs 3
   Animal without segmented legs 2
2. Segmented body 3
   Unsegmented body 10
3. Body shape worm-like without apparent head, mouth pieces absent. Segmented legs, prolegs or other appendages absent 4
   Animals with a more or less differentiated head, in which mouth pieces can be observed. Segmented legs, prolegs and/or other appendages might be present 6
4. Body with one or two suckers 5
   Body without suckers (Fig. 2.1a) .... Cl. **Oligochaeta**
5. Animal without eyes, crustacean parasite, small size (generally <12 mm). Only one sucker (posterior) present (Fig. 2.1b) .... F. **Branchiobdellidae**
   Eyes present. Suckers at both ends, posterior and anterior (Fig. 2.1c) .... Cl. **Hirudinea**
6. Animal without segmented legs, although prolegs maybe present. Body shape worm-like. Head with differentiated sensory organs or segmented appendages maybe present. Mouth provided with some kind of mouth pieces, although these might be reduced (Fig. $2.1d_1$) .... Subph. **Hexapoda**
   Animal with segmented legs 7
7. Animal with three pairs of legs, body clearly segmented. Antennae present (although they might be very reduced) (Fig. $2.1d_2$) .... Subph. **Hexapoda**
   More than three pairs of segmented legs (with or without antennae). If three pairs of legs are present then antennae absent, body spherical, chitinous in general and mostly not segmented 8
8. Five or more pairs of segmented legs. Antennae present (Fig. 2.1f) ....Supercl. **Crustacea**
   Less than five pairs of segmented legs. Animals without antennae 9
9. Adults with four pairs of legs, immature with three pairs of legs. Legs with five or six free segments. Body quite spherical, chitinous and mostly not segmented. Cephalothorax and abdomen are often fused (Fig. 2.1e) .... **Hydrachnidia (Hydracarina)**
   Four pairs of legs. Legs with seven free segments. Separate abdomen and cephalothorax .... O. **Araneae**
10. Calcareous shell present (Fig. 2.1g) .... Ph. **Mollusca**
    Calcareous shell absent 11
11. Animals that live encrusting or attached to stones, branches or other underwater objects. Surface pierced by many holes of various sizes, texture similar to sponges. Spicules present (Fig. 2.1h) ... . F. **Spongillidae**
    Without those characters 12
12. Colonial animals, i.e., a certain amount of “heads” (lophophores) are attached to a single common body. Each of those lophophores has a certain number of ciliated tentacles (like very small flagella). Colonies branched or gelatinous, generally fixed to a substrate, although sometimes with limited motility (Fig. 2.1i and Fig. 3.1n) ....Ph. **Bryozoa**
    Without those characters 13
13. Body dorsoventrally flattened (Fig. 2.1j) .... Cl. **Turbellaria**
    Body not flattened 14
14. Tentacles present .... Ph. **Cnidaria**
    Tentacles absent, animal with long, cylindrical body 15
15. Very large and very long animals (more than 1 cm long) .... Ph. **Nematomorpha**
    Smaller animals (in general less than 1 cm long) (Fig. 2.1k).................................... Ph. **Nematoda**

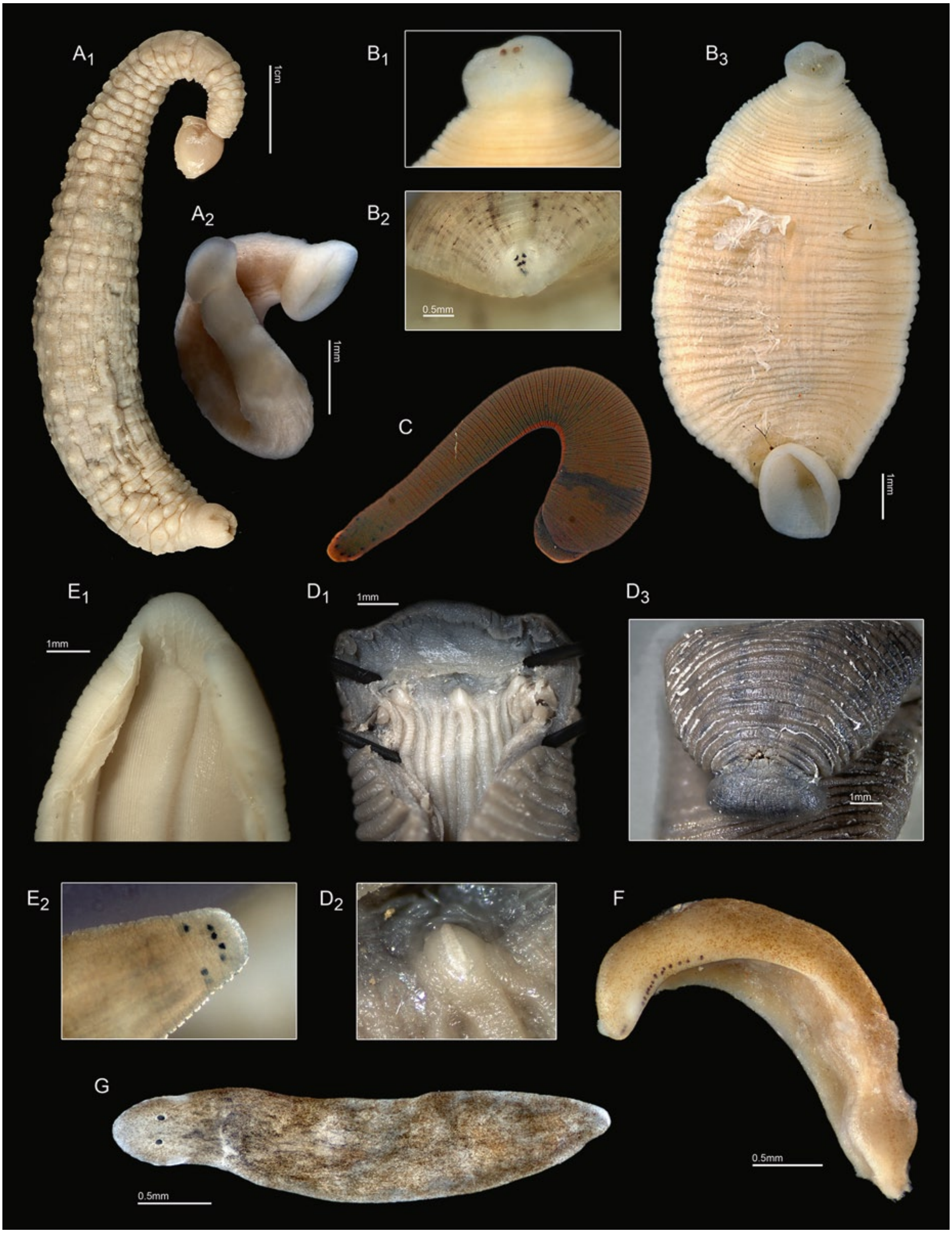

Fig. 2.2 Key Illustrations: Hirudinea and Turbellaria. (**a**) Piscicolidae: marine (a_1) and freshwater (a_2) species; (**b**) Glossiphoniidae: eye distribution (b_1 and b_2), ventral view (b_3); (**c**) Hirudinidae, more than three pairs of eyes; (**d**) Haemopidae: pharynx (d_1), serrated jaw (d_2), anal sucker and opening (d_3); (**e**) Erpobdellidae: pharynx (e_1), eye distribution (e_2); (**f**) Planariidae, many marginal eyes; (**g**) Dugesiidae, head lanceolate with two central eyes

Key 2 Hirudinea

1. Body somewhat cylindrical, anterior sucker (oral) clearly wider than the body (Fig. 2.2a) .... F. **Piscicolidae**
   Body more or less dorsoventrally flattened, anterior sucker always narrower than the body (even if widened) (Fig. 2.2b$_3$) 2
2. One to three pairs of eyes centrally located (Fig. 2.2b$_{1-2}$)........................... F. **Glossiphoniidae**
   More than three pairs of eyes (Fig. 2.2c) 3
3. With five pairs of eyes, pharynx with serrated jaws (Fig. 2.2d$_1$) 4
   With four pairs of eyes, pharynx without jaws (Fig. 2.2e$_1$) 5
4. In the pharynx, jaws have about 15 small teeth arranged in two rows. Wide anal opening. Posterior sucker considerably narrower than the maximum diameter of the body (Fig. 2.2d$_{2-3}$) .... F. **Haemopidae**[1]
   Each jaw has at least 30 teeth distributed in a single row. Anal opening narrow, pore-like. Posterior sucker width is equal or more than three quartes of the diameter of the body (Fig. 2.2c) .... F. **Hirudinidae**
5. Leech with eyes in two longitudinal and parallel rows, one pair of eyes per segment .... F. **Glossiphoniidae**
   Eyes in two segments, each segment containing two pairs of eyes (Fig. 2.2e$_2$) .... F. **Erpobdellidae**

Key 3 Turbellaria

1. Many marginal eyes along the anterior region (Fig. 2.2f)...................................... F. **Planariidae**
   One pair of eyes anteromedially located (Fig. 2.2g) 2
2. One pair of tentacles on the anterior region (cephalic) ....F. **Planariidae**
   Head more or less angular, without tentacles 3
3. Animal of an off-white colour 4
   Animal of a more brownish-greyish colour, whether uniform or not 5
4. Eyes usually wide apart .... F. **Dendrocoelidae**
   Eyes quite close together .... F. **Planariidae**
5. Width of the head smaller than that of the body. Frontal edge lobular ....F. **Dendrocoelidae**
   Width of the head is equal or slightly bigger than that of the body 6
6. Head triangular (lanceolate) or spatulate, in which case the distance between the eyes is greater than the distance to the edge of the body (Fig. 2.2g)... F. **Dugesiidae**
   Head squared. Distance between the eyes always smaller than the distance to the edge of the body ....F. **Planariidae**

[1] Some authors consider this family within F. Hirudinidae.

Fig. 2.3 Key Illustrations: Mollusca (Bivalvia). (**a**) Unionidae: *Unio mancus* (**a**$_1$), *Potomidae littoralis* (**a**$_2$ and **a**$_4$), *Anodonta cygnea* (**a**$_3$); (**b**) Dreissenidae, *Dreissena polymorpha*; (**c**) Sphaeriidae: general view (**c**$_1$), ligament internal (not externally protected) (**c**$_2$); (**d**) Corbiculidae: ligament externally protected by a calcareous furrow; (**e**) Margaritiferidae, *Margaritifera auricularia*

Fig. 2.4 Key Illustrations: Mollusca (Gasteropoda). (**a**) Neritidae, operculum crescent-shaped; (**b**) Viviparidae, three shaded stripes; (**c**) Bithyniidae, operculum protruded; (**d**) Valvatidae, umbilicus open; (**e**) Hydrobiidae, aperture subelliptical; (**f**) Melanopsidae, aperture elongated; (**g**) Ancylidae, shell oval and apex straight; (**h**) Ferrissiidae, apex directed towards the right; (**i**) Planorbidae, spiral flattened; (**j**) Physidae, dextral shell; (**k**) Lymnaeidae, sinistral shell

Key 4 Mollusca

1. With two shells (Bivalvia) (Fig. 2.3) 2
   With just one shell (Gastropoda) (Fig. 2.4) 7
2. Resembles a small mussel. Byssus present (Fig. 2.3b) .... F. **Dreissenidae** *Dreissena polymorpha* (Non-indigenous)
   Resembles a clam or a small oyster. Byssus absent 3
3. Valves symmetric or slightly asymmetric in relation to the umbo. Maximum size of about 30 mm in adult individuals (Fig. 2.3c_1) 4
   Valves clearly asymmetric in relation to the umbo. Size varies from a few mm (juveniles) to more than 150 mm in adults of some species (Fig. 2.3a_{1-2}) 5
4. Ligament internal (Fig. 2.3c_2) .... F. **Sphaeriidae**
   Ligament externally protected by a marked calcareous furrow that sticks out on each valve (Fig. 2.3d).......F. **Corbiculidae** (Non-indigenous)
5. Without cardinal hinge teeth, shell generally thin (Fig. 2.3a_3) .... F. **Unionidae** (in part)
   With cardinal hinge teeth, shell generally thicker 6
6. Shell quite thick and heavy (Fig. 2.3e) .... F. **Margaritiferidae**
   Shell less thick and heavy (Fig. 2.3a_4) .... F. **Unionidae** (in part)
7. Operculum present (Fig. 2.4a–f) 8
   Operculum absent (Fig. 2.4g–k) 13
8. Operculum and opening of the shell crescent-shaped (Fig. 2.4a) .... F. **Neritidae**
   Operculum and opening oval or circular 9
9. Shell with two or three shaded stripes, size generally >20 mm (Fig. 2.4b) .... F. **Viviparidae**
   Shell without shaded stripes 10
10. Calcareous operculum protruding from the shell (Fig. 2.4c).................................... F. **Bithyniidae**
    Operculum retracting inside the first spiral of the shell 11
11. Umbilicus open, shell aperture more or less circular. Alternatively, a flat shell (similar to Planorbidae) (Fig. 2.4d) .... F. **Valvatidae**
    Umbilicus closed, shell aperture not circular 12
12. Shell ovo-conical, up to 10 mm. Shell aperture oval or subelliptical. Operculum with a few or several whorls (Fig. 2.4e) .... F. **Hydrobiidae**
    Shell ovo-conical, up to 20 mm. Shell aperture narrower and elongated. Operculum with a few whorls (Fig. 2.4f) .... F. **Melanopsidae**
13. Shell uncoiled (limpet-like) (Fig. 2.4g–h) 14
    Shell spirally coiled (Fig. 2.4i–k) 16
14. Shell oval, tip (apex) more or less straight (Fig. 2.4g) .... F. **Ancylidae**[2]
    Shell elongated, tip (apex) not straight 15
15. Apex sharp more or less directed towards the left .... F. **Acroloxidae**
    Apex blunter, more or less directed towards the right (Fig. 2.4h) .... F. **Ferrissidae**[3]
16. Shell with flattened spiral (Fig. 2.4i) .... F. **Planorbidae**
    Shell with spiral not flattened 17
17. Shell aperture to the left (facing the opening) (Fig. 2.4j) .... F. **Physidae**
    Shell aperture to the right (facing the opening) 18
18. In live specimens tentacles are cylindrical with eyes at the tips of the tentacles. Their thin, fragile shells are translucent and amber-coloured. Usually live in damp habitats such as marshes (Fig. 3.4f) .... F. **Succineidae**[4]
    In live specimens tentacles are fleshy and triangular with eyes at the base of the tentacles. Shells are more robust (Fig. 2.4k) .... F. **Lymnaeidae**

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[2] Currently this group is considered to be included in F. Planorbidae.

[3] Currently this group is considered to be included in F. Planorbidae.

[4] This family is not present in the reference database. Some species of amber snails (F. Succineidae) are amphibious organisms living in damp habitats and river banks. Although they are generally considered as terrestrial organisms and thus not included in biotic indices, we have included it here because their similarity to pond snails (Lymnaeidae) can lead to erroneous identification of specimens.

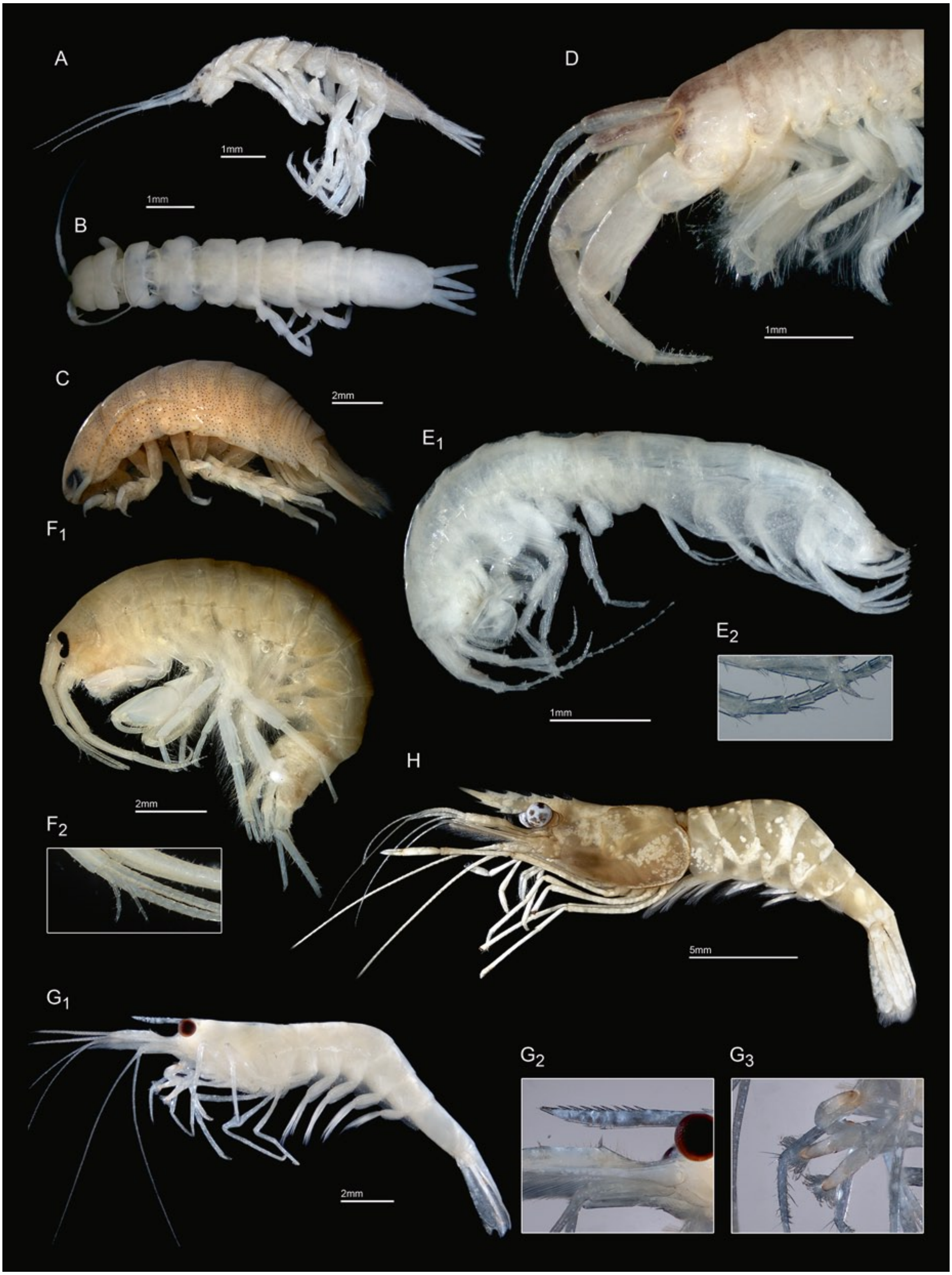

Fig. 2.5 Key Illustrations: Crustacea. (**a**) Asellidae; (**b**) Stenasellidae; (**c**) Cirolanidae; (**d**) Corophiidae, antenna II very developed; (**e**) Niphargidae: general view ($\mathbf{e}_1$), flagellum of antenna I ($\mathbf{e}_2$); (**f**) Gammaridae: general view ($\mathbf{f}_1$), flagellum of antenna I ($\mathbf{f}_2$); (**g**) Atyidae: general view ($\mathbf{g}_1$), rostrum finely serrated ($\mathbf{g}_2$), both parts of the chela of the first two pereiopods with dense tuft of apical setae ($\mathbf{g}_3$); (**h**) Palaemonidae

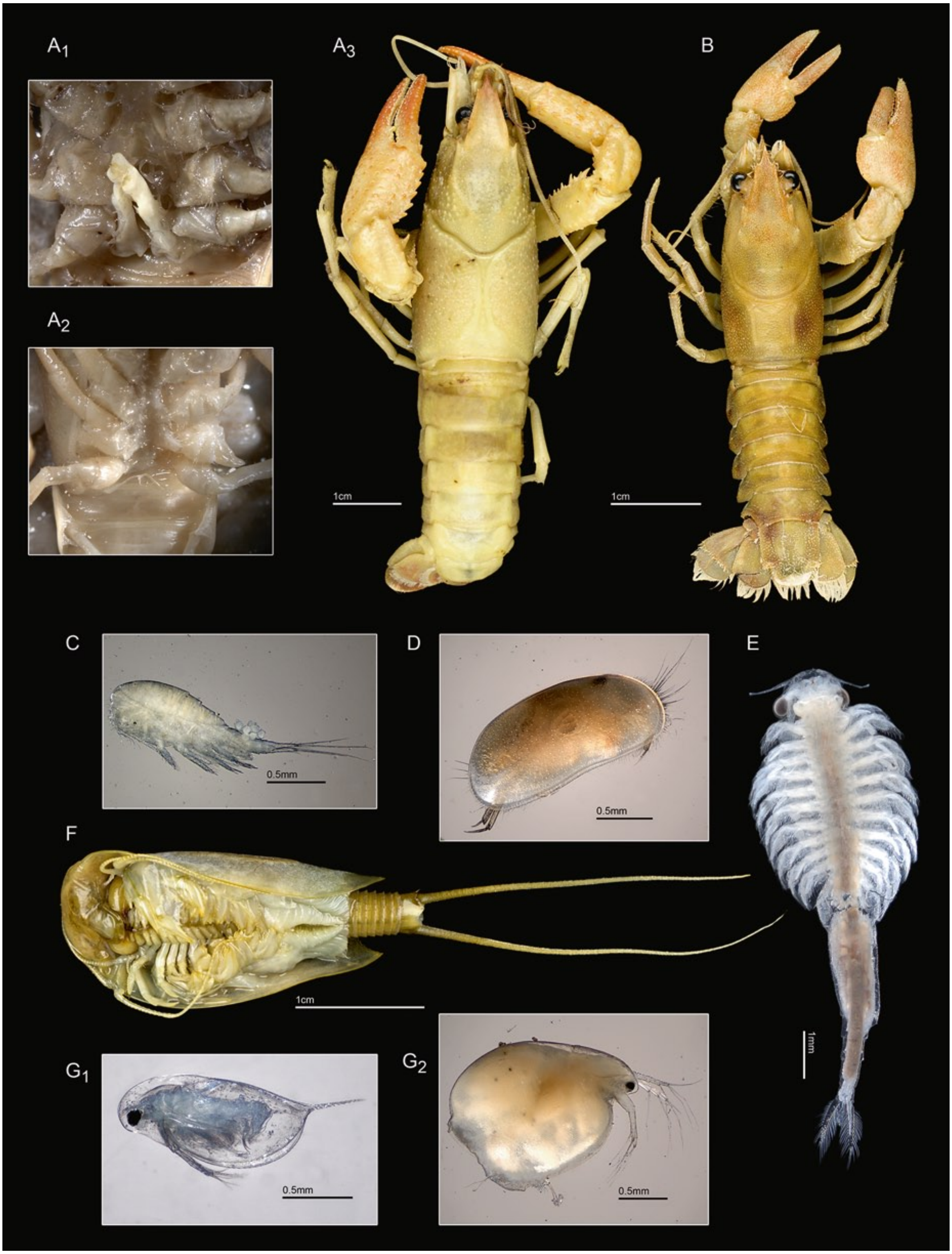

Fig. 2.6 Key Illustrations: Crustacea. (**a**) Cambaridae: pleopods of the first abdominal segment in a male ($\mathbf{a}_1$) and female ($\mathbf{a}_2$), *Procambarus clarkii* ($\mathbf{a}_3$); (**b**) Astacidae: *Pacifastacus leniusculus*; (**c**) Copepoda; (**d**) Ostracoda; (**e**) Anostraca; (**f**) Notostraca;(**g**) Anomopoda

Key 5 Crustacea

1. Body dorsoventrally flattened, with dorsal carapace. Antennae transformed into hooks and maxillae into suckers. Parasite of fish ..... F. **Argulidae**
   Without those characters 2
2. Resembles a crayfish, prawn or shrimp. With claws or with seven pairs of appendages that clearly look as legs 3
   Without those characters (Fig. 2.6c–g) 13
3. Body without cephalothorax (Fig. 2.5a–f) 4
   Body with cephalothorax 9
4. Body somewhat dorsoventrally flattened (Fig. 2.5a–c) 5
   Body laterally compressed (Fig. 2.5d–f) 7
5. Uropods insert lateral to the pleotelson (Fig. 2.5c) .... F. **Cirolanidae** (Fig. 3.6k)
   Uropods insert terminally at the apex of the pleotelson 6
6. First two segments of the pleon not very developed, not dorsally visible. Pleotelson subcircular (Fig. 2.5a and Fig. 3.6.h) .... F. **Asellidae**
   First two segments of the pleon well developed and always dorsally visible. Pleotelson elongated (Fig. 2.5b) .... F. **Stenasellidae** (Fig. 3.6l)
7. Antenna II very developed (Fig. 2.5d) .... F. **Corophiidae**
   Antenna II with normal development 8
8. Flagellum of Antenna I with 1–2 segments. Eyes absent (Fig. 2.5e$_{1-2}$) .... F. **Niphargidae**
   Flagellum of Antenna I with 4–5 segments. Eyes generally present (Fig. 2.5f$_{1-2}$) .. F. **Gammaridae**
9. Typical crayfish, with strong claws (chela) on the first pereiopod (Fig. 2.6a–b) 10
   Claws of the pereiopod small (Fig. 2.5g–h) 12
10. First abdominal segment without pleopods in both sexes .... F. **Parastacidae** (Non-indigenous)
    First abdominal segment with pleopods, vestigial in females (Fig. 2.6a$_{1-2}$) 11
11. Dorsal sutures converging in the middle (Fig. 2.6a$_3$) ..... F. **Cambaridae** (Non-indigenous)
    Dorsal sutures not converging in the middle (Fig. 2.6b) .... F. **Astacidae**
    + Claws with reddish ventral side, on the dorsal side they have a whitish-greenish blotch where both parts of the claw meet .... *Pacifastacus leniusculus* (Non-indigenous)
    + Claws with whitish ventral side, dorsal side without a whitish-greenish blotch .... *Austropotamobius pallipes*
12. Rostrum finely serrated, with more than ten spines. Supraorbital spine present. Chelae of the first two pereiopods similar, with both parts of the chela bearing a dense tuft of setae apically (Fig. 2.5g$_{1-3}$) .... F. **Atyidae**
    Rostrum not finely serrated, with big teeth, in general less than 10. Without supraorbital spine. The chela from the second pair of pereiopods is bigger than that of the first pair of pereiopods, and neither have a tuft of setae apically (Fig. 2.5h) .... F. **Palaemonidae**
13. Very small animals, with pear-shaped body. Carapace absent, first thoracic segment (sometimes the second) fused to the head (Fig. 2.6c) .... Cl. **Copepoda**
    Without those characters 14
14. Animal with bivalve carapace enclosing the whole body. Valves without rings or growth lines. Usually not more than two pairs of appendages on the trunk (Fig. 2.6d) .... Cl. **Ostracoda**
    Without bivalve carapace enclosing the whole body, and if present, the valves have growth lines and more than two appendages on the trunk (Fig. 2.6e–g) .... 15 (Cl. **Branchiopoda**)
15. Body without carapace. Leaf-like appendages, eyes stalked. Swim on their back (Fig. 2.6e) .... O. **Anostraca**
    Without all those characters 16
16. Carapace forming a dorsal shield, eyes sessile. Leaf-like appendages. Swim on their belly (Fig. 2.6f) ....O. **Notostraca**
    Without all those characters 17
17. Bivalve carapace covering the whole body, so that all the appendages retract in the valves .... O. **Spinicaudata**
    Bivalve carapace normally not covering the head, so that the antennae cannot be retracted inside .... 18 (**Cladocera**)
18. Four pairs of thoracopods present .... O. **Onychopoda**
    More than four pairs of thoracopods 19
19. Six pairs of thoracopods, all of similar morphology .... O. **Ctenopoda**
    Five pairs of thoracopods (rarely six) very different from each other (Fig. 2.6g) .... O. **Anomopoda**

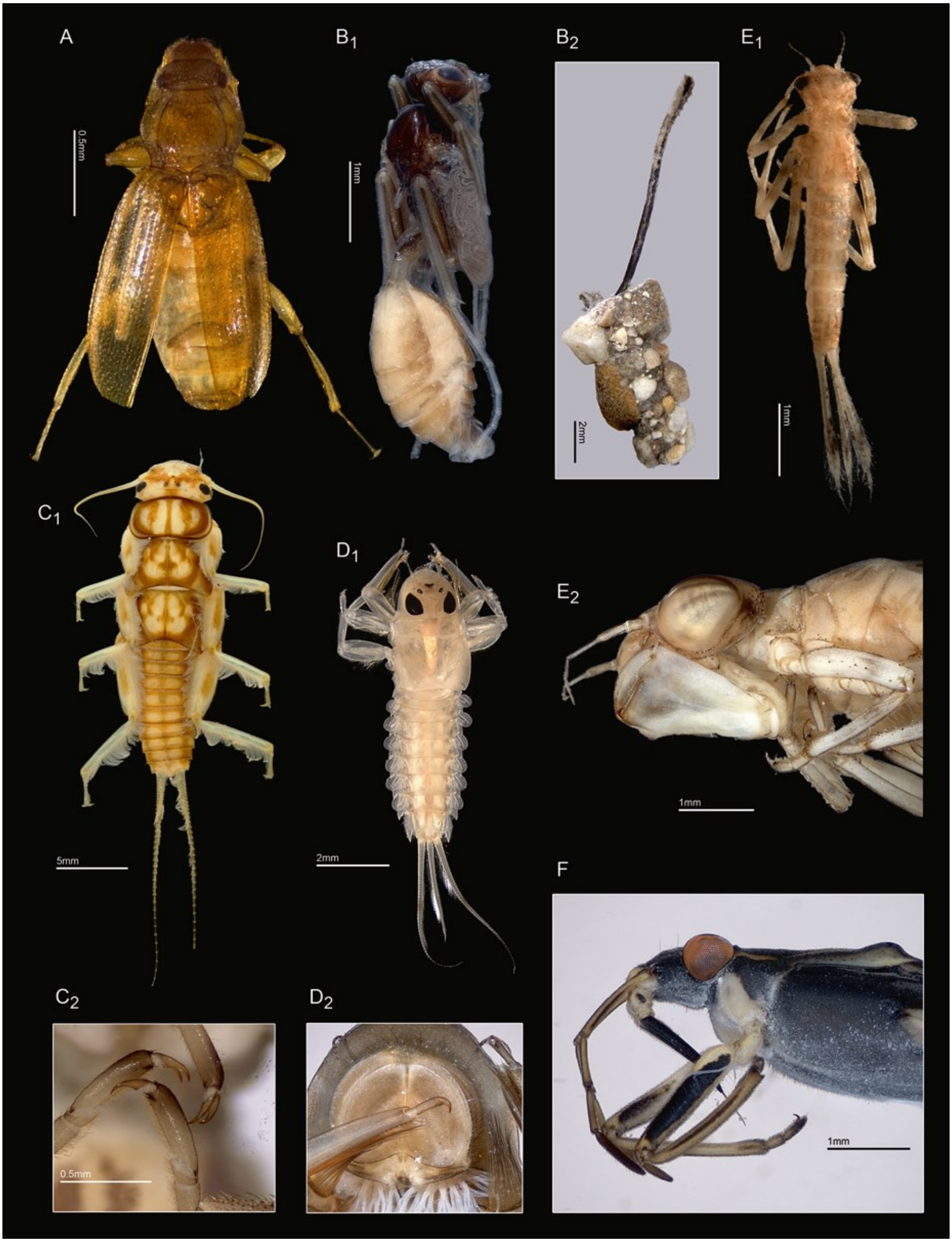

Fig. 2.7 Key Illustrations: Insecta. (**a**) Coleoptera: Hydraenidae; (**b**) Ichneumonidae: *Agriotypus armatus* specimen (**b**$_1$), Goeridae (Trichoptera) case parasitized (**b**$_2$); (**c**) Plecoptera: Perlidae (**c**$_1$), tarsal claws of a Nemouridae (**c**$_2$); (**d**) Ephemeroptera: Oligoneuriidae, dorsal view (**d**$_1$) and tarsal claws (**d**$_2$); (**e**) Odonata: Platycnemididae (**e**$_1$), head of a Coenagrionidae (**e**$_2$); (**f**) Hemiptera, Gerridae

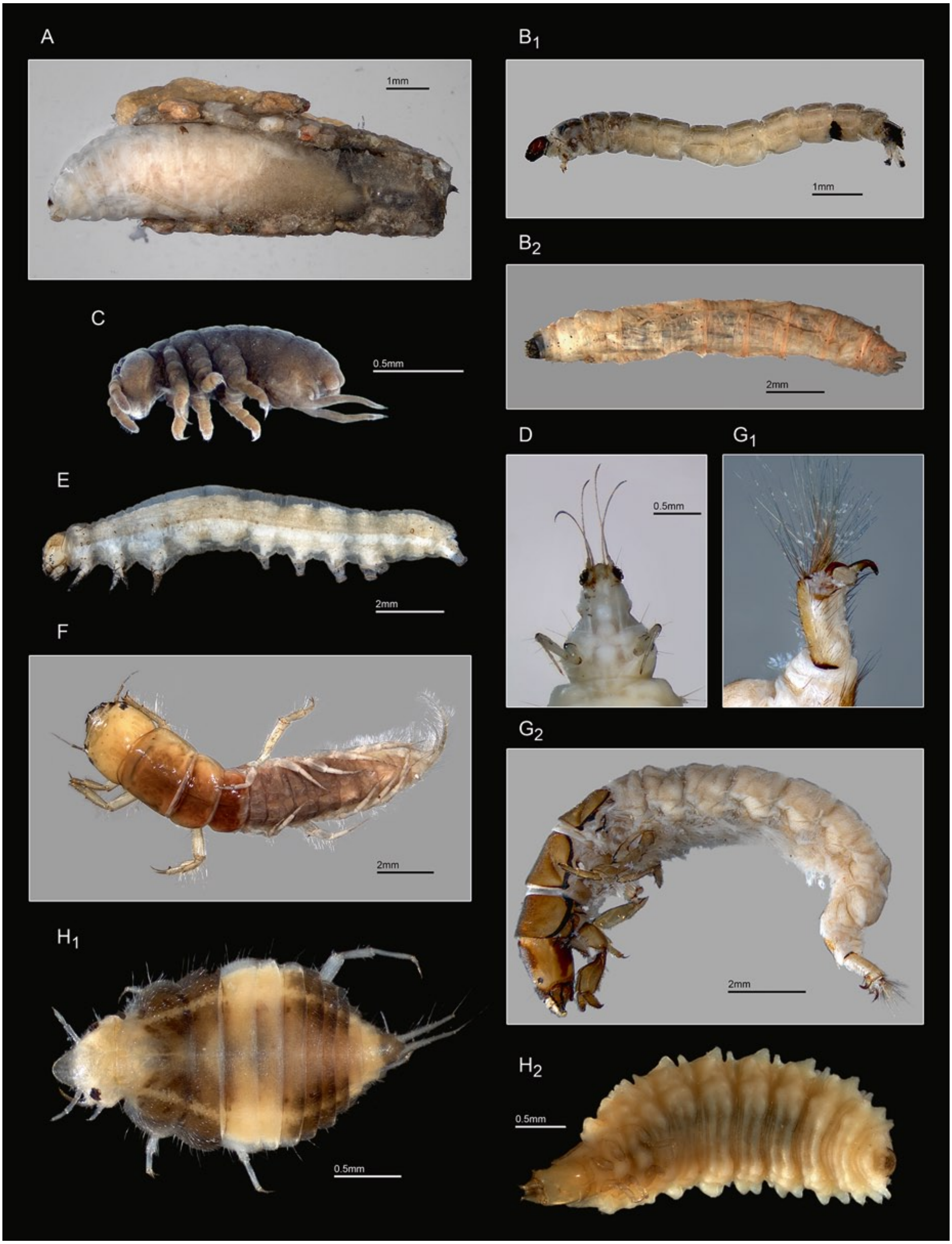

Fig. 2.8 Key Illustrations: Insecta. (**a**) Hymenoptera, Ichneumonidae: *Agriotypus armatus*, parasitic larva; (**b**) Diptera: Chironomidae ($\mathbf{b}_1$), Tipulidae ($\mathbf{b}_2$); (**c**) Collembola, Poduridae, *Podura aquatica*; (**d**) Neuroptera, Sisyridae; (**e**) Lepidoptera, Pyralidae; (**f**) Megalopterea, Sialidae; (**g**) Trichoptera, Hydropsychidae: anal hooks ($\mathbf{g}_1$) and general view ($\mathbf{g}_2$); (**h**) Coleoptera: Dytiscidae ($\mathbf{h}_1$), Hydrophilidae ($\mathbf{h}_2$)

Key 6 Hexapoda (General)

1. Compound eyes present. In well developed larvae, wing pads present; in adults, wings present (Fig. 2.7) 2
   Simple eyes (if present). Wing pads or wings absent (Fig. 2.8) 7
2. Well developed elytra present (Fig. 2.7a) .... O. **Coleoptera** (adults)
   Elytra absent 3
3. Parasite species found in the case of trichoptera families Goeridae and Odontoceridae. Presence of fifth larval, nymph or imago can be detected by the presence of a respiratory tube (Fig. 2.7b$_{1-2}$) .... O. **Hymenoptera** – F. **Ichneumonidae** (*Agriotypus*)
   Without those characters 4
4. Two or three multisegmented caudal appendages (cerci) 5
   Caudal appendages absent or if present, not multi-segmented 6
5. Legs with two tarsal claws. Abdomen ending in two cerci (Fig. 2.7c$_{1-2}$) .... O. **Plecoptera**
   Legs with one tarsal claw. Usually three cerci (sometimes two) (Fig. 2.7d$_{1-2}$) .... O. **Ephemeroptera**
6. Mouthparts with the labrum modified into a mask-like structure (Fig. 2.7e$_{1-2}$) .... O. **Odonata**
   Mouthparts not as above. Sucking (beak-like) mouthparts present (Fig. 2.7f) ...... O. **Hemiptera**
7. Thorax without segmented legs (prolegs might be present) 8
   Thorax with segmented legs (Fig. 2.8c–h) 10
8. Parasitic larva found in the case of some trichoptera (Fig. 2.8a) .... O. **Hymenoptera** – F. **Ichneumonidae** (*Agriotypus*)
   Non-parasitic larva 9
9. C-shaped (scarabaeiform) larva .... O. **Coleoptera**
   Larva not as above (Fig. 2.8b$_{1-2}$) .... O. **Diptera**
10. Abdominal jumping furcula present (Fig. 2.8c) .... O. **Collembola**
    Abdominal furcula absent 11
11. Mandibles much longer than the head (Fig. 2.8d) .... O. **Neuroptera** (Plannipenne)
    Mandibles either shorter or equal in length to the head 12
12. Five pairs of abdominal prolegs (Fig. 2.8e) .... O. **Lepidoptera** – F. **Pyralidae**
    Abdominal pseudopods absent 13
13. Animal with conical and sharp anal filament, abdominal lateral segmented gills present (Fig. 2.8f) .... O. **Megaloptera** – F. **Sialidae**
    Without those characters 14
14. One pair of hooks present in the anal region (Fig. 2.8g$_{1-2}$) .... O. **Trichoptera**
    Hooks absent or four hooks very close together (Fig. 2.8h$_{1-2}$) .... O. **Coleoptera** (larvae)

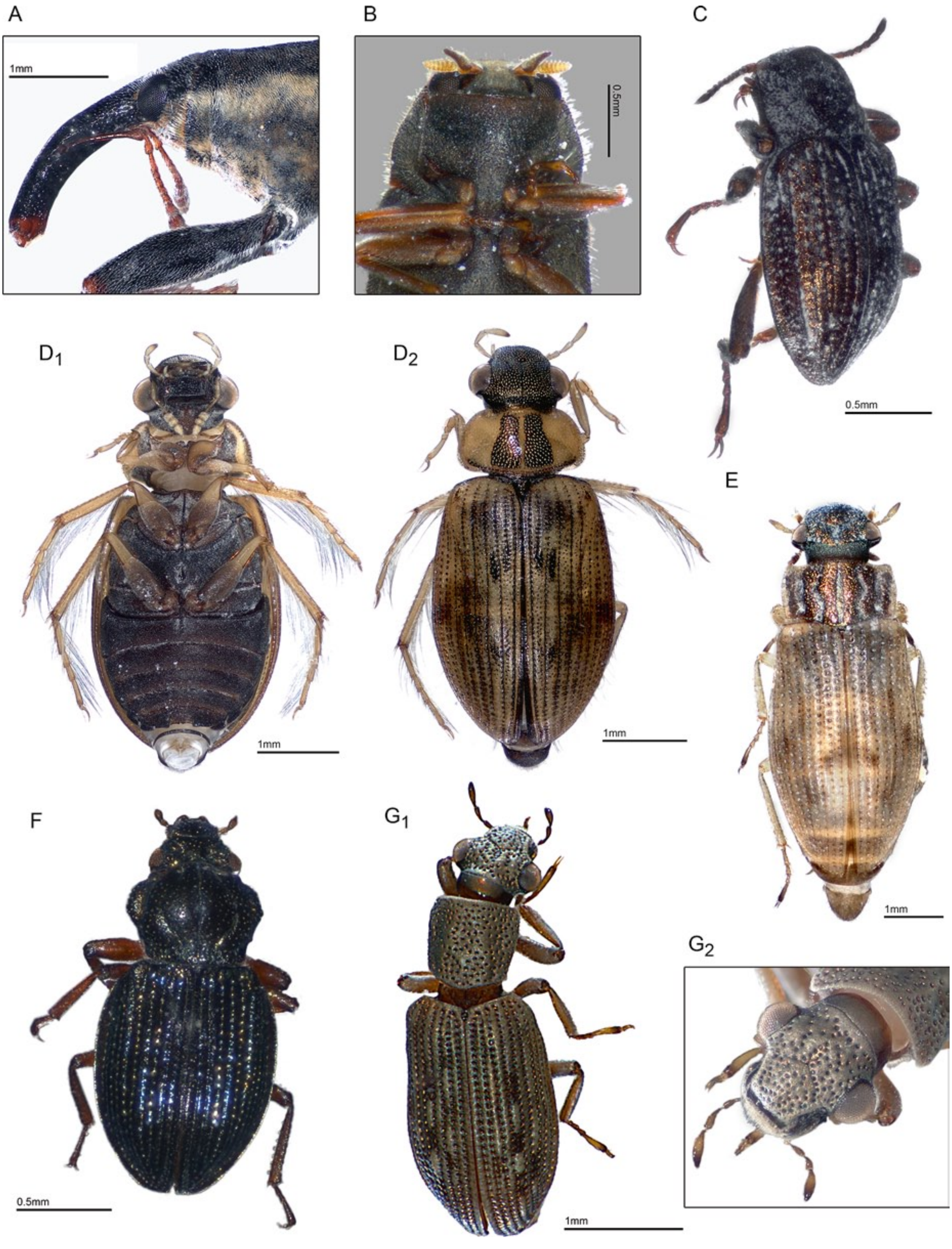

Fig. 2.9 Key Illustrations: Coleoptera (adults). (**a**) Curculionidae, antennae over the rostrum; (**b**) Dryopidae, antenna with a club on the second segment; (**c**) Elmidae, antennae filiform and metatarsi with five segments; (**d**) Hydrophilidae: maxillary palpi similar in length to the antennae ($\mathbf{d}_1$), pronotum wider at the end ($\mathbf{d}_2$); (**e**) Gen. *Helophorus*, pronotum with five longitudinal grooves; (**f**) Hydraenidae, normal eyes; (**g**) Hydrochidae: dorsal view ($\mathbf{g}_1$), clypeus straight and protruding eyes ($\mathbf{g}_2$)

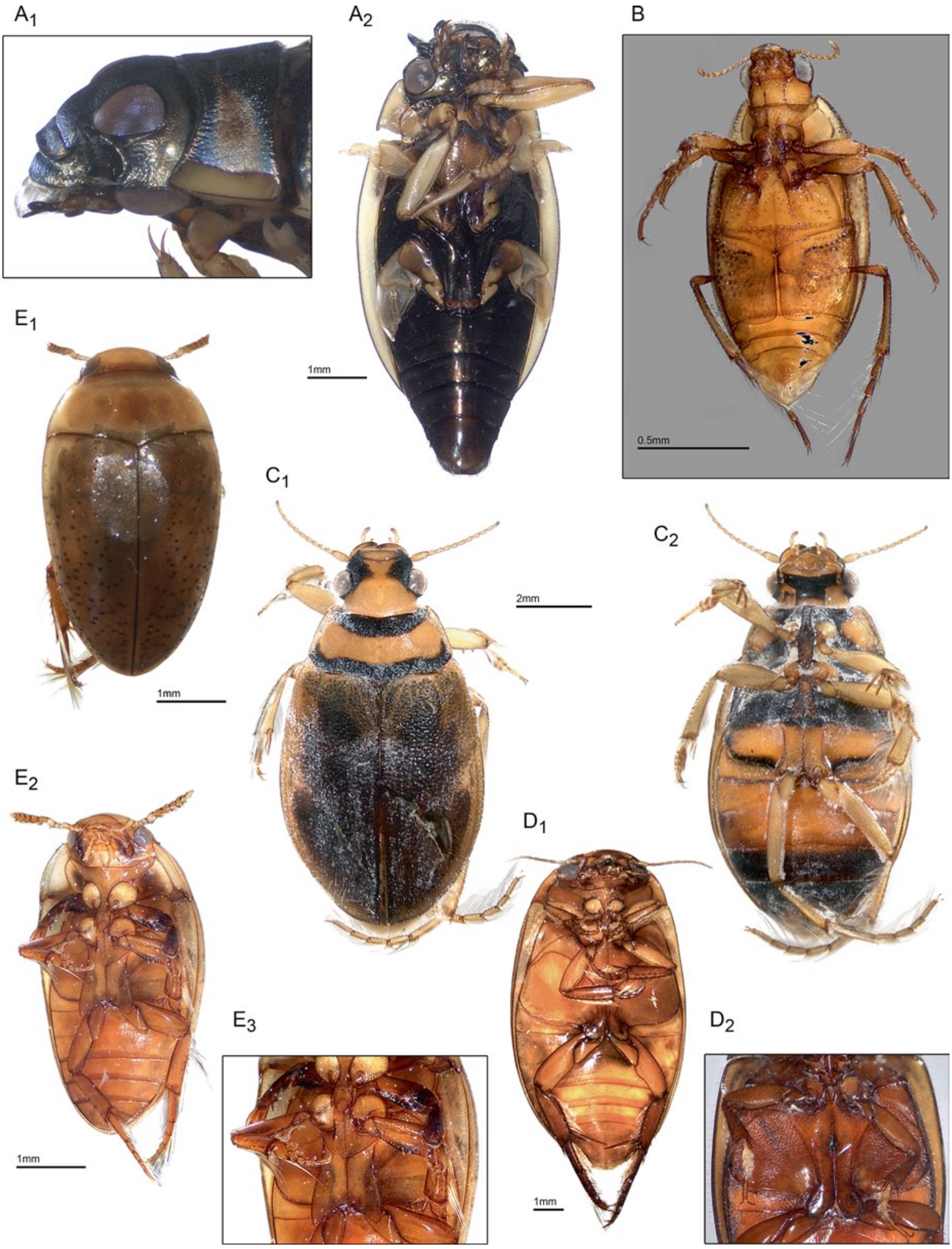

Fig. 2.10 Key Illustrations: Coleoptera (adults). (**a**) Gyrinidae: head with eyes divided ($\mathbf{a}_1$), legs III paddle-like ($\mathbf{a}_2$); (**b**) Haliplidae, metacoxal plates present; (**c**) Hygrobiidae: neck present ($\mathbf{c}_1$), ventral view ($\mathbf{c}_2$); (**d**) Dytiscidae: ventral view ($\mathbf{d}_1$), metacoxal apophysis narrow ($\mathbf{d}_2$); (**e**) Noteridae: neck absent ($\mathbf{e}_1$), ventral view ($\mathbf{e}_2$), metacoxal apophysis wide ($\mathbf{e}_3$)

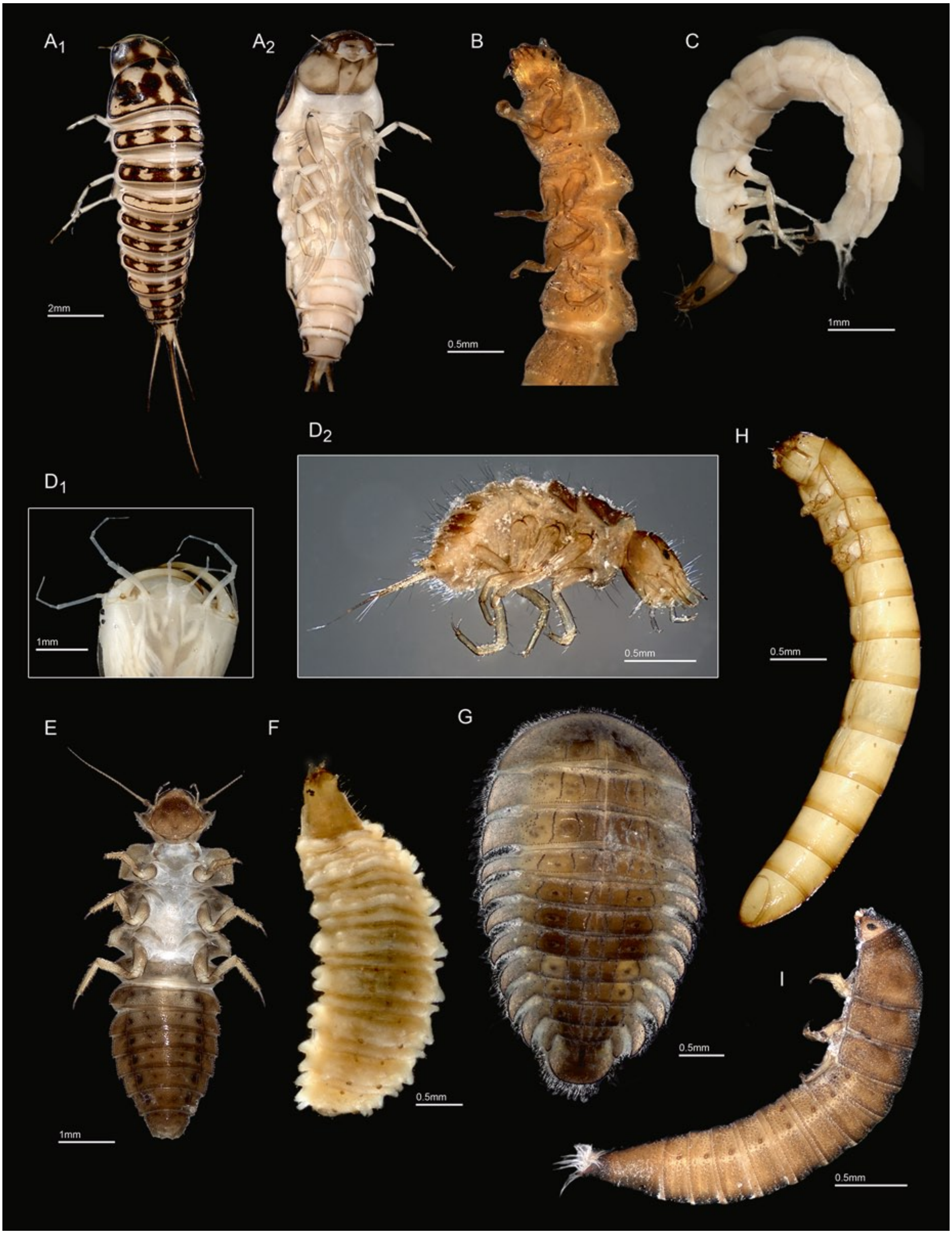

Fig. 2.11 Key Illustrations: Coleoptera (larvae). (**a**) Hygrobiidae: three cerci ($\mathbf{a}_1$), ventral gills only ($\mathbf{a}_2$); (**b**) Haliplidae; (**c**) Gyrinidae, lateral abdominal gills and four hooks at the end of the abdomen; (**d**) Dytiscidae: elongated and arched mandibles ($\mathbf{d}_1$), legs end in two claws ($\mathbf{d}_2$); (**e**) Scirtidae, eight abdominal segments and antennae long; (**f**) Hydrophilidae, antennae short; (**g**) Psephenidae, head not dorsally visible; (**h**) Dryopidae, anal gills absent and circular cross-section; (**i**) Elmidae, anal gills present

Key 7 Coleoptera

Key to Adult Specimens

1. Metacoxae not fused, not covering the first abdominal segments (Fig. 2.9d_1) 2
   Metacoxae fused, covering the first abdominal segments (Fig. 2.10) 13
2. Head with rostrum upon which the antennae are located (Fig. 2.9a) .... F. **Curculionidae**[5]
   Rostrum not as above 3
3. Antennae long and filiform 4
   Antennae not as above 5
4. Metatarsi with 4 segments. Each elytron with an apex .... F. **Chrysomelidae**
   Metatarsi with 5 segments (Fig. 2.9c) .... F. **Elmidae**
5. Maxillary palpi shorter than the antennae 6
   Maxillary palpi longer or similar in length to the antennae (Fig. 2.9d_1) 8
6. Elytra truncated at the back .... F. **Hydroscaphidae**
   Elytra not truncated 7
7. Antenna short with a club on the second segment (Fig. 2.9b) .... F. **Dryopidae**
   Without a club on the second segment of the antenna .... F. **Hydrophilidae** (in part)
8. Pronotum wider at the back 9
   Pronotum wider at the beginning or at the center 10
9. Elytra truncated at the back .... F. **Hydraenidae** (in part)
   Elytra not truncated at the back (Fig. 2.9d_2) .... F. **Hydrophilidae** (in part)
10. Pronotum with five longitudinal grooves (Fig. 2.9e) ....F. **Helophoridae**[6] (Fig. 3.14f–g)
    Without grooves 11
11. Clypeus concave and emarginated .... F. **Spercheidae**[7]
    Clypeus straight (Fig. 2.9g_2) 12
12. Protruding eyes (Fig. 2.9$g_{1–2}$) .... F. **Hydrochidae**
    Normal eyes, not protruding (Fig. 2.9f) .... F. **Hydraenidae**
13. Legs III (metathoracic) short and paddle-like for swimming, eyes divided in two separate parts, one on top and one below (Fig. 2.10$a_{1–2}$) .... F. **Gyrinidae**
    Legs III not as above, eyes arranged normally, not divided 14
14. Metacoxal plates present, partially covering the femurs (Fig. 2.10b) .... F. **Haliplidae**
    Metacoxal plates absent 15
15. "Neck" present (Fig. 2.10$c_{1–2}$) .... F. **Hygrobiidae**
    "Neck" absent (Fig. 2.10e_1) 16
16. Metacoxal apophysis narrow (Fig. 2.10$d_{1–2}$) .... F. **Dytiscidae**
    Metacoxal apophysis wide (Fig. 2.10$e_{2–3}$) .... F. **Noteridae**

[5] There are no apparent morphological differences that allow to distinguish between terrestrial and aquatic curculionids. To determine origin, adults need to be classified to species level.

[6] Currently this group is considered to be a subfamily of Hydrophilidae.

[7] According to Ribera et al (1999) this family is not present in the Iberian Peninsula. Currently this group is considered to be a subfamily of Hydrophilidae.

Key to Larvae

1. Larva with "C"-shaped body (scarabaeiform) 2
   Larva not as above 3
2. Thoracic legs short. Ten abdominal segments. Abdominal segment VIII has claws or stigmatic hooks .... F. **Chrysomelidae**
   Legs absent. Abdominal segment VIII has no stigmatic claws .... F. **Curculionidae**
3. Thoracic legs with five segments (Fig. 2.11a–d) 4
   Thoracic legs with four segments (Fig. 2.11e–i) 9
4. Gills present (Fig. 2.11a_2, c) 5
   Gills absent 7
5. Ventral gills only. Three cerci (Fig. 2.11$a_{1–2}$) .... F. **Hygrobiidae**
   Dorsal or lateral gills 6
6. Dorsal and lateral gills, both on the thorax and abdomen .... **F. Haliplidae** (in part)
   Lateral abdominal gills. At the end of the abdomen there are four strong nails or hooks close together (Fig. 2.11c) .... F. **Gyrinidae**
7. Legs end in just one claw (Fig. 2.11b) .... F. **Haliplidae** (in part)
   Legs end in two claws (Fig. 2.11d_2) 8
8. Elongated and slightly arched mandibles with a groove (Fig. 2.11d_1) .... F. **Dytiscidae**
   Mandibles not as above .... F. **Noteridae**

9. Abdomen with eight segments 10
Abdomen with more than eight segments 11
10. Antennae long (Fig. 2.11e) .... F. **Scirtidae**
Antennae short (Fig. 2.11f) ...... F **Hydrophilidae**
11. Abdomen with nine segments 12
Abdomen with ten segments 14
12. Head covered by the pronotum, not dorsally visible (Fig. 2.11g) .... F. **Psephenidae**
Head dorsally visible 13
13. Anal gills absent. Roughly circular cross-section. Last abdominal segment slightly longer than wide, with round and intact apex and similar in length to the preceding segment. Legs very short and relatively thick (Fig. 2.11h) ....
.... F. **Dryopidae** (Fig. 3.12k–l)
Anal gills present (maybe retracted under the opercular plate). Usually flat or triangular cross-section. Last abdominal segment longer than wide (more or less triangular), usually emarginated. In specimens with circular cross-section the last abdominal segment is similar in length to the sum of the two preceding segments. Legs not so short or sturdy (Fig. 2.11i) .... F. **Elmidae**
14. Abdomen more or less rounded ....
.... F. **Spercheidae**[8]
Abdomen narrows towards the end ....
.... F. **Hydroscaphidae**

[8] According to Ribera et al (1999) this family is not present in the Iberian Peninsula. Currently this group is considered to be a subfamily of Hydrophilidae.

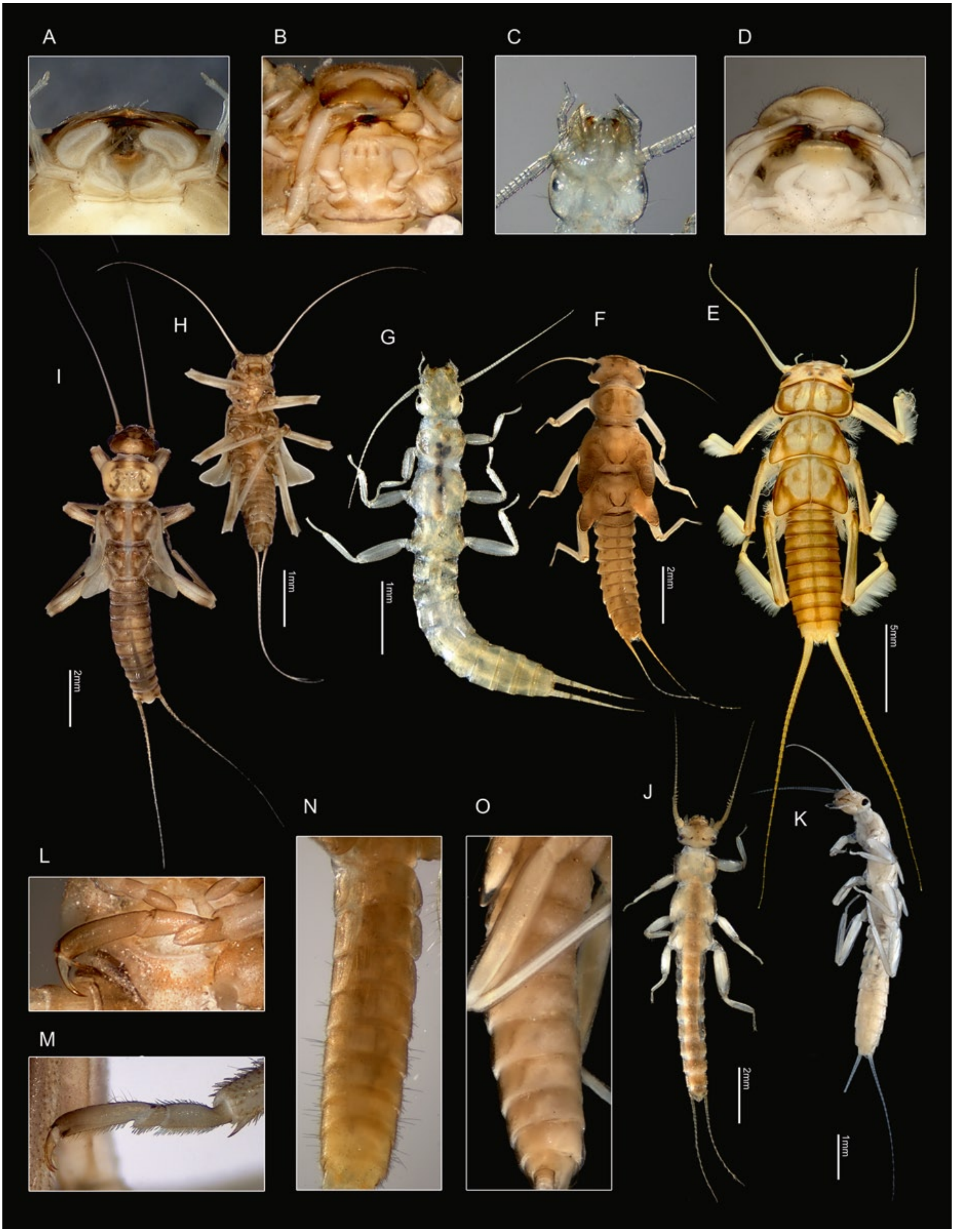

Fig. 2.12 Key Illustrations: Plecoptera. (**a**) Perlidae, glossae smaller than paraglossae; (**b**) Nemouridae, glossae and paraglossae similar in size; (**c**) Chloroperlidae, head showing the maxillary palpi; (**d**) Perlodidae, mouth pieces; general views: (**e**) Perlidae; (**f**) Perlodidae; (**g**) Chloroperlidae; (**h**) Taeniopterygidae; (**i**) Nemouridae; (**j**) Leuctridae; (**k**) Capniidae; (**l**) Taeniopterygidae, tarsi; (**m**) Nemouridae, tarsi; (**n**) Leuctridae, abdomen; (**o**) Capnidae, abdomen

Key 8 Plecoptera

1. Glossae smaller than paraglossae (Fig. 2.12a) 2
   Glossae and paraglossae similar in size (Fig. 2.12b) 4
2. Thoracic gills present (Fig. 2.12e) ...... F. **Perlidae**
   Thoracic gills absent 3
3. Width of the last segment of the maxilary palpus about four times narrower than the preceding segment. Wing pads with rounded external edges (Fig. 2.12c, g) .... F. **Chloroperlidae**
   Width of the last segment of the maxilary palpus approximately half the width of the preceding segment. Wing pads with straight external edges (Fig. 2.12d, f) .... F. **Perlodidae**
4. Segments of the tarsi are similar in length or increasingly longer (Fig. 2.12h, l) .... F. **Taeniopterygidae**
   Second segment of the tarsi clearly shorter than the other two (Fig. 2.12m) 5
5. Body sturdy, posterior legs usually surpassing the abdomen. Wing pads diverging from the longitudinal axis (Fig. 2.12i) .... F. **Nemouridae**
   Body longer, usually posterior legs do not surpass the abdomen. Wing pads more or less parallel to the body axis 6
6. First nine abdominal segments with tergites and sternites clearly separated (Fig. 2.12k, o) .... F. **Capniidae**
   Tergites and sternites generally separated in the first four or five (up to seven) abdominal segments (Fig. 2.12j, n) .... F. **Leuctridae**

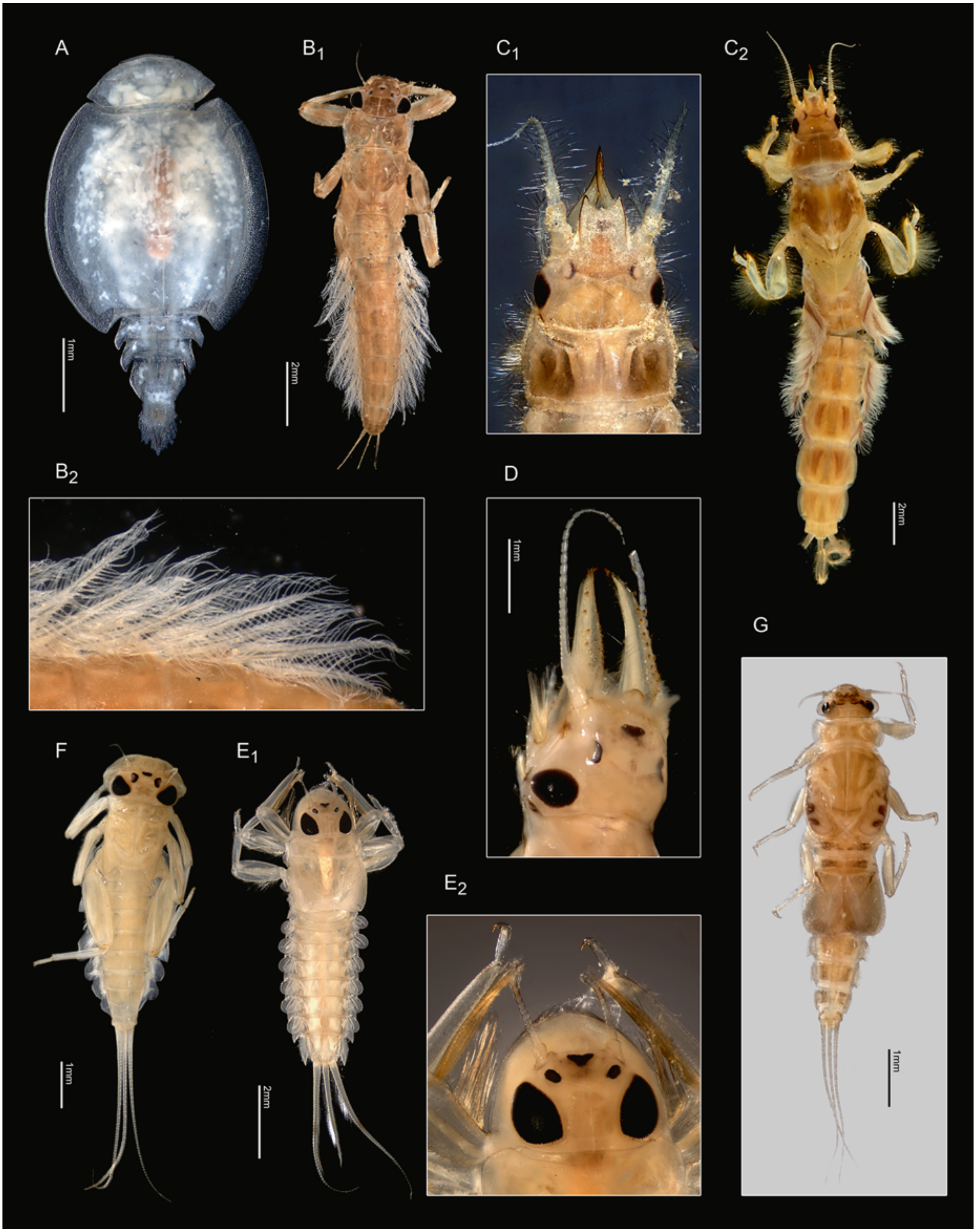

Fig. 2.13 Key Illustrations: Ephemeroptera. (**a**) Prosopistomatidae; (**b**) Potamanthidae: dorsal view (**b**$_1$), gills (**b**$_2$); (**c**) Ephemeridae: head with protruded and arched mandibular processes (**c**$_1$), dorsal view (**c**$_2$); (**d**) Polymitarcyidae: head showing the edges of the mandibular processes pointing inwards; (**e**) Oligoneuriidae: dorsal view (**e**$_1$), a row of long setae on the anterior margin of tibia I (**e**$_2$); (**f**) Heptageniidae; (**g**) Caenidae, second pair of abdominal gills transformed into two plates

Fig. 2.14 Key Illustrations: Ephemeroptera and Neuroptera. (**a**) Siphlonuridae; (**b**) Baetidae: general view ($\mathbf{b}_1$), cerci with setae only on their inner margins ($\mathbf{b}_2$); (**c**) Ephemerellidae: general view ($\mathbf{c}_1$), cerci with setae both on the inner and outer margins ($\mathbf{c}_2$); (**d**) Leptophlebiidae: general view ($\mathbf{d}_1$), several types of gills ($\mathbf{d}_2$, $\mathbf{d}_3$, $\mathbf{d}_4$); (**e**) Sisyridae: general view ($\mathbf{e}_1$), head showing antennae and maxillomandibular stylets ($\mathbf{e}_2$)

Key 9 Ephemeroptera

1. Dorsal plate covering the thorax and part of the abdomen. Resembles a crustacean (Fig. 2.13a) .... F. **Prosopistomatidae**
   Without such plate 2
2. Gills bifid, feather-like (Fig. 2.13b$_2$) 3
   Gills not as above 5
3. Mandibular processes protruding over the head 4
   Mandibular processes do not go over the head (Fig. 2.13b$_1$) .... F. **Potamanthidae**
4. Mandibular processes arched with the edges pointing outwards. Surface relatively smooth (Fig. 2.13c$_{1-2}$) .... F. **Ephemeridae**
   Mandibular processes arched with the edges pointing inwards. Surface spiny (Fig. 2.13d) ....F. **Polymitarcyidae**
5. Head and body somewhat depressed, eyes clearly in a dorsal position 6
   Head and body not depressed or slightly depressed, eyes lateral or dorsolateral 7
6. Head subtriangular, tibia of Legs I with a row of long setae on their anterior margin (Fig. 2.13e$_{1-2}$) .... F. **Oligoneuriidae**
   Head not subtriangular (more sub-elliptical or sub-trapezoidal), wider than it is long, tibia of Legs I without long setae on their anterior edge, just a few short setae on their posterior edge (Fig. 2.13f) .... F. **Heptageniidae**
7. Second pair of abdominal gills transformed into two plates that cover the remaining abdominal gills (Fig. 2.13g) .... F. **Caenidae**
   Second pair of abdominal gills not transformed into plates 8
8. Cerci with setae only on their inner margins (Fig. 2.14b$_2$) 9
   Cerci with setae both on the inner and outer margins (Fig. 2.14c$_2$) 11
9. Inner margins of the anterior legs with a double row of very long setae .... F. **Isonychiidae**[9]
   Without such long setae on the anterior legs ... 10
10. Posterior end of the last abdominal segments very pointy (as if they were spines). Antennae short (in general two times shorter than the head is wide) (Fig. 2.14a) .... F. **Siphlonuridae**
    Posterior end of the last abdominal segments not pointy. Antennae long (more than three times the head width) (Fig. 2.14b$_1$) .... F. **Baetidae**
11. Seven pairs of lateral gills. Gills are forked or conformed by two plates (Fig. 2.14d$_{1-4}$) .... F. **Leptophlebiidae**
    Five pairs of dorsal gills (Fig. 2.14c$_{1-2}$) .... F. **Ephemerellidae**

Key 10 Neuroptera (Planipennia)

1. Antennae shorter than the maxilo-mandibular stylets. Stylets wide at the base. Abdominal ventral gills absent .... F. **Osmylidae**
   Antennae slender, longer than the maxilo-mandibular stylets. Stylets relatively thin diverging in the apex. Abdominal ventral gills present, thoracic legs with just one tarsal claw (Fig. 2.14e$_{1-2}$ and Fig. 3.12e) .... F. **Sisyridae**

[9] This family is not present in the reference database, but it has been included in this key because it is considered to be present in the Iberian Peninsula by Alba-Tercedor and Jaimez-Cuellar (2003).

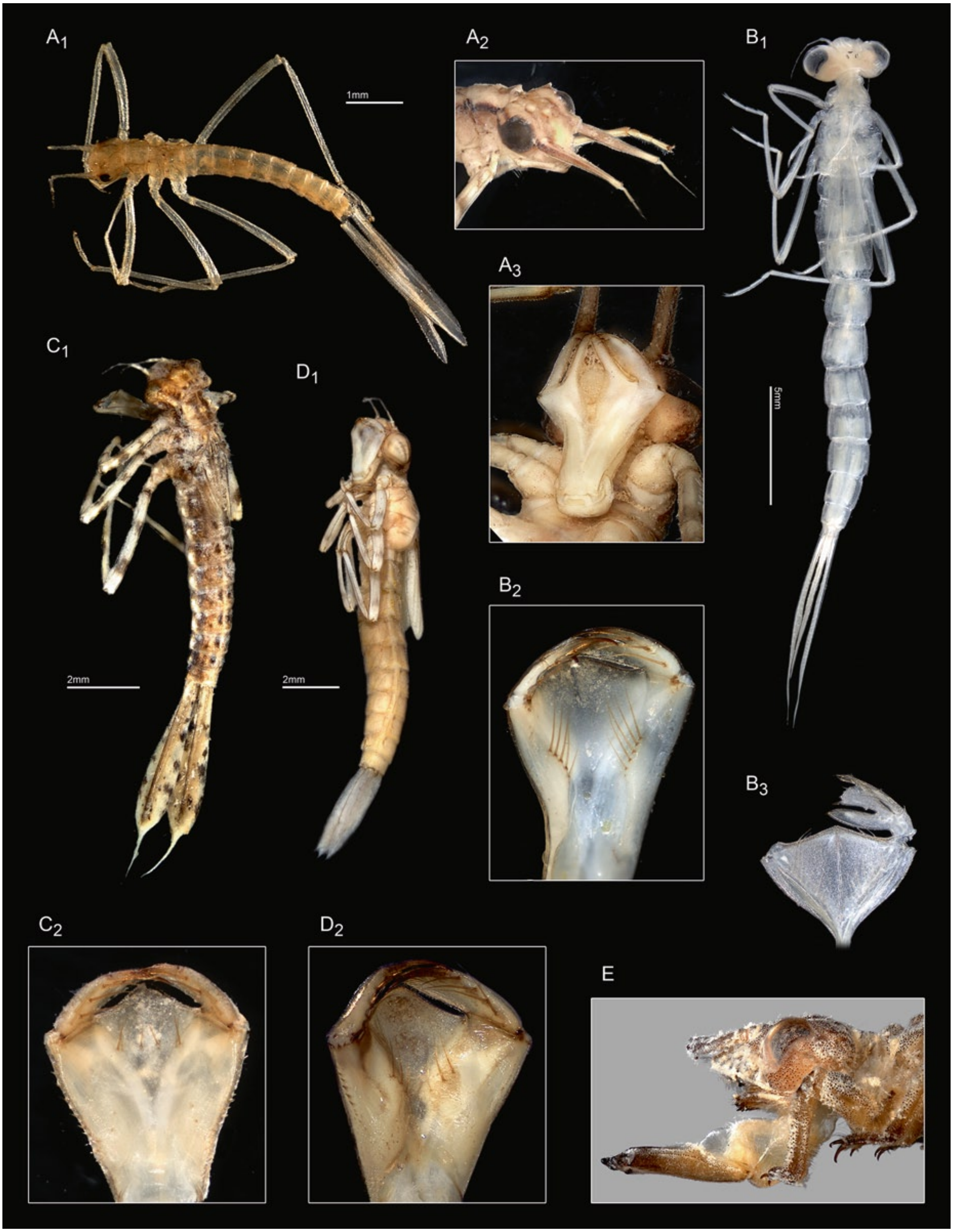

Fig. 2.15 Key Illustrations: Odonata. (**a**) Calopterygidae: general view ($\mathbf{a}_1$), first antennal segment very large ($\mathbf{a}_2$), diamond-shaped cleft in the prementum ($\mathbf{a}_3$); (**b**) Lestidae: general view ($\mathbf{b}_1$), inner view of the mask ($\mathbf{b}_2$), a deep groove in the first segment of the labial palp ($\mathbf{b}_3$); (**c**) Platycnemididae: general view ($\mathbf{c}_1$), inner view of the mask ($\mathbf{c}_2$); (**d**) Coenagrionidae: general view ($\mathbf{d}_1$), inner view of the mask ($\mathbf{d}_2$); (**e**) Gomphidae, head

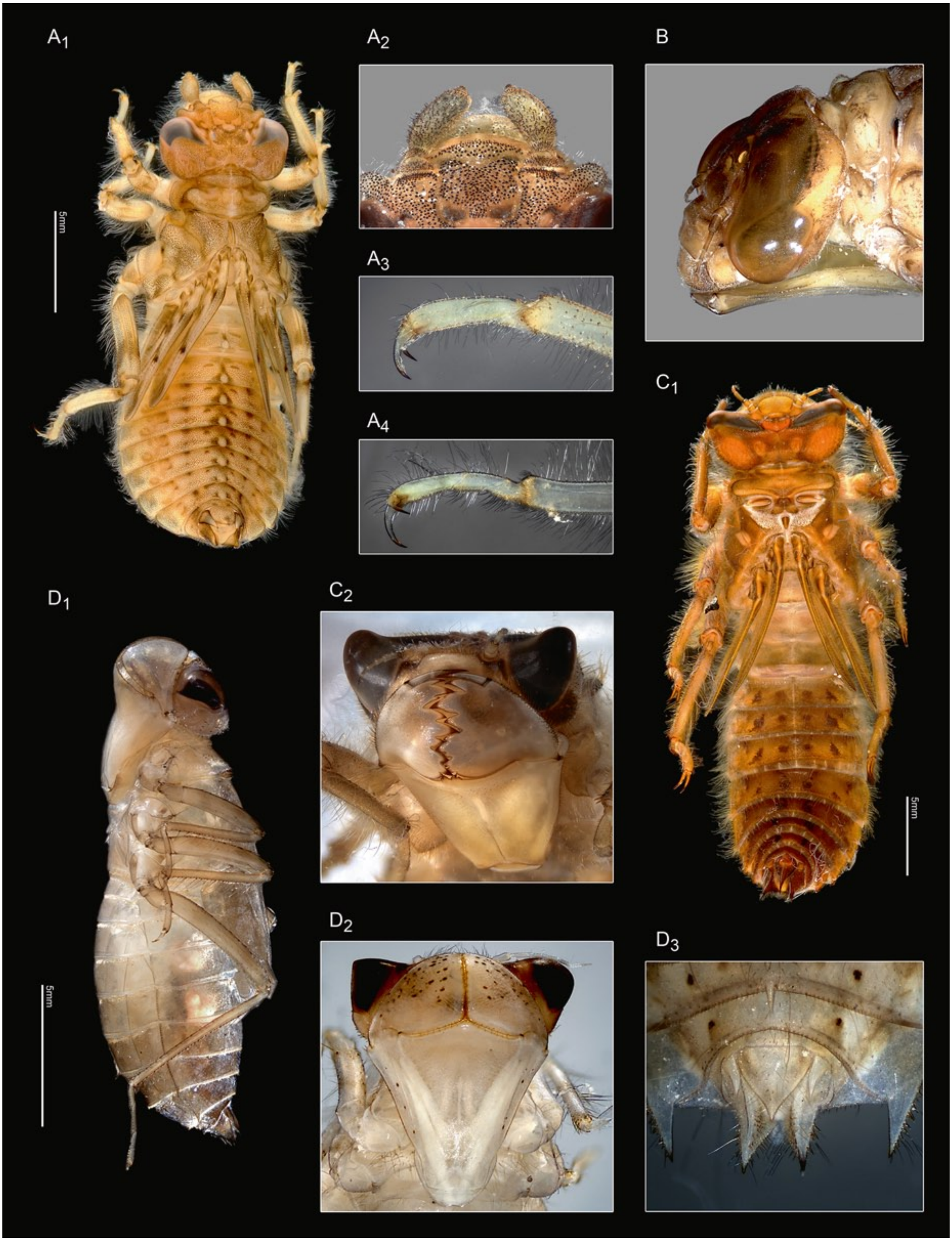

Fig. 2.16 Key Illustration: Odonata. (**a**) Gomphidae: general view (a_1), antennae (a_2), mesothoracic tarsi (a_3), metathoracic tarsi (a_4); (**b**) Aeshnidae, head; (**c**) Cordulegastridae: general view (c_1), frontal view of the head and mask (c_2); (**d**) Libellulidae: general view (d_1), frontal view of the head and mask (d_2), abdominal cerci and paraprocts (d_3)

Key 11 Odonata

1. Abdomen ending in three long trancheobranquial lamellae (Fig. 2.15a–d) 2
   Abdomen ending in five short, spinous appendages (Fig. 2.16a–d) 5
2. Antennal first segment longer than the remaining segments combined. Mask with diamond-shaped cleft in the prementum (Fig. 2.15a_{1-3}) .... F. **Calopterygidae**
   Antennal first segment similar to the remaining segments. Mask without such cleft 3
3. Prementum with small incision in the distal margin. First segment of the labial palp with a deep groove. Second segment of the labial palp with a row of conspicuous setae (Fig. 2.15b_{1-3}) .... F. **Lestidae**
   Prementum without distal margin incision. First segment of the labial palp with a shallow groove. Second segment of the labial palp without setae 4
4. Prementum with four dorsal setae in a horizontal row, transversal to the mask. Caudal lamella ending in a thin and long filament (Fig. 2.15c_{1-2}) .... F. **Platycnemididae**
   Prementum with setae arranged in two dorsal oblique rows opposed to each other. Caudal lamella blunt or with a rounder apex (Fig. 2.15d_{1-2}) .... F. **Coenagrionidae**
5. Mask flattened (Fig. 2.15e) 6
   Mask concave, spoon-like (Fig. 2.16d_1).............. 7
6. Antennae with four segments, the third one usually longer than the sum of the other three. Tarsi of prothoracic and mesothoracic legs with two segments, tarsi of metathoracic legs with three segments (Fig. 2.16a_{1-4}) .... F. **Gomphidae**
   Antennae with six or seven filiform segments. Tarsi with three segments in all legs (Fig. 2.16b) .... F. **Aeshnidae**
7. Metathoracic legs do not surpass the length of the abdomen. Labial palp with strong teeth of sharp distal margins (Fig. 2.16c_{1-2}) .... F. **Cordulegastridae**
   Metathoracic legs equal or surpassing the length of the abdomen. Labial palp at most with blunt and reduced teeth (as undulations) (Fig. 2.16d_{1-2}) 8
8. Labial palpus with more or less marked crenations. Legs slender and long. Cerci of the end of the abdomen similar to the paraprocts, at the very least more than half as long as the paraprocts .... F. **Corduliidae**
   Labial palpus with straight margin or with shallower crenations. Legs not so long. Cerci of the end of the abdomen shorter than the paraprocts, equal or less than half as long as the paraprocts (Fig. 2.16d_{1-3}) .... F. **Libellulidae**

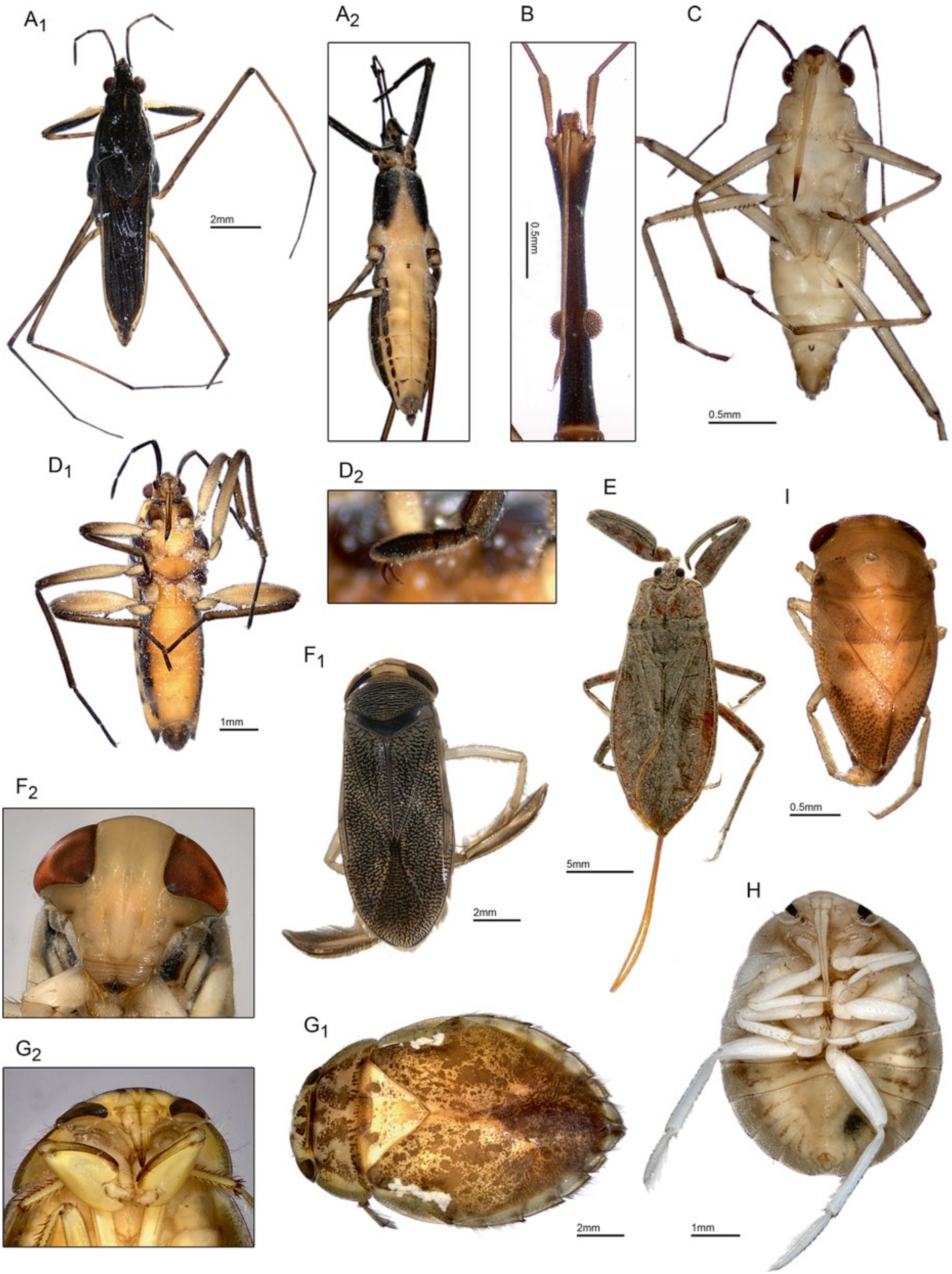

Fig. 2.17 Key Illustrations: Hemiptera. (**a**) Gerridae: dorsal view (**a**$_1$), ventral view (**a**$_2$); (**b**) Hydrometridae, ventral view of the head; (**c**) Mesoveliidae; (**d**) Veliidae: ventral view (**d**$_1$), claws inserted subapically (**d**$_2$); (**e**) Nepidae; (**f**) Corixidae: dorsal view (**f**$_1$), rostrum (**f**$_2$); (**g**) Naucoridae: dorsal view (**g**$_1$), rostrum and anterior legs (**g**$_2$); (**h**) Aphelocheiridae; (**i**) Pleidae

Key 12 Hemiptera

1. Antennae longer than the head (Fig. 2.17a–d) 2
   Antennae shorter than the head (Fig. 2.17e–i) 6
2. Head very elongated, eyes located in the medial zone (Fig. 2.17b) .... F. **Hydrometridae**
   Head not elongated, similar in length and width 3
3. Antennae appear to have five segments. Beak protruding .... F. **Hebridae**
   Antennae with four segments. Beak not protruding 4
4. Mesothoracic legs closer to metathoracic legs than to prothoracic legs; as a result, the mesosternum is very long. Metathoracic femurs elongated, clearly surpassing the abdomen (Fig. 2.17a$_{1-2}$) .... F. **Gerridae**
   Mesothoracic legs more or less equidistant to metathoracic and prothotoracic legs, mesosternum shorter. Metathoracic femurs usually shorter than the abdomen 5
5. Mesothoracic legs very close to each other, separated by less than a coxa's width. Mesothoracic and metathoracic legs insert ventrally, in such a way that metathoracic legs seem to converge in the body axis. Claws inserted apically (Fig. 2.17c) .... F. **Mesoveliidae**
   Mesothoracic legs more separated between them than prothoracic and metathoracic legs. Mesothoracic and metathoracic legs insert laterally in such a way that the metathoracic legs seem at most parallel to the body axis. Claws inserted subapically (Fig. 2.17d$_{1-2}$) .... F. **Veliidae**
6. Abdomen terminating in a respiratory tube (Fig. 2.17e) .... F. **Nepidae**
   Without respiratory tube 7
7. Ocelli present. Rostrum elongated (live in water edges) .... F. **Ochteridae**
   Ocelli absent. Except *Aphelocheirus*, rostrum shorter 8
8. Scutellum not very visible. Rostrum without true segments (just one), relatively short and usually with transversal grooves (Fig. 2.17f$_{1-2}$) .... F. **Corixidae**
   Scutellum very visible. Rostrum with well defined segments (four) 9
9. Anterior legs raptorial. Body dorsoventrally flattened (Fig. 2.17g$_{1-2}$) .... F. **Naucoridae**
   Anterior legs not raptorial 10
10. Body dorsoventrally flattened. Rostrum very long, the edge surpassing the mesothoracic coxae (Fig. 2.17h) .... F. **Aphelocheiridae**[10]
    Body usually convex or laterally compressed. Rostrum shorter, never reaching the mesothoracic coxae 11
11. Small animals (adults do not normally surpass 3 mm), body relatively short and strongly arched, laterally compressed. Pronotum and hemielytra coarsely punctate (Fig. 2.17i) .... F. **Pleidae**
    Larger animals (adults usually over 8 mm), body not strongly arched. Pronotum and hemielytra smooth, at most weakly punctate .... F. **Notonectidae**

[10] Some authors consider Aphelocheiridae within the family Naucoridae.

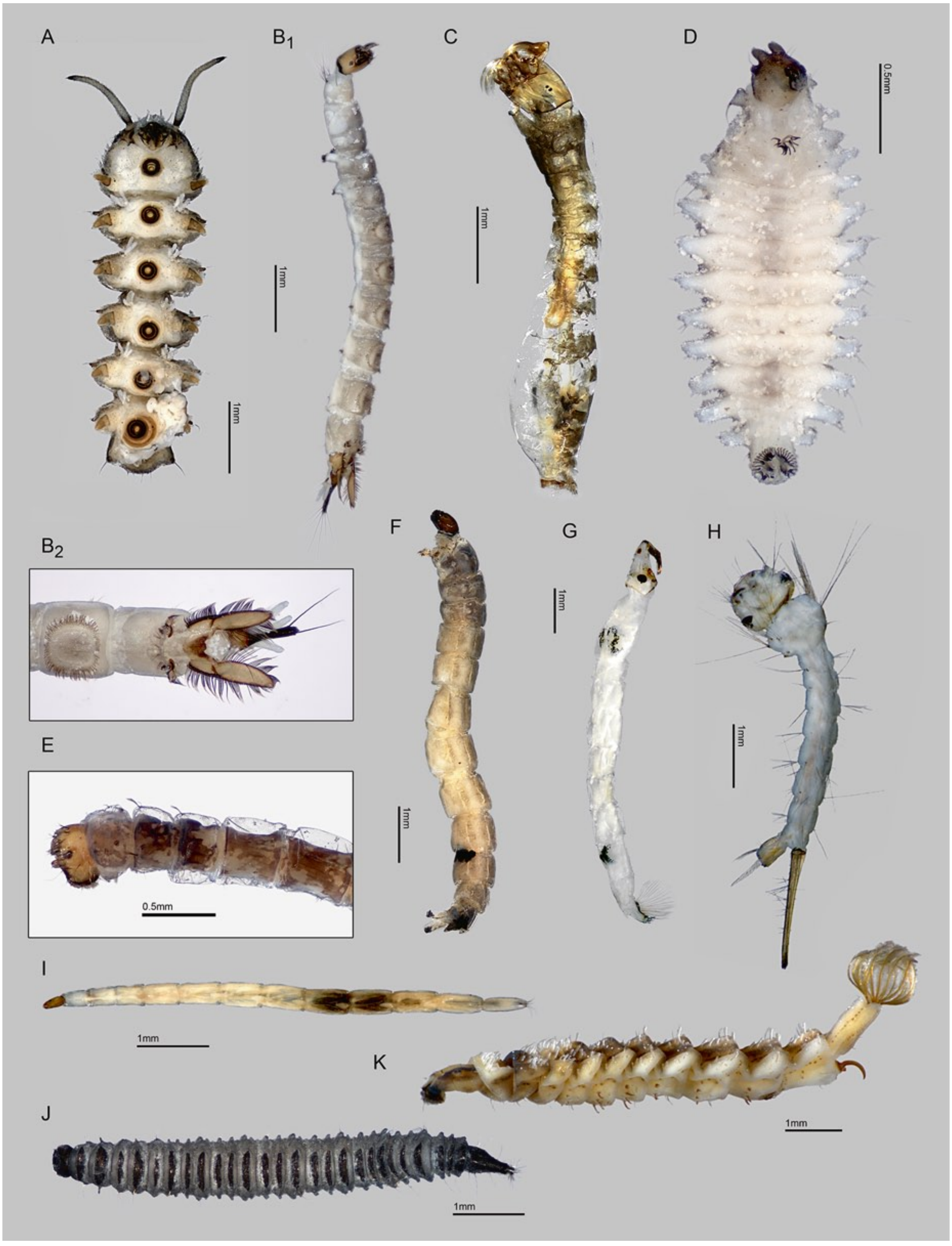

Fig. 2.18 Key Illustrations: Diptera. (**a**) Blephariceridae, ventral view showing the suckers; (**b**) Dixidae: lateral view (**b**$_1$), chitinous siphon and lobes of the abdominal end (**b**$_2$); (**c**) Simuliidae; (**d**) Ceratopogonidae; (**e**) Thaumaleidae, lateral view of the anterior region showing the hypognathous disposition and protuberances of the head; (**f**) Chironomidae; (**g**) Chaoboridae; (**h**) Culicidae; (**i**) Ceratopogonidae; (**j**) Psychodidae, dorsal plates; (**k**) Stratiomyidae

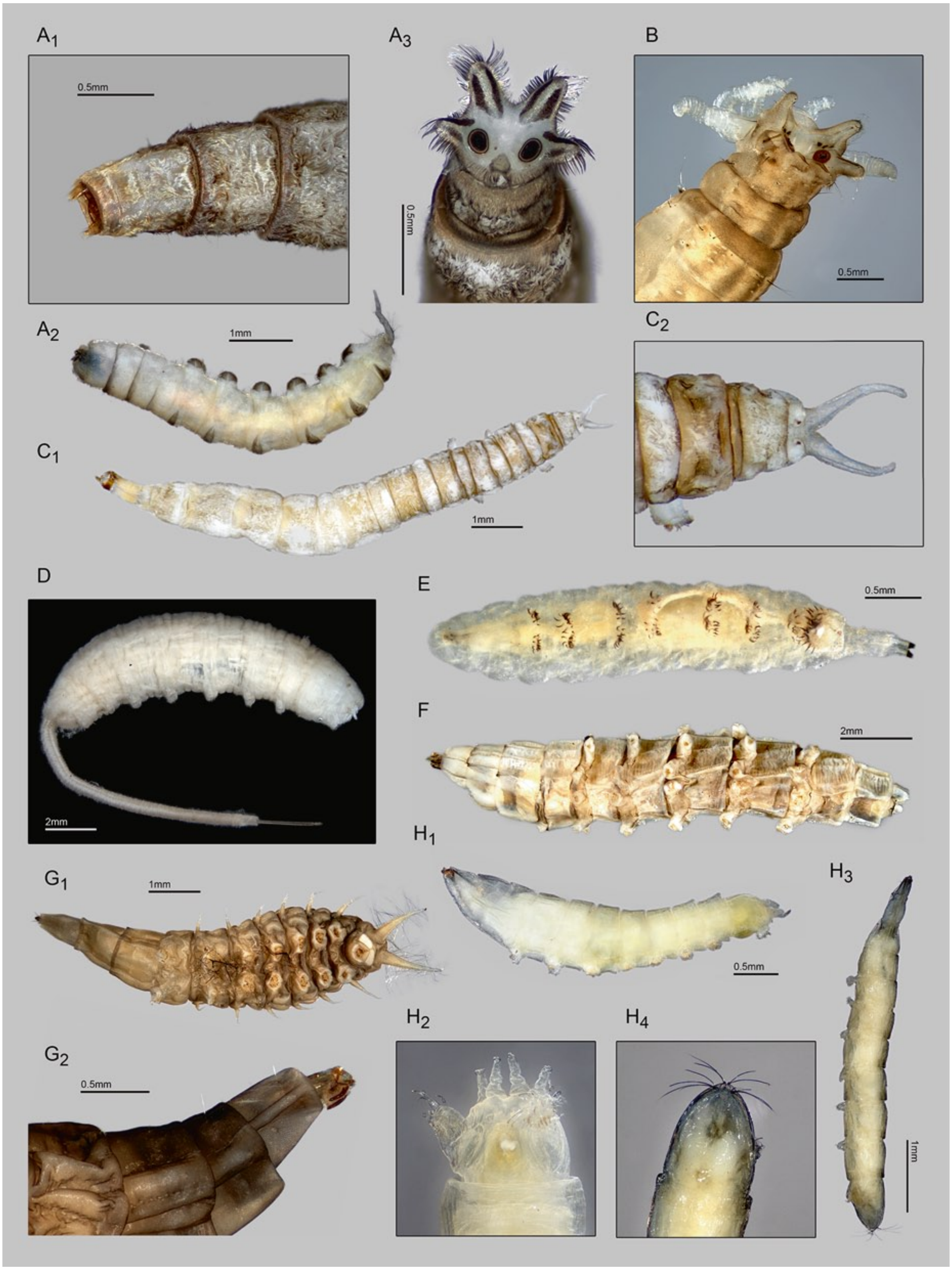

Fig. 2.19 Key Illustrations: Diptera. (**a**) Limoniidae: anterior region showing the mandibles ($\mathbf{a}_1$), general view ($\mathbf{a}_2$), spiracular disc ($\mathbf{a}_3$); (**b**) Tipulidae: spiracular disc; (**c**) Pediciidae: general view ($\mathbf{c}_1$), anal region with spiracles ($\mathbf{c}_2$); (**d**) Syrphidae; (**e**) Ephydridae; (**f**) Tabanidae; (**g**) Athericidae: ventral view ($\mathbf{g}_1$), anterior region showing the mandibles ($\mathbf{g}_2$); (**h**) Empididae: general view ($\mathbf{h}_1$ and $\mathbf{h}_3$), details of the abdomen ($\mathbf{h}_2$ and $\mathbf{h}_4$)

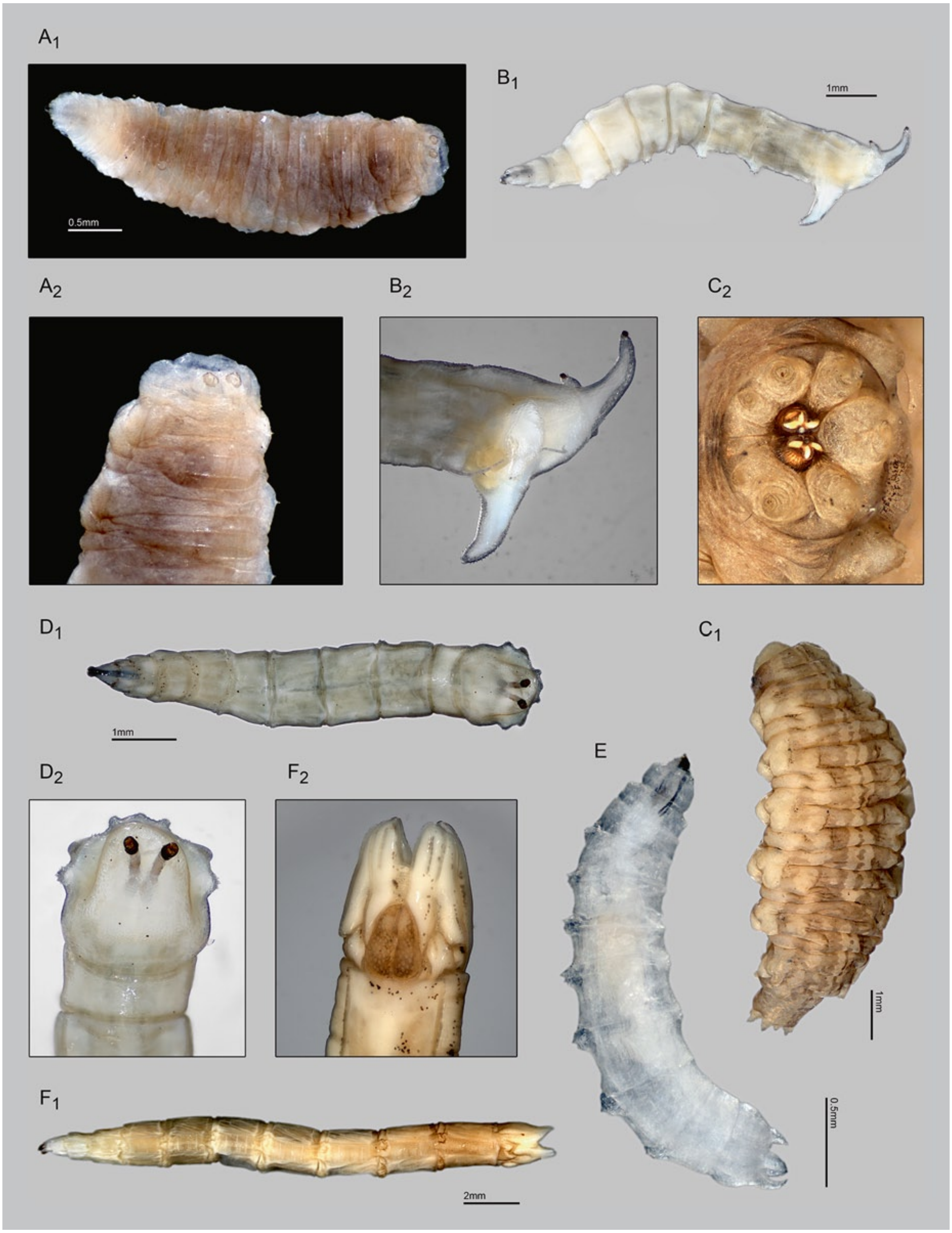

Fig. 2.20 Key Illustrations: Diptera. (**a**) Scathophagidae: general view ($\mathbf{a}_1$), abdominal spiracles and lobes ($\mathbf{a}_2$); (**b**) Anthomyiidae: general view ($\mathbf{b}_1$), abdominal processes ($\mathbf{b}_2$); (**c**) Sciomyzidae: general view ($\mathbf{c}_1$), posterior spiracles ($\mathbf{c}_2$); (**d**) Muscidae: general view ($\mathbf{d}_1$), spiracles ($\mathbf{d}_2$); (**e**) Dolichopodidae; (**f**) Rhagionidae: general view ($\mathbf{f}_1$), anal plate ($\mathbf{f}_2$)

Key 13 Diptera

1. With six ventral suckers (Fig. 2.18a) .... F. **Blephariceridae**
   Without those characters 2
2. Head capsule usually well defined and sclerotized, separated from the thorax (Fig. 2.18) 3
   Head capsule not well defined, possibly retracted into the thorax (Fig. 2.19 and 2.20) 14
3. Prolegs present 4
   Prolegs absent 9
4. Prolegs on abdominal segments I and II. Abdomen ending in a chitinous siphon and two lobes with a row of setae (Fig. 2.18b$_{1-2}$) .... F. **Dixidae**
   Prolegs present on thorax or anal region. Abdomen not as above 5
5. Prolegs on prothorax absent, only present on anal region (retractile) .. F. **Ceratopogonidae** (in part)
   Prolegs present on the prothorax, maybe also on the anal region 6
6. Prolegs only present on the prothorax (Fig. 2.18c .... F. **Simuliidae**
   Prolegs present on both the prothorax and the anal region 7
7. Body with long protuberances and setae (Fig. 2.18d) .... F. **Ceratopogonidae** (in part)
   Body without protuberances 8
8. Head capsule hypognathous, perpendicular to the body. Head capsule with protuberances. Only one prothoracic proleg. One pair of open spiracles on the thorax and another one at the apex of the abdomen. Dorsal mottled pigmentation (Fig. 2.18e) .... F. **Thaumaleidae**
   Head capsule without protuberances and not perpendicular to the body. Thoracic prolegs in pairs, although sometimes they might be fused at the base and so close together that they may appear as one. Without opened spiracles (Fig. 2.18f) .... F. **Chironomidae**
9. Thorax without obvious segmentation, wider than the rest of the body 10
   Thorax with obvious segmentation, similar in width to the rest of the body 11
10. Antennae ending in long setae used to catch prey. Very characteristic head. Usually with air sacs or hydrostatic organs on the thorax and at the end of the abdomen (Fig. 2.18g) .... F. **Chaoboridae**
    Antennae without long setae, maybe with short setae. Without hydrostatic organs (Fig. 2.18h) .... F. **Culicidae**
11. Abdomen ending in a respiratory siphon of variable size and two gills .... F. **Ptychopteridae**
    Without those characters 12
12. Body quite elongated, head and segments longer than they are wide (Fig. 2.18i) .... F. **Ceratopogonidae** (in part)
    Without those characters 13
13. Body with marked chitinous dorsal plates, roughly cylindrical cross-section. Body appears to have more than 14 segments (not counting the head) (Fig. 2.18j) .... F. **Psychodidae**
    Body without marked dorsal plates, with a flatter cross-section. Body with 11 segments (not counting the head). Usually with a brush of setae at the end of the abdomen (Fig. 2.18k) .... F. **Stratiomyidae**
14. Mandibles well developed, moving against each other on a horizontal plane (Fig. 2.19a$_1$) 15
    Mandibles parallel to each other, moving on a vertical plane (Fig. 2.19g$_2$).................................. 18
15. Body with bifid or serrated processes .... F. **Cylindrotomidae**
    Body without those processes 16
16. Spiracular disc with six lobes on the anal region (Fig. 2.19b) .... F. **Tipulidae**
    Spiracular disc with five lobes at most 17
17. Spiracular disc with two lobes on the anal region. Spiracles present (Fig. 2.19c$_{1-2}$) .... F. **Pediciidae**
    Spiracular disc with a different number of lobes. If two lobes, spiracles absent (Fig. 2.19a$_{2-3}$) .... F. **Limoniidae**
18. Abdomen ending in a siphon 19
    Abdomen without siphon, maybe with other pair structures (not siphons) 21
19. Very long, telescopic siphon. Anterior part of the body blunt (Fig. 2.19d) .... F. **Syrphidae**
    Siphon not as long or telescopic. Anterior part of the body not as above 20
20. Siphon ending in two tubular retractile processes. Ventral prolegs present, usually ending in hooks (Fig. 2.19e) .... F. **Ephydridae**
    Siphon not as above, shorter and retractile. Body covered with prolegs or similar structures (Fig. 2.19f) .... F. **Tabanidae**

21. Prolegs used for locomotion 22
Prolegs absent but locomotory pads maybe present 24
22. Abdomen ending in processes (two or five pairs) longer than the last prolegs (Fig. 2.19g) ....
.... F. **Athericidae**
Abdomen not ending in processes or if processes present, they are shorter than the last prolegs 23
23. Abdomen not ending in processes or setae ....
.... F. **Muscidae**
Abdomen ending in processes; if these are absent, tuft of setae present (Fig. $2.19h_{1-4}$) ....
.... F. **Empididae**
24. Abdominal end truncated, with spiracles and short conical lobes (Fig. $2.20a_{1-2}$) ... F. **Scathophagidae**
Without those characters 25
25. Abdomen ending in four curved processes (Fig. $2.20b_{1-2}$) .... F. **Anthomyiidae**
Without those characters 26
26. Body wrinkled, last segment with posterior spiracles surrounded by lobes and usually protected by water-repellent, branched setae (Fig. $2.20c_{1-2}$) .....
.... F. **Sciomyzidae**
Without those characters 27
27. Abdomen not ending in lobes, with slightly protruding spiracles (Fig. $2.20d_{1-2}$) .... F. **Muscidae**
Abdomen ending in four lobes that create a chamber where the spiracles are located 28
28. Abdomen ending in four conical lobes, the ventral ones usually pointy and more developed than the dorsal ones. Body with longitudinal grooves. Anal plates subtriangular and of pale colouration (Fig. 2.20e) .... F. **Dolichopodidae**[11]
Abdomen ending in four leaf-like lobes of similar size. Body with two longitudinal and lateral furrows, more or less conspicuous. Anal plates ovoid or elliptical, generally of dark (ferrous) colouration (Fig. $2.20f_{1-2}$) .... F. **Rhagionidae**

[11] Families Rhagioniidae and Dolichopodidae not easily differentiated. We indicate some characters used to differentiate them, but they cannot always be classified accurately.

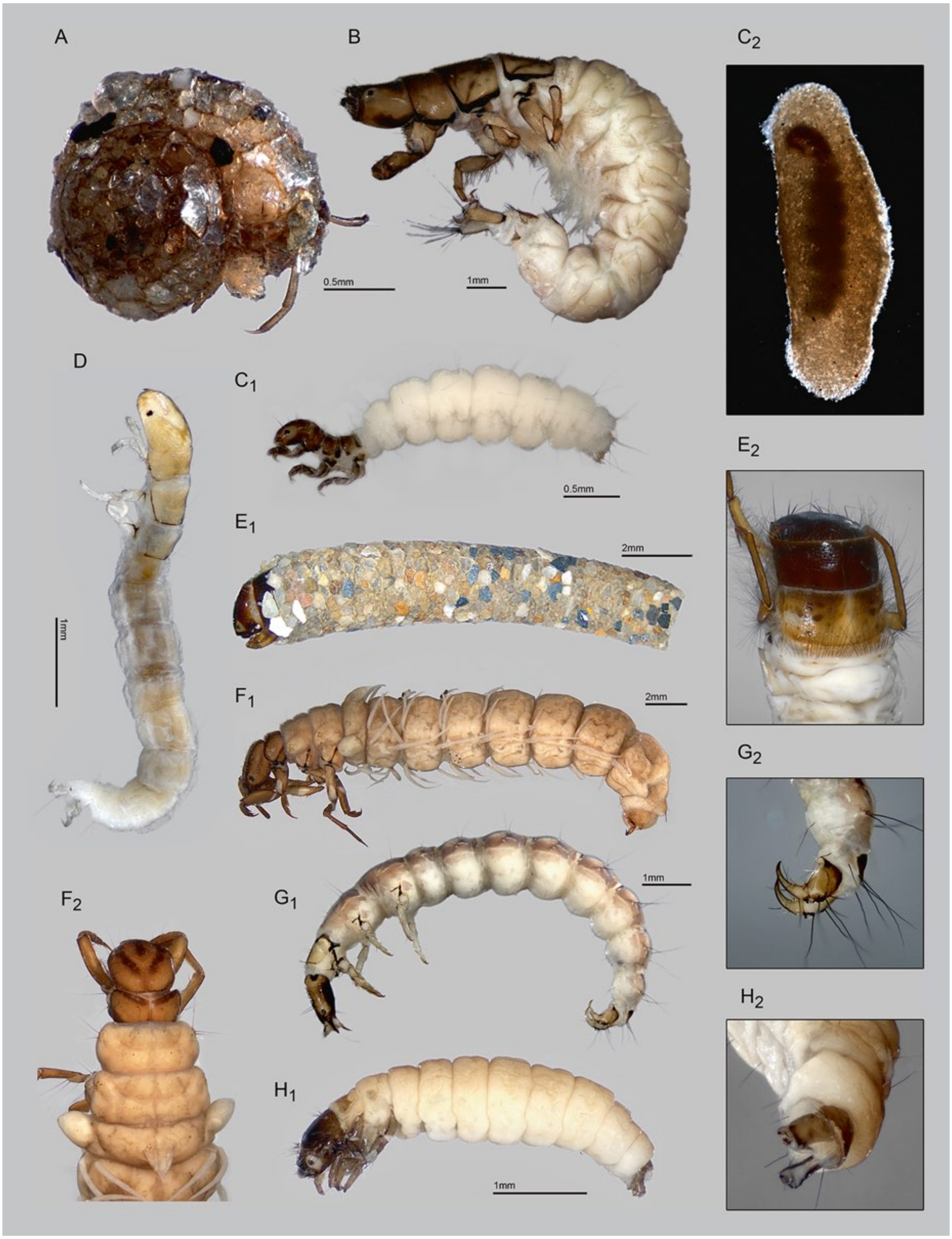

Fig. 2.21 Key Illustrations: Trichoptera. (**a**) Helicopsychidae, case; (**b**) Hydropsychidae; (**c**) Hydroptilidae: general view ($\mathbf{c}_1$), case ($\mathbf{c}_2$); (**d**) Ecnomidae; (**e**) Sericostomatidae: larva inside the case ($\mathbf{e}_1$), head and thorax ($\mathbf{e}_2$); (**f**) Phryganeidae: general view ($\mathbf{f}_1$), protuberances of the first abdominal segment ($\mathbf{f}_2$); (**g**) Rhyacophilidae: general view ($\mathbf{g}_1$), anal claws ($\mathbf{g}_2$); (**h**) Glossosomatidae: general view ($\mathbf{h}_1$), anal claws ($\mathbf{h}_2$)

Fig. 2.22 Key Illustrations: Trichoptera. (**a**) Psychomyiidae: general view (a_1), anal appendages (a_2); (**b**) Philopotamidae: general view (b_1), tarsal claws (b_2); (**c**) Polycentropodidae: general view (c_1), tarsal claws (c_2); (**d**) Beraeidae; (**e**) Leptoceridae: general view (e_1), metathoracic leg (e_2), antennae (e_3); (**f**) Brachycentridae; (**g**) Lepidostomatidae

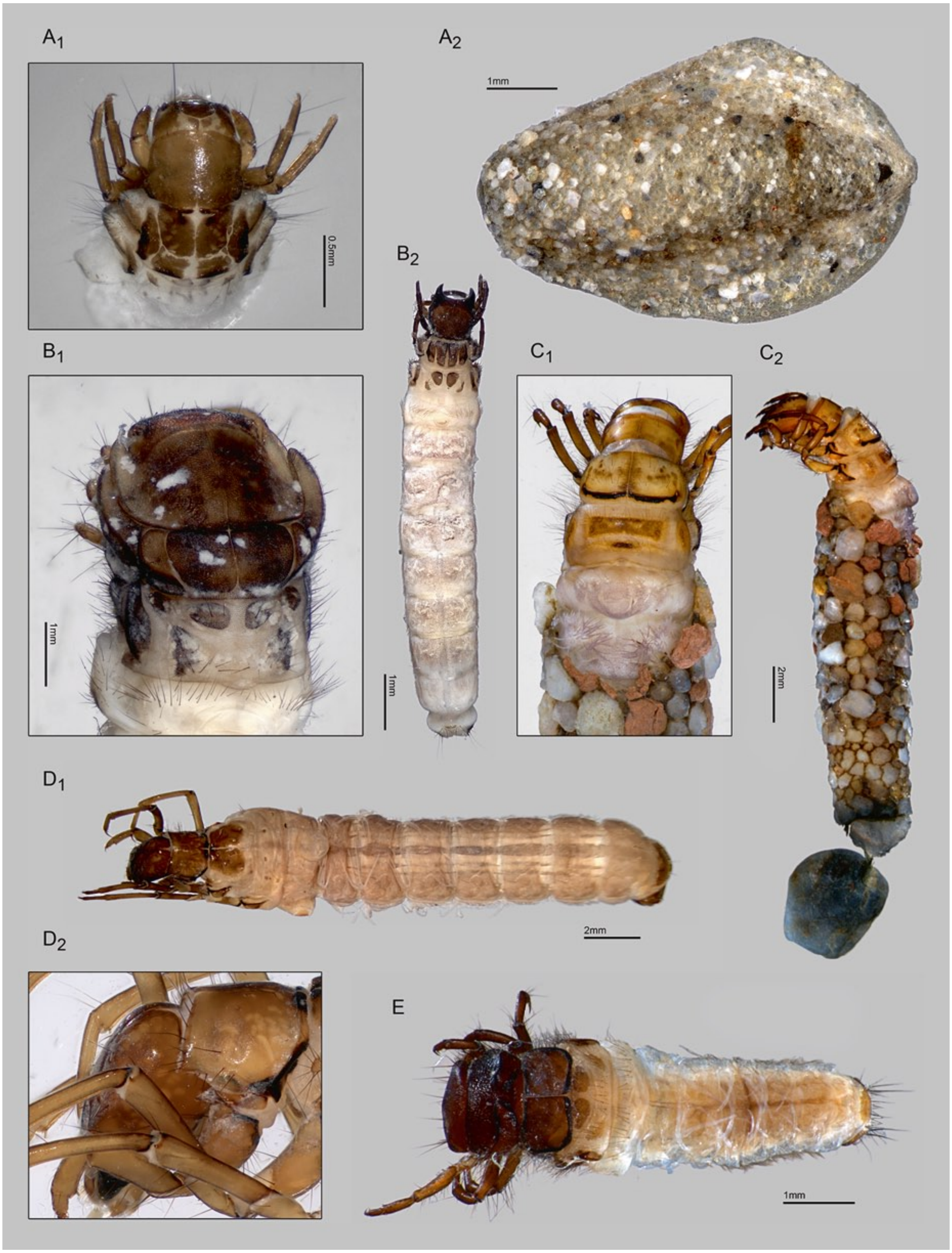

Fig. 2.23 Key Illustrations: Trichoptera. (**a**) Uenoidea: sclerites of the thorax ($\mathbf{a}_1$), case ($\mathbf{a}_2$); (**b**) Goeridae: sclerites of the thorax ($\mathbf{b}_1$), general view ($\mathbf{b}_2$); (**c**) Odontoceridae: arrangement of metathoracic sclerites ($\mathbf{c}_1$), general view of the specimen inside its case ($\mathbf{c}_2$); (**d**) Calamoceratidae: general view ($\mathbf{d}_1$), lateral view of the pronotum margin ($\mathbf{d}_2$); (**e**) Limnephilidae

Key 14 Trichoptera

1. Anal claws comb-shaped (with several teeth). Larva in snail-shaped case constructed of sand grains (Fig. 2.21a) .... F. **Helicopsychidae**
   Anal claws hook-shaped 2
2. Metanotum fully sclerotized (Fig. 2.21b–d) 3
   Metanotum not sclerotized or partially sclerotized 5
3. Abdominal ventral gills present (Fig. 2.21b) .... F. **Hydropsychidae**
   Abdominal ventral gills absent 4
4. Small larva, with anal appendages short (only one segment). Abdominal segment IX with a sclerite. Abdomen usually bigger than the rest of the body, looks swollen. Very characteristic case, laterally flattened, constructed of silk to which vegetable matter or sand particles can be attached (Fig. $2.21c_{1-2}$) .... F. **Hydroptilidae**
   Anal appendages longer, with two segments, a basal membranous one and a sclerotized distal one. Dorsal part of abdominal segment IX membranous. Abdomen of similar size (both in width and height) than the rest of the body, cylindrical shape. Larva lives inside a silk gallery attached to the substrate (Fig. 2.21d) .... F. **Ecnomidae**
5. Mesonotum completely membranous or with a few small plates covering less than half the dorsum 6
   Mesonotum completely sclerotized or bearing sclerotized plates covering more than half the dorsum 12
6. Larva with protuberances on the first abdominal segment (Fig. $2.21f_{1-2}$) 7
   Larva without protuberances on the first abdominal segment 8
7. Case constructed with mineral elements. Mesonotum (and metanotum) with two transversal rows of long setae (as in Fig. $2.21e_{1-2}$) .... F. **Sericostomatidae** (early stages)
   Circular case constructed with vegetable matter arranged in a spiral or a ring. Setae of the mesonotum arranged differently .... F. **Phryganeidae**
8. Dorsum of abdominal segment IX with a chitinous plate 9
   Dorsum of abdominal segment IX without a chitinous plate 10
9. Anal prolegs long, with strong claws. Free-living larva (Fig. $2.21g_{1-2}$) .... F. **Rhyacophilidae**
   Anal prolegs short, with more brittle claws. Case with two lower openings, similar to a tortoise shell (Fig. $2.21h_{1-2}$) .... F. **Glossosomatidae**
10. Anal appendages short, with one segment (Fig. $2.22a_{1-2}$) .... F. **Psychomyiidae**
    Anal appendages long, with two segments 11
11. Head of uniform colour, usually orange. Labrum membranous and T-shaped. Tarsal claws much smaller than the tarsi (Fig. $2.22b_{1-2}$) .... F. **Philopotamidae**
    Head with different colouration. Labrum sclerotized, oval-shaped. Tarsal claws similar or longer than the tarsi (Fig. $2.22c_{1-2}$) .... F. **Polycentropodidae**
12. Metanotum membranous 13
    Metanotum partially sclerotized 17
13. Mesonotum with two transversal rows of long setae pointing forward. Metanotum also with many setae pointing forward (Fig. $2.21e_2$) .... F. **Sericostomatidae**
    Mesonotum with setae arranged differently 14
14. Pronotum with transverse carina ending in a lobe or an expansion of the anterior margin. First abdominal segment with lateral rounded protuberances. Generally with a thick anal setum (Fig. 2.22d) .... F. **Beraeidae**
    Without those characters 15
15. Claws of the third pair of legs different, much smaller or sharper than those of anterior and intermediate legs and also covered with setae .... F. **Molannidae**[12]
    Claws of the third pair of legs similar to the rest 16
16. Antennae relatively long and prominent (at least six times longer than they are wide) or with a pair of posterolateral curved and dark projections on the mesonotum. Third pair of legs generally very long. Trochanter similar in length to the femur, with a proximal femoral piece in the joint between both segments (Fig. $2.22e_{1-3}$) ..... F. **Leptoceridae**
    Antennae usually short. Trochanter shorter than the femur (two or three times shorter), without a femoral piece in the joint between both segments .... F. **Beraeidae**
17. First abdominal segment without protuberances (Fig. 2.22f) .... F. **Brachycentridae**

[12] The presence of this family in the Iberian Peninsula has been questioned.

First abdominal segment with protuberances 18

18. Abdominal segment I without dorsal protuberances, only two lateral ones (Fig. 2.22g) .... F. **Lepidostomatidae**
    Abdominal segment I with a dorsal protuberance and two lateral ones 19
19. Mesonotum with four to six sclerotized plates (Fig. 2.23a, b) 20
    Mesonotum with two sclerotized plates (Fig. 2.23c–e) 21
20. Mesonotum with six sclerites and metanotum with four. Case characteristic, similar to the shell of Ancylidae, or tubular and conical and covered with detritus particles (Fig. 2.23a_{1-2}) .... F. **Uenoidae**
    Mesonotum with four or six sclerites and metanotum with six or eight. Pronotum anterior margin usually ending in a sharp expansion. Case not as above (Fig. 2.23b_{1-2}) .... F. **Goeridae**
21. Sclerites of the metanotum arranged characteristically: two transversal (the anterior one rectangular and larger than the posterior one) and two lateral. Mineral case, cylinder-conical; case end blocked with a larger stone (Fig. 2.23c_{1-2}) .... F. **Odontoceridae**
    Sclerites of the metanotum arranged differently. Case not as above 22
22. Pronotum ventral anterior margin sharp. Dorsal plates of the mesonotum with blurred margins. Labrum dorsal surface with a transversal continuous row with numerous thick setae (c. 30) in the central region (Fig. 2.23d_{1-2}) .... F. **Calamoceratidae**
    Pronotum ventral anterior margin rounded. Mesonotum dorsal plates with well defined margins. Labrum dorsal surface with a maximum of six thick setae arranged differently 23
23. Without anterodorsal plates on the metanotum .... F. **Apataniidae**
    With anterodorsal plates on the metanotum (Fig. 2.23e) .... F. **Limnephilidae**

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3 Taxa Description and Biology

Abstract

This section of the book includes brief morphological and anatomical descriptions of the studied taxa. Data on the biology of the families is also provided, partly for completeness but also to allow the reader to gain a better understanding of these animals. The list of authors for each taxon is included in the front matter of this book.

Spongillidae

Description

Morphologically, sponges constitute one of the simpler animal groups (Fig. 3.1a–e): basically, they are an organised group of cells (choanocytes) specialised in circulating water through a net of fine pores and channels. The body porous structure is maintained by the skeletal function of minute spicules (calcium carbonate or siliceous) and collagen fibers that constitute the sponge's non-cellular matrix. Although there are some other cellular types that carry out different functions, sponges do not posses true organs or tissues. Also, as sessile animals, they do not require sensory organs or a nervous system. Freshwater sponges can be hard to recognise, as they do not look like animals. Their morphology varies depending on the ecological conditions of the environment where they develop, generally appearing as a pale crust covering the substrate. Only in still waters they develop vertically or branch out. Size varies with species, age and ecological factors, although they are generally small.

Biology

Sponges are primarily marine species, with Spongillidae being the only freshwater family. They colonise a variety of aquatic habitats, from rivers to lakes, or even human-made ponds or channels. Usually they cover the bottom part of boulders on areas with running water or encrust around the branches of riverbank vegetation. Symbiosis with some algae and bacteria is not uncommon, which shows by a green or yellowish colouration. As sessile, filter feeders, some amount of suspended organic matter can be beneficial for them. However, sponges living in rivers need high oxygen levels and therefore the organic matter load cannot be too high. They are also vulnerable to the increase of turbidity in the water. Nonetheless, some studies point out that this group can tolerate some extreme environmental conditions (see Pronzato and Manconi 2001 for more information). During the winter, they develop small (500 µm in diameter) spherical buds known as gemules. Gemules are a form of resistance and dispersion. Identification to species level requires analyses of gemule structure. In the Iberian

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Fig. 3.1 (**a**–**e**) Spongillidae: live specimens (**a**–**b**), specimen with gemmules (**c**), gemmuloscleres (**d**), gemmuloscleres on gemmule surface (**e**); (**f**–**g**) Dugesiidae: general view (**f**), specimen with four eyes (**g**); (**h**–**j**) Nematoda; (**k**–**m**) Nematomorpha, Gordiidae; (**n**–**o**) Bryozoa: general view (**n**), lophophore (**o**)

Peninsula, five freshwater sponge species have been reported (Traveset 1986; Pronzato and Manconi 2001; Oscoz et al. 2009).

Hydridae

Description

Cnidarians are regarded as the oldest true animals and as such, they possess an extremely simple functional and structural organisation. Despite its simple nature, they are highly diverse and widely distributed. They live in both freshwater and marine habitats, although it is in the latter where they have had the largest radiation. One of the phylum's main characteristic is the alternation of the polyp and medusa morphologies during their life cycle, although depending on the group, one of the two can be very reduced or completely absent. While the medusa stage is free living and solitary, the polyp is attached to the substrate and can form colonies. The family Hydridae is constituted by soft-bodied, small-sized animals that only develop the polyp stage (Campaioli et al. 1994). The polyp has a very simple morphology, with radial symmetry. It resembles a tube or a vertical column attached to the substrate by a pedal disc. In the opposite end, they have a crown of retractile tentacles in the centre of which opens the mouth. The tentacles are filiform, although they may appear monoliform due to the presence of stinging cells on their distal part. The number of tentacles varies, although in freshwater species this is normally small. Members of this family have a white colouration, although through symbiosis with algae they can also show shades of green (Puig 1999).

Biology

The family Hydridae is only represented by one genus, Hydra. They are solitary animals inhabiting the freshwaters of rivers, streams, channels and lakes. They are more frequent in medium and low flow rivers with clean and cold waters, where they prefer areas with no current. They usually attach to the substrate with a pedal disc, although they are capable of locomoting using the pedal disc and the tentacles, or by floating with the current (Rueda Sevilla and Hernández Villar 2009). The substrates to which they attach can be vegetation or boulders in gravel and sand areas. They have a high regenerative capacity.

Hydroids are carnivorous animals that feed mainly on oligochaetes, microcrustaceans and insects on early larval stages. The tentacles on the crown have several stinging and adherent cells that paralyse and catch prey, which is later directed towards the single opening (mouth and anus) located in the centre of the crown. They seem capable of tolerating moderate levels of pollution.

Planariidae

Description

Planariidae is a family of unsegmented non-parasitic freshwater flatworms, pigmented or white. Planariidae representatives have a truncate or rounded head, never triangular. Eyes are usually present (Fig. 2.2f) and multiocularity is not uncommon. Planariidae species lack the anterior glandulomuscular adhesive organ or 'sucker' that is present in Dendrocoelidae species (Cannon 1986).

Currently 12 genera are known (Sluys et al. 2009), of which 4 are present in the Iberian Peninsula: *Atrioplanaria* de Beauchamp 1932, *Crenobia* Kenk 1930, *Phagocata* Leidy 1847 and *Polycelis* Kenk 1930. *Crenobia* is a two-eyed genus with a tentacle on each side of the head. *Atrioplanaria* and *Phagocata* are usually small, two-eyed unpigmented or white planarians. *Polycelis* is characterized by a row of eyes around the anterior margin of the body. It is possible to externally differentiate the two species of this genus present in the Iberian Peninsula based on the presence (*P. felina* (Dalyell 1814)) or absence (*P. nigra* (Muller 1774)) of the pair of tentacles (Baguñà et al. 1981).

Biology

Planariids are sexually reproducing hermaphrodites. As in other triclad groups, they do not have complex larval stages and the hatchlings are small replicas of the adults, except with no reproductive organs and not as pigmented. They lay spherical or ovoid cocoons which attach to the substrate without a stalk.

Crenobia alpina (Dana 1766) and *Polycelis felina* are stenothermal species of cold waters, inhabiting alpine lakes and upper reaches of rivers. *Polycelis nigra* is present in the warmer waters of coastal plain areas.

Planariidae species are essentially predators of invertebrates. They are attracted by damaged preys that they detect through chemosensory cells located in their head grooves. Disturbances in the water produced by a potential prey may trigger orientation of planariid species towards the prey item. Apparently, intact invertebrates are not predated upon by planariids.

Dugesiidae

Description

Dugesiidae are unsegmented and usually small (between 1 and 2 cm long) free-living freshwater flatworms (Fig. 3.1f–g). Their main external characteristic is a triangular (sometimes rounded) head with two eyes in the middle, although occasionally they can present supernumerary eyes (Fig. 3.1g). Unlike Dendrocoelidae, Dugesiidae species do not have anterior adhesive organs. They are usually pigmented, from light brown to black (Cannon 1986).

One genus is present in the Iberian Peninsula: *Dugesia* Girard 1850. This genus shows a more or less well-defined triangular (sometimes rounded) head with distinct auricules. *Dugesia tigrina* Girard 1850, one of the species of this genus cited in the Iberian Peninsula, is an invasive species from North America and can be identified by its blotchy and grey body.

In the family Dugesiidae, it is almost impossible to externally differentiate the species within each genus and therefore, histological analyses of the reproductive organs and the karyotype are needed.

Biology

Dugesiidae is a worldwide distributed freshwater flatworm family (Sluys et al. 2009). Similarly to other freshwater planarian families, Dugesiidae species inhabit any kind of freshwater bodies, from little springs to large rivers and lakes. These animals are prone to desiccation and they depend on continuous freshwater bodies to survive. They tend to aggregate under rocks, aquatic vegetation or leaves on the shore. While resting they take an ovoid shape, but once they start to move they adopt an elongated and flattened shape.

Specimens belonging to genus *Dugesia* are eurythermal species. This family can reproduce sexually and/or asexually. Sexual populations are hermaphrodites and produce rounded and stalked cocoons that contain a few eggs. These cocoons are about 2 mm in diameter and attach to solid surfaces through a pedicel, which is cemented at the base. When the cocoons hatch, small adult replicas of the parents emerge. Triclad development is direct; there are no complex larval stages as in other Platyhelminthes groups. Asexual populations of dugesiids reproduce by transverse fission. Populations that only reproduce in this manner usually lack reproductive organs.

Species of this family are mainly predators of invertebrates, such as insects or annelids. As any triclad, they feed through a cylindrical, muscular and retractile tube, the pharynx, which pumps the food into the three-branched gut through peristaltic muscle contractions (Ball and Reynoldson 1981).

Dendrocoelidae

Description

Dendrocoelidae are unsegmented free-living freshwater flatworms, characterized by the presence of a glandulomuscular organ (or 'sucker') situated beneath the anterior margin (Sluys et al. 2009). In some species this organ is secondarily reduced. They are usually unpigmented and eyes can be present (from two to several, multiocularity is not rare) or absent. They measure between 3 and 4 cm in length (Cannon 1986).

The family Dendrocoelidae is the most diverse of all the freshwater flatworm families, with about 150 known species. Two genera are present in the Iberian Peninsula: *Dendrocoelum* Oersted 1843 and *Dendrocoelopsis* Kenk 1930. *Dendrocoelum* is a white planarian with two small anterolateral projections on its head and eyes wide apart.

Biology

Similarly to other freshwater planarians, dendrocoelids avoid light and tend to aggregate under stones or debris. They require a firm substrate to locomote, although they can glide on the underside of the water.

Dendrocoelum, a widespread genus in Europe, tolerates low temperatures and can be found in calm waters. Dendrocoelids are hermaphrodites and reproduce sexually. They have a direct life cycle, without free-living larval stages, and they lay spherical and unstalked cocoons that contain several eggs that attach to the substrate. Mature individuals can be recognised by the presence of a gonopore, which looks as a white spot situated between the mouth and the posterior end of the body (Ball and Reynoldson 1981).

Dendrocoelidae species are predators, feeding on other invertebrates such as arthropods or oligochaetes. Unlike Dugesiidae and Planariidae, Dendrocoelidae members are active hunters. As in other freshwater triclads, once a dendrocoelid contacts a prey, the retractile pharynx starts to secrete mucus in order to hold and pre-digest it. Chemosensory detection of damaged preys does not seem to have an important role in this group. The largest known freshwater planarians belong to this family. They reach up to 40 cm long and can be found in Lake Baikal, Russia.

Nematoda

Description

Nematodes are unsegmented cylindrical worms that constitute one of the most diverse phyla, distributed across all types of habitats worldwide (Fig. 3.1h–j). They are adapted to marine, freshwater and terrestrial environments, and their distribution ranges from tropical to polar latitudes, from mountains to ocean depths. Similarly, they show all types of interactions with other organisms in the ecosystem, from parasitism to free life. Freshwaters nematodes are small animals, usually between 0.2 and 8.0 mm, and usually free-living, although the larval stages of one group of nematodes (Family Mermithidae) are parasites of other invertebrates. The body is filiform, with the anterior margin either truncate or rounded and the posterior end filiform or rounded. They are unpigmented; thus under a magnifying glass they appear as small, semitransparent and slightly curved worms. They can also appear coiled if they are long and thin enough. They show bilateral symmetry, with a dorsal and ventral side. The latter can be identified by the presence of an anus and genital organs (Ocaña 1990).

Biology

Freshwater nematodes generally live in all sorts of aquatic environments associated with the upper strata of the benthic sediment, especially where organic matter buildups occur. They also appear where accumulations of algae or roots of some aquatic plants are present. Many species are very tolerant to extreme environmental conditions and can be found in thermal waters and strongly mineralized waters. Some species have amphibian properties, as they can be found in freshwaters as well as moss areas or on the soil.

They cover all the usual trophic niches, from strict phytophagous (mainly feeding on diatoms) to saprophagous, detritivorous, parasitic or predators of animals such as rotifers, tardigrades, small oligochaetes and other nematodes. They usually have separated sexes, although in many species males are not frequent and reproduction occurs through parthenogenesis. Some species are hermaphrodites. In such cases, self-fertilization is common. Females can be oviparous or ovoviviparous, and larvae need four moults before reaching adulthood.

Nematomorpha

Description

Nematomorpha is a poorly known relict phylum that has no clear or close relationship with any other living form (Fig. 3.1k–m). It comprises two classes, the freshwater hairworms (Gordiacea), with some 326 described species (Poinar 2008), and the marine hairworms (Nectonematoidea). Their common name comes from the old belief that these worms originated from horse hairs that had fallen into the water. The superstition was so deeply rooted that its refutation required scientific tests which even recorded the reaction of horse hairs placed in water for several months (Leidy 1870). The free-living aquatic adult worms are yellowish or dark in colour, with an unsegmented long (from several centimetres to a meter) and slender body. The different superficial structures of the thin external epicuticule are very important taxonomic features, which in most cases require the use of an electron microscope for their correct appreciation. Hairworms have separate sexes. The genus *Gordius* Linnaeus 1758 presents sexual dimorphism, with male specimens having a bilobate posterior ending.

Biology

Nematomorphs have free-living aquatic adults and parasitic larvae. They occur in a wide variety of aquatic habitats, including fast and shallow streams, but are most common in environments such as puddles, ponds and marshes. Hairworms have a very interesting life history composed of four stages: the egg, the preparasitic larva, the parasitic larva (found solely in arthropods), and the free-living aquatic adult. After copulation, fertilised eggs are deposited by the female on suitable submerged substrata. The preparasitic larva that hatches from the egg, morphologically very different from the adult, may then follow three different parasitic cycles. The first involves direct ingestion by a definitive invertebrate host where the larva develops by burrowing through the intestinal wall and feeding on the host tissues until it matures. A second cycle includes an intermediate host which initially ingests the larva, which then burrows into the host tissues where it encysts. Only when the host is eaten by an invertebrate predator or scavenger, the parasite initiates development.

The last cycle involves the preparasitic larva encysting on submerged leaves or detritus, where it remains until the water level drops and it is ingested along with the exposed vegetation by a suitable definitive host. Emergence of the adult hairworm requires the host to come into contact with water. This can be a problem if the larva has developed inside a terrestrial invertebrate. Entry into the water may occur accidentally, but it appears that the larva can incite the host to seek out water when it is ready to emerge. This might be a response of the host to partial desiccation or some kind of physiological alteration of the host caused by the activity of the parasite. Once the host enters the water, the larva moults and leaves the host by perforating its body wall. Adults do not feed and become sexually mature soon after emergence.

Bryozoa

Description

Bryozoans are sessile, modular aquatic invertebrates that grow in colonies attached to submerged surfaces (Fig. 3.1n–o). They have been traditionally divided into two groups: the Entoprocta (a mainly marine group with a single freshwater species, *Urnatella gracilis* Leidy 1851) and the Ectoprocta. However, they are currently recognised as two distinct and unrelated phyla; the Ectoprocta representing the Bryozoa sensu stricto. An ectoproct bryozoan colony is formed by multiple identical zooids joined together into a single structure. A zooid is composed of an organ system (the polypide) inserted in a body wall. The polypide, which in some species can be retracted into the wall, ends in a prominent structure (the lophophore) composed of a series of ciliated tentacles arranged either in a circle or a U-shape around a central mouth. All zooids are usually interconnected via a common internal cavity (the coelom). A distinctive taxonomic feature of most ectoproct bryozoans are the statoblasts: encapsulated dormant buds that maintain populations through periods of unfavourable environmental conditions and contribute to the passive dispersal of the colony (e.g. Figuerola et al. 2004). A bryozoan colony can range in size from a few centimetres to cover an area of several square decimetres, depending on the species.

Biology

Freshwater bryozoans are very common and widely distributed animals, both in standing and running freshwaters. There are around 5700 species described worldwide (Chapman 2009) of which only some 94 occur in freshwater environments and 21 have been recorded in the European Paleartic zone (Massard and Geimer 2008). They are sessile suspension feeders that can attach to almost any kind of submerged material, from where they capture organic particles, unicellular algae and protozoans from the water column. Some species tolerate turbid waters and even thrive well in environments polluted with sewage or industrial waste. It is not unusual to find intake grilles and irrigation pipes clogged by bryozoans when growth conditions are favourable (e.g. organically enriched waters).

Bryozoans are sexually active during a single brief period of the year. Fertilisation and embryonal development take place in the coelom. The embryo develops into a free-swimming ciliated larva which is released into the water, usually after dark. Settling and metamorphosis of the larva into a new colony occur shortly after its release. Asexual reproduction can be achieved by either budding, fission or through the statoblasts. Following the period of winter dormancy, statoblast activity is triggered when environmental conditions are favourable to colony growth. Each statoblast germinates into a single zooid, which rapidly buds into new zooids. Growth is very rapid under favourable temperature conditions and colonies can be completed in a matter of a few days. In temperate regions, they commonly have two or even three annual generations.

Oligochaeta

Description

Aquatic oligochaetes are very variable in size (from 1 to 30 mm up to 150 mm) and have an elongated bilaterally symmetrical body divided into many segments (Fig. 3.2a–b). With the exception of the first segment, each of these segments has four bundles of hairs (chaetae). The number and form of the chaetae is highly variable between species and comprises a very useful taxonomic feature. Some taxa might not have chaetae in some or all segments, but this is unusual. Sexually mature specimens present a single-layer glandular thickening (the clitellum) by the genital region. Aquatic oligochaetes look very similar to terrestrial earthworms. However, earthworms are bigger and usually have only two chaetae per bundle.

Biology

The global diversity of freshwater oligochaetes is set at about 1119 species (including hypogean species) belonging to some 193 genera (Martin et al. 2008). There is an extended general notion of aquatic oligochaetes being pollution-tolerant organisms and thus serving as indicators of degraded water bodies. This notion is based on the fact that some species (e.g. *Tubifex tubifex* (Muller 1774)) can live in severely polluted waters with low dissolved oxygen levels and high rates of organic enrichment. However, these animals have a much wider range of ecological niches and can actually be found in every kind of freshwater and estuarine habitat, both superficial and subterranean. Oligochaetes are mainly detritivores which feed on the organic matter and bacteria extracted from the ingested sediment. Exceptions include species of Naididae, which feed primarily on algae and other epiphytic material or prey on a variety of small invertebrates. Oligochaetes represent an important food source for many macroinvertebrates and fish.

Oligochaetes are hermaphrodite. During copulation worms line up ventrally in opposite directions while the sperm is transferred to the spermathecae. After the copula, a cocoon is secreted from the clitellum where fertilisation of the eggs occurs. The worm then releases the cocoon and the fertilised eggs develop internally. Once development is complete, a variable number of young worms hatch to the exterior. Asexual reproduction occurs in the family Naididae, and some species of Tubificidae and Lumbriculidae. It is done by fission or fragmentation, where the worm is divided into two parts from which complete individuals are regenerated, or paratomy (only Naididae), in which complex chains of individuals are formed by regeneration of parts before separation.

Freshwater oligochaetes play a very important ecological role in the bioturbation of deposited sediments that accumulate in lakes and streams. Through their burrowing, feeding, locomotive, respiratory and excretory activities, they mediate both physical and chemical processes near the sediment-water interface, such as nutrient cycling, the availability of contaminants or the oxygen exchange and penetration into the sediment layer (e.g. Pelegri and Blackburn 1995; Reible et al. 1996).

Glossiphoniidae

Description

Hirudinea are usually regarded as a class of the phylum Annelida or as a subclass of the class Clitellata, with Oligochaeta being the other subclass. They have segmented bodies that are muscular and contractile and have suckers at both ends. The body has 34 somites or segments: six for the head, three preclitellar, four for the clitellum, eleven on the trunk, three on the anal region and seven for the posterior sucker (Davies 1991; Sawyer 1986). The true segmentation is internal, delineated by the nervous system. Usually, each somite is superficially divided into 3–5 annuli, although sometimes more than ten annuli can be observed. Externally the segmentation is evidenced by the position of the sensory organs (eyes, papillae and tubercles) on the body.

The family Glossiphoniidae belongs to the Rhynchobdellae order, which is characterised by the presence of a mouth that forms a pore on the anterior sucker and has an eversible proboscis that is inserted into the prey when feeding (Fig. 3.2d–f). They are broad-bodied, markedly flattened leeches with a pear-shaped resting outline and an indistinct anterior sucker, except for *Hemiclepsis* Vejdowsky 1884. Along the

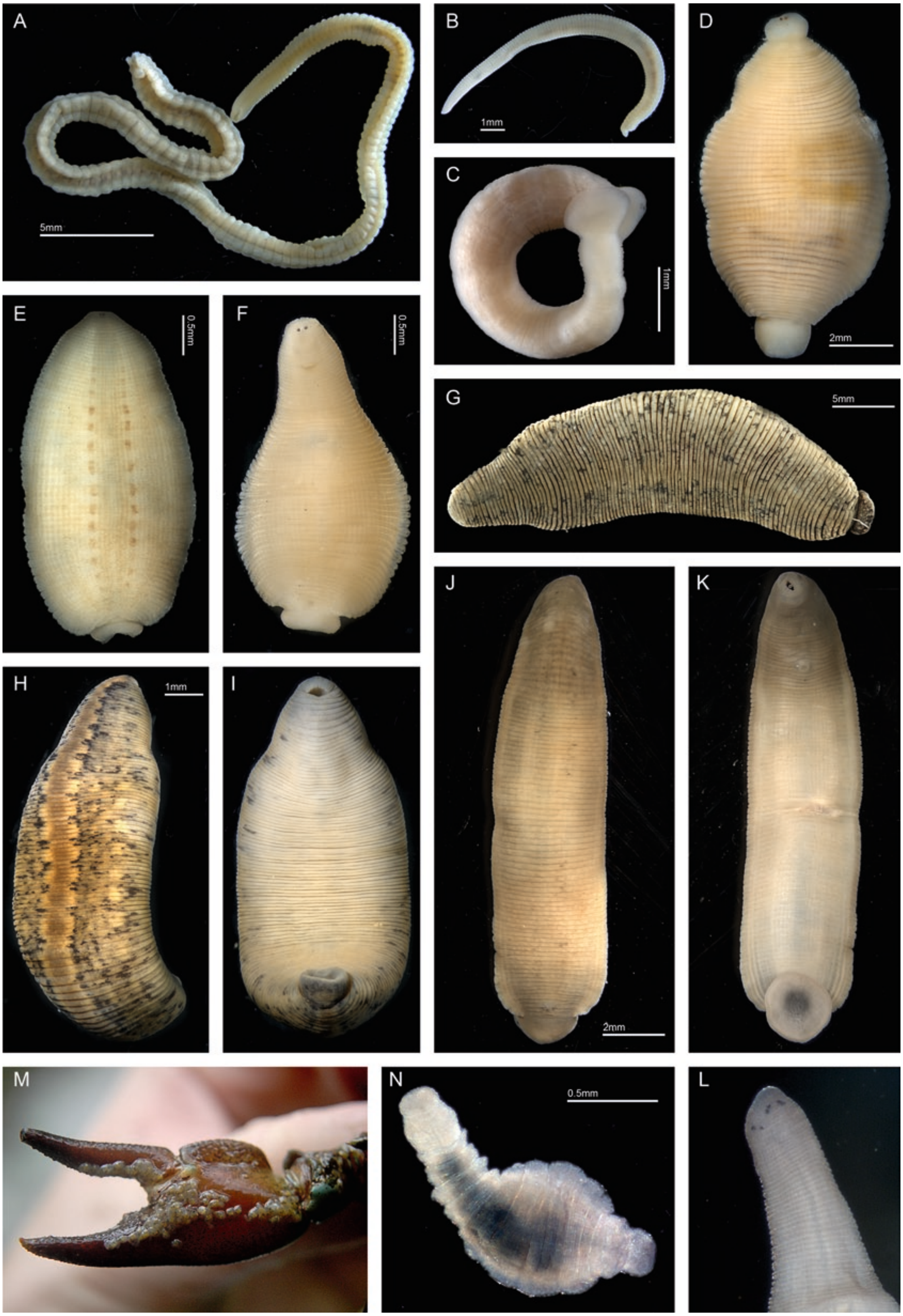

Fig. 3.2 (**a**, **b**) Oligochaeta; (**c**) Piscicolidae; (**d**–**f**) Glossiphoniidae; (**g**–**i**) Haemopidae; (**j**–**l**) Erpobdellidae; (**m**–**n**) Branchiobdellidae: *Pacifastacus* claw with Branchiobdellidae specimens (**m**), general view (**n**)

body, annuli are arranged in groups of three; thus, when there is a pattern on the dorsal surface, this repeats every three annuli.

Biology

The family has a worldwide distribution. All species occur in freshwater and they are the only group that brood their eggs and carry their young. Most of them are predators or scavengers, moving about actively in search of worms, molluscs or other small invertebrates from which they suck their body fluids (*Glossiphonia* Johnson 1816, *Hellobdella* R. Blanchard 1896, *Alboglossiphonia* Lukin 1976). Some species are sanguivorous ectoparasites of fish (*Hemiclepsis*), amphibians (*Placobdella* R. Blanchard, 1896, *Hemiclepsis*), reptiles (*Placobdella*), water birds (*Placobdella*, *Theromyzon* Philippi 1867) and mammals (*Placobdella*).

All leeches are hermaphrodites, reproduce sexually and cross fertilize. The male (anterior and more visible) and female (posterior) gonopores are located on the clitellum and are separated by an often species-specific number of annuli. The clitellum is a specialised saddle-shaped glandular segment that secretes cocoons or egg cases. Mating is carried out by traumatic external insemination of spermatophores into the integument of a recipient leech. Fertilized eggs are deposited on the underside of the parent and brooded until they hatch. The young are then carried to their first blood meal by the parent leech. In most glossiphoniids the young leeches will eventually detach one by one but in *Theromyzon* the young leeches remain attached to the parent until the parent dies.

Most species can be found in almost all bodies of water and can tolerate a wide range of physical and chemical conditions. The availability and abundance of food is the most important factor affecting their distribution and abundance.

Piscicolidae

Description

Piscicolidae also belong to the Rhynchobdellae order. They have a proboscis that perforates the gills of fish in order to feed on their blood (Fig. 3.2c). They are cylindrical leeches, with prominent and well-defined suckers, and two pairs of eyes. They have small and numerous annuli (more than 200) and pulsating vesicles along the lateral margins of the posterior half of the body.

Biology

The family has a worldwide distribution. Most are marine species and only a few live in freshwater habitats. *Piscicola geometra* (Linnaeus 1758) is the only species found in Spanish rivers. They are typically ectoparasites of fish. The anterior sucker facilitates attachment to the fish, and using both suckers they can move towards the gills or the base of the fins, where they feed on blood. Leeches can feed for several days and they only drop off the fish when satiated. Afterwards, they are able to remain unfed for several months. Rhynchobdellids protect themselves against the clotting of blood using a different biochemical mechanism than Arrhynchobdellids. Some species secrete the enzyme hementin, which dissolves clots after they have formed (Sawyer 1986).

When leeches are not attached to fish, they live freely on submerged stones or macrophytes. *P. geometra* is found in well oxygenated waters (Mann 1962; Elliot and Mann 1979). Its life cycle probably takes less than a year, with two generations hatching each year. The winter generation hatches in September, deposits cocoons from the end of February onwards, and the parent population disappears between April and June. The summer generation reproduces from June to September. Copulation occurs on the substratum. Piscicollids exhibit external traumatic insemination of spermatophores into the integument of a recipient leech. Brown cocoons are laid on stones, plants or the fish in which they prey upon. The cocoons are very resistant to desiccation. A leech can lay between 50 and 90 cocoons, each containing only one egg. Hatchlings can survive about 3 weeks without food.

Piscicolids, as all the other leeches, are epimorphic (i.e. the young that come out of the cocoon have a fixed number of segments). Biologically, and in contrast with Oligochaetes (Sawyer 1986), this allows for a higher degree of specialisation of the different body regions.

Hirudinidae

Description

Hirudinidae are large leeches with more or less parallel sides and slightly flattened bodies (Fig. 2.2c). They show intricate red and green patterning on the dorsum (upper surface), yellow medial lines or bright orange lateral ones, and a tan ventral surface. Usually they are 10 cm long or more, and up to 1 cm wide. They have a parabolic arc of 10 cephalic eyes arranged in five pairs that can detect two-dimensional movement. Hirudinidae belong to the order Gnathobdellae. Their mouth occupies the whole concave centre of the sucker and it has a short muscular pharynx armed with three jaws. Each jaw has a single row of sharp fine teeth.

Biology

The family has a worldwide distribution. They often leave the water to lay their cocoons. The main two species in this group are the medicinal leech *Hirudo medicinalis* Linnaeus 1758, and *Limnatis nilotica* (Savigny 1822). They are excellent and agile swimmer leeches that can be easily attracted by splashing in the water. Vertical wavelike motions and the use of the caudal sucker provide forward movement and thrust. They apply negative pressure to surfaces with their oral and caudal suckers for suction and attachment purposes.

H. medicinalis feeds on the blood of mammals, amphibians and small fish. It pierces the external skin of its host, gorges with blood in one meal and then detaches. *L. nilotica* feeds primarily on the blood of mammals and opportunistically on other groups. It seems to be unable to pierce the external skin of the host, as its jaws are soft instead of rigid like *H. medicinalis* (Orevi et al. 2000). It sucks blood from internal soft vascular tissue (nasal cavity, throat, urethra, vagina) and may stay inside the host for several weeks, thus inducing severe and sometimes fatal cases of anaemia. Hirudinids create a three-part incision with their jaws and use negative pressure to draw out the upwelling blood. In a meal they can take two to five times their own weight in blood. They protect themselves against the clotting of ingested blood in the gut by secreting a non-enzymatic polypeptide (hirudin) which specifically inhibits the clotting enzyme (thrombin) (Sawyer 1986).

Mating takes place through gonopore-to-gonopore copulation involving an eversible penis and a vaginal pouch, which allows for internal insemination. They lay sclerotized cocoons with approximately 10 eggs each in damp soil or under stones near the water's edge, leaving the hatchlings to search for the water on their own. *H. medicinalis* probably takes at least 2 years to reach the breeding stage. Slow growing individuals may need 3–4 years to be able to breed (Elliot and Mann 1979).

H. medicinalis occurs naturally in freshwater lakes, ponds, streams, and marshes of subtropical regions. Its distribution is very irregular and patchy. It comprises the British Isles, Southern Scandinavia and most of continental Europe (up to the eastern limit of the Urals and to the west of Turkey). *L. nilotica* can be found in brooks, streams, rivers and ponds in circum-Mediterranean countries, the Middle East and Southwestern Asiatic countries.

Haemopidae

Description

Haemopidae are large freshwater leeches with slightly flattened bodies and ten eyes arranged in a crescent (Fig. 3.2g–i). The adults have a dark green or brown dorsal surface mottled with black pigment, which is separated from the grey underside by a pale yellowish line along each flank. Haemopidae also belong to the order Gnathobdellae, and have a short muscular pharynx with toothed jaws. Each jaw has two rows of blunt teeth incapable of piercing the human skin.

Biology

The main species is *Haemopis sanguisuga* (Linnaeus 1758). Its feeding habits are carnivorous and they can include invertebrates as well as fish and carrion on their diet. Small invertebrates are usually swallowed whole. Digestion is very rapid; the largest meal can be digested in 2 days. Despite being known as the 'horse leech' *H. sanguisuga* does not attack horses or any other mammals because its teeth are too blunt to pierce their skin.

Haemopidae leeches are also good swimmers, and often leave the water to lay their cocoons or to search for food. They can be found under large stones or sheltering in the leaf bases of the bankside vegetation, and they can even burrow in the soil.

Like Hirudinidae, Haemopidae leeches exhibit internal insemination through gonopore-to-gonopore copulation, a mechanism that prevents sperm desiccation. The male system produces spermatophores that are driven into the female body and then release the sperm, which swims to the two ovisacs. The testisacs are discrete paired structures located intersegmentally in all leech families except Erpobdellidae. The cocoons are sclerotized, and are deposited during the summer in damp places (under stones or amongst grass roots) above the water line. They contain 6–16 eggs and take about a month to hatch.

H. sanguisuga has been found in almost all types of freshwaters, but it is not as well adapted to fast flowing waters as other leeches. This is because its cocoons are attached loosely to stones and can be swept away by the current.

Erpobdellidae

Description

Erpobdellidae are slender, slightly flattened leeches with an indistinct anterior sucker and eight eyes arranged in two transverse rows (Fig. 3.2j–l). As all the members of the order Pharyngobdellae, this family has a weak muscular pharynx with no jaws or teeth, but capable of swallowing whole preys. Salivary glands secreting digestive enzymes open into the pharynx, which is followed by a tube-like crop. Unlike other leech families, the crop in Erpobdellidae lacks lateral caeca. After the crop, the intestine leads to the anus. In predatory species the crop and the intestine are used for digestion and absorption, while in sanguivorous leeches only the intestine has those functions. Colouration varies between reddish-brown and greyish-brown, and sometimes they have a black and yellow pattern superimposed to their basic pigmentation.

Biology

The family has a worldwide distribution. All species occur in freshwater and some are semi-terrestrial. *Erpobdella octoculata* (Linnaeus 1758) may briefly leave the water to search for food. Leeches of the genus *Trocheta* Dutrochet 1817 are amphibious, but they always return to the water for breeding.

Most species are predators of chironomid larvae and other invertebrates, including members of their own species (genus *Erpobdella* Blainville 1818 and *Dina* R. Blanchard 1892), and some are scavengers as well as predators (*Trocheta*). The range of prey species is quite diverse and changes seasonally. Leeches are primarily fluid feeders. Predatory leeches that ingest prey, like Erpobdellidae, will quickly remove fluids and store them in the crop, and then evacuate the hard parts through either the mouth or the anus. Digestion is rapid and may be completed in 12–24 h. Availability of food is the single most important factor determining their distribution, abundance and physiological state. The type of substrate affects the feeding habits of *E. octoculata*, which forages more effectively over cobble substrates than over fine gravel.

The life cycle of the species of this family frequently takes more than 1 year. The length of the cycle of *E. octoculata* varies with location, sometimes depending on the availability of food. In such cases, the abundance of food facilitates an annual cycle (Elliot and Mann 1979; Murphy and Learner 1982). Erpobdellids are hermaphrodites, reproduce sexually and cross fertilize. Leeches do not have true ovaries or testes. Instead, they possess testisacs and ovisacs. The testisacs in Erpodellidae are multifollicular columns, resembling bunches of grapes that lie on both sides of the ventral nerve cord. Erpobdellids lay several sclerotized cocoons with a variable number of eggs on stones, macrophyte leaves, dead leaves and submerged twigs.

They occur in a wide variety of waters and some species thrive in organically enriched environments.

Branchiobdellidae

Description

Branchiobdellidae are small annelids (up to 10 mm, generally less than 5 mm, Tachet et al. 2000) related both to oligochaetes and hirudinids, although externally they are more similar to the latter (Fig. 3.2m–n). The body does not present eyes or setae and is characteristically pear-shaped or rod-shaped (terete), with the first four segments rounded and cylindrical, and the remaining segments generally dorsoventrally flattened (disc-shaped). They have a single sucker at the posterior end of the body. They are usually light-coloured, their colours ranging from whitish to yellowish.

Biology

Branchiobdellids are hermaphrodites with cross-fertilization. They are forced ectosymbionts, living on the gills and the inner side of the branchial chamber of river crayfish, as well as on some areas of their exoskeleton, such as the lower side of their claws or legs. They feed mainly on organic matter, diatoms and small invertebrates, which would mean they are opportunistic ectocommensals (Grabda and Wierzbicka 1969; Souty-Grosset et al. 2006). However, some species living in the branchial chamber have some sort of parasitic relationship with their host, feeding on its tissues and causing damage to the gills. Similarly to leeches, they locomote by alternate binding, which they do through an adhesive secretion generated both in the sucker and in the lower part of the lip (they do not use the mouth as a sucker for locomotion) (Gelder and Rowe 1988; Souty-Grosset et al. 2006). Embryonal cocoons need a live host in order to develop and mature. In the Iberian Peninsula, specimens from the genus *Xironogiton* Ellis 1920 (non-indigenous species) have been found on signal crayfish (*Pacifastacus leniusculus* (Dana 1852)) (Gelder 1999; Oscoz et al. 2010).

Viviparidae

Description

Viviparidae are gastropods with a smooth, conical and spherical shell (Fig. 3.3a–b). The shell typically lacks the umbilicus, which if present is very narrow. The shell has a uniform greenish colouration or can, alternatively, have a series of darker spiral bands. The apex can be blunt or sharp, depending on the species. Some individuals are very large, with shells up to 6 cm tall. They have a characteristic transparent, horny operculum that grows concentrically and therefore has dark and light bands on it. This operculum closes the aperture and the animal carries it on its dorsum when it exits the shell. They also have long tentacles, the right one modified for copulation in males. The eyes are located at the tip of two small peduncles at the base of the tentacles. The female gonopore is located on the right side, at the edge of the mantle. Haemocyanin serves as their respiratory pigment, which gives the haemolymph a greenish-blue colour (Girod et al. 1980).

Biology

There are no species from this family that occur naturally in the Iberian Peninsula, although the presence of *Viviparus viviparus* (Linnaeus 1758) has been recorded. Its distribution is affected by human activity, appearing in garden ponds and in irrigation channels. It can be mistaken with *Bithynia tentaculata* (Linnaeus 1758), a species belonging to the family Bithyniidae.

They inhabit rivers, channels and pools, where they can become very abundant. Viviparids are usually observed feeding over vegetation, both in running and stagnant waters, although they prefer well oxygenated waters with high levels of calcium. They can also live on muddy substrates with aquatic vegetation, in ponds and in temporary waters. Viviparidae are herbivorous, detritivorous and filtering molluscs that tolerate pollution. They have separate sexes and are ovoviviparous, with embryos staying inside the mother during winter.

Neritidae

Description

The shell of Neritidae molluscs is flattened, small, semi-spherical, fast-growing, thick and sturdy (Fig. 3.3c–g). It has very few whorls with different colours and patterns, all very attractive and sometimes of reddish colours. The last whorl practically covers the whole shell and usually presents a variable pattern (reticulated, banded, zigzag, etc.). Sometimes the whole shell is uniforminlgy black. Commonly it measures 8 mm tall and 10–13 mm wide. The aperture is smooth and semicircular. To the left of the aperture a flat whitish plate can be observed. This plate is a special feature of this family. The operculum is horny and has a very characteristic crescent shape with one or two protuberances. Neritidae is the only family of freshwater gastropods to have such an operculum. The tentacles are pointed and eyes are stalked (Girod et al. 1980).

Fig. 3.3 (**a**–**b**) Viviparidae; (**c**–**g**) Neritidae; (**h**–**j**) Valvatidae; (**k**) Bithyniidae; (**l**) Hydrobiidae; (**m**–**n**) Melanopsidae

Biology

The Neritidae family has both marine and freshwater species. In Spain there are several freshwater species. *Theodoxus fluviatilis* (Linnaeus 1758) is the most common one, as it can be found in almost all Iberian river basins. Other species such as *T. valentinus* (Graells 1846) or *T. baeticus* (Lamarck 1822) are endemic species and therefore have a very limited distribution. These species are also endangered, mainly due to habitat loss. Sexes are separated. White and oval ovigerous capsules are deposited almost invariably on conspecific shells, although they can also be found on rocks, stones or cement. Each capsule has 30–70 eggs.

Neritidae species live in rivers, canals, irrigation channels and lakes, over rocks or over other hard substrates. They tolerate a certain amount of salinity and they prefer well oxygenated waters with high levels of calcium. They are resistant to pollution. They can live both in lentic or fast waters. They are herbivores that feed on diatoms and other types of algae.

Valvatidae

Description

Several Valvatidae species have been cited in the Iberian Peninsula, with *Valvata piscinalis* (O.F. Muller 1774) as the most common species. Shell colouration can vary from a yellowish-whitish colour to a greyish-greenish one. The shell is also small, spherical or disc-shaped, with a marked umbilicus and a circular aperture, although there is considerable geographical and ecological variation (Fig. 3.3h–j). The operculum is thin, multispiraled, circular, transparent and horny. The tentacles are long and slender, with eyes at their base. The foot is divided into two lobes. The gill is very developed and usually shows when the animal leaves the shell. Species with flat shells can be mistaken with Planorbidae. However, they can be differentiated by the presence of an operculum, which is never present in Planorbidae species (Girod et al. 1980).

Biology

Valvatidae live burrowed in the thin sediments of rivers, channels, ponds and lakes. They can also be found amongst macrophytes, but rarely ever in temporary waters. They prefer slow and well oxygenated waters, being able to live at considerable depths. Valvatidae species tolerate soft waters and some species even tolerate a certain degree of salinity. When abundant, they are part of the diet of fish. They can be found up to 1,000 m a.s.l. They are both herbivorous and detritivorous.

Valvatidae are hermaphrodite, laying eggs in horny ovigerous capsules that they deposit over leaves, branches, macrophytes or shells. They lay 2–40 eggs.

Bithyniidae

Description

Bithyniidae are gastropods that have a solid, smooth and spherical shell of variable colouration (transparent to brown) (Fig. 3.3k). The apex is rounded and the aperture almost circular. The operculum is calcareous, with concentric growth lines (Fig. 2.4c). It hermetically seals the aperture. Translucent shells allow for the appreciation of dark spots on the skin (melanocytes). Males have a very well developed penis (Girod et al. 1980).

Biology

Bithyniidae species live preferentially in stagnant waters or waters with weak currents associated with the macrophytes they feed on. They can also feed on diatoms and some species show a very peculiar feeding habit: they filter water through a net of mucus located on the paleal cavity that traps suspended particles. Bithyniidae can be found in coastal areas (where they withstand mesohaline waters), all the way to mountain lakes at more than 2,000 m a.s.l.

Their most salient biological feature is the presence of haemocyanin as their respiratory pigment. Most species have an annual life cycle and individual animals can live for about 3 years. They are common species of paleartic distribution.

Hydrobiidae

Description

All Hydrobiidae species are characterised by their small size. In general, they have a smooth shell and a horny operculum (Fig. 3.3l). In this family we can observe a morphological convergence of the shell as well as an extreme variability of shell characteristics depending on the environment in which the animals live.

Biology

Most Hydrobiidae species are obvious crenophiles, typically found in river sources and springs. Their distribution is limited by their stenotherm condition. Thus, many preferentially inhabit hypogeal environments (where temperature does not fluctuate) instead of rivers. In this group, allopatric speciation processes have been favoured. It is estimated that 85% of the Iberian species of this family are endemic. Most species have separated sexes, although in some cases some species have ovoviviparous partenogenetic reproduction (Boeters 1988).

Melanopsidae

Description

Melanopsidae species have a solid shell of variable size with a relatively large last whorl (Fig. 3.3m,n). The horny operculum retracts inside. The shell also has a basal emargination. Shells are very polymorphic, including keeled and smooth shell shapes. This feature has allowed for the description of many species of dubious taxonomical validity (Bilgin 1973).

Biology

Members of the family Melanopsidae can be found in all sorts of environments, lotic or lentic. However, they prefer shallow waters where they live forming colonies consisting of a large number of individuals. They live on hard substrates, although they can also locomote over silt sediments. They are very sensitive to low temperatures, which limits their distribution and reveals the tropical past of this family. They can temporary resist desiccation and usually show amphibian habits. They are microphagous, feeding on algae and detritus. They show a preference for particles that can be scraped (periphyton), including small fragments of stone and sand.

They have separated sexes, although males do not have a penis. Females lay eggs in two different ways: over sand substrates, they lay unprotected, individual eggs; over gravel substrates, they lay capsules with 17 eggs on average. Most species are first intermediate hosts in the life cycle of many digenea trematodes, which causes them serious damages on their reproductive system.

Acroloxidae

Description

Acroloxidae shells are white, elliptical and limpet-like. The apex is very pronounced and points towards the left. The protoconch is smooth, a character that differentiates this family from other gastropods of similar morphology. Within Basommatophora, this family is less evolved since female and male organs are not very developed. Acroloxidae are very similar to Ancylidae due to a morphological convergence of the shell.

Biology

Acroloxidae live in standing waters or waters with barely any current. They are primarily found over muddy substrates and most species prefer cold waters. In the Iberian Peninsula this family has a very restricted distribution due to its Eurosiberian dispersion. They live over macrophytes in underwater springs and marshlands.

Planorbidae, Ancylidae and Ferrissidae

Description

The families Planorbidae (Fig. 3.4a), Ancylidae (Fig. 3.4b–c) and Ferrissidae (Fig. 3.4d,e) constitute a very heterogeneous group whose taxonomic allocation is uncertain.

Ancylidae and Ferrissidae are characterised by the presence of a limpet-like, uncoiled shell that has a high morphological variability. Under drought conditions, Ferrissidae species develop a septum as a means to resist the hostile environment. Planorbidae species have a shell with 4–5 whorls that grow on the same plane.

Biology

In such a heterogeneous group, both rheophilic (Ancylidae) and limnophilic (Ferrissidae and

Fig. 3.4 (**a**) Planorbidae; (**b**–**c**) Ancylidae; (**d**–**e**) Ferrissidae; (**f**) Succineidae; (**g**–**h**) Lymnaeidae; (**i**–**l**) Physidae

Planorbidae) species exist. They live in all types of waters, with the exception of acidic waters. They have a varied diet that includes encrusting algae, macrophytes and detritus deposits.

They tolerate moderate pollution. In the case of Ancylidae, the higher the degree of pollution, the bigger the size of the individuals and the smaller the population. Some Planorbidae species are intermediate hosts to parasites transmitting the hematuric bilharziasis (Fretter and Graham 1962).

Lymnaeidae

Description

Lymnaeidae have a characteristic fragile shell without operculum, and whose aperture is always on the right side (Fig. 3.4g–h). In some species the aperture is very large, resembling an ear (auricle). The systematics of this family is very complicated due to the large variability in shell and specimen morphology. Some species of amber snails (*F. Succineidae*) (Fig. 3.4f) could be mistakenly identified as Lymnaeidae.

Biology

Most Lymnaeidae species live in lentic enviroments, although some individuals can be found in areas with current. They are very frequent in rivers with detritus deposits. They feed on algae, macrophytes and even small invertebrate carcasses. They are hermaphrodites and some species self-fertilize.

They are very tolerant to organic pollution. Their paleal cavity has been transformed into a lung that allows them to breathe air from the atmosphere. Most species are intermediate hosts of dignea trematodes, which cause illnesses such as hepatic fasciolasis (Dussart 1979).

Physidae

Description

Physidae species have a fragile, semi-transparent shell with the aperture on the left side (levogyre or sinistral). The shell does not bear operculum or umbilicus, but it does have a pointy apex. In some species, the mantle can have finger-like extensions that go over the shell (Fig. 3.4i–l).

Biology

Physidae can live in all sorts of environments, although they prefer areas with gravel substrates. They tolerate environments with high salinity as well as high temperatures. Their diet includes both detritus and algae. Physidae is a very diversified family, with Holartic and Neotropical distribution. Eggs are encapsulated in a gelatinous substance that can hold between 40 and 180 eggs inside. Some species are very tolerant to all types of organic pollution. Species of this family have been recorded in sewage treatment plants (Larraz et al. 2007).

Margaritiferidae – Unionidae

Description

Margaritiferidae (Fig. 3.5a) and Unionidae (Fig. 3.5b–e) are the only two naiad (freshwater bivalves) families found in the Iberian Peninsula (Superfamily Unionidea). Their shell consists of two large and pearly valves which enclose the animal's soft body. Despite the similarities between both families, the main differences are found in anatomical characters, with Margaritiferidae usually having a black and bigger shell.

Biology

In Spain, two species of Margaritiferidae can be found: *Margaritifera auricularia* (Spengler 1793) (found exclusively in the River Ebro) and *M. margaritifera* (Linnaeus 1758) (common in the siliceous rivers of the peninsular northeast, not occurring south of the Duero basin). There are also eight Unionidae species: *Unio delphinus* Spengler 1793, *U. tumidiformis* Castro 1885, *U. gibbus* Spengler 1793, *U. mancus* Lamarck 1819, *U. ravoissieri* Deshayes 1847, *Potomida littoralis* (Cuvier 1798), *Anodonta cygnea* (Linnaeus 1758) and *A. anatina* (Linnaeus 1758).

The life cycle is one of the most salient features of these mollusks: they have a larval stage – known as glochidida – that requires a fish host in which, after metamorphosis, the juvenile stage takes place. Specificity between naiads and fish is also frequent; thus, not all fish species can be host to the glochidia of all naiads. Among other reasons, this explains why presently naiads are regarded as one of the most endangered groups on the planet.

Fig. 3.5 (**a**) Margaritiferidae; (**b–e**) Unionidae; (**f–g**) Dreissenidae: general view (**f**), zebra mussel colony (**g**); (**h**) Sphaeridae; (**i**) Corbiculidae

Margaritiferidae and Unionidae species live in lakes, rivers and permanent streams, rarely in reservoirs. Although more common in calm waters, they can also live burrowed in gravel in areas with turbulent waters, especially *Margaritifera margaritifera*. Other species, such as *Potomida littoralis*, can populate calmer waters or live in between the stones of rapids. They are mostly sessile animals that live burrowed in gravel, sand or muddy substrates and they have a basic role in the freshwater ecosystems they inhabit: they intervene in the nutrient dynamics of freshwater systems by stirring phytoplankton, bacteria and organic matter in the water and sediment. They also take part in the biotubation of the bottom, increasing its oxygen content. An average-sized *M. margaritifera* naiad filters up to 50 l of water per day. Given that these species live in colonies of up to 700 individuals per square meter, a section of a river holding an average colony could filter 35,000 l per day. They are also species with a high potential as bioindicators: the presence (or documented absence) of reproductive populations (with juvenile individuals) of these molluscs can be of great use to determine changes in the status of the quality and conservation of surface waters, which makes naiads excellent sentinel species.

They are also very interesting animals to study evolutionary processes in time and space, since their phylogeny reflects the influence of processes such as the breaking up and separation of Pangaea during the Mesozoic, as well as the evolution of the hydrographic basins during the Tertiary until the last glaciations of the Pleistocene.

Dreissenidae

Description

Dreissenidae larvae are planktonic, round, compressed and somewhat translucent. The adults are easily identified by their triangular shape, their blunt external margin and the characteristic bissus that they use to attach to the substrate. Under a polarized microscope, the distribution of the calcium crystals of the larva of *Dreissena polymorpha* (Pallas 1771) arrange into two dark crossing stripes known as the Maltese cross. The adult of this species is easily identified by its characteristic dark and light, zigzag stripes; however, due to polymorphism, a great variety of colourations are possible (Oscoz et al. 2006; Fig. 3.5f, g).

Biology

The family Dreissenidae has two of the most invasive mollusc species (due to their high reproductive potential) in continental water ecosystems (DAISIE 2008b): *Dreissena polymorpha* and *Dreissena bugensis* Andrusov 1897. In this family, temperature is the factor that regulates the life cycle. When the water reaches 12–13°C, eggs and sperm are released into the water to be externally fertilized (for *D. bugensis* the temperature can be lower, around 9°C). Once fertilization has occurred and after the embryo stage, the resulting larva goes through the following developmental stages: trochophore, veliger, pediveliger and plantigrade. This family inhabits rivers, reservoirs and freshwater ponds in temperate regions. They require lentic waters for their development: if water speed surpasses 1.5 m/s, larvae are not capable to attach to the substrate. Calcium is also a limiting factor for larval development, as it is needed to form the shell. Their filtration rate is set at around 1–2.5 l of water per day. They require oxygen concentrations above 10% for their development and reproduction, although they can survive several days in anaerobic conditions. *D. polymorpha* is present in the Iberian Peninsula, where it was first observed in 2001 in the Ribaroja reservoir in the Ebro basin. The zebra mussel, indigenous to the Ponto-Caspian region, has had numerous economic and ecological impacts in the Ebro basin since it first appeared (Durán et al. 2007, 2010).

Sphaeriidae

Description

Sphaeriidae is a bivalve family whose members are generally small and inconspicuous (Fig. 3.5h), very different than the representatives of the other two families of freshwater bivalves in the Iberian Peninsula, Margaritiferidae and Unionidae. This is a group for which the determination of taxonomic characters is very difficult and therefore, identification to species level is not easy. However, species can be determined after the careful and rigorous study of series of multiple individuals (from juvenile stages to adults) from the largest possible number of sites. The main taxonomic characters are the shape, the shell structure and the shape and distribution of the cardinal teeth. In the Iberian Peninsula, three different genera can be found: *Sphaerium* Scopoli 1777, *Musculium* Link 1807 and *Pisidium* C. Pfeiffer 1821 the latter being the genus with the most species. The largest *Pisidium* species has a maximum length of one centimeter, while the other two genera are slightly bigger.

Biology

Most Sphaeriidae species are cosmopolitan and distribute along continental waters all over the world. However, in Spain, *Pisidium hibernicum* Westerlund 1894 and *P. lillgeborgii* Clessin 1886 can only be found on the high mountain lakes of the Pyrenees. They live semi-burrowed in bottoms with fine organic matter sediments. They can also live in sand and in between the roots of the aquatic vegetation. They can be very numerous. Despite generally inhabiting lentic waters, they can also live in turbulent waters burrowing under stones. Through filtration and direct intake from the sediment, they feed on vegetal detritus, diatoms, algae and microorganisms of the interstitial environment.

Sphaeriidae species are hermaphrodite and ovoviviparous, incubating the embryos on their gills until they reach the juvenile stage. A pregnant female can carry inside tenths of juveniles. These females can be transported by birds, amphibians or insects; thus, Sphaeriidae can easily colonize new habitats. This also enables them to live in temporary ponds.

Corbiculidae

Description

Corbiculidae are freshwater bivalves that inhabit river and lake sediments. The name *Corbicula* Megerle von Muhlfeld 1811 (from *corbus*, small basket) refers to their characteristic thick and globular valves, whose periostrach is shiny and has several concentric ribs (costae). They have a triangular shilouette with a posterior margin somewhat longer than the anterior one. They can present several shades of olive green and the inside of their valves is usually tainted in violet (Fig. 3.5i).

Biology

The family Corbiculidae reproduces at around 15°C and tolerates a range of temperatures between 2 and 34°C. They mature after 3 months. Larvae are incubated on the gills, from which they will be expelled after a few days so they can finish developing outside. They have more than one generation per year, between the end of spring and autumn. They tolerate atmospheric exposure for weeks, but they cannot survive under low oxygen conditions. Due to their great reproductive potential, this family, native to Southeast Asia, Australia and Africa, is considered a threat in the new ecosystems it settles in. In the Iberian Peninsula, the species *Corbicula fluminea* (O. F. Muller 1774) (Asiatic clam) is listed as an exotic and invasive species (Pérez Quintero 1990, 2008; DAISIE 2008a). It was first observed in the River Tajo in the early 80 s, and ever since it has exponentially grown in the Spanish basins (Pérez Quintero 2008).

Branchiopoda

Description

Branchiopoda are crustaceans characterised by having their respiratory organs on the thoracopods. They are a very heterogeneous group. In the Iberian Peninsula, it is represented by about 100 species belonging to six orders (Alonso 1996). Three of those orders are included in the group known as "large brachiopods": Notostraca (one dorsal shield on the cephalothorax, two long caudal cerci, brown colour, up to 7 cm, Fig. 3.6a), Anostraca (without carapace, two stalked and compound eyes, body usually not pigmented, up to 10 cm, Fig. 3.6b) and Spinicaudata (body protected by two chitinous valves with growth marks that resemble bivalve molluscs, brown or brownish-yellowish colouration, up to 1.7 cm). Except for Notostraca, sexual dimorphism is patent. In Anostraca males, the second pair of antennae is very developed and prehensile. Males also have penises. Females have a large, usually pigmented ovigerous pouch. Spinicaudata males have a claw in the first two thoracopods and the females have dorsal filaments on the last thoracopods where eggs are grouped.

The remaining orders within Branchiopoda do not usually surpass 3 mm. Onychopoda have a reduced carapace, a big rounded head fully occupied by a

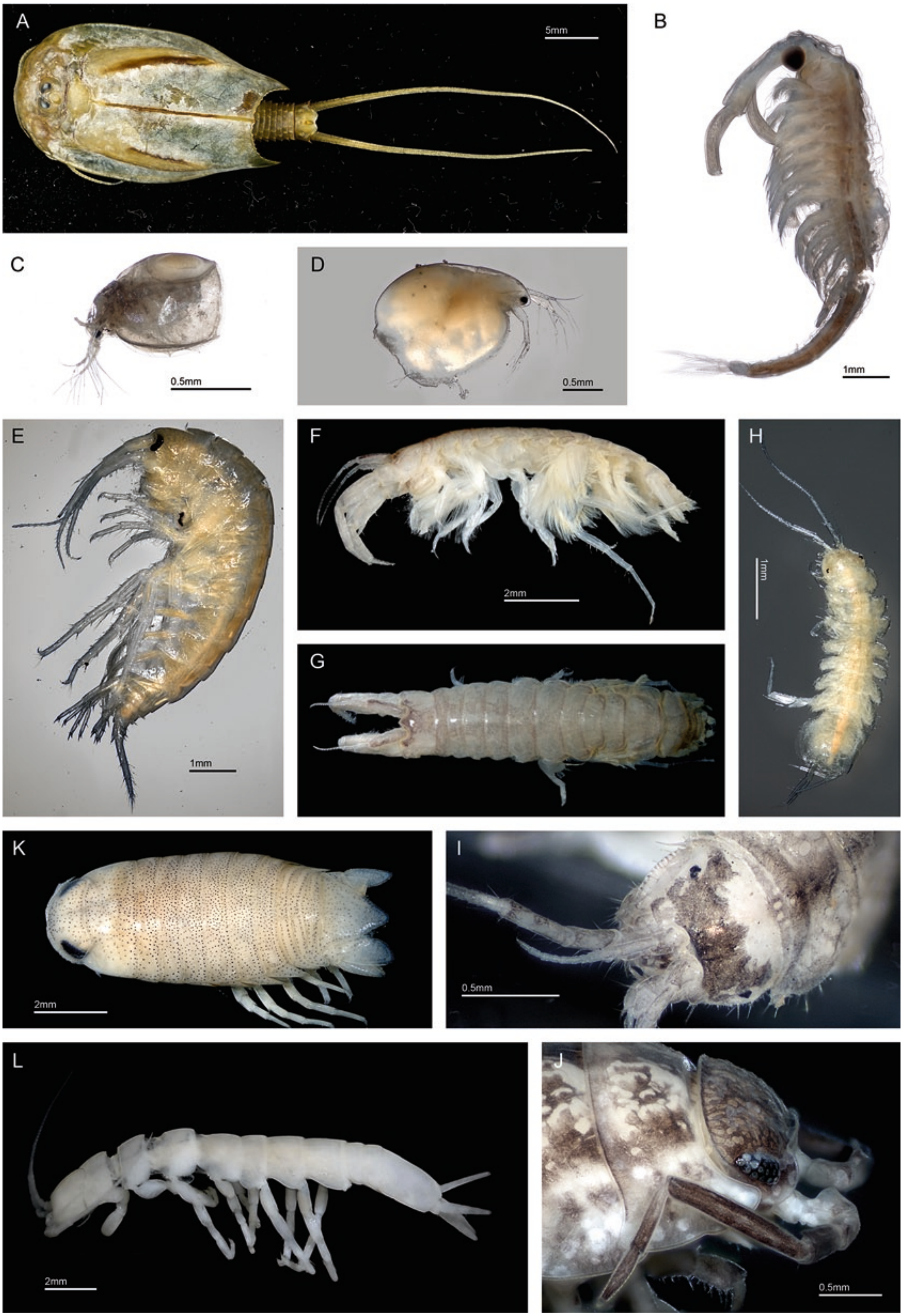

Fig. 3.6 (**a**) Notostraca; (**b**) Anostraca; (**c**–**d**) Anomopoda; (**e**) Gammaridae; (**f**–**g**) Corophiidae; (**h**–**i**) Asellidae: general view (**h**), freshwater specimen with two pairs of antennae (**i**); (**j**) Terrestrial isopod with one pair of antennae; (**k**) Cirolanidae; (**l**) Stenasellidae

single compound eye, and four pairs of prehensile thoracopods. The most diversified and abundant Branchiopoda are those known as "Cladocera". Cladocerans have a short body protected by the cephalic helmet, or cephalic shield, which protects the head, and a carapace with a longitudinal dorsal crest that covers the rest of the body. The body ends in a structure known as postabdomen, very important for taxonomical purposes. Ctenopoda belong to this group. They have six pairs of very homogeneous thoracopods. Also Anomopoda (Fig. 3.6c, d), which have 5–6 pairs of thoracopods with different function and morphology. Cladocera are also sexually dimorphic: males have larger and mobile antennae and their sperm duct ends in the postabdomen; they also have a copulatory hook on their first thoracopod. Planktonic Ctenopoda and Anomopoda have delicate structures and are usually unpigmented and transparent. Benthonic Anomopoda, Chydoridae in particular, are more pigmented and opaque.

Biology

Branchiopoda colonise any kind of epicontinental waters, but species are generally stenoic and faithful to particular properties of aquatic ecosystems. They are most common in lentic waters, irrespective of their saline level or their permanence. They are also species adapted to fluvial environments (especially families Chydoridae and Macrothricidae). They are generally microphagous and filterers. Large brachiopods normally reproduce sexually. Other brachiopods alternate between parthenogenetic and gametogenic phases. They all have mechanisms of resistance (eggs) that allow them to survive under non-favourable conditions and colonise new environments through different vectors.

Gammaridae

Description

Gammaridae have a laterally compressed, more or less curved body with two compound eyes (Fig. 3.6e). The second pair of antennae is normally developed and similar to the first pair. They have an elongated and oval-shaped gnathopod propod. The flagellum on the first pair of antennae is multisegmented. They can grow up to 2 cm in length. European freshwater Gammaridae are mainly represented by the genera *Gammarus* Fabricius 1775 (endopod of the Uropod III reaches at least half the exopod) and *Echinogammarus* Stebbing 1899 (endopod of Uropod III very reduced; Tachet et al. 2000).

Biology

Gammaridae species are detritivorous, collecting organic matter and shredding fragments of vegetal origin such as leaves and decomposing twigs. However, they can also behave as omnivorous, including on their diet live or dead invertebrates. Males are bigger than females, and they are necessary for taxonomic determination (mature specimens). Frequently, males and females are found joined together in precopulation. Females carry their eggs in a ventral pouch, where fertilization and embryonal development occur. Hatchlings are morphologically similar to adult individuals (Ruffo and Simetto 1994). From all the freshwater Gammaridae genera, *Echinogammarus* shows the highest degree of tolerance to salinity and pollution.

Niphargidae

Description

Niphargidae are blind amphipods with a whitish, elongated and laterally compressed body (Fig. 2.5e). Their first two pairs of antennae are similar in size. Aside from being blind, other differences with the family Gammaridae are that (i) the propod of the gnathopod is short and quadrangular, and (ii) the flagellum of the first pair of antennae only has one or two segments (Tachet et al. 2000). They can grow to be more than 1 cm long.

Biology

Niphargidae species feed primarily by collecting small organic particles, shredding vegetal fragments and even catching other invertebrates. They are stygobiont organisms, that is, hypogeal or underground organisms, although they can also live in the interstitial or hyporheic environments of rivers, streams and springs.

They are most diverse in the karstic systems of the center and south of Europe, where underground water frequently surfaces (Väinölä et al. 2008). There are two Niphargidae genera in Spanish rivers: *Niphargus* Schiodte 1849, mainly in the Pyrenees, and *Haploginglymus* Mateus and Mateus 1958, across the rest of the Peninsula. The latter is considered to be the Iberian vicariant of *Niphargus* (Iannilli et al. 2009).

Corophiidae

Description

Unlike all other Amphipoda, Corophiidae have a dorsoventrally compressed and subcylindrical body (Fig. 3.6f, g). The second pair of antennae is very developed and modified into a long and sturdy leg (Tachet et al. 2000); the first pair of antennae does not present a flagellum. They can reach 9 mm in length.

Biology

Corophiidae are indigenous of marine environments, but have recently colonised the saline waters of estuaries, lagoons and some European rivers (Väinölä et al. 2008). The genus *Corophium* Latreille 1806, indigenous to the Caspian Sea and the estuaries of the Black Sea and the Azov Sea (Ponto-Caspian region), is experimenting a facilitated expansion from its native area due to the building of channels and reservoirs, changes in hydric regime and the introduction of commercial shipping (Mordukhai-Boltovskoi 1964). They can live in meso-eutrophic waters of lower reaches of rivers and estuaries of large rivers. However, due to the fact that they tolerate a wide range of saline concentrations, they have also colonised some freshwater reaches further up from the estuaries.

Corophiidae are tubicoles and they build their tubes on very different substrates, such as stones, sand, clay, silt, macrophytes, shells, wood, etc. They feed by scraping, shredding or collecting organic particles from sediments and other substrates. In order to do so, they use the second pair of long and sturdy antennae, while the rest of the body stays inside the tube. Different species belonging to the genus *Corophium* have been used as toxicity indicators on marine and estuarine sediments (Marquiegui and Pérez 2006).

Asellidae

Description

Asellidae have a dorsoventrally flattened body composed by a head (cephalon), a thoracic region (pereon), and an abdominal region (pleon) (Fig. 3.6h–i). The cephalon has a pair of sessile eyes and two pairs of antennae, the outer pair much shorter than the inner pair. Terrestrial isopods have only one pair of antennae (Fig. 3.6j). The pereon is composed of seven segments, each with a pair of lateral locomotory legs (pereopods). In adult males, the first anterior pair of legs has a claw-like ending. Breeding females bear a series of characteristic thoracic ventral flaps which form a brood-pouch. The pleon is composed of six segments (pleonites), where the first five are free segments and the sixth is fused to the telson to form the pleotelson. In males, the pleon bears five ventral pairs of appendages (pleopods). The anterior two pairs are small simple structures, the second pair serving as coupling structures. The structure of these two pleopods, especially of the second pair, is of the greatest importance for the taxonomic classification of Asellidae species. The remaining three pairs of pleopods are large biramous, plate-like structures, which function as respiratory structures. A final pair of terminal abdominal appendages (uropods), visible in dorsal view, projects backwards from the posterior margin of the pleotelson. Female Asellidae lack the first pair of pleopods.

Biology

Asellidae represent the largest family of freshwater isopods, with about 379 described species (Wilson 2008). They are a widespread family adapted to all types of epigeal and hypogean freshwater systems. In surface environments, they are found beneath cobbles and amongst submerged macrophytes, root mats, decomposing leaves and debris in a variety of aquatic habitats; most commonly of lentic nature. Generally described as leaf litter shredders, they can also function as facultative collector-gatherers, feeding on decomposing fine particulate organic matter. Some species of Asellidae such as *Asellus aquaticus* (Linnaeus 1758) are generally regarded as tolerant to a range of pollutants, especially to organic enrichment. Hynes (1970) included *Asellus*, together with tubificids and chironomids, within the pollution fauna that serve as indicators of badly organically polluted zones in rivers. *Asellus* has also been reported to tolerate the accumulation of fine sediments in streams (e.g. García Molinos and Donohue 2009).

Sowbugs are not quite as prolific as scuds (Amphipoda), but in certain waters they are common and represent an important food source for macroinvertebrate predators and fish. Asellidae have internal fertilisation. A female spawn can involve the production of 100–200 eggs which are carried in the ventral pouch, where hatchlings remain until they are released as small adults. Although the life history of Asellidae is taxonomically and geographically very variable, they have generally two annual generations and breeding can occur throughout the entire year.

Atyidae

Description

Atyidae are decapod crustaceans belonging to the infraorder Crustacea Caridea. They are mostly tropical freshwater species. The family is comprised by 39 genera (Zariquiey Alvarez 1968). They are small shrimp of elongated and laterally compressed bodies, with very developed pleopods that are modified for swimming. The first two pairs of pereiopods are similar to each other and ending in claws which insert on the distal margin of the carpus and have dense brushes of setae. The rostrum is well developed and both its margins are serrated (Fig. 3.7a, b).

In the superficial continental waters of the Iberian Peninsula, two genera can be found, *Atyaephyra* de Brito Capello 1867 and *Dugastella* Bouvier 1912, each with a single species. They can be differentiated from each other by the serrated superior margin of the rostrum, which starts right after the orbital margin in *Atyaephyra* and right before it in *Dugastella*. *Atyaephyra desmaresti* (Millet 1831) has a circum-Mediterranean distribution, but it has recently colonised rivers in the center of Europe, reaching as far as the Baltic Sea, the North Sea and the Black Sea. *Dugastella valentina* (Ferrer Galdiano 1924) has a more restricted distribution to the Mediterranean Sea (Sanz-Brau and Gómez 1984).

Typhlatya miravetensis Sanz and Platvoet 1995, the only stygobian shrimp to be found in the Iberian Peninsula (and only in one location) also belongs to this family. It is easily identified by its unpigmented eyes and white colouration, typical of many underground organisms (Sanz and Platvoet 1995).

Biology

Atyidae prefer calm, well oxygenated waters where macrophytes abound. They tolerate remarkable temperature and salinity oscillations, being able to develop in mesohaline waters (Sanz-Santos and Sanz-Brau 1994). They can be found in rivers, reservoirs, rice fields, channels, springs, coastal lakes and even temporary rivers. They are good swimmers that move around the bottom looking for detritus or plants. They can be omnivorous or detritivorous. Ovigerous females can be observed from mid-spring until the end of the summer. Incubation takes around 5 weeks. They have continuous growth, moulting regularly. Atyidae are commonly used as fish bait.

Astacidae

Description

Astacidae, or river crayfish, are decapod crustaceans belonging to the infraorder Macrura Reptantia. Their body is slightly depressed and the pleopods are not very developed. The claws (or chelae) of the first pair of pereiopods are much bigger than the rest.

The family Astacidae is characterised by (i) absence of spurs (although they can have spines) on the inferior margin of the carpus of the chela, (ii) inferior margin of the propod shorter than the movable finger of the chela, and (iii) first abdominal segment with pleopods in both sexes, although these can be vestigial in females. External sexual dimorphism is very marked: males have pleopods modified for reproduction in the first and second abdominal segments.

Two species can be found in Spain: the indigenous *Austropotamobius pallipes* (Lereboullet 1858) (Fig. 3.7g), and the non-indigenous *Pacifastacus leniusculus* (Dana 1852) (Fig. 3.7e, f), native to pacific North America and intentionally introduced in 1974 (Alonso et al. 2000). The former can be differentiated from the latter by the presence of spines after the cervical suture, a single pair of postorbital ridges, absence of a clear blotch in the joint of the

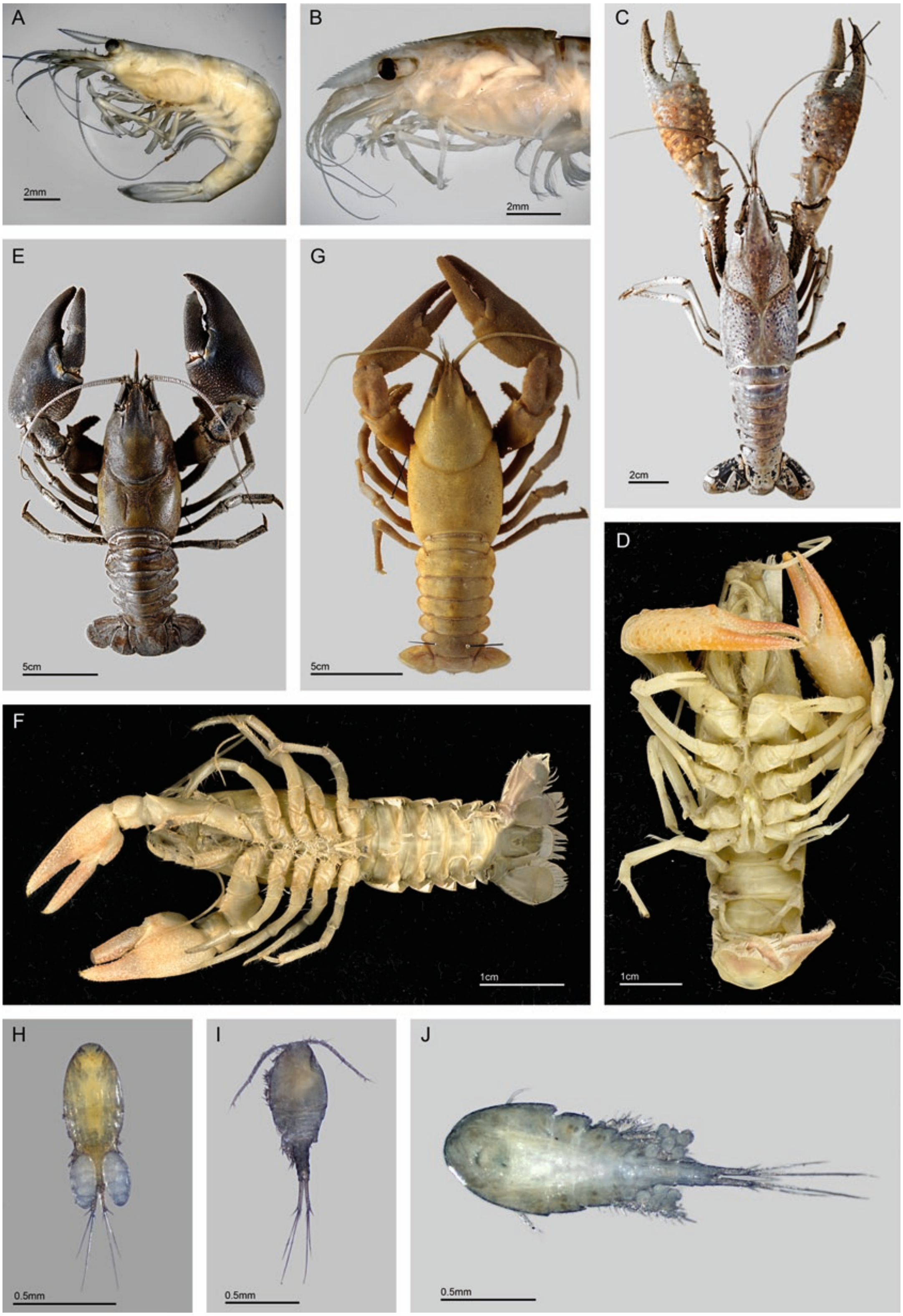

Fig. 3.7 (**a**, **b**) Atyidae; (**c**, **d**) Cambaridae: *Procambarus clarkii*; (**e**, **f**) Astacidae: *Pacifastacus leniusculus*; (**g**) Astacidae: *Austropotamobius pallipes*; (**h**–**j**) Copepoda

chela, convergent rostrum margins (as opposed to subparallel) and ventral surface of the chela whitish (as opposed to reddish).

Biology

Astacidae are primarily found in small rivers and streams, on high and middle reaches of rivers, over carbonate lithologies, although they can also inhabit diverse environments, from lakes and reservoirs to artificial channels, ponds and large rivers, even in siliceous basins. They are relatively tolerant to organic load. Heat and mating take place in the autumn. Females reach sexual maturity on their second to third year of life. They spend the winter sheltering, externally carrying the eggs that open between May and early July. They are omnivores and the animal part of their diet decreases as they age. Their abundance is limited by the availability of shelter. They are primarily crepuscular, and they are minimally active during the winter. Due to their large size (up to 150 mm total length) and high biomass (up to 120 g/m2) they can arrange invertebrate and macrophyte communities, and even the fluvial microhabitat. They can live up to 15 years in captivity; however, in the wild they rarely live over 6–8 years.

They are very appreciated for human consumption (and bred with that purpose) and recreational fishing. However, the family's European species have been decimated by the crayfish plague (aphanomycosis), disease caused by the parasitic pseudofungus *Aphanomyces astaci* Schikora 1906, to which they are very sensitive. The American species is a carrier of this disease. The presence of both species at any given time is related to the dispersion of the aphanomycosis, reintroductions carried out by the government and illegal introductions, all of which undermines their actual value and score in the most commonly used bioindeces (Gil-Sanchez and Alba-Tercedor 2001).

Cambaridae

Description

Cambaridae is a very diverse family of crayfish, with more than 400 species. Its original distribution covers North and Central America and the Eastern tip of Asia (Zariquiey Alvarez 1968). However, some species have been introduced in large areas of the rest of the world. Species present in Europe are medium to large (up to 150 mm total length) and are characterised by the presence of a strong spur on the inferior margin of the carpus, under the chela. The inferior margin of the propod of the chela is shorter than the dactylus. The first abdominal segment has pleopods in both sexes, although these are vestigial in females.

There is only one Cambaridae species in the Iberian Peninsula, the Balearics and the Canary Islands: *Procambarus clarkii* (Girard 1852) (Fig. 3.7c, d). This species is indigenous of the south east of North America, and it was intentionally and illegally introduced in 1973. On top of the characteristics described above, it can also be identified because the sutures of the cephalothorax contact dorsally, and also by the presence of many spiny tubercles on the chelae and the cephalothorax. It has a dark red or brownish-red colouration. Juveniles are brown or greenish, which sometimes leads to misidentification.

Biology

Procambarus clarkii is particularly adapted to live in wetlands that undergo seasonal drought, but it is flexible and greatly adaptable to other conditions. Outside of its native range it has successfully colonised rivers, lakes, channels, wetlands, rice fields, etc. It prefers warm waters, but it can also be found in lakes, reservoirs and sometimes small Mediterranean mountain streams. It tolerates low concentrations of oxygen, high temperatures and salinity really well and tolerates quite well organic pollution.

This species has a short life cycle and high fecundity. It rarely lives longer than 12–18 months. Growth is really fast: under favourable conditions it can reach 80 mm total length in 3 months. Members of this species are omnivores, although most of their diet is vegetal matter. They also feed on detritus. As a family, Cambaridae shows a unique cyclic dimorphism in which both sexes alternate between one sexually active form (form I) and a sexually inactive form (form II), with slight morphological differences. Each female lays an average of 500 eggs. Eggs open in about 2–3 weeks, depending on water temperature. Under favourable conditions they can reproduce more than once a year, with presence of mature females at any time of the year. They burrow deep (up to 2 m) galleries in order to resist desiccation and to reproduce.

Procambarus clarkii is a species of commercial interest. Spain is one of the largest producers of red swamp crawfish. It is also appreciated for recreational fishing. *Procambarus clarkii* is a carrier of aphanomycosis and the IUCN considers it as one of the 100 most dangerous aquatic invasive species. During periods of invasion it can cover up to 3 km at night, sometimes even across land.

Palaemonidae

Description

Palaemonidae are decapod crustaceans belonging to the infraorder Caridea. It is a very diverse family with 134 genera of mostly marine species (Zariquiey Alvarez 1968). Members of the family Palaemonidae are small shrimp (up to 60 mm total length). They have an elongated, laterally compressed body, with developed pleopods modified for swimming (Fig. 2.5h). The carpus of the two first pairs of legs is distally excavated and the claw inserts laterally on the internal angle of the excavation. The first pair of pereiopods ends in a small claw. The second pair ends in a larger, sturdier claw. The last three pairs end in claws and are shorter than the second pair. The telson is long and triangular, apically ending in a sharp angle and with four spines on its margin (two short external and two longer and internal), among which there is a variable number of long and feather-like setae.

In continental waters of the Iberian Peninsula two genera can be found. Their species can be differentiated by the presence (*Palaemon* Weber 1795) or absence (*Palaemonetes* Heller 1869) of mandibular palpi.

Biology

The genus *Palaemon* is only found in ponds separated from the sea that have similar saline characteristics to marine and estuarine waters. The genus *Palaemonetes* can also be found in freshwaters, such as ponds, wetlands, channels with vegetation, upwelling waters and slow reaches of rivers, preferably with plenty vegetation (Sanz-Brau 1986).

Palaemonidae are good swimmers. They are primarily carnivorous, feeding on small macroinvertebrates, but also algae and other food items. Ovigerous females can be found from spring to mid-summer, depending on water temperature. They lay between 20 and 140 eggs, depending on the species and the size of the female.

They are very sensitive to heavy metals, such as copper, nickel, zinc and lead, and therefore they are good bioindicators. Palaemonidae also includes some marine species of comercial interests, such as *Macrobrachium rosenbergii* De Man 1879.

Parastacidae

Description

Parastacidae are medium to large (up to 150 mm total length) river crayfish. Their main characteristic is that the inferior margin of the propod is longer than the dactyl (movable finger) of the chela. They also have a strong spur on the inferior margin of the carpus, under the chela, and the anterior region of the cephalothorax has two longitudinal keels and a pair of postorbital ridges. The surface of the cephalothorax and the claws is smooth. Colouration can vary between brown to almost black, and blue is common among captive specimens. The first abdominal segment lacks pleopods in both sexes. They do not show cyclic dimorphism.

The family Parastacidae is native to Madagascar, Australasia and the southern part of South America. There is only one species present in the Iberian Peninsula, the freshwater yabby (*Cherax destructor* Clark 1936), which was intentionally and illegally introduced between 1983 and 1985.

Biology

The freshwater yabby is a very adaptable species. In its native areas, it can be found in very diverse habitats, from alpine rivers to desert springs, and also subtropical streams and wetlands, although is stops growing at temperatures below 15°C. It can tolerate high levels of salinity and low oxygen concentrations. In Spain, very local populations in ponds of Aragon and Navarre are known.

Females lay 300 eggs on average, which they carry until they open. Incubation lasts between 19 and

40 days, depending on temperature conditions. Larvae hatch in the summer. Under favourable conditions, they can reproduce up to five times in the same year. Like other river crayfish, it is an omnivorous species, although detritus and vegetal matter seem predominant on its diet. They are active burrowers. *Cherax destructor* is very sensitive to aphanomycosis. It has been eradicated in some Spanish localities through biological control techniques.

The family Parastacidae includes several species of commercial interest. Among them, some from the genus *Cherax* are bred for human consumption. This family also has the world's largest freshwater invertebrate, the crayfish *Astacopsis gouldi* (Clark 1936), in Tasmania, which can have a biomass of 5 kg.

Copepoda

Description

Copepoda are small crustaceans, generally smaller than 6 cm (Fig. 3.7h–j). Their body is divided in two tagmata: the prosome (anterior) and the urosome (posterior and generally narrower), which articulate at the juncture. In the Iberian Peninsula, only about a hundred species are known. Due to the little research carried on this group, the number of Iberian species is likely to be a gross underestimation.

The prosome contains the cephalosome, which is dorsally covered by a single cephalic shield resulting from the fusion of the tergites of its six somites; these have ventrally and in the following order the antennules, long multisegmented antennae modified for swimming, the mandibles, the maxillae and the maxillipedes. After the cephalosome, there are five thoracic somites with a pair of swimming biramous legs, the first four similar to each other and the fifth pair modified and sometimes very reduced. This last pair has great taxonomic importance. The urosome has one genital somite with vestigial legs, followed by three somites without legs. Finally, the telson has two caudal branches bearing setae, among which the anus opens.

There are three orders known in epicontinental waters (Dussart 1967, 1969; Kiefer 1978; Margalef 1953). In Calanoida, the prosom is much longer than the urosome and their long antennae generally surpass the urosome. In males, the antenna and the fifth right leg have prehensile function. Female have a single ventral pouch of eggs. In Cyclopoida, the prosome is similar in length but much wider than the urosome, giving the animal a pear-like shape. The antennae are generally not longer than the prosome. Both antennae are pehensile in males and the fifth pair of legs is very reduced. Females have two lateral ovigerous pouches. In Harpacticoida, both the prosome and the urosome have similar widths and both the antennae and the caudal branches are very short. In males, both antennae have prehensile function and females have just one ventral ovigerous pouch.

Biology

Copepoda species colonise any type of epicontinental water environment, wheather lentic or lotic, including interstitial and cave environments, where particularly Harpacticoida species are very diverse. Calanoida are filterers with the ability to select particles. The largest Cyclopoida are predators, while the smaller ones, like Harpacticoida species, are non-filtering microphages. Sexes are separated. Reproduction consists of sperm transfer using spermatophores that the male actively applies to the female. Nauplius larvae emerge from the eggs. After six different stages, the nauplius larvae enter the copepodite stage, which will reach adulthood after five stages.

Ostracoda

Description

Ostracods (Fig. 2.6d) are a group of very small crustaceans (typically 0.5–3 mm long) with a bivalve calcitic carapace, unapparent or absent body segmentation, and a high taxonomic and ecological diversity (see Meisch 2000 for an updated account of the morphology and biology of Western European non-marine ostracods). They occur in all kind of aquatic systems, both marine and inland waters. Their valves – of calcium-carbonate nature – are so well preserved in ocean and lake sediments that the group has the richest fossil record among all arthropods (ostracod fossil record traces back to the Ordovician; Hou et al. 1996). Non-marine ostracods have eight pairs of limbs: antennules, antennae, mandibles, maxillules, three pairs of thoracopods and a caudal ramus. Reproductive organs are complex, especially in males, but very useful as taxonomic characters (Baltanás 2004).

Biology

About 2000 extant species of non-marine ostracods have been described so far, with the total number of recent ostracod species being around 20,000 (Horne et al. 2002). They are quite unevenly distributed in 12 families—with Cyprididae and Candonidae including 80% of all described species—belonging to three phylogenetic lineages (superfamilies Darwinuloidea, Cypridoidea and Cytheroidea, all in the order Podocopida). Because some areas (mainly the tropics) and some habitats (e.g., the hyporheic and groundwater habitats) have not been intensively sampled yet, some increase in non-marine ostracod global diversity is still expected.

Non-marine ostracods occur in most inland aquatic systems, even in hot springs with water temperatures well beyond 400°C (Külköylüoglu et al. 2003; Martens et al. 2008). And although most species are benthic, there are some exceptions (e.g., the hyponeustonic *Notodromas* Lilljeborg 1853, the ectoparasitic Entocytheridae, the phytotelmic *Elpidium* O. F. Müller 1880 and the limno-terrestrial *Terrestricythere* Schornikov 1969). Non-marine ostracods lay eggs that can be either subitaneous or resistant (frequently both types are mixed in each offspring). After hatching, ostracod larvae grow by moulting and pass through eight larval stages before reaching adulthood. Males and females are easily differentiated because ovaries and testes can be seen by transparency already in the last larval stage. Sexual dimorphism is common in males, which usually are smaller than females. However, many non-marine species reproduce parthenogenetically, a feature that makes ostracods an ideal model organism for evolutionary studies. Life span is variable, ranging from 2 to 3 months in most species to more than 2 years in *Cytherissa lacustris* (Sars 1863) (Geiger 1998).

Non-marine ostracods have been extensively used for palaeoenvironmental reconstruction, using approaches based on community species composition (Wrozyna et al. 2009) and on trace elements and stable isotopes contained in ostracod valves (Chivas et al. 1986; von Grafenstein et al. 1999; Griffiths and Holmes 2000). More recently, ostracods have been used as bioindicators for the assessment of ecosystem health (Mezquita et al. 2005; Pieri et al. 2007) and as model organisms in toxicity tests (Chial and Persoone 2002; Sánchez-Bayo 2006; Khangarot and Das 2009).

Hydrachnidia (Hydracarina)

Description

Hydrachnidia are aquatic mites found in continental waters (Fig. 3.8a–c). They are very small (1–5 mm). Generally, they are spherical, of just a few millimetres in size, although they can also be dorsoventrally flattened or laterally compressed, elongated or rounded. They have a soft tegument, with secondarily sclerotized plates that can cover the body entirely. Their body is divided in two main parts: the anterior region, or gnathosoma (mouth and sensory organ) and the posterior region, or idiosoma, which results from the fusion of the cephalotthorax and abdomen. Ventrally and originally, the coxal plates 1–2 and 2–3 are fused and separated by a membranous area, although there is a trend towards fusion and extension (Davids et al. 2007). The genital opening is located in the central or posterior ventral region. The genital opening has great importance for taxonomy, along with the pedipalps and chelicerae of the gnathosoma.

Biology

Among Acari, the life cycle of Hydrachnidia is unique (Di Sabatino et al. 2000). Hydrachnidia postembryonal development comprises six stages: prelarva, larva, protonymph, deutonymph, tritonymph and adult, all completed in 1–6 months. Adults can live from 6 months to 2 years. Three of these stages (prelarva, protonymph and tritonymph) are immobile and do not feed. The two types of nymph correspond to the two pupal stages. Development is heteromorphic, as in holometabolous insects, with six-legged larvae and nymphs and adults with eight legs. Except in a few occasions (Moreno et al. 2008), aquatic mites lay eggs attaching them to different substrates. From the eggs, larvae with terrestrial or aquatic habits emerge. These larvae actively seek hosts. The deuteronymph is similar to the adult, but less sclerotized and without a genital opening

Fig. 3.8 (**a**–**c**) Hydrachnidia (Hydracarina); (**d**, **e**) Collembola: *Podura aquatica*; (**f**, **g**) Baetidae; (**h**, **i**) Ephemerellidae; (**j**–**l**) Ephemeridae; (**m**–**p**) Heptageniidae

(gonopore). Both the deuteronymph and the adult are voracious predators of other invertebrates (insect larvae and eggs, microcrustaceans), while the larva is parasitic or phoretic, mainly on insects (Davids et al. 2007).

Aquatic mites can be found in all types of waters: current or stagnant, freshwater or saline, temporary or permanent. They generally show high species richness in rivers, with usually between 20 species in streams and springs, and 50 species in large rivers (Di Sabatino et al. 2000). They are very sensitive to physical and chemical changes, and therefore, they are good indicators of the perturbations suffered by the aquatic ecosystems. Despite the fact that aquatic mites are one of the most diverse and characteristic group of continental waters, they are quite unknown and scarcely used as indicators. This is partly due to their small size (between meio- and macrofauna), which has normally excluded them from the macroinvertebrates.

Collembola

Description

Collembolans are small-sized animals (rarely exceeding 4 mm). Their body is divided following the general hexapod pattern: head, 3-segmented thorax and abdomen (Fig. 3.8d, e). The latter is comprised by six segments, which can be fused in some groups. They have three pairs of locomotory appendages on the thorax and they do not have wings. Antennae are usually divided into four segments, although some species can have more segment subdivisions, and thus more flexibility. Eyes contain a maximum of eight ocelli, although there are cave species that are completely blind. The most characteristic feature of this group is located on the fourth abdominal segment: the furcula, which allows them to make big jumps and thus move really fast. These general, group-level characteristics are greatly variable, as collembolans show multiple adaptations to the different environments they inhabit. Thus, in aquatic systems, species with elongated bodies and with the thorax and abdomen clearly segmented can be found (genus *Podura* Linnaeus 1758), as well as more spherical species with the thorax and abdomen partially fused and a less clear segmentation (genus *Sminthurides* Borner 1900). For more detailed information on this group's anatomy, taxonomy and biology, see Hopkin (1997).

Biology

Collembolans are among one of the more abundant and widely distributed groups of terrestrial arthropods. They can be found in all continents, including Antarctica, at altitudes ranging from sea level to more than 7000 m a.s.l. They are very numerous on soil and fallen leaves. There they carry out an extremely important function for the ecosystem, namely, soil structuring and nutrient return. Freshwater species are however quite reduced, with freshwater species living in rivers and estuarine areas, usually in calm or backwater areas. Of these species, the most abundant and widely distributed on the North Hemisphere is *Podura aquatica* Linnaeus 1758, the only representative of the family (Poduridae). This species is perfectly well adapted to live in surface waters and can be found on the epineuston of rivers. They feed on organic matter and pollen (Rueda Sevilla and Hernández Villar 2009). During summertime, large quantities of these individuals can be observed over the blue surface of backwater areas, forming a bluish thin layer.

Baetidae

Description

Baetidae species have a fusiform, subcylindrical body, although some species show a degree of both lateral and dorsoventral compression (Fig. 3.8f, g). The eyes are dorsolateral and antennae are longer than the head. The labrum is subquadrangular, with a medial notch on the distal margin. Maxilary palpi with 2–3 segments. The lobes of the labium (glossae and paraglossae) are narrow and elongated, with a rounded tip. Labial palpi with three segments. Usually they have seven (sometimes six) pairs of abdominal gills that can be uni- or bilamellar. Cerci only bear setae on their inner margin and they are longer or at least similar in length to the terminal filament (paracercus). They are very similar to Siphonuridae, but they do not have posterior spines on the lateral margins of the last abdominal segments.

Biology

The family Baetidae is the most common mayfly family in Spanish waters. It can be found in all types of rivers and streams, both in running and standing waters (lakes as well as ponds) (Elliott et al. 1988). They prefer pebble, gravel or sand substrates. They feed primarily on diatoms, small algae and small particles of organic matter. They are excellent swimmers thanks to their fusiform body, even swimming against the current for short intervals (González and Cobo 2006). Species with better natatorial skills have three caudal cerci, roughly all of the same size and bearing setae modified for swimming. Despite some species barely tolerating pollution, some species show higher levels of tolerance (Campaioli et al. 1994; Puig 1999); thus, their presence cannot be taken as an indicator of high quality waters, at least not at the family level. In the Iberian Peninsula, 45 species belonging to this family have been recorded (Alba-Tercedor and Jaimez-Cuellar 2003).

Caenidae

Description

Caenidae (Fig. 2.13g) larvae have gills on abdominal segments I–VI, although the first pair is reduced. The second pair is quadrangular and large, operculiform, superposed in the middle line of the body, and covering the posterior gills, which have fringed borders. Mature larvae do not have hind wing pads.

Two genera and ten species inhabit Spanish aquatic ecosystems (Alba-Tercedor 2002). *Brachycercus* Curtis 1834 can be differentiated from *Caenis* Stephens, 1835 by the presence of three frontal tubercles on the head, which are more or less prominent depending on the species. *Brachycercus harrisella* Curtis 1834 and *B. kabyliensis* Soldan 1986 are rare species, only found in the Duero basin (Sartori 1990) and the Guadalete stream (Gallardo-Mayenco 2002–2003) respectively. *Caenis* species have a widespread distribution in Spain, with the exception of *Caenis nachoi* Alba-Tercedor and Zamora-Muñoz 1993. This species has a restricted area of distribution and is listed as endangered in the Red Book of Spanish Invertebrates (Alba-Tercedor 2006).

Biology

Caenis species are present in all types of streams and rivers at altitudes lower than 1400 m a.s.l. There are two exceptions: *Caenis beskidensis* Sowa 1973 which inhabits mountain streams in the Ebro river basin, with maximum altitudes recorded for this family in Spanish streams above 1700 m a.s.l. in the Pyrenees (Vinçon 1987; Puig et al. in press); and *Caenis horaria* (Linnaeus 1758) which is found at higher altitudes, above 2000 m a.s.l. in Pyrenean lakes (de Mendoza pers. comm.).

Their special gill morphology allows Caenidae larvae to live in areas with slow current velocity and in stagnant waters, on sand and gravel, or within the interstitial zone. Usually, these habitats present deposits of detritus and, in some cases, low oxygen levels. The tolerance of any *Caenis* species to these conditions, transforms inputs of organic pollution in favorable conditions for increasing the population of some species, such as *Caenis luctuosa* (Burmester 1839), the most common Caenidae species in Spain (Alba-Tercedor 1981b). Detritus seem to be the basic component of the diet of Caenidae, or at least they are the only food item usually observed in the gut contents of *Caenis luctuosa* in some streams (Puig 1993; Riaño 1998). However, when detritus is scarce after floods in Mediterranean streams, the larvae eat algae and small invertebrates, with special preference for midge larvae (Puig 1999).

In Spanish ecosystems, only the life cycle of *Caenis luctuosa* is known. This comprises one generation in the cold waters of Sierra Nevada (Alba-Tercedor 1981a) or Atlantic short streams (Riaño 1998; Gonzalez et al. 2001), and two generations with some cohorts in Mediterranean warm streams (Soler and Puig 1999). Larvae float to the water surface for adult emergence. Females make the oviposition after mating also on the water surface. Differences found in the thickness of the chorion layer have led to suggest that eggs could resist dry periods in temporary streams by the swelling of a particular layer (Ubero-Pascal 2004).

Ephemerellidae

Description

Ephemerellidae species are mayflies with dorsolateral eyes and a subquadrangular labrum with a sinuate anterior margin (Fig. 3.8h, i). Maxillary and labial palpi are 3-segmented (maxillary palpi very reduced). They have five pairs of dorsolateral branchial lamellae over abdominal segments III–VII. These lamellae have a single dorsal plate and a ventral tracheal trunk. The caudal cerci and paracercus bear setae around the tip of the last segment.

Biology

Ephemerellidae species are detritivorous, feeding mainly on algae and organic matter. Their mouth pieces are arranged into a chewing structure that allows them to occasionally include invertebrates on their diet. They inhabit a wide variety of habitats, although they prefer areas with current water, with moss or pebbles and gravel (Puig 1999). They have a defense mechanism by which they bend their abdomen upward and forward, so the cerci are placed over the head. In this way, they display a larger volume and size than they actually have. They can tolerate a certain degree of thermal variation, but they are highly intolerant to environmental variations, such as organic pollution. In the Iberian Peninsula, 11 species of this family have been recorded (Alba-Tercedor and Jáimez-Cuéllar 2003).

Ephemeridae

Description

Ephemeridae have a subcylindrical body, quite wide and sturdy, with relatively short and sturdy legs (Fig. 3.8j–l). The forelegs are wider to facilitate burrowing. The head has a characteristic pair of mandibles, very well developed and projecting forward in a diverging manner. On the abdomen we can find seven pairs of gills. The first pair of gills is reduced, but the gills of the remaining pairs are bifid and have two series of finger-like extensions bearing setae (plumose gills). The caudal filaments usually fold over themselves and have a high number of setae.

Biology

Ephemeridae species are common in areas where mud and clay substrates accumulate. Therefore, they are associated with lakes or lower reaches of rivers, on basins where the water flows over clay, although they can also be found in mountain rivers over sand substrates (Belfiore 1983). They burrow U-shaped galleries in soft river beds, where they remain burrowed (Sansoni 1988). They circulate water with the movement of their gills to obtain water and food. Therefore, they are filtering animals that retain particles with the help of the setae on their legs and their mouth pieces. They have high dissolved oxygen requirements, which make them not very tolerant to water pollution (Puig 1999). In the Iberian Peninsula, four species belonging to this family have been found (Alba-Tercedor and Jáimez-Cuéllar 2003).

Heptageniidae

Description

Heptageniidae are animals with a depressed body and a wide, subelliptical or trapezoidal head in which eyes are located dorsally (Fig. 3.8m–p). Labial and maxillary palpi 2-segmented. Legs are sturdy, with very flattened femurs. Their whole body is markedly dorsoventrally flattened, which allows them to stay at the limiting layer of stones in areas of strong current. Some species even show adaptations (such as gills forming a ventral sucker or areas with a higher density of setae) that increase their resistance and help them avoid being swept by the current. They have seven pairs of lamellar gills on the abdomen. Cerci are similar or longer than the paracercus, which is altogether absent in one genus (genus *Epeorus* Eaton 1881).

Biology

Heptageniidae are typically rheophilic mayflies, associated with stony substrates of mountain rivers and headwater rivers (Belfiore 1983; Campaioli et al. 1994). Their morphology is perfectly adapted to live in areas with mostly coarse particle substrates (such as stones and pebble substrates), since they remain under the limiting layer formed by the water flow. Besides, they are really tolerant to low temperatures and they have high oxygen requirements (Puig 1999). They are grazers that feed on algae and the microorganisms they find over rocks. All these characteristics make the presence of this family an indicator of good quality waters. In the Iberian Peninsula, 41 species belonging to this family have been recorded (Alba-Tercedor and Jáimez-Cuéllar 2003).

Leptophlebiidae

Description

Leptophlebiidae larvae (Fig. 3.9a–c) are characterized by having three-segmented labial and maxillary palps, seven pairs of abdominal gills, and three caudal filaments of similar size. These characters do not easily allow for the identification of the larvae, and usually further inspection under a microscope is required. However, it is possible to directly identify the seven genera present in Spanish waters using a few characters.

The larvae of *Choroterpes* Eaton 1881 have a seemingly quadrangular head and are dorsoventrally flattened due to the position of their mandibles, which are visible dorsally and laterally from the head. The gills in abdominal segments II–VII are similar to each other, with two plate-like lamellae and terminated in three processes (medial process longer tan lateral processes). The head of *Thraulus* Eaton 1881 larvae is less quadrangular than that of *Choroterpes*. They have dorsolateral gills, and the first pair has two lanceolate and slender branches. The other six pairs of gills have two oval plates with fringed margins. The larvae of *Habrophlebia* Eaton 1881 have seven pairs of similar gills, plate-like with two portions ending in 3–10 filamentous processes. The larvae of *Leptophlebia* Westwood 1840 are characterised by having gills on segments II–VII, all similarly shaped. These gills are plate-like, with each lamella ending in one slender filamentous process. The first pair or gills is deeply forked and slender. The larvae of *Paraleptophlebia* Lestage 1917, have seven pairs of gills, all similar to each other, which are deeply forked and slender. The larvae of *Habroleptoides* Schoenemund 1929, are similar to those of *Paraleptophlebia*, but their gills are bifurcate and have variable width. They also have an unbranched trachea.

Biology

The species of this family can inhabit a wide range of freshwater habitats. They can be found either in high mountain lakes, as *L. marginata* (Linnaeus 1767) in the Pyrenees (de Mendoza pers. comm.), in streams and rivers with high to low current velocities, and in the summer isolated pools of temporary streams at low altitudes, as *T. bellus* Eaton 1881, which is found in the middle reaches of Matarranya stream. The majority of species prefer cold waters, but two species of *Choroterpes*, *Habrophlebia confusa* Sartori and Jacob 1986 and *T. bellus*, can also tolerate warm waters. In the case of *Choroterpes*, Flowers (2009) suggested that its tolerance to warm waters was possible because its ancestors were distributed along both sides of the Tethys Sea during the Mesozoic Era.

The life cycle of species from this family often has one generation per year, with some cohorts emerging in spring (*P. submarginata* (Stephens 1835)) or in spring-early fall (*Habrophlebia fusca* (Curtis 1834) and *H. lauta*) Eaton 1884 in Sierra Nevada (Alba-Tercedor 1981a). However, the information about *H. confusa* in the Basque Country suggests that some species may have two generations per year, one short in the summer and a longer one with larval development in winter-spring (Riaño 1998).

The larvae of this family are mostly gathering-collectors or shredders, feeding on detritus, plant fragments and algae (Riaño 1998; Pupilli and Puig 2003).

Oligoneuriidae

Description

Oligoneuriidae larvae can be recognized by their depressed body, a head capsule shaped as a conic helmet in dorsal view, and big eyes in dorsal position (Fig. 3.9d). However, the taxonomic characters that define this family are the presence of tufts of filamentous gills on the maxillas and 2-segmented maxillary palpi. These characters are complemented by the presence of two rows of long bristles on the inner margin of the femur and tibia of the forelegs, and the location of the gills (first pair of gills in ventral position, remaining gills (segments II–VII) in dorsal position). These characters are applied together in the subfamily Oligoneuriinae, the only reported subfamily in Spanish rivers.

Biology

Two genera and four species inhabit Spanish ecosystems (Alba-Tercedor 2002): *Oligoneuriopsis* Crass 1947, with one species, and *Oligoneuriella* Ulmer 1924, with three species. *Oligoneuriopsis skhounate* Dakki and Giudicelli 1980, native to the north of Africa,

Fig. 3.9 (**a**–**c**) Leptophlebiidae; (**d**) Oligoneuriidae; (**e**) Siphlonuridae; (**f**) Polymitarcidae; (**g**) Capnidae; (**h**) Chloroperlidae; (**i**) Nemouridae; (**j**, **k**) Perlidae: phoretic acari on Perlidae thoracic gill (**j**), general view (**k**); (**l**) Leuctridae

is widespread in Spanish rivers, such as the rivers of the Guadalete, Segura, Ebro, and Duero basins (González del Tánago and García de Jalón 1983; Ubero-Pascal et al. 1998; Jáimez-Cuellar and Alba-Tercedor 2001; Gallardo-Mayenco 2002–2003). Here, it inhabits middle and low reaches of rivers. It has one generation per year. In the Guadalete basin, larval development is carried out from winter to summer (Gallardo-Mayenco 2002–2003). However, in the Duero basin and the north of Spain, larval development begins in the fall (González del Tánago and García de Jalón 1983).

Oligoneuriella marichuae Alba-Tercedor 1983 is a rare species that usually inhabits mountain streams. It has only been captured in Sierra Nevada (Alba-Tercedor 1981a) and Serranía de Ronda (Jáimez-Cuéllar et al. 1999). It has a univoltine life cycle, with postembryonal development from early winter to late summer (Alba-Tercedor 1981b). *Oligoneuriella duerensis* González del Tánago and García de Jalón 1983 has been caught in the Duero, Tajo and Segura river basins (González del Tanago and García de Jalón 1983; Ubero-Pascal et al. 1998, Baltanás pers. comm.). The presence of *Oligoneuriella rhenana* (Imhoff 1852) has only been confirmed in the north half of Spain (González del Tánago and García de Jalón 1983; Puig 1984; Puig et al. 1994; Oscoz et al. 2007). Its populations inhabit streams in current and riffle areas, with high current velocity and low-middle depths, on rock and stone bottoms or on hygropetric surfaces partially covered by gravel and pebbles. Its larval development is carried out in spring and summer (González del Tánago and García de Jalón 1983; Puig 1984).

Some Oligoneuriidae species were regarded as filtering-collectors due to the structure of their forelegs (Alba-Tercedor 1981b). However, the structure of their mouthparts allows them to feed as scrapers as well (Puig 1999). In Spanish aquatic ecosystems, *O. skhounate* appears as the most tolerant species to organic pollution compared to other species of this family (González del Tánago and García de Jalón 1983, Ubero-Pascal et al. 1998).

Polymitarcyidae

Description

Polymitarcyidae species have larvae with long mandibular tusks, clearly projected beyond the anterior margin of the head, apically curved downwards, and with numerous tubercles on the upper surface (Fig. 3.9f). The labial and maxillary palpi have two segments. They have seven pairs of abdominal gills over the back. The first one might be vestigial and the rest are thinly plated and strongly bifurcate with fringed margins. The larvae are burrowers with digging legs.

Biology

Only one genus and one species occur in Spain, *Ephoron virgo* (Olivier 1791). Populations of this species have been captured in the middle and lower reaches of rivers such as Tajo, Guadalquivir, Guadalete, Ter and Ebro (Alba-Tercedor 1981, Gallardo-Mayenco 2002–2003; Benito 2007). Some populations inhabit valleys with small slopes and Mediterranean mountain areas at altitudes lower than 500 m a.s.l., such as the Mundo (Ubero-Pascal et al. 1998) and Fluvià streams (Puig 1984; Benito 2007).

Larvae usually live in areas with current, in mud and clay banks, or in river channels with bottoms of clay, sand and pebbles, where they dig out galleries with similar structure to those built by Ephemeridae. As filtering-collectors, members of this species are more abundant in waters with fine particulate matter and plankton in suspension or with detritus deposits (Puig 1999; Cid et al. 2008a). However, they are intolerant to high eutrophic conditions (Oscoz et al. 2007). They can tolerate moderate levels of heavy metals and act as bioaccumulators, introducing these elements in the river food web, as it has been reported to happen in the lower Ebro (Cid et al. 2008b).

E. virgo has a single generation per year, with coordinated emergence of all specimens of a population in a few summer days (8 days in the lower Ebro), from late July to late August (Cid et al. 2008a). The nuptial fly of adults can be observed swarming over the river banks near the lights of streets, bridges, and runaways. After copulation, the river banks appear covered by dead males, and the water surface is covered by females laying eggs. In the lower Ebro, the life cycle of this species occurs earlier than in other areas, with the adult emergence peak beginning 3 weeks earlier. This is believed to be associated with the increase of temperature in this area, which has also affected adult sex ratios (F:M): females were predominant (1:4) in 2005 as opposed to male predominance (2:1) in 1987 (Cid et al. 2008a).

The eggs are considered to be a form of resisting adverse conditions (Tachet et al. 2000), at least for the French populations of this species. Unfortunately, there are no data to support this for Spanish populations.

Potamanthidae

Description

Potamanthidae larvae (Fig. 2.13b) are characterised by having seven pairs of lateral gills on abdominal segments 1–7. The first pair is simple and reduced, while the other pairs are longer, slender and bifurcate with fringed margins. The mandibles have a short conical projection and, in European species, do not extend beyond the front of the head.

Biology

Only one genus and one species occur in Spain, *Potamanthus luteus* (Linneo 1767). They were initially caught in the Ebro and Tajo Rivers (Alba-Tercedor 1981b; Jáimez-Cuéllar and Alba-Tercedor 2001), and the species was later confirmed to be widespread in the Ebro basin (Oscoz et al. 2007), also occurring in the small Mediterranean watersheds of the Llobregat (Puig 1984) and the Segura streams (Ubero-Pascal et al. 1998). In this last basin, it has a wide altitudinal distribution, from 190 to 1300 m a.s.l. (Ubero-Pascal et al. 1998), which exceeds the upper limit registered in the Ebro basin of 750 m of maximum altitude (Oscoz et al. 2007).

Potamanthus luteus inhabits middle reaches of large Spanish rivers, in areas with mainly gravel and sand, or sands with macrophytes. When it lives in upper reaches and little streams, it prefers bottoms of stones and gravels; but always in areas with slow to moderate water velocity (Puig 1984). Eggs have attachment structures which allow them to fix onto any kind of substrate (Ubero-Pascal and Puig 2007). Maximum densities have been recorded in the Aiguadora stream (Llobregat river basin), with 257 individuals by square meter (Sotomayor 1998). Here, the larvae spend part of their life cycle in the upper interstitial zone as burrowers, especially during winter (Puig 1999), and as sprawlers the rest of their aquatic lives. This species is univoltine in Spanish waters, flying in the summer from June to August, with the recruitment of first instars in November in the north east of Spain.

P. luteus is a gathering collector or filtering-collector, feeding mainly on detritus and different types of small algae (Puig 1999). In Spanish rivers and streams, this species disappears in polluted waters, mainly inhabiting unpolluted or slightly polluted waters.

Prosopistomatidae

Description

The morphology of the family Prosopistomatidae is completely different to that of other mayflies. The body is covered by a plate (formed by the fusion of the pronotum and the mesonotum) that expands over the thorax and part of the abdomen (Fig. 2.13a), leaving only the last segments free. In this way, they resemble more a crustacean than a mayfly. The gills are protected underneath the plate. In general, the body is depressed and eyes are clearly dorsal. The caudal cerci are very reduced, retractile and bearing setae.

Biology

There is only one species in Spanish freshwaters, *Prosopistoma pennigerum* (Muller 1785) (Alba-Tercedor and Jáimez-Cuéllar 2003). This species lives in middle and lower reaches of rivers with a certain amount of flow and with river beds with a gravel and sand substrate, where they live burrowing (Puig 1999). They are not common and therefore not frequently sampled either.

Siphlonuridae

Description

Siphlonuridae larvae have a subcylindrical, not very depressed body, with lateral eyes and antennae of similar length to the head (Fig. 3.9e). The labrum is subtriangular, and maxillae are narrow and long, with 3-segmented palpi. They have seven oval-shaped and very large abdominal gills, some of which are bilamellar and others monolamellar. The cerci are similar or slightly bigger than the paracercus, and they do not bear setae on their external margin (only on the inner margin). The margins of the last abdominal segments have very marked hind corners forming sharp points, feature that differentiates them from Baetidae.

Biology

Siphlonuridae live over sand substrates in streams with weak currents and cold and well-oxygenated waters. They are swimming organisms, mainly detritivorous, although they can include algae and some small invertebrate on their diet. Their nymphs have a short development that occurs in a few months during spring and summer. They are considered indicators of clean waters (Puig 1999). In the Iberian Peninsula, eight species belonging to this family have been found (Jáimez-Cuéllar and Alba-Tercedor 2001, Alba-Tercedor and Jáimez-Cuéllar 2003).

Capniidae

Description

Capniidae nymphs are medium to small (between 4 and 9 mm when mature), very elongated animals with a cylindrical and pale yellowish body (Fig. 3.9g). They have narrow pterothecae, parallel or slightly diverging with respect to the longitudinal body axis. The abdominal tergites and sternites are separated by a membranose area in the first nine abdominal segments. Paraprocti are short. The male can be already recognised in the last nymphal stages due to the development of the epiproctum development, which is visible at the end of the abdomen.

The family Capniidae has about 315 species worldwide (Fochetti and Tierno de Figueroa 2008), of which ten are present in Spain. Spanish species belong to three genera: *Capnia* Pictet 1841, *Capnioneura* Ris 1905 and *Capnopsis* Morton 1896 (Tierno de Figueroa et al. 2003).

Biology

Capniidae species typically have annual life cycles. Most nymphs develop during the coldest months, although in this family (as well as in some other Plecoptera families), there are thermophilic representatives in temporary environments (whether seasonal or intermittent). In some species there is a nymphal diapause that helps them resist periods of adverse conditions. Within this family, ovoviviparous species have been recorded. Most Iberian species fly during autumn or winter, although some species in some localities have an extended flight period until the spring. Nymphs feed on organic detritus, vegetable matter and diatoms, although the proportions on their diet depend on the stage of development of the nymph, the species and the particular population.

For more information on description and biology of Capniidae species, see Tierno de Figueroa et al. (2003).

Chloroperlidae

Description

Chloroperlidae have small to medium-sized (between 6 and 12 mm when mature) nymphs of a pale yellowish or brownish colour (Fig. 3.9h). The body is elongated and cylindrical. They are easily identified because (i) their pteropthecae are short and have the external margin rounded, and (ii) the last segment of the maxillary palpus is narrower than the rest (less than a third of the width of the preceding segment). The first and second segments of the tarsi are short, while the third one is long.

This family holds more than 200 species worldwide (Fochetti and Tierno de Figueroa 2008). In Spain there are seven species belonging to three genera: *Chloroperla* Newman 1836, *Siphonoperla* Zwick 1967 and *Xanthoperla* Zwick 1967 (Tierno de Figueroa et al. 2003).

Biology

Chloroperlidae nymphs live in the interstitial environment and occupy small spaces between the particles of the river bed. Their life cycle normally lasts a year, although some populations have 2-year-long cycles. Adults emerge in spring and/or summer. The nymphs are predators, although they also feed on vegetable matter, especially during the first stages of development. Adults feed mainly on pollen and are peculiar among stoneflies because of their low fertility. The mechanism of tremulation (or abdominal vibration) that male and female use to communicate to gather for mating is also characteristic. Chloroperlidae inhabit different types of rivers and streams depending on the species, although normally they live on small, well oxygenated streams.

For more information on description and biology of this family, see Tierno de Figueroa et al. (2003).

Leuctridae

Description

Leuctridae have small to medium-sized nymphs (usually between 5 and 12 mm when mature) with pale brown or yellowish colour (Fig. 3.9l). They have an elongated and cylindrical body. The pterothecae are parallel to the body axis. The hind legs, when extended, do not surpass the length of the abdomen. The second segment of the tarsus is shorter than the other two. The abdominal tergites and sternites are separated by a membranous area in the first seven (at most) abdominal segments. They have elongated paraprocti are elongated and long cerci with a ring of more or less long bristles on the distal margin of each segment. They do not have tracheal gills of any kind. The family Leuctridae has around 230 species worldwide (Fochetti and Tierno de Figueroa 2008). In Spain, 50 species are present, belonging to three genera: *Leuctra* Stephens 1836, *Pachyleuctra* Despax 1929 and *Tyrrhenoleuctra* Klapalek 1903 (Tierno de Figueroa et al. 2003; Fochetti and Tierno de Figueroa 2009).

Biology

Although usually Leuctridae are linked to clean, relatively cold and well oxygenated rivers, the nymphs of some species can inhabit very different environments, such as quasi stagnant puddles in low altitude streams, potamal environments and temporary streams. Many occupy the interstitial environment of the river bed. Most species have an annual life cycle, sometimes with eggs and nymphs going through stationary stages in temporary environments. Species that require several years to complete their development are also known, and normally occur in cold high mountain regions. Given the family's species richness (it is the most diverse stonefly family in the Iberian Peninsula), there are species with flight periods in winter, autumn, spring and summer.

The nymphs are primarily shredders or gatherers of deposits. Adults feed mostly on cyanobacteria, algae, lichens and fungi, in the proximities of rivers and streams, where they dwell on rock or riverside vegetation. Although most species are oviparous, some reported cases of ovoviviparids exist.

For more information on description and biology of this family, see Tierno de Figueroa et al. (2003).

Nemouridae

Description

Nemouridae have small to medium-sized nymphs (usually between 4 and 10 mm when mature). Their body is short and sturdy, usually brown (Fig. 2.12i). The pronotum is quadrangular or rectangular, with a variable and species-specific presence and length of setae. On the posterior border of the abdominal tergites they also have bristles of variable length that are useful for species determination. The abdomen is short and hind legs normally surpass it (when extended). The second segment of the tarsus is shorter than the other two. In mature nymphs, the pteropthecae clearly diverge from the body axis (Fig. 3.9i). In Nemouridae nymphs, tracheal gills might be absent (genera *Nemoura* Latreille 1796 and *Nemurella* Kempny 1898) or present on the prosternum (between the head and the thorax) as two tufts of filaments (*Amphinemura* Ris 1902) or as two groups of three digitiform filaments (*Protonemura* Kempny 1898).

This family has over 630 species worldwide (Fochetti and Tierno de Figueroa 2008). In Spain, 37 species can be found, belonging to the four aforementioned genera (Tierno de Figueroa et al. 2003; Vinçon and Pardo 2003; Vinçon and Ravizza 2005; Tierno de Figueroa and López-Rodríguez 2010).

Biology

Because Nemouridae represents such a diverse group, it is difficult to generalise about the environmental requirements of the nymphs of this family. Thus, we can find highly stenophilic species but also species capable of adapting to different habitats, whether lotic or almost lentic, whether pristine or slightly polluted. Some species are exclusive to mountain streams with cold, clean and very oxygenated waters; other species can inhabit temporary waters with summer drought periods that can sometimes be long-lasting. In these last instances, nymphal eggs are capable of undergoing through resting stages or to use the interstitial milieu when conditions are not favourable. They usually have an annual life cycle, although there are known instances of multivoltinism or semivoltinism. In Spain, a new species has recently been described (Tierno de Figueroa and López-Rodríguez 2010). This species fulfills its whole life cycle inside a cave and has morphological adaptations in the adult to the cave-dwelling lifestyle. The flight period can be extended (taking up to three seasons in a year) or more or less short, but in any case we can find winter, autumn, spring and/or summer species.

Nemouridae nymphs feed mostly on detritus and vegetable matter, and they act mainly as shredders or gatherers of deposits. Adults feed primarily on algae, cyanobacteria, lichens and fungi. For more information on description and biology of this family, see Tierno de Figueroa et al. (2003).

Perlidae

Description

The main diagnostic character that defines Perlidae nymphs (Fig. 3.9j, k) is the presence of thoracic tufted tracheal gills, although in some species there is also an anal tuft. Nymphs can reach considerable sizes (more than 3 cm in some Spanish species when mature). They also have dark and light contrasting colours that form characteristic patterns. The body is dorsoventrally flattened, with a slightly convex dorsum. The pteropthecae diverge and legs have wide femurs and many swimming setae. Tarsal segments I and II are short, while segment III is long.

Perlidae is the most diverse stonefly family in the world, with more than 1000 species described (Fochetti and Tierno de Figueroa 2008). In Spain, nine species can be found, belonging to four genera: *Dinocras* Klapalek 1907, *Eoperla* Illies 1956, *Marthamea* Klapalek 1907 and *Perla* Geoffroy 1762 (Tierno de Figueroa et al. 2003; Fochetti and Tierno de Figueroa 2009).

Biology

Perlidae have long life cycles that take a few years to complete. In some cases, resting stages have been observed during egg development. Eggs are oval and normally have attachment discs, also a common feature in Perlodidae and Chloroperlidae. Adults emerge in spring and early summer, and the flight period is short. Nymphs inhabit rivers and permanent streams of cold and well oxygenated waters. In fact, when oxygen levels drop, nymphs perform a series of distinct stretches that help them oxygenate the gills. Nymphs are mostly predators of Chironomidae, Baetidae and other macroinvertebrates, although they also ingest vegetal matter, especially during the first nymphal stages. Adults do not feed. In fluvial environments without fish, Perlidae, along with Odonata and a few other macroinvertebrates become the main predators of the freshwater trophic webs. When fish are present, Perlidae become an important component of their diet.

For more information on description and biology of this family, see Tierno de Figueroa et al. (2003).

Perlodidae

Description

Perlodidae have medium to large nymphs (between 10 and 25 mm when mature, depending on the species) without thoracic or abdominal tracheal gills (Fig. 3.10a–b). The body is elongated and cylindrical, generally of a brownish-yellowish colour. They show more or less defined and species-specific patterns. In most species, legs usually have strips of long swimming hairs. Tarsal segments I and II are very short, while the third one is long. Pteropthecae (especially the hind pteropthecae) diverge slightly and have a subtriangular shape.

The family Perlodidae has around 300 species worldwide (Fochetti and Tierno de Figueroa 2008). In Spain, 17 of those species can be found, belonging to six genera: *Arcynopteryx* Klapalek 1904, *Besdolus* Ricker 1952, *Guadalgenus* Stark and Gonzalez del Tanago 1986, *Hemimelaena* Klapalek 1907, *Perlodes* Banks 1903 and *Isoperla* Banks 1906 (Tierno de Figueroa et al. 2003; Tierno de Figueroa and Vinçon 2005; Luzón-Ortega et al. 2010).

Biology

Perlodidae are stoneflies that complete their life cycle within a year, although populations of some species have been observed to take longer to develop. They live in springs and source waters (rhithron) as well as relatively calm waters (potamon). Within this family, species can be found both in permanent and temporary waters. Species living in temporary environments develop typical adaptations to these environments, such as a long embryonal development (with or without diapause), nymphal quiescence, asynchrony emergence and a high overlap of individuals of all sizes, all of which reflects on an extended emergence period. However, most species have a spring or summer flight period.

Most nymphs are predators, although they also feed on vegetal matter or detritus, at least in early developmental stages. Adults feel mainly on pollen (medium-sized species) or do not feed at all (large species). Among Perlodidae, mating calls produced through vibration seem to be very diversified, as these can be produced via several mechanisms (drumming, tremulation, dragging or a combination).

For more information on description and biology of this family, see Tierno de Figueroa et al. (2003).

Taeniopterygidae

Description

Taeniopterygidae have medium-sized (usually between 8 and 13 mm when mature), relatively sturdy nymphs of a uniform dark or light colour (Fig. 3.10c–d). They do not have tracheal gills, but if these are present, they are found on the coxae (genus *Taeniopteryx* Pictet 1841). Legs are long and slender, with tarsal segments progressively longer. Pteropthecae diverge with respect to the longitudinal axis of the body. The abdomen is short and wide, but not as short as that of Nemouridae. The first seven or eight abdominal sternites are membranous. In some cases (genus *Taeniopteryx*) the abdomen (and sometimes the thorax as well) has dorsal ridges, while other genera (*Brachyptera* Newport 1849 and *Rhabdiopteryx* Klapalek 1902) show a more or less conspicuous ventral plate.

The family Taeniopterygidae has around 150 species worldwide (Fochetti and Tierno de Figueroa 2008). In Spain, 14 species can be found, belonging to the three aforementioned genera (Tierno de Figueroa et al. 2003).

Biology

Most Taenioptegiridae have an annual life cycle, with a relatively short nymphal development. Depending on the species, they can be found in high mountain areas or areas of medium or low altitude. Some species only inhabit mountain streams, while others can live in temporary environments that generally undergo summer droughts. The latter usually complete their nymphal development in a few months and, in some species, this includes a nymphal diapause, a rare feature among stoneflies. Adults can be found in winter or spring, and flight periods vary according to species and locality.

Nymphs feed on organic detritus and vegetal matter. Diatoms – which they ingest scraping rocks or leaves with their maxillae – are a typical component of their diet, as well as other algae and sometimes even leaf particles.

For more information on description and biology of this family, see Tierno de Figueroa et al. (2003).

Aeshnidae

Description

Among Odonata, Aeshnidae species have the largest larvae of the Iberian Peninsula, both in terms of size and body mass (Fig. 3.10e, f). They are long larvae, with hind legs that do not surpass the edge of the abdomen. They have a flat mask, like Gomphidae species. While resting, the border of the mask does not fully cover the other mouth pieces (mandibles and maxillae). They have long antennae of six or seven segments, similar to each other in shape and length (Robert 1958, Heidemann and Seidenbuch 2002).

Generally, the larvae of this family are brownish-greenish with dark stripes that give them a veined appearance. The legs also have dark and light stripes. The eyes are really big and have a peculiar shape: the anterior part is located at the edge of the head and the posterior part is narrowed in a lobe that inserts in the head. The spines at end of the abdomen are very developed. In females, the outline of the ovipositor is clearly appreciated in the ventral surface of the ninth abdominal segment.

Biology

The largest Iberian dragonflies belong to the family Aeshnidae. Spanish species belong to six genera: *Aeshna* Fabricius 1775 (four species); *Anaciaeschna* Sélys 1878 (one species); *Anax* Leach 1815 (two species); *Hemianax* Sélys 1883 (one species); *Brachytron* Sélys 1850 (one species) and *Boyeria* McLachlan 1896 (one species).

Larvae generally inhabit stagnant waters or waters with weak currents, with the exception of *Boyeria irene* (Fonscolombe 1838) which occurs in good quality flowing waters (Torralba-Burrial 2009). Among species that live in stagnant waters, there is an array of ecological requirements. *Brachytron pratense* (Müller 1764) is typical of good quality stagnant waters with great botanic diversity (Ocharan et al. 2007); *Anax imperator* (Leach 1815) inhabits any kind of stagnant water regardless of its level of pollution, even in weak currents; and *Aeshna cyanea* (Müller 1764) larvae can live even in small livestock water troughs . Given their large size, they can catch amphibian larvae and even attack adult frogs (Torralba-Burrial and Ocharan 2004).

B. pratense is a member of this family and it has been listed as Endangered (EN) in Spain (Ocharan et al. 2009). Also *Aeshna juncea* (Linnaeus 1758), which is listed as Vulnerable (VU) in Spain (Ocharan et al. 2006a). The former inhabits low altitude stagnant waters that have good ecological quality, whereas the latter lives in acidic oligotrophic lakes and ponds, generally in mountain areas.

Cordulegastridae

Description

Cordulegastridae larvae (Fig. 3.10g) are similar to those of Aeshnidae. In female larvae, the outline of the ovipositor can be appreciated, a character that cannot be observed in adult specimens (adult females have a pseudovipositor of different origin). Eyes are small, slightly protruding and similar to those of Libellulidae. They are very hairy, with numerous rigid hairs that give the animal a characteristic appearance. The mask is not flat. Due to the arrangement of the palpi, the mask has a characteristic spoon-like shape, typical of this family and the families Corduliidae and Libellulidae. Cordulegastridae can be differentiated because both palpi have long, sharp and unequal teeth on their margins, while in Corduliidae and Libellulidae the teeth are smaller and blunt (Robert 1958; Heidemann and Seidenbuch 2002).

Biology

Cordulegastridae are the characteristic spiketails, large and black dragonflies with yellow stripes. Unlike other Anisoptera, their eyes only make contact in one point. There is only one Iberian genus – *Cordulegaster* Leach 1815 – with two very similar species.

They can be found in running waters, usually small and with soft bottoms of sand or mud. Larvae live burrowed in the bottom, which they access in a very different way compared to clubtails. The Cordulegastridae larva lies over the soft bottom. With their legs of elongated tarsi, it removes the sediment under its body, digging in this manner a ditch where it sinks. Then, the larva contracts and shakes, in such a way that it ends up covered by mud or sand, leaving only the end of the abdomen on outside. Finally, it removes the sediment from its head with its fore legs, freeing the eyes and the anterior part of the mask (Robert 1958). Libellulidae burrow in a similar manner. One of the two Iberian species, *Cordulegaster boltonii* (Donovan 1807) lives in good quality waters (Torralba-Burrial 2009), so much so that it could be considered as an indicator species. We do not know if the other Iberian species, *C. bidentata* Sélys 1843, which can only be found in the Spanish Pyrenees, shares this character, although it seems possible (Grand and Boudot 2006).

Corduliidae

Description

Corduliidae have a spoon-like mask with less marked teeth than Cordulegastridae, but more marked than Libellulidae. Also, they can be differentiated from Libellulidae because their legs are longer and more slender, and the relative length between cerci and paraprocti of the end of the abdomen is also different

Fig. 3.10 (**a**, **b**) Perlodidae; (**c**, **d**) Taeniopterygidae; (**e**, **f**) Aeshnidae; (**g**) Cordulegastridae; (**h**, **i**) Gomphidae; (**j**) Libellulidae; (**k**) Platycnemididae

(although this character is difficult to observe in early developmental stages). The presence or absence of the different cephalic protuberances, as well as abdominal spines, facilitates the differentiation between species (see keys in Heidemann and Seidenbuch 2002; Askew 2004).

Biology

Corduliidae are medium to large-sized Anisoptera, usually metal lic green marked with black or yellow. Four genera can be found in Spain, each represented by a single species: *Oxygastra* Sélys 1871, *Macromia* Rambur 1842, *Somatochlora* Sélys 1871 and *Cordulia* Leach 1815, these last two only present in the Pyrenees (Lérida).

The two Ibero-Maghrebian species, *Macromia splendens* (Pictet 1843) and *Oxygastra curtisii* (Dale 1834), have relatively similar requirements, living in running waters with pools or backwater areas. Larvae of *O. curtisii* can be found among vegetal detritus at the bottom of the river and in roots mats of riverbank vegetation that project into the water (Leipelt and Suhling 2001; Heidemann and Seidenbuch 2002; Grand and Boudot 2006). *M. splendens* specimens seem to depend on forest clearings, where adults feed (Cordero Rivera 2000). *Somatochlora metallica* (Vander Linden 1825) and *Cordulia aenaea* Leach 1815, preferentially live in standing waters or waters with weak currents, sometimes sharing habitats (Heidemann and Seidenbuch 2002; Dijkstra and Lewington 2006).

In Spain, two species in this family, *M. splendens* and *O. curtisii*, are endangered (Azpilicueta-Amorín et al. 2009b; Azpilicueta-Amorín et al. 2009c) and therefore protected by the Habitats Directive and the Spanish National Catalogue of Endangered Species. Iberian populations of both species are crucial for the conservation of these species.

Gomphidae

Description

Gomphidae larvae are dorsoventrally flattened (Fig. 3.10h, i). They have a flat mask that, while at rest and similarly to Aeshnidae, does not cover other mouth pieces. Unlike Aeshnidae, Gomphidae has short and stout antennae with only four segments (the third one longer than the remaining three combined). Their morphology is dictated by their peculiar burrowing behaviour, head first into the substrate. This causes a decrease in the number of antennal segments and the engrossment of the antennae. Besides, they have spurs on the tibiae to help them dig, and they have shorter and sturdier tarsi than other families. Larvae are very hairy, thus usually covered with detritus (Robert 1958).

Biology

Gomphidae are medium-sized dragonflies. Four genera can be found in the Iberian Peninsula: *Gomphus* Leach 1815 (four species), *Paragomphus* Cowley 1934 (one species), *Onychogomphus* Sélys 1854 (three species) and *Lindenia* De Haan 1826 (one species). They are normally black with yellow stripes, although *Lindenia tetraphylla* (Vander Linden 1825), *Onychogomphus costae* Sélys 1885 and *Paragomphus genei* (Sélys 1841) are straw-coloured (Askew 2004).

Larvae normally live in running waters, although *L. tetraphylla* is typical of standing waters; and *P. genei*, *G. pulchellus* Sélys 1840 and *G. simillimus* Sélys 1840 frequently reproduce in standing waters.

They live burrowed most of their lives, digging galleries in the substrate and even eating inside it (leeches, molluscs, crustaceans, insect larvae, fish and insect eggs). They are mostly nocturnal (Heidemann and Seidenbuch 2002). They burrow in a very different way than Cordulegastridae and some Libellulidae. Gomphidae larvae insert in the substrate (silt or more frequently sand) head first. They burrow a gallery with their fore and mid-legs, in which they introduce the head and the body while they hold onto the substrate with their hind legs to push (Robert 1958). Quite frequently the end of the abdomend remains outside of the substrate to favour breathing (Heidemann and Seidenbuch 2002). They have a characteristic way of emerging. Usually, the larva lies flat on a rock and the adult emerges from this position, while the rest of the Odonata larvae stand on vertical supports. In Spain, *Lindenia tetraphylla* is listed as critically endangered (CR) (Ocharan 2009), *Gomphus graslinii* Rambur, 1842 as endangered (EN) (Azpilicueta-Amorín et al. 2009a) and *G. simillimus*, *G. vulgatissimus* Linnaeus 1758 (Ocharan and Ferreras Romero 2006; Ocharan et al. 2006c) and *O. costae* as vulnerable (VU).

Libellulidae

Description

Libellulidae have a spoon-like mask (Fig. 3.10j) with the teeth on the palpi relatively inconspicuous. The cerci are smaller than half the length of the paraprocti, although this character is not always visible on the first larval stages. Legs can be quite long, but they are shorter and more slender than those of Corduliidae. Libellulidae larvae are also smaller than Corduliidae in the last larval stages. For identification to species level, the following characters are used: cephalic morphology, number and distribution of setae on the inner side of the mask, and degree of development of the abdominal spines (see keys in Heidemann and Seidenbuch 2002; Askew 2004). However, the degree of development of the abdominal spines varies among individuals and populations in some species, especially when predator fish are present (e.g. Flenner et al. 2009).

Biology

Libellulidae are medium to small dragonflies, usually of a reddish, bluish or yellow colouration. Within Odonata, it is the most diverse family in Spain, both with regards to the number of genera (10) and the number of species (28). So far, the genera found in the Iberian Peninsula are: *Libellula* Linnaeus 1758 (three species); *Orthetrum* Newmann 1833 (six species); *Diplacodes* Kirby 1889 (one species); *Brachythemis* Brauer 1868 (one species); *Crocothemis* Brauer 1868 (one species); *Sympetrum* Newmann 1833 (eight species); *Leucorrhinia* Brittinger 1850 (two species); *Trithemis* Brauer 1868 (two species); *Zygonyx* Hagen 1867 (one species) and *Selysiothemis* Ris 1897 (one species).

Given this great diversity, they can be found in almost all aquatic habitats. They are mostly associated with standing waters or waters of weak currents, although there are exceptions, such as *Libellula depressa* Linnaeus 1758, *Orthetrum coerulescens* (Fabricius 1798), *Orthetrum brunneum* (Fonscolombe 1837) and *Sympetrum striolatum* (Charpentier 1840), that develop in both types of aquatic environments. Their life cycle can be quite short, with several generations within a year in temperate species, such as *Sympetrum fonscolombii* (Sélys 1840) and *Crocothemis erythraea* (Brullé 1832); or they can have long cycles of up to 3 years, as it is the case for high altitude populations, such as those of *Libellula quadrimaculata* Linnaeus 1758; or even 5 years, as suggested for some French populations of *Leucorrhinia dubia* (Vander Linden 1825) (Grand and Boudot 2006; Boudot et al. 2009).

Calopterygidae

Description

Calopterygidae adults and larvae are the largest among European Zigoptera. Larvae are easily identified by their antennal basal segment (Fig. 2.15a), longer than the remaining segments combined (Robert 1958). This character separates this family from the rest of the Zygoptera families. Identification to species level is more complex and usually only reliable with larvae on their last developmental stages or with exuviae (see key in Heidemann and Seidenbuch 2002).

Biology

Calopterygidae is represented in Europe by a single genus, *Calopteryx* Leach 1815, with three species present in the Iberian Peninsula. They are commonly known as damselflies. Adults are sexually dimorphic and can have metallic blue, green or copper colours, with the wings partially darkened. Males are more conspicuous and potentially territorial, while females are roamers. They show a very elaborate courtship and females stick their eggs in aquatic vegetation (partially or totally submerged).

They live in running waters, from source water streams to large river mouths. Each Iberian species has particular ecological requirements for their larvae, which limit their distribution in the different reaches and areas of the river, and also in the different regions of the Iberian Peninsula (Outomuro et al. 2010). Among the factors limiting habitat selection, water temperature is paramount (Schütte and Schrimpf 2002). *Calopteryx virgo meridionalis* Sélys 1873 is typical of fast, cold, well oxygenated streams with plenty riverside vegetation; *Calopteryx xanthostoma* (Charpentier 1825) inhabits medium reaches of slower and warmer waters, generally with floating hydrophytes; *Calopteryx haemorrhoidalis* (Vander Linden

1825) requires fast and well oxygenated streams, clearly prefering Mediterranean regions (Dijkstra and Lewington 2006; Grand and Boudot 2006). This requirements mark their distribution in the Iberian Peninsula (Outomuro et al. 2010): *Calopteryx virgo meridionalis* is very frequent across the Euro-Siberian region, while restricted to mountain regions in the Mediterranean region. *Calopteryx xanthostoma* has a wider distribution in both regions. *Calopteryx haemorrhoidalis* is very frequent in the Mediterranean region, while restricted to coastal thermal areas in the Euro-Siberian region (Boudot et al. 2009).

They have between 12 or 13 larval stages (Rüppell et al. 2005). They live among the submerged roots of phanerogaoums, helophytes and hydrophytes, and also among vegetal detritus. They are active predators, seemingly nocturnal (Rüppell et al. 2005). Larvae spent one single winter in the water. They start to emerge (staggered) in May, with the adult flight period extending until the end of October (Ocharan 1987), depending on the species, and the altitude and latitude where they are found.

Coenagrionidae

Description

Coenagrionidae (Fig. 2.15d) generally have pointy caudal lamellae, transversally divided. However, and unlike Platycnemididae, these are not prolonged. The cerci at the base of the lamellae are very short and obtuse. On the mask, the movable hook at the end of the labial palpi never bears setae. In order to identify genera and species, some keys consider the number of antennal segments (six or seven). This is not recommended, since the number is variable, even between the antennae of the same specimen (Heidemann and Seidenbuch 2002). However, the shape and distribution of setae on the caudal lamellae are more reliable characters, although some degree of intraspecific variability might exist (Askew 2004).

Biology

Adult Coenagrionidae are small damselflies, very similar to Platycnemididae, although their tibiae are never flat and widened. It is a very diverse family, also in the Iberian Peninsula, where six genera and 14 species can be found: *Pyrrhosoma* Charpentier 1840 (one species); *Erythromma* Charpentier 1840 (two species), *Coenagrion* Kirby 1890 (six species), *Enallagma* Charpentier 1840 (one species), *Ischnura* Charpentier 1840 (three species) and *Ceriagrion* Sélys 1850 (one species).

Most Iberian species inhabit standing waters or waters with weak currents. Some species that live in standing waters in the Euro-Siberian region of the Iberian Peninsula inhabit running waters in the Mediterranean region (Ocharan 1987). Larvae usually live among shallow aquatic vegetation. Although generally the larval cycle lasts less than a year (Heidemann and Seidenbuch 2002), the duration of the life cycle can vary with respect to latitude and/or altitude. Some species have several generations per year, some just one annual generation, and some even have longer larval developments (Grand and Boudot 2006).

In Spain, *Coenagrion scitulum* (Rambur 1842), *Coenagrion caerulescens* (Fonscolombe 1838) and *Coenagrion mercuriale* (Charpentier 1840), are listed as vulnerable (VU; Ocharan et al. 2006b).

Lestidae

Description

Lestidae (Fig. 2.15b) have very characteristic labial palpi, with a deep medial cleft which divides them into two lobes, and two movable distal hooks bearing 2–4 large setae. The tracheal gills have a rounded apex, which is not sharp (as in Platycnemididae) or divided in two (as in Coenagrionidae). Distinction between species is based mainly on the mask setae, although there is intraspecific variability in this character (see keys in Heidemann and Seidenbuch 2002; Askew 2004).

Biology

In Europe and the Iberian Peninsula, three genera can be found: *Sympecma* Burmeister 1839 (one species), *Chalcolestes* Kennedy 1920 (one species) and *Lestes* Leach 1815 (six species). They are Zigoptera of metallic colourations, intense green in *Chalcolestes* and *Lestes*, chestnut-brown and slightly metallic in *Sympecma*. The body is frequently pruinose. While at rest, mature adults of *Chalcolestes* and *Lestes* keep their wings in a semi-opened position (Askew 2004), at least most of the time (Torralba-Burrial and Ocharan 2003).

Species of this family generally inhabit standing waters and some are even characteristic of temporary waters. Eggs can resist low temperatures, larvae develop fast and adults disperse widely (Dijkstra and Lewington 2006). The larval stage does not hibernate (Heidemann and Seidenbuch 2002).

Females deposit eggs inside vegetal tissues. *Chalcolestes viridis* (Vander Linden 1825) sticks its eggs inside the bark of live branches of trees and bushes just over the water, so that the larvae will fall into the water when they leave the egg; this species seems to be the only one to develop in running waters (Askew 2004). *Lestes barbarus* (Fabricius 1798) and *Sympecma fusca* (Vander Linden 1820) can tolerate a certain degree of salinity (Askew 2004), while *Lestes macrostigma* (Eversmann 1836) is typically found in brackish waters. In Spain, this last species is listed as vulnerable (VU) due to its limited and fragmented distribution (Ocharan et al. 2006d), as well as its potential decline across Europe (Sahlén et al. 2004).

Platycnemididae

Description

Platycnemididae (Fig. 3.10k) are morphologically very similar to Coenagrionidae. However, both families can be easily differentiated by the shape of the caudal lamellae: in Plactycnemididae, these are apically pointed in a sort of rigid and very elongated filament (Fig. 2.15c), while in Coenagrionidae no prolongation of any kind exists. Caudal tracheal gills never show transversal medial divisions.

The labial palpi of Platycnemididae only have 2–4 long setae (5–7 in Coenagrionidae) and bear short setae on the external margin (absent in Coenagrionidae) (Heidemann and Seidenbuch 2002; Askew 2004).

Identification to species level is very complex due to intraspecific variations. According to Heidemann and Seidenbusch (2002), existing keys are only reliable with the most characteristic larvae and not applicable to a quarter of the specimens.

Biology

Adult Platycnemididae are small damselflies, very similar to Coenagrionidae. Platycnemididae males can be differentiated due to their leaf-like, flattened and broadened tibiae (see Ocharan 1987). In Europe, only one genus is present, *Platycnemis* Burmeister 1839, with three species in the Iberian Peninsula.

This family always inhabits running waters. In Spain, larvae of *Platycnemis latipes* Rambur 1842 are one of the most common, living in very different types of waters (even waters with deficient ecological conditions). On the contrary, *Platycnemis acutipennis* Sélys 1841 is very rare and *Platycnemis pennipes* (Pallas 1771) has only been cited in the far northeastern part of the Peninsula (Boudot et al. 2009).

Aphelocheiridae

Description

Aphelocheiridae (Fig. 3.11a–c) are animals with a very flattened, more or less oval body, similar to Naucoridae. The dorsum is darker than the ventral side. The head is subtriangular and the eyes are relatively small. The do not have ocelli. The antennae are elongate and slender, sometimes observed in dorsal view. They have a characteristic rostrum, which is relatively long and surpasses the insertion area of the mid-legs. The forelegs are slender, with the femur barely widened or flattened. Unlike Naucoridae, the forelegs are not raptorial. They generally have small hemielytra that do not cover the abdomen, although apterous specimens are most common (Nieser et al. 1994).

Biology

Aphelocheiridae are benthonic organisms that live in running oxygen-rich waters, although its presence has also been recorded in northern European lakes and in some ponds and wetlands. They are primarily nocturnal, which might have biased the results of the sampling efforts. They prefer areas with stone and gravel substrates, where they live in microhabitats with slower currents and margins with vegetation. They are not good swimmers and usually walk on the river bottom, looking for food. They are predators that feed on other aquatic invertebrates, sucking their juices with their long beak. They have a plastron (a patch of cuticle around the abdomen covered with hairs which retain a thin layer of air) that allows them to live permanently submerged, as it exchanges gases

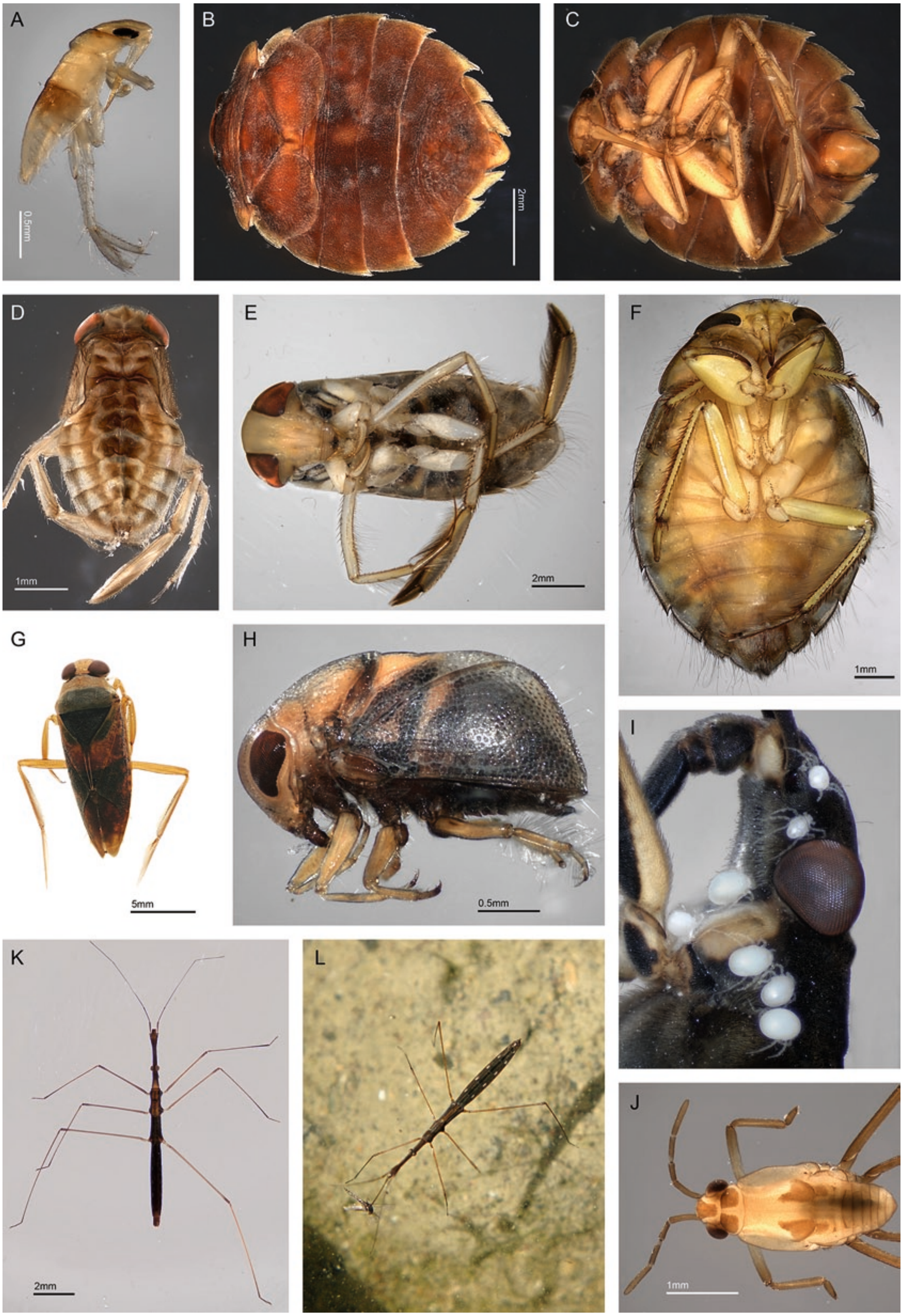

Fig. 3.11 (**a**–**c**) Aphelocheiridae; (**d**, **e**) Corixidae; (**f**) Naucoridae; (**g**) Notonectidae; (**h**) Pleidae; (**i**, **j**) Gerridae: phoretic acari on Gerridae specimen (**i**), immature specimen (**j**); (**k**, **l**) Hydrometridae

with water in a similar manner than lungs or gills. In the Iberian Peninsula, three species belonging to this family have been found. They are considered to be indicators of good quality waters due to their low tolerance to pollution.

Corixidae

Description

Corixidae have a flattened and more or less oval-shaped body (Fig. 3.11d, e). Their head is triangular (in frontal view), with two big eyes, one on each side of the head. They do not have ocelli. The antennae are smaller than the head (3–4 segments) and are hidden behind the eyes. The rostrum has one segment. It is relatively wide and short, triangular, and in some species it can have transversal grooves. They have a dorsal pattern with small light and dark markings. The scutellum is hidden by the pronotum (except in the subfamily Micronectinae). The hind legs are modified for swimming: their tarsi are flattened and bear numerous setae. The first pair of legs is not modified for swimming and it is used for feeding instead.

Biology

In the Iberian Peninsula, Corixidae is the most extended and diverse family within Heteroptera (Nieser et al. 1994). It is also the best adapted to freshwater environments. They live mainly in lentic environments, such as river backwaters and streams, reservoirs, lagoons, lakes and ponds (both temporary and permanent), where they can be very abundant. They are very good swimmers and feed mainly on algae and detritus, although some species are omnivorous and even predators. They usually live close to the bottom. While resting, they anchor to some object with the claws on their mid-legs. Periodically, they ascend from the bottom to renew the air supply, delineating characteristic zigzag patterns. Adults have a good flight capacity. Thus, dispersion to new aquatic environments or abandonment of those in which conditions have become unfavourable is relatively easy. Some species can live in environments with high salinity. In the Iberian Peninsula, 42 species have been recorded.

Naucoridae

Description

Naucoridae are small to medium-sized insects, dorsoventrally compressed and oval-shaped (Fig. 3.11f). The head is not very visible in dorsal view. Antennae are short (four segments), hidden under the eyes. The beak-shaped rostrum is small, barely reaching the base of the first pair of legs. Ocelli are absent. The pronotum is trapezoidal and the scutellum triangular, with the wings covering most of the abdominal segments but not their margins. The forelegs are raptorial, with a greatly broadened femur. The hind legs are modified for swimming.

Biology

Naucoridae live in fluvial systems with weak or no currents (Nieser et al. 1994). They can be found inside dense clumps of macrophytes. They are very active predators that dive to catch their prey (mainly insects, small crustaceans and aquatic mollusks), although they can also hunt by stalking prey. They need to renew their air supply, resurfacing from time to time. Their bite can be very painful. Adults can disperse between sites due to their flight abilities. In the Iberian Peninsula, two species belonging to this family have been recorded.

Nepidae

Description

Nepidae (Fig. 2.17e) are greyish-brownish animals that can show two morphologies: either oval-shaped and dorsoventrally flattened, or more or less cylindrical and elongated. The head is very prognathous, very small and with rounded lateral eyes and a beak-like rostrum. Antennae are 3-segmented and shorter than the head. The forelegs are raptorial, very specialised for this function as the tibia is folded completely over the femur forming a claw. The remaining legs are locomotory and not modified for swimming. They have a characteristic long respiratory siphon, located at the tip of the abdomen. The siphon is made by two terminal processes or anal appendages that form a tube when they merge. This character, along with the first pair of legs, differentiates them from the other aquatic

Hemiptera. In the youngest specimens the siphon can be reduced. Two species have been recorded in the Iberian Peninsula (Nieser et al. 1994). *Nepa cinerea* Linnaeus 1758 has a very flattened and oval body. *Ranatra linearis* (Linnaeus 1758) has a cylindrical, slender and elongated body, resembling a branch.

Biology

Nepidae live in backwaters of rivers and streams, as well as wetlands and lakes. They are usually on the banks of rivers with submerged vegetation or in areas with sediments that can be used for camouflage. They are predators of insects, young fish or tadpoles, which they hunt using their raptorial legs, stalking among the vegetation or slowly advancing on the substrate. In order to breathe, they take the tip of their respiratory siphon to the surface of the water (Sansoni 1988). Of the species that live in the Iberian Peninsula, *Ranatra linearis* requires cleaner waters with few detritus, while *Nepa cinerea* can tolerate a certain degree of organic matter content in the environment. It appears that *Nepa cinerea* can hibernate on land during the winter.

Notonectidae

Description

Notonectidae are medium-sized insects with an elongated and slightly broadened body, more or less cylindrical, although the ventral side is flatter and the dorsal side is more convex (Fig. 3.11g). Because they swim on their back, some species show a reverse colouration, with a darker ventral side and a lighter dorsal side. The head is opisthognathous, with relatively big eyes, small antennae that hide beneath the eyes, and a short and cylindrical beak. The pronotum is smooth, without marks on its surface. Similarly, and unlike Pleidae, the wings that completely cover the abdomen are also smooth, without marks on their surface. The hind legs are well developed and have a strip of setae. They are also modified for swimming, and therefore appear paddle-like.

Biology

Notonectidae live preferentially in standing waters, such as lakes, reservoirs or ponds, although they can also be found in river pools and backwaters, as well as marshes and temporary waters. They swim on their dorsum, beating their third pair of legs. The second pair of legs is used to clasp to vegetation and catch their prey, for which they also use their first pair of legs. When they feel threatened, they quickly swim towards the bottom or towards nearby vegetation to hide. They usually swim on the surface with the tip of the abdomen in contact with the water surface to renew the air chamber that they have under the wings and abdomen. They are predator species, feeding on a great variety of prey, from zooplankton to small tadpoles or young fish, although they mainly eat larvae and pupae of aquatic Diptera. The youngest individuals normally eat small crustaceans and as they grow up, prey size increases. If they accidentally bite humans, the bite is very painful (Tamanini 1979). Most species lay eggs inside soft plant tissues, although some stick them on stones or on the outer parts of aquatic plants (Nieser et al. 1994). In general, they tolerate some degree of pollution and alterations in water flow.

Pleidae

Description

Pleidae are small Hemiptera, generally less than 3 mm (Fig. 3.11h). Their body is greatly broadened and somewhat laterally compressed, triangular in cross-section and with a very convex dorsum, which gives them a characteristic appearance of humpback organisms. They are chestnut-brown with small dark markings. Antennae are small (3-segmented) and hidden beneath the eyes. The beak is short (4-segmented) and the scutellum is clearly visible, small and triangular. The surface of the pronotum and the hemielytra has multiple dotted marks. Similarly to other groups, the hind legs are modified for swimming, although they only bear one strip of setae and they are not paddle-like. All legs have similar size and end in two tarsal claws.

Biology

Pleidae preferentially live in lentic areas with plenty macrophytes, such as lakes, ponds, marshes or wetlands. They are not too frequent in rivers, although they can appear in pools or lower reaches of rivers with good emergent vegetation (Tamanini 1979). They are good swimmers and swim on their backs, although they barely move and can usually be found among plants, where they shelter from other predators and also stalk preys. They are predators, usually feeding on small crustaceans, mosquito larvae and other invertebrates, by sucking their juices with their strong beak. They lay eggs on the stalks of aquatic plants. Along with Aphelocheiridae, Pleidae are the only Hemiptera that breathe using a plastron. They use this respiratory system especially during hibernation (Nieser et al. 1994). In the Iberian Peninsula, only one species has been recorded (*Plea minutissima* Leach 1817) (Nieser et al. 1994).

Gerridae

Description

Gerridae are medium-sized insects with an elongated body and dark colouration (Fig. 2.17 and Fig. 3.11i, j). Their head is short, more or less triangular, and with a pair of big and spherical eyes that protrude laterally. Their antennae (4-segmented) are longer than the head, and the mouth pieces are modified into a long sucking beak. The legs, modified to walk on the water surface, are long and have hydrophobic setae in order to avoid breaking the surface tension of the water. The first pair of legs is very separated from the second pair. The femur of the hind legs surpassses the end of the abdomen. Some species show a high wing polymorphism (with macropterous, brachypterous and apterous individuals), which allows them to have different adaptive strategies in their life cycles.

Biology

Gerridae are the most common and widely known group of semiaquatic hemipterans. They live in standing waters such as pools, lakes, backwaters and rivers and streams of weak currents. The family also comprises some marine species. They form large aggregations of individuals, gliding over the water with the help of their second and third pair of legs. They can locomote on land, although they are not very agile (Nieser et al. 1994). They are active predators that catch their prey with their beak and use their forelegs to manipulate them. They mainly feed on terrestrial insects that fell in the water, but also on all sorts of macroinvertebrates that get close to the surface to either breathe or emerge. They tolerate environmental changes (such as organic pollution) very well, as long as the surface tension of the water is not reduced, which would prevent them from gliding over it.

Hebridae

Description

Hebridae are small hemipterans, similar to Veliidae. They can be differentiated from the latter because their claws insert apically. The body is short and stout, more or less oval-shaped and velvety, due to the dense net of hairs they possess. The pronotum is trapezoidal, with prominent “shoulders”. The head is similar in length and with salient bucculae. The antennae seem to have five segments due to a subdivision of the fourth segment. The rostrum is cylindrical. There are only winged forms.

Biology

Hebridae species mainly inhabit well vegetated shores of different aquatic systems, such as ponds, marshes and rivers (Campaioli et al. 1994). They live on floating plant accumulations or over moss in these very same ecosystems. They are considered semi-aquatic organisms. They are predators that feed on small arthropods. In the Iberian Peninsula, only one species has been found so far (*Hebrus pusillus* (Fallen 1807)).

Hydrometridae

Description

Hydrometridae have a very characteristic morphology (Fig. 3.11k, l). They have a dark body, extremely thin, with long and slender legs. Their most peculiar feature is their head, almost as long as the thorax and with spherical posteromedial eyes (Fig. 2.17b). The antennae are 4-segmented and also very long (sometimes longer than the head). The beak is very long as well. The legs end in two tarsal claws that insert terminally. There are both, macropterous and micropterous specimens.

Biology

Hydrometridae are semiaquatic hemipterans that live on river shores nearby riverside vegetation, as well as in terrestrial habitats with high humidity and on water surfaces with floating vegetation. They walk over the surface of the water, stones and blocks on the shore. They feed on terrestrial insects and aquatic invertebrates, normally those that are wounded or dead (Puig 1999). According to Nieser et al. (1994), only one species has been recorded in the Iberian Peninsula (*Hydrometra stagnorum* (Linnaeus 1758)). Similarly to the family Gerridae, they show a certain degree of tolerance to different alterations in the environment.

Mesoveliidae

Description

Mesoveliidae (Fig. 3.12a, b) are morphologically very similar to Veliidae and Gerridae. They are olive green with dark markings. Their body is more or less elongated and they have 4-segmented antennae. The rostrum is cylindrical. The tarsal claws insert apically. The legs are progressively longer and the coxae of the third pair of legs insert ventrally, with the legs appearing as if they are converging in the body axis. The femur of the hind legs surpasses the tip of the abdomen. There are macropterous forms, although apterous forms are more common (Tamanini 1979; Campaioli et al. 1994).

Biology

Mesoveliidae species live in well vegetated shores of marshes, lakes, lagoons or rivers, preferentially occupying shaded areas (Tamanini 1979). They can also be found on floating plants, such as *Nuphar* Sibthorp and Smith 1809, *Lemna* Limnaeus 1758 and *Nymphaea* Limnaeus 1753, and sometimes even in terrestrial habitats with high humidity. They feed preying on dying or dead insects (particularly dipterans) on riverbanks or on the water surface (Nieser et al. 1994). They lay eggs on plant tissues. In the Iberian Peninsula, only one species has been recorded (*Mesovelia vittigera* Horvath 1895) (Nieser et al. 1994).

Veliidae

Description

Veliidae are very dark hemipterans (Fig. 3.12c), morphologically very similar to Gerridae species, but with a shorter and more broadened body, and a similar distance between pairs of legs. The antennae are 4-segmented and longer than the head. The rostrum is cylindrical. Tarsal claws insert subapically, which helps them locomote over the water surface. The coxae of the hind legs insert laterally. In general, the femur of the hind legs does not surpass the end of the abdomen, which is truncated in adult animals. Although usually apterous, individuals of some species can have wings.

Biology

Veliidae live in groups over the water surface in standing water areas or areas of slow water areas in all sorts of aquatic ecosystems (Tamanini 1979). They prefer shaded areas with clean and calm waters, such as the sheltered shores of rivers, streams, ponds or reservoirs; living among vegetation, or under trunks or rocks. It is not usual to find them in the open, unsheltered waters. Their feeding habits are similar to Gerridae, catching prey (small crustaceans, dipteran larvae and mayflies) with their forelegs. They glide over the water with the help of their second pair of legs. In the Iberian Peninsula, 10 species belonging to this family have been recorded.

Sialidae

Description

Sialidae (Fig. 3.12d) is the only megalopteran family present in the Iberian Peninsula (Monserrat 1986). It is the most primitive group within Neuroptera, and includes around 300 species distributed in temperate and tropical regions (Aspöck et al. 2001). Among the Iberian fauna, three valid species belonging to this family have been found: *Sialis lutaria* (Linnaeus 1758), *Sialis fuliginosa* Pictet 1836 and *Sialis nigripes* Pictet 1865. The different species are easily differentiated by their genitalia (of both male and female), and larvae can be differentiated by their tegumentary

Fig. 3.12 (**a**, **b**) Mesoveliidae; (**c**) Veliidae; (**d**) Sialidae; (**e**) Sisyridae; (**f**–**h**) Pyralidae; (**i**) Ichneumonidae; (**j**) Curculionidae; (**k**, **l**) Dryopidae: larva (**k**), adult specimen (**l**)

structures and pigmentation (Killington 1936, 1937; Kimmins 1944; Elliott et al. 1979).

Imagos in this family are large insects, with chewing mouth pieces, and if they feed at all at this stage, their feeding habits are unknown. They are black or of a very characteristic dark brownish color. While resting, they fold their wings roof-like over the abdomen (Gepp 1984, 1990).

Biology

Sialidae imagos are inconspicuous, do not fly very well and are usually not very active (slightly more active in the morning) (Elliott 1977). They have short lives, dying in 1–2 weeks. They are associated with running waters, lakes and pools, where they can be locally frequent in the spring (Kimmins 1962). It is easy to spot them landed on the riverside vegetation, where they spend most of their time and where they deposit their peculiar, compact lays of up to 900 eggs. Females are a bit larger than males. Both sexes produce courtship sounds through abdominal vibration. Mating occurs on land and sperm is transferred via a spermatophore. They have a single annual generation and larvae are aquatic. On their first days, larvae are planktonic and are dragged by the current, but they eventually become benthonic. They are campodeiform, predatory (eating chironomid larvae and oligochaetes) and have characteristic respiratory structures on the abdomen. Up to ten developmental stages have been observed. They have one single annual generation and their biological cycle (from egg to imago) takes 2 years. Although they are obviously adapted to non-anthropomorphic environments, they are relatively tolerant with respect to the quality of the water where they develop. Pupae are exarate and terrestrial, going through pupation burrowed in humus and in the substrate (Aspöck et al. 1980; Fitter and Manuel 1986).

Osmylidae

Description

Osmylidae is a cosmopolitan and diverse family with around 160 species (Aspöck et al. 2001). There is only one species among the Iberian fauna: *Osmylus fulvicephalus* (Scopoli 1763). Its imagos are medium-sized insects, with slightly falciform wings. These wings present a dense, much reticulated venation that bifurcates towards the wing margin (Kimmins 1944; Monserrat 2005). They are also iridescent, hyaline and mottled with brown. While resting, their wings are folded roof-like over the abdomen. They have chewing mouth pieces (Gepp 1984, 1990).

Biology

Imagos of this family are fluid suckers or predators of small arthropods. They also feed on pollen, nectar and fungal hyphae. They are not very active, do not fly much and are crepuscular or nocturnal (Killington 1932). For all these reasons, they are not very visible or familiar. They are active at the end of the spring and during the summer, and they are associated with running waters and shaded areas with plenty arboreal riverside vegetation, where they can be relatively abundant. Sometimes they can be found under bridges. They do not tolerate environmental disturbances, which is why they are very selective and their distribution is regressing. Imagos live for several months and males have abdominal glands that can be evaginated to attract females. Sperm transfer occurs via a spermatophore. Females lay around 30 eggs among vegetation and moss near the water. They only have one generation per year and their biological cycle (from egg to imago) requires a year to be fulfilled (Kimmins 1962). Larvae are campodeiform and have three larval stages with characteristic long mouth pieces and terminal serrated structures that can be evaginated. They are predators (first of acari and collembola, and as they grow, they feed on dipteran larvae). They can be terrestrial or aquatic, although they are better described as amphibian, living under boulders and barks, at the riverside and on mosses. Pupae are exarate, terrestrial and deposited on land, particularly over moss (Ward 1965; Aspöck et al. 1980).

Sisyridae

Description

The family Sisyridae (Fig. 3.12e) is cosmopolitan and comprises some 50 species (Navás 1935; Parfin and Gurney 1956; Monserrat 1977). In the Iberian Peninsula, four of these species can be found: *Sisyra nigra* (Retzius 1783), *Sisyra terminalis* Curtis 1854, *Sisyra dalii* McLachlan 1866 and *Sisyra iridipennis*

Costa 1884 (Monserrat 1986). Adults of these species can be easily identified by the colour of their tegument and wings, and particularly by their genitalia (of both male and female). Larvae are also easy to identify by their structures and tegument pigmentation. The imagos are small-sized insects. Their wings have rounded margins and they are iridescent and straw-coloured, sometimes mottled with dark colours. While resting, the wings fold roof-like over the abdomen.

Biology

Sisyridae usually inhabit bankside vegetation, from the end of the spring and through the summer. They are active, although they do not fly much and adults have brief lives. Imagos are crepuscular or nocturnal, and thus not very visible or familiar. However, they can be locally very abundant. Imagos also have chewing mouth pieces, feeding on fluids or predating on small arthropods. They also feed on pollen, nectar, algae, yeasts and fungal hyphas (Kokubu and Duelli 1983; Pupedis 1987). They are associated with lakes, rivers, channels, etc. Usually they do not tolerate pollution and are therefore very selective, with a regressing distribution. Sperm transfer occurs via a spermatophore. Females lay a few eggs on vegetation, barks and objects near the water. They have one or two annual generations, and their biological cycle (from larva to imago) requires less than a year to be completed. If conditions are favourable, it might only take 4–5 months. Larvae are campodeiform, with three larval stages. Larvae also have characteristic elongated mouth pieces and abdominal respiratory structures. They are predators or parasites of freshwater sponge colonies (*Spongilla* Lamarck 1816, *Ephydatia* Lamouroux 1816), following their distribution and requirements (Brown 1952; Parfin and Gurney 1956). They have also been found on algae and bryozoa. Their pupae are exarate, terrestrial and laid on barks, in cracks or over walls.

Pyralidae

Description

Pyralidae is one of the few lepidopteran families that have aquatic larvae (Fig. 3.12f–h). In general, aquatic larvae are morphologically similar to terrestrial larvae (except for *Paraponyx* Guenée 1854, which has gills on its body). They have three pairs of relatively small segmented legs and a well sclerotized cephalic hypognathous capsule. They have short antennae and two areas with several simple eyes on each side of the head. The pronotum has at least one sclerite, while the remaining segments of the thorax are membranous. They have five pairs of prolegs ending in a crown of hooks in abdominal segments 3–6 and 10. Some species have filiform and branched gills in some thoracic and abdominal segments.

Biology

There are not many true aquatic lepidopterans (i.e. lepidopterans whose larvae live submerged in water for all or most of their larval stage). Therefore, many could be more appropriately considered semiaquatic. They live both in standing and lentic areas of running waters, and always associated with macrophyte plants. They are phytophagous and therefore, these are their main food item. Close associations between species can be observed. Some feed also on microscopic algae that can be found on vegetation and the microflora associated with decaying vegetal matter (Puig 1999). Respiratory mechanisms comprise tegumentary structures all the way to gills in some species. Some larvae can build cases with vegetable particles that can attach to plants during pupation, similar to caddisfly cases but less elaborated (González and Cobo 2006).

Ichneumonidae

Description

The only sampled specimens from the family Ichneumonidae are specimens of the species *Agriotypus armatus* Curtis 1832 (Fig. 3.12i). Mature larvae are apodal and hemicephalic, with a semi-spheric head. The thorax has three visible segments and the abdomen 10. The mouth pieces and adjacent sclerites to the cranium are well sclerotized. They have a labrum sclerite and single-toothed mandibles, which are also wide and triangular, not divided and each with two rows of tooth-like projections on the external distal area. The labial sclerite is subquadrangular. Maxillary and labial palpi are disc-shaped. Antennae are papillate. The thorax and the abdomen are weakly sclerotized. The thorax has spiracles in the posterior part of the prothorax, although they have a mesothoracic origin. The abdomen has a respiratory caudal siphon. For more details on the cephalic morphology of Ichneumonidae, see Short (1978).

Biology

Agriotypus armatus is an idiobiont ectoparasite of the prepupae and pupae of the caddisfly families Goeridae and Odontoceridae (Grenier 1970; Elliott 1982). Their life cycle is univoltine (Clausen 1962; Elliott 1982). During spring, the female submerges in the water to find a host, using an air bubble that contains the antennae, the dorsum and the wings, and that she has previously built thanks to the dense pubescence of her body (Clausen 1962). Females may lay one or more eggs, but only one of those eggs will develop (Elliott 1982, 1983). Larvae go through five larval stages (Elliott 1982). The pupal stage takes place between August and October (Grenier 1970; Elliott 1982). The imago stage goes through winter diapauses inside the host cocoon (Fisher 1932), until the following spring, where it will emerge when water temperature reaches 13°C (Clausen 1962).

Chrysomelidae

Description

Chrysomelidae adults have a head without a rostrum, usually with a frontal groove. Antennae are long and filiform, with 11 antennomeres. The external margin of the elytra is has a strong distal denticle. Tarsi are 4-segmented, with the third segment short and bilobate. Body length ranges from 5.6 to 13.5 mm.

Larvae are thick and curved, C-shaped (scarabeiform). The labrum is separated from the cephalic capsule by a suture. They have ten abdominal segments and claws or stigmatic hooks on the eighth abdominal segment. Legs have four segments.

Biology

Chrysomelidae is a family of mostly terrestrial coleopterans, with only two aquatic representatives within the subfamily Donaciinae. In the Iberian Peninsula, two genera have been recorded, *Donacia* Fabricius 1775, and *Plateumaris* C.G. Thomson 1866, with a total of 20 species (Ribera et al. 1999). They are commonly known as "water lily beetles". Species of this family live associated with leaves, roots, aquatic plants and riverbank vegetation.

Both adults and larvae are phytophagous. Adults feed on plants floating on water surfaces or on submerged or emergent parts of macrophytes. Larvae feed on submerged roots and stems, even burrowing inside plants to obtain nourishment (Nilsson 1996).

Most species are univoltine, with one generation a year. Mating takes place on emergent parts of macrophytes. Females deposit amalgamations of eggs on plant surfaces or over the water surface (Nilsson 1996). After hatchling, larvae look for a place in a plant to settle in. Larvae, and perhaps adults, can remain under water for long periods, using submerged plants to obtain oxygen. Larvae pupate on the same plant, inside air-filled cocoons.

Curculionidae

Description

Curculionidae adults are rarely mistaken with other coleopterans due to the presence of a well developed rostrum with two antennae (Fig. 3.12j). The antennae have 7–11 antennomeres and a club of 1–4 antennomeres. The labrum is not visible and the palpi are reduced and immobile. Tarsi are 5-segmented, with the fourth segment reduced and covered by the lobes formed by the third segment. They are 0.8–40 mm long.

Larvae are easily differentiated because they do not have legs (Peterson 1960). They are thick and curved, C-shaped (scarabeiform). Labial palpi have two segments. The abdominal spiracles normally form processes similar to spines. The third tergite has three transversal grooves.

Biology

The family Curculionidae is the most diverse worldwide, with approximately 60,000 species described (Jäch and Balke 2008). The only aquatic representatives belong to the tribe Bagoini. In the Iberian Peninsula, only the genus *Bagous* Germar 1817 has been recorded, with 23 species (Ribera et al. 1999). Bagoini species are associated with aquatic plants.

Usually only adults are sampled in aquatic habitats; however, in the case of *Bagous*, both adults and larvae live in standing waters with weak currents (Palm and Nilsson 1996). Adults creep among submerged vegetation, while larvae live inside aquatic plant stems filled with air. Both adults and larvae are phytophagus shredders (Palm and Nilsson 1996). Adults feed on leaves, while larvae burrow tunnels inside petioles and feed on the plant internal tissues. This behaviour causes tissue decay and death.

They mate in the emergent parts of aquatic plants and they use their long rostrum to perforate plant tissue and insert the eggs in an internal cavity. Larvae hatch in 3–4 days and go through 3–4 larval stages. The last larval stage leaves the plant to pupate on dry soil.

Dytiscidae

Description

Dytiscidae adults have a series of adaptations for swimming, such as a hydrodynamic body, strong hind legs, swimming hairs and very large coxae (Fig. 3.13a–i). Body shape and colour vary, from oval to elongated, from light brownish to black. Antennae are filiform with 11 antennomeres. Metacoxal apophyses are narrow but vary in shape. Tarsi are 5-segmented. Body length fluctuates between 1 and 55 mm. The head of larvae are longer than wide, with the labrum fused to the cephalic capsule without a suture (Peterson 1960). Mandibles are long, narrow, arched and with a groove. Legs are long, with five segments and two claws. They do not have gills. They have very developed urogomphi and a conical terminal tergite.

Biology

Dytiscidae are one of the most diverse aquatic coleopteran families, with 4,000 species described belonging to 175 genera (Jäch and Balke 2008). Currently, there are 33 recorded genera and 151 species in the Iberian Peninsula (Ribera et al. 1999; Fery and Fresneda 2007). "Diving beetles" live in almost all types of aquatic habitats, being very abundant on lake shores, ponds, puddles, dams, temporary streams and lagoons.

Both larvae and adults are predators of insects, crustaceans, leeches, molluscs, tadpoles and small fish. Many larvae have their mouth opening shut, and use the mandibular groove to inject digestive enzymes inside their prey and then suck the resulting fluids (González and Cobo 2006).

Larvae and adults breathe atmospheric air. Adults take air on from the water surface before they submerge again and storage it in bubbles underneath the elytra. Larvae use a siphon located at the tip of the abdomen to take air.

Males have a great variety of strategies to mate. For example, they can use the setae on their leg suckers to retain females so these cannot escape. Females lay eggs inside stems of aquatic plants. The first larval stage remains inside the plant, which makes it independent of atmospheric air, while the second and third stages need to breathe atmospheric air, using a pair of spiracles at the margins of their abdomen. Pupation occurs outside the water (Nilsson 1996), on wet soils and in cells build by larvae. The new adults return to water and retain their capacity to fly, which they use to move from one environment to another when conditions are adverse.

Elmidae

Description

Elmidae adults have an elongated or oval body, black or brownish, sometimes with reddish or brownish markings or stripes (Fig. 3.13j–k). The surface of the dorsum is glabrous and the ventral surface has modified setae to trap oxygen from water, forming a respiratory plastron. Antennae are long, filiform or claviform with 7–11 antennomeres. Legs are long, slender, with very developed claws. Tarsi have five segments. Body size varies between 1 and 10 mm long. Larvae usually have an elongated body, sometimes depressed (Peterson 1960). The labrum is separated from the head by a suture. The abdomen has nine segments. The last abdominal segment is longer than wide, triangular and emarginated, with anal gills that sometimes retract underneath the operculum. Legs are 4-segmented.

Biology

Worldwide approximately 1,330 species are known, belonging to 146 genera (Jäch and Balke 2008). In the

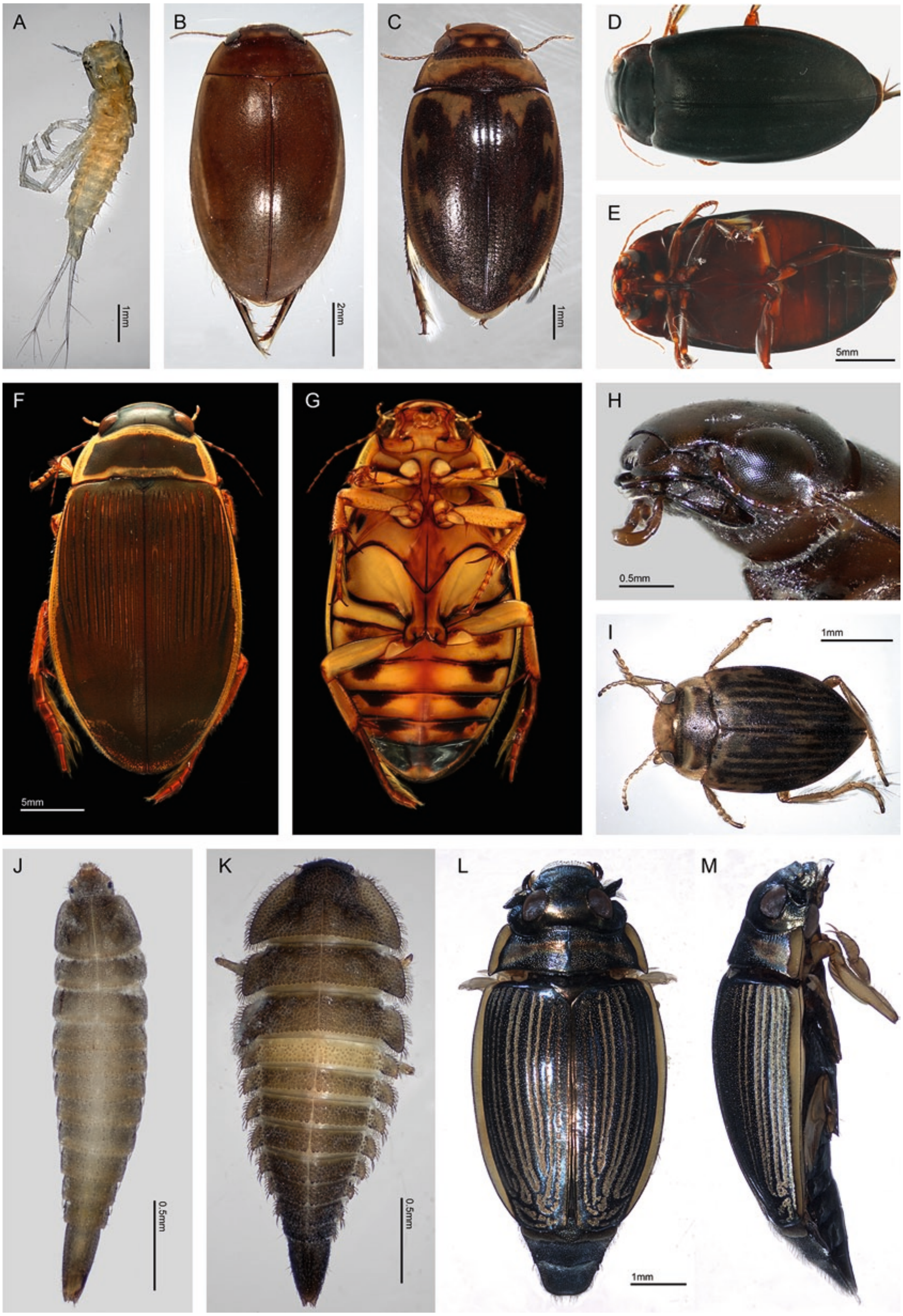

Fig. 3.13 (**a**–**i**) Dytiscidae; (**j**, **k**) Elmidae larvae; (**l**, **m**) Gyrinidae adult specimens

Iberian Peninsula, 10 genera and 30 species have been described (Ribera et al. 1999). They live mainly in lotic environments, usually with well oxygenated, clear and clean waters. They prefer stone bottoms with strong currents. The subfamily Elminae presents species in which both larvae and adults are aquatic, while Larainae species' larvae are aquatic but their adults are semiaquatic and live in marginal areas or on the emergent surface of rocks and stones in streams and rivers. They are phytophagous (Nilsson 1996). They feed on vegetable matter, algae and fine detritus, or pieces of submerged wood associated with algae and fungi. Larvae breathe through tracheal gills. Elminae adults breathe dissolved oxygen using a respiratory plastron. Larainae breathe atmospheric air. Most species live grazing over the substrate, both in the larval stage and as adults, as they are capable of active swimming. Elmidae species have very long life cycles, of up to 3 years. Eggs are laid over submerged rocks. Larvae undergo 5–6 larval stages (Nilsson 1996). The last larval stage develops a series of spiracles on the body edges, which allows them to exit the water. Pupation occurs on wet soil on the margins of water bodies where they can survive for long periods. After emerging, adults have a short flight period, after which they submerge in the water and do not fly ever again (Nilsson 1996).

Gyrinidae

Description

Gyrinidae adults have a shiny elliptical body, clearly hydrodynamic, black with shades of green, blue, golden or copper (Fig. 3.13l, m). The shape of the eyes is the distinctive character of this group, as they are divided in two parts (dorsal and ventral). Antennae are short, claviform, with 8–11 antennomeres fused in different degrees depending on the species.

Gyrinidae are excellent gliders, with the last two pairs of legs modified into swimming paddles. Tarsi are 5-segmented. The length of the body can range from 3 to 15 mm, although most species range between 5 and 6 mm long. Larvae have narrow, falcate mandibles with internal perforation. The labrum is completely fused to the cephalic capsule (Peterson 1960). Legs have five segments and two claws. The abdomen has lateral gills and four anal claws (Fig. 2.11c).

Biology

Worldwide, 750 species have been described, belonging to 13 genera (Jäch and Balke 2008). In the Iberian Peninsula, three genera and 11 species have been recorded (Ribera et al. 1999). Both adults and larvae are strictly aquatic. Usually they inhabit clear, clean waters with weak or no current, especially at the margins of lakes, lagoons, dams and backwaters of rivers. Adults are predators of insects found on the superficial layer of the water. They locate preys using a specialised organ situated on their antennae. This organ is sensitive to superficial waves (González and Cobo 2006). Larvae are predators that inhabit on the substrate and feed on a great variety of animals of soft bodies, such as earthworms, chironomid larvae and odonate nymphs.

They are commonly known as whirligig beetles, due to their habit of spinning in circles over the water surface (Nilsson 1996). They have gregarious habits and form colonies over the water surface. Their eyes are divided, which allows them to see both over and under the water surface. Larvae stay submerged during all stages and they obtain oxygen from water using their abdominal gills (Nilsson 1996).

Mating occurs on the water surface. Females lay eggs on stems of emergent vegetation under the water surface. Eggs open after 8–14 days (Nilsson 1996). Larvae undergo 2–3 developmental stages. The last larval stage ascends to the surface and crawls to the shore, where it pupates over sand or mud.

Haliplidae

Description

Haliplidae adults have an oval and glabrous body, with colours that go from testaceous to black, usually with markings on the elytra (Fig. 3.14a–c). Antennae are long, filiform and with 11 antennomeres. Legs are elongated. They have enormous metacoxal plates that cover most of the hind legs. These, along with the first three abdominal sternites, are the distinctive characters of this group. Tarsi are 5-segmented. Body length ranges from 1.5 to 5 mm.

Larvae mandibles are wide at the base and narrow at the apex, with internal perforation. The labrum is completely fused to the cephalic capsule.

Fig. 3.14 (**a**–**d**) Haliplidae: adult specimens (**a**–**c**), larva (**d**); (**e**) Hydraenidae; (**f**, **g**) Helophoridae; (**h**) Hydrophilidae larva; (**i**) Psephenidae larva in ventral view; (**j**) Scirtidae

The tenth abdominal segment is much longer than the preceding one (Fig. 3.14d). Legs have five segments and one tarsal claw.

Biology

There are approximately 200 Haliplidae species known, belonging to five genera. They can be found in every continent, although they are more diverse in northern temperate regions (Jäch and Balke 2008). In the Iberian Peninsula, three genera and 14 species can be found (Nilsson and Van Vondel 2005). Both adults and larvae live in a wide variety of freshwater habitats. They are most commonly found in permanent ponds or lakes with clean, nutrient-rich waters or in backwaters (Nilsson 1996).

Adults and larvae are phytophagous, shredders and perforators. Larvae feed on algae and other plants. Some can suck vascular tissues through the perforations on their mandibles. Adults feed on several types of algae, although some can be predators of small insect larvae. They are commonly known as "crawling water beetles". Adults comb the surface, as they are not good swimmers. They can also walk on land and are capable of flying. Adults breathe atmospheric air, which they store in a subelytral cavity and in between the metacoxal plates. Larvae creep on the bottom or over submerged vegetation, and they have cutaneous or tracheo-branchial respiration. Mating occurs from spring to autumn. Females lay eggs at the beginning of the spring and during the autumn, over filamentous algae or in cavities opened by the oviscapt or the mandibles inside plant stems (González and Cobo 2006). Eclosion is followed by three larval stages. The last larval stage exits the water to pupate on the humid soil of water margins (Nilsson 1996). In areas with Mediterranean climate, species are very seasonal and adults emerge when the rainy season starts.

Hydraenidae

Description

Hydraenidae adults are small coleopterans (usually less than 2 mm) (Fig. 3.14e). The main distinctive characteristic of this group is the long maxillary palpi. They have an elongated body (or broadened in the case of the genus Limnebius Leach 1815) and dorsal brown, reddish or black colouration, rarely testaceous. Some Ochthebius Leach 1815 species have metallic, greenish or copper colourations. Ventrally they can have a hydrophobic pubescence, capable of retaining water oxygen and therefore forming a respiratory plastron. Antennae have 8–9 antennomeres, with the last five forming a pubescent club. Tarsi are 5-segmented.

Larvae have antennae with three antennomeres and maxillary palpi with 2–3 segments. The labrum is separated from the cephalic capsule by a complete suture. The ninth tergite has a segmented urogomphus. Legs are 4-segmented.

Biology

The family Hydraenidae has around 40 genera and 1420 species worldwide (Jäch and Balke 2008). In the Iberian Peninsula, four genera and 139 species have been described (Ribera et al. 1999). They inhabit a wide variety of aquatic environments, such as river margins and streams with gravel or sand substrates and permanent or temporary standing waters. Adults of most species are aquatic, but some are riparian or terrestrial and a few species are exclusively found over rocks in hypersaline ponds. In general, larvae are riparian or terrestrial (Hansen 1996), although in some species the first larval stage is aquatic. They cannot fly and tend to get trapped in the superficial layer of the water, where they appear as silvery spots. To avoid this, these beetles remain in the lower part of the superficial layer of the water and when they get close to an emergent object, they attach to it and quickly crawl beneath the surface.

Adults are phytophagous and feed on algae, while larvae are phytophagous, detritivorous or even scavengers. Eggs are deposited over wooden substrates or small boulders under the surface of the water. The first larval stage exits the water to continue its life cycle on land, undergoing two more larval stages until pupation.

Hydrochidae

Description

Hydrochidae adults (Fig. 2.9g) have a narrow body with strongly punctate elytra that leave the last two abdominal segments free. Antennae have 7–9 antennomeres, with the last few (3–4) forming a pubescent club. The eyes are protruding. The pronotum is widest on the anterior or medial regions. The basal segment of the last tarsi is shorter than the second one. The length of the body ranges from 0.5 to 7 mm.

Larvae have a labrum that is completely fused to the cephalic capsule. The mandibles have a tooth at the apex and a pubescent lobe at their base. The abdomen has nine tergites and the eighth spiracle forms an elongated spiracular chamber.

Biology

The only genus of this family, *Hydrochus* Leach 1817, comprises 180 species worldwide (Jäch and Balke 2008), of which 11 have been recorded in the Iberian Peninsula (Ribera et al. 1999). All species are strictly aquatic. They live both in running and standing water environments. Adults are common wherever standing waters occur, living in a wide range of habitats, from lakes to stony margins of large rivers, usually in areas with submerged vegetation.

They are phytophagous and detritivorous, and they feed on parts of plants, periphyton and detritus. Adults cannot swim; instead, they crawl near aquatic plants, submerged branches and other substrates. Eggs are deposited individually inside cocoons (Hansen 1996). Larvae undergo three stages before pupation.

Hydrophilidae

Description

Hydrophilidae adults have an oval or oval-elongated body (Fig. 3.14h). Their ventral surface has a thin pubescence. They are characterised by having long palpi and relatively short antennae, with 7–9 antennomeres and a pubescent club of three antennomeres. The club is preceded by a glabrous, dome-like transversal segment. Tarsi have five segments, rarely four. Body length ranges from 1 to 50 mm.

Larvae have a labrum separated from the cephalic capsule by a suture (Peterson 1960). Mandibles have an apical tooth. The abdomen has eight segments and the legs four.

Biology

The family Hydrophilidae has around 2652 species worldwide, distributed in 174 genera. 1800 species are aquatic (Jäch and Balke 2008). In the Iberian Peninsula, 20 genera and 89 species have been recorded (Ribera et al. 1999).

This family has aquatic, semiaquatic and terrestrial representatives. Adults and larvae of aquatic species are found both in running and standing waters (Hansen 1996). Many species inhabit streams of slow currents, or standing waters, such as lakes, dams, ponds and irrigation channels. However, some species can also be found in streams of fast currents.

Despite their common name (scavenger beetles), the larvae are mainly predators and they feed on snails, earthworms, small crustaceans and insect larvae, with the exception of species of the genus Helochares Mulsant 1844, which are phytophagous. Adults are scavengers or phytophagous, and they can also feed on decaying organic matter (Hansen 1996).

Both larvae and adults ascend to the water surface to renew the oxygen supply. Most Hydrophilidae species are not good swimmers.

Adults are very abundant during spring and summer. Larvae and pupae are more abundant at the end of the spring and the beginning of summer. Most species spend the winter as adults, although larvae can also be found in this season. Males have calling signals under the water to find mates. Females of many species carry the eggs under the abdomen, although most enclose their eggs in cocoons. These cocoons are attached to emergent vegetation just about the water line or on the adjacent marginal vegetation. Pupation occurs on wet soil, not far from the water (Hansen 1996).

Hydroscaphidae

Description

Hydroscaphidae are minute (1–2 mm) coleopterans with short elytra that resemble small rove beetles (Staphylinidae). Adults have an oval and elongated body, usually brown, and a head without rostrum. Antennae are claviform and have eight antenomeres with a club of one antennomere. Elytra are short, truncated on the posterior end. Metacoxal plates are large.

Tarsi have three segments. The larva has legs with four segments and an abdomen with 10.

Biology

There are 21 Hydroscaphidae species known, belonging to three genera (Jäch and Balke 2008). In the Iberian Peninsula, only one species has been recorded, *Hydroscapha granulum* (Motschulsky 1855) (Ribera et al. 1999).

Hydroscaphidae are part of the interstitial fauna, as they live in between sand grains on the margins of water bodies. Besides, they can also be found in running waters, especially waterfalls, or even between the filamentous algae of pools and thermal springs, where they can tolerate temperatures up to 45° C.

They are phytophagous scrapers, and they feed on algae that grow on stones. Adults trap atmospheric air, which they store underneath the elytra. Larvae are completely aquatic and obtain oxygen from the water through their gills.

Hygrobiidae = Paelobiidae

Description

Hygrobiidae adults (Fig. 2.10c) have an oval, elongated and dorsally convex body. Colouration goes from brown to black, with markings on the elytra. Antennae are long, glabrous, with 11 antennomeres. Eyes are protruding and well separated from the anterior margin of the pronotum. The head is separated from the pronotum by a "neck". Legs are 5-segmented. Body size ranges from 8.5 to 10 mm.

Larvae (Fig. 2.11a) have a big and elongated head, with the labrum completely fused to the cephalic capsule. The abdomen has the eighth tergite elongated and two long cerci. Gills are ventral and are located on the thorax and the first three abdominal segments. Legs are slender, with five segments and two tarsal claws.

Biology

The family Hygrobiidae is composed by a single genus, Hygrobia Latreille 1804, and six species (Jäch and Balke 2008). In the Iberian Peninsula the only known species is *Hygrobia hermanni* (Fabricius 1775) (Ribera et al. 1999).

Hygrobiidae is a small coleopteran family that dwells in standing waters with plenty vegetation. Adults are predators and preferably feed on larvae and nymphs of odonates, dipterans and megalopterans. Larvae are also predators and feed on preys that live on the substrate, mainly oligochaete and chironomids. Adults are relatively slow and produce a strong noise when they are disturbed or when trapped (González and Cobo 2006). They have an air chamber underneath the elytra, which they refill by exiting the water from time to time and separating the elytra from the abdomen at the anterior end. In larvae, the gas exchange is conducted through tracheal gills. The life cycle from egg to adult takes 9–15 weeks. Eggs are deposited over submerged vegetation during spring. The larva undergoes three stages and pupation occurs outside the water, lasting around 16 days approximately. The adult hibernates on water.

Noteridae

Description

Noteridae adults have an oval body, with a very convex dorsal side and a flat ventral side (Fig. 2.10e). Colouration varies from light to dark brown or reddish. The dorsal surface is finely microreticulate and punctate, mostly glabrous. Antennae are filiform with 11 antennomeres. Metacoxal apophyses are arranged forming an inverse "V" and cover the base of the trochanters. Tarsi have five segments. The length of the body ranges from 0.5 to 5 mm. Larvae have a compact and fusiform body, with the head partially retracted under the prothorax. Mandibles are short, wide and without internal perforation. The labrum is separated from the cephalic capsule by a suture. The eighth abdominal tergite forms a conical process, with apical spiracles and without ventral gills. Urogomphi are reduced and not visible. Legs have five segments and two tarsal claws.

Biology

Currently, there are 250 species described belonging to 14 genera, which can be found in every continent (Jäch and Balke 2008). In the Iberian Peninsula, two genera and three species have been recorded (Ribera et al. 1999).

Both adults and larvae can be found in shallow standing waters or waters with weak currents (Nilsson 1996), usually between the roots of floating aquatic plants, such as some Liliaceae and Araceae species, or on emergent plants. Adults are phytophagous and larvae omnivorous. They feed on vegetal matter and small invertebrates. However, some species have predator adults or larvae. Adults are good swimmers, but usually creep among vegetation. They have an air chamber under the elytra, which they refill by exiting the water from time to time and separating the elytra from the abdomen at the posterior end. Some larvae obtain air by using a siphon at the end of their abdomen, which they use to take advantage of the air inside plant stems (Nilsson 1996). Adults of many species are able to fly.

Females lay eggs on the roots of floating or emergent plants. The larval cycle lasts between 4 and 6 weeks (Nilsson 1996). Larvae of some species pupate under the water in air-filled cocoons, built from vegetal particles (Nilsson 1996).

Psephenidae

Description

Psephenidae adults have a flattened, oval and pubescent body (Fig. 3.14i). The representatives of the subfamily Eubriinae are compact individuals, with crenulations at the base of the prothorax. Antennae have 11 antennomeres, and can be filiform, serrate or pectinate. The tarsi have five segments. Body size is 3–5 mm long. Larvae have a very oval body, strongly depressed (disc-shaped), with the head completely covered by the prothorax. The labrum is separated from the cephalic capsule by a complete suture. The abdomen has nine segments with an apical operculum that hides three tufts of slender gills. Legs have four segments and one tarsal claw.

Biology

The family Psephenidae comprises 272 species belonging to 35 genera (Jäch and Balke 2008). In the Iberian Peninsula, only one species is known: *Eubria palustris* (Germar 1818) (Ribera et al. 1999).

They are commonly known as "water penny beetles". Larvae adhere to rocks in areas of strong currents of streams and rivers, but they can also survive in well oxygenated standing waters. Adults are terrestrial and cryptic, and normally hide under leaves and small branches or among riverbank vegetation remains.

Larvae are phytophagous and scrapers, and feed on the biofilm associated with rocks. In the darker hours, they creep towards the superior surface of stones; to avoid light, they hide on their inner part. Larvae breathe dissolved oxygen in water through a tube of anal gills (Nilsson 1996), although they can breathe atmospheric air when they exit the water. The larval cycle can vary between 12 and 24 months. Adults live more than 3 weeks on land, where they mate. Females return to the water to lay eggs over submerged rocks. Larvae undergo 5–6 stages. Temperature seems to be one of the most important factors for larval development, as larvae grow little during winter time. The last stage exits the water in spring and remains over rocks, trunks or on soil nearby the water for a few weeks before pupating. There is one prepupal stage after which pupation occurs. Pupae usually group in the same place. The pupal stage lasts 2–3 weeks. Adults do not live more than a few weeks between spring and summer.

Scirtidae

Description

Scirtidae adults are small (1.5–4.5 mm) coleopterans with and oval and somewhat depressed body. Body surface can be glabrous or pubescent. The head is declinated and has filiform antennae of 11 antennomeres. The hind femurs are usually enlarged modified for jumping. Tarsi have five segments, with the fourth one lobulated. Scirtidae larvae can be differentiated due to their long antennae, which are the longest among holometabolous insects (Fig. 3.14j). These antennae surpass the head and have ten antennomeres. The labrum is separated from the cephalic capsule by a complete suture. The abdomen has eight segments and the legs are 4-segmented.

Biology

This family has approximately 900 species belonging to 30 genera worldwide (Jäch and Balke 2008). In the

Iberian Peninsula, six genera and 34 species belonging to this family have been recorded (Ribera et al. 1999).

They are commonly known as "marsh beetles". Scirtidae adults are terrestrial and can be found on riverbank vegetation. Larvae are aquatic and live mainly in standing waters, such as ponds, puddles and lakes, although they can also be found in running waters, associated with marginal vegetation. Other species can be found in subterranean waters or water accumulations in plants (Klausnitzer 1996).

Larvae are filterers and feed on detritus deposited on the surfaces of leaves and rocks, using their complex comb-shaped mouth pieces. They have a single pair of functional spiracles in an apical position. They need to renew oxygen every 10–20 min, which they do by ascending to the water surface or by obtaining air bubbles from plants and aquatic algae (Klausnitzer 1996).

In temperate regions they have one annual cycle, with one generation. The larva pupates at the end of the summer, among dead leaves or mud, without forming a true cocoon (Klausnitzer 1996). Emerged adults have short lifes.

Beraeidae

Description

The shape and colour of the head of Beraeidae are either round and uniformingly reddish (*Beraea* Stephens 1836 and *Ernodes* Wallengren 1891), or slightly elongated, black and yellow (*Beraeodes* Eaton 1867). The right mandibles present a brush of hairs on the inner (concave) side. The lateral margins of the gular sclerite are indistinct. The prosternal horn is absent. The pronotum and mesonotum are entirely sclerotized, while the metanotum is membranous. Larvae of some Beraeidae (*Beraea* and *Ernodes*) bear a transverse carina on the pronotum, which is extended to form a rounded anterolateral lobe on each side (Pitsch 1993). In other specimens (*Beraeodes*), the pronotum shows a characteristic dark mosaic pattern. The legs are uneven and in some cases, the metathoracic legs are very long and slender. The first abdominal segment always has both dorsal and lateral humps. Gills are present forming groups or completely absent. The lateral sclerite of each anal proleg is greatly reduced or absent. Each anal proleg bears a posterior lobe that supports a stout seta, and also a setaceous and membranous surface below the anal claw (except *Beraeodes*). Early instars of Sericostomatidae larvae resemble *Beraea* and *Ernodes*, but the anal proleg lacks all the features described above. The genus *Beraeodes* resembles Leptoceridae larvae in its slender appearance, long antenna and metathoracic legs. However the pattern of the pronotum and the numerous setae on the frontoclypeus, differentiate the larvae of this genus from those of leptocerids.

Beraeid larvae construct cylindrical cases of fine sand grains fitted together to form a smooth surface (Fig. 2.22d). Cases are tapered and slightly curved. They are closed at the posterior end by a membrane with a central hole, except in the case of Ernodes, which shows a hemispherical prominence over which the opening is ventrally situated. A detailed description of Beraeidae is available in Vieira-Lanero (2000), Wallace et al. (1990, 2003) and Wiggins (2004).

Biology

Beraeidae are cold-stenoterm larvae mainly found in headwater reaches of medium to high altitudes. They are usually associated with mosses from marginal river banks. This trichopteran family is found in several biogeographic regions but the number of genera and species is relatively low. Larvae are considered collector-gatherers although some species have also been classified as shredders or grazers. Their life cycle is usually semivoltine, with an emergence period that goes from spring to summer. Some species have also been observed emerging during the autumn (Vieira-Lanero 2000; Graf et al. 2008).

Brachycentridae

Description

Brachycentridae species frequently have a flat head, bearing a dorsolateral carina on each side. The prosternal horn is absent in the Iberian genera. The pronotum bears a transverse carina or ridge, and each mesonotal plate is frequently subdivided lengthwise by a narrow suture. On the metanotum, only sclerites in positions sa2 and sa3 are present, sclerite sa1 lacking entirely or represented only by a single seta without a sclerite. Meso- and metathoracic legs are longer than prothoracic legs. In the genus *Brachycentrus* Curtis 1834, meso- and metathoracic femurs are two times longer than tibiae and bear ventral projections on the tibiae. The first abdominal segment lacks both dorsal and lateral humps. Gills are single, multiple or absent. The lateral fringe is reduced (segments III–VII only) or absent.

Larvae construct cases from plant or rock materials, and some species use only silk (*Micrasema longulum* McLachlan 1876) or a mixture of silk and mineral particles (Fig. 3.15a–f). *Brachycentrus* (subgenus *Brachycentrus*) build 4-sided cases. When Branchycentrid use plant parts, these are slender and arranged transversely. *Micrasema servatum* (Navas 1918) places numerous pieces of plant material hanging on the external surface of the case. Other genera build cylindrical cases. The cases are closed at the posterior end by a membrane with a central hole. The shape of this hole (rounded, trilobed or even tetralobed, as in *Micrasema cenerentola* Schmid 1952) has, sometimes, specific value. For more on the description of this group, see Vieira-Lanero (2000), Wallace et al. (2003) and Wiggins (2004).

Biology

Brachycentridae have euriterm larvae that can be found in both, high mountain rivers and lowland reaches, depending on the genus and the species considered. Although some larvae of the genus *Brachycentrus* are grazers, most of them are classified as predators/filterers and obtain preys by exposing meso- and metathoracic legs to the water current. These legs catch the feeding particles and bring them to the mouth helped by the prothoracic legs. Larvae of the genus *Micrasema* are exclusively grazers and are associated with mosses, where they can reach very high densities. Larvae of some species group together during the pupation phase and attach themselves to stones in riffles. Brachycentridae have univoltine cycles and have an emergence period that occurs mainly from spring to summer, although it is not uncommon to find adults in autumn or even in winter (Vieira-Lanero 2000; Graf et al. 2008).

Calamoceratidae

Description

Calamoceratidae larvae (Fig. 2.23d) are large insects, easily differentiated from other caddisflies by the setation of the labrum, formed by a transverse row of numerous long and stout setae across the central part. The prosternal horn is absent. The anterolateral margins of the pronotum are extended forming pointed lobes, as in Sericostomatidae species. The mesonotum is covered by two big central sclerotized plates and two small anterolateral sclerites, bearing sa3 setae. The metanotum is entirely membranous. The first abdominal segment bears both dorsal and lateral humps. Abdominal gills are multiple in the only species found in the Iberian Peninsula: *Calamoceras marsupus* Brauer 1865.

Larvae construct cases of plant materials, which they arrange in various ways. They are well known for their flattened cases, made of large pieces of excised leaves that completely camouflage the larva from above. Others build tubular cases hollowing twigs (frequently of alder) to use as cases. Occasionally, they use the gravel cases of some other caddisflies, such as those of Sericostomatidae. More information about Calamoceratidae can be found in Vieira-Lanero (2000), Wallace et al. (2003) and Wiggins (2004).

Biology

Calamoceratidae larvae are mainly found in undisturbed headwater reaches of medium to high altitude, under a wide variety of environmental conditions. The family with only has two European species, which are distributed in the southern regions (*C. marsupus* and *C. illiesi* Malicky and Kumanski 1974). Larvae are associated to lentic zones dominated by gravels, sand and leaf litter. They are considered as shredders, although sometimes some grazing and predatory behaviour has been observed. Adult emergence is relatively short and takes place during spring and summer (Vieira-Lanero 2000; Graf et al. 2008).

Ecnomidae

Description

In Ecnomidae species, all three thoracic segments are dorsally covered by sclerotized plates (Fig. 3.15g). The trochantin of the prothorax is long and pointed. All legs are equal in size. The body does not present gills, but it has a lateral fringe of thick setae. Anal prolegs project freely from the abdomen, and have large claws that are at least as long as the preceding sclerotized segment. The dorsum of abdominal segment IX

Fig. 3.15 (**a**–**f**) Brachycentridae; (**g**) Ecnomidae; (**h**–**j**) Glossosomatidae; (**k**, **l**) Goeridae; (**m**) Helicopsychidae

does not have a sclerotized plate. In the Iberian Peninsula, two species of this family can be found: *Ecnomus tenellus* (Rambur 1842) and *Ecnomus deceptor* McLachlan 1884. They can be easily differentiated from each other by the head colouration pattern and the extension of the lateral fringe of the pronotum.

Larvae construct tubes of silk and fine sand grains, open at both ends, which are attached to rocks, wood, or submerged vegetation, and occur in both running and standing waters. See Edington and Hildrew (1981, 1995), Vieira-Lanero (2000) and Wiggins (2004) for further information.

Biology

Ecnomidae are warm-stenotermus trichopterans, characteristic of lowland reaches and lakes. However, in some occasions, they have also been found in springs at higher altitudes. Their prefer lentic habitats with a wide variety of substrates, from stones to fine sediments or sediments associated with organic matter (algae, macrophytes or wood). Larvae are predators and catch preys with their tubular nets. They have univoltine life cycles with an emergence period that goes from spring to autumn (Vieira-Lanero 2000; Graf et al. 2008).

Glossosomatidae

Description

Glossosomatidae have an oval-shaped head with mandibles bearing a uniform scraping edge rather than separated teeth (Fig. 3.15h–j). The prosternal horn is absent. The pronotum is sclerotized and the prosternal plates are prominent. The meso- and metanotum are membranous in the genus *Glossosoma* Curtis 1834, although in the other three genera found in the Iberian Peninsula (*Agapetus* Curtis 1834, *Catagapetus* McLachlan 1884 and *Synagapetus* McLachlan 1879), these bear small sclerites. All legs are approximately of the same length. Thoracic and abdominal gills are absent (only anal gills present) and the dorsum of segment IX bears a sclerotized plate. The abdominal segments are well-marked and the first abdominal segment lacks protuberances. The basal half of each anal proleg is broadly attached to segment IX, and the anal claw has at least one dorsal accessory hook.

Larvae construct tortoise-like, domed portable cases of rock fragments. As the larvae grow, a new case is constructed. Both openings of the case are similar and the larvae regularly reverse its position. Unlike other cased caddisflies, the spaces between sand grains in Glossosomatidae cases are not filled with silk; therefore they enable a current of water for respiration. Cases are rebuilt between instars and they can be synchronically abandoned during unfavourable periods. For more details on the description of this group, see Vieira-Lanero (2000), Wallace et al. (2003) and Wiggins (2004).

Biology

Glossosomatidae larvae are common in headwater reaches of a variety of altitudes, although sometimes they are also found in middle reaches. They prefer habitats with stones and moderate current velocities. They are considered grazers that move over the substrate, although it has also been suggested that they can harvest algae inside the case, similarly to Psychomyiidae larvae. These caddisflies have univoltine cycles, although depending on environmental conditions, some species can show a more flexible life cycle. The emergence period takes place between spring and autumn, although some species can also emerge in winter (Vieira-Lanero 2000; Graf et al. 2008).

Goeridae

Description

Goeridae have distinctive extensions of the mesotharacic pleura, forming prominent processes on each side (Fig. 3.15k–l). The anterior-lateral corners of the pronotum are also pointed, forwardly-directed processes (Fig. 2.23b). Mesonotal plates are subdivided in two (in genera *Goera* Leach 1815 and *Larcasia* Navas 1917) or three pairs (in genera *Lithax* McLachlan 1876, *Silo* Curtis 1833 and *Silonella* Fischer 1966) of small sclerites. The metanotum is mainly membranous, with three or four pairs of small sclerites. The prosternal horn is present. Mandibles have only one tooth, typical of scrapers. All legs are approximately of the same length. The first abdominal segment always has both dorsal and lateral humps. Abdominal gills can be single or multiple, depending on the genera.

Goeridae larvae construct cases entirely of rock fragments; some genera incorporate larger rock fragments laterally to balance their bodies and to maintain themselves in front of the current. When the larva retracts into its case, the head and the first and second thoracic segments form a domed plug that closes the anterior opening of the case. The posterior end of the case is filled with silk, only leaving a small aperture. In the genus *Lithax*, sand grains are included into the membrane. For a more detailed description of the family, see Vieira-Lanero (2000), Wallace et al. (2003) and Wiggins (2004).

Biology

Goeridae larvae are euriterm and are found in headwater reaches of medium to high altitudes. However, some species have also been found in lentic ecosystems. They are grazers and, in river ecosystems, they are found in stone substrates under moderate to high water velocity. It is very common to observe Goeridae pre-pupae and pupae parasitized by the Hymenoptera *Agriotypus armatus*. The presence of this parasite can be detected by a breathing filament coming out of the case (Wallace et al. 2003) (Fig. $2.7b_2$). Goeridae have univoltine life cycles and the emergence period goes from spring to summer, although some emerging adults have been observed in autumn (Vieira-Lanero 2000; Graf et al. 2008).

Helicopsychidae

Description

The pronotum and mesonotum of Helicopsychidae larvae are sclerotized, while the metanotum is membranous (Peterson 1960) (Fig. 3.15m). The eighth abdominal segment has a lateral row of spinules. The main claw of the annal appendages has several dorsal teeth that form a comb or a fan.

They have a very characteristic mineral coiled case, similar to dextral shells of small snails (5–6 mm). Larvae build cases using small mineral particles they consolidate with silk. The spire of the case of the last instar has three and a half whorls; the first one, made by a young larva, is usually destroyed, and the last instar usually occupies the last and part of the penultimate whorl. Inside the case, larvae rest laterally on the left wall, with their abdomen more curved dorsoventrally than laterally.

Biology

Helicopsyche Siebold 1856 is the only Iberian genus of this family. Its larvae live preferentially in small running waters of cold, clean and shallow waters, where they can be found over submerged rocks and among the mosses that cover them. They are particularly abundant in springs and headwaters, forming groups of numerous individuals over the rocks. They are grazers and scrapers, and they feed mainly on leave fragments, filamentous algae and diatoms.

Larvae have some ability to keep their abdomen always in contact with a small amount of water that they retain inside the case. This allows them to live temporarily outside the water – in hygropetric environments – feeding on wet surfaces and in between vegetal matter accumulated there, where they go unnoticed thanks to their slow movements and cryptic cases.

Hydropsychidae

Description

Hydropsychidae have all three thoracic segments dorsally covered by sclerotized plates (Fig. 3.16a–c). The posterior margins of the meso- and metanotal sclerites are lobate. The abdomen is cylindrical and slender. The hydropsychids are easily recognised because the abdomen and the last two thoracic segments bear ventral branched gills and a tuft of many long stiff setae on each anal proleg. Instars I–II lack gills and they can be misidentified as Hydroptilidae or Ecnomidae. They can be differentiated from the latter due to their tuft of setae on the anal proleg and the posterior margins of the thoracic segments. The body is covered with dark-coloured spicules. Anal claws form a stout hook apically. The shape of the frontoclypeal apotome and the presence or absence of long stiff setae on the head and pronotum enable the differentiation of the three Iberian genera (*Diplectrona* Westwood 1840, *Cheumatopsyche* Wallengren 1891 and *Hydropsyche* Pictet 1834). The genus *Hydropsyche* is the most diverse in the Iberian Peninsula, with several endemic species.

Fig. 3.16 (**a**–**c**) Hydropsychidae; (**d**–**f**) Hydroptilidae; (**g**, **h**) Lepidostomatidae; (**i**, **j**) Leptoceridae; (**k**–**m**) Limnephilidae

The larva does not construct a portable case. Instead, it inhabits a fixed tubular retreat adjacent to a small silken net, which is attached to small stones or vegetable debris, perpendicular to the running water. The pupa builds domed cases with material collected near the pupation site and attach them to cobbles in riffles. More information about Hydropsychidae is available in Edington and Hildrew (1995), Vieira-Lanero (2000) and Wiggins (2004).

Biology

Hydropsychidae are one of the most widely distributed Trichoptera around the world, containing numerous and very abundant species that replace themselves along river ecosystems. They are mainly found in stone substrates with moderate to high current velocity. However, in some cases, larvae can also be found on macrophytes or wood. Larvae are filter-feeders and the drifting material is caught by the net in the retreat. The mesh size of this net varies depending on the species and the river section that they inhabit. Thus, headwater species have a larger mesh size than downstream species. The net shape can also change depending on water quality (e.g. presence of metals can cause deformities) or general environmental parameters such as temperature. Because larvae try to find the best microhabitats to filter, they are very territorial and are able to stridulate moving the head back and forth over the forelegs. They feed on a wide variety of materials and the proportion of vegetal versus animal material changes depending on the instar and the season. Hydropsychidae species usually have univoltine life cycles, but some species can also have more than one generation per year. The emergence period usually goes from spring to autumn, although some species are also able to emerge in winter (Vieira-Lanero 2000; Graf et al. 2008).

Hydroptilidae

Description

Hydroptilidae larvae are small (between 3 and 6 mm) and, unusual among Trichoptera, morphologically different along the larval development (Peterson 1960). The first to fourth instars are elongated, with very long setae, transversal sclerites over the abdominal tergites, and long anal claws. The last instar (fifth) has an eruciform shape, with the abdomen markedly broadened on segments III–V or IV–VI and with reduced anal claws that are generally fused to the sides of segment X. Legs vary in shape and size, but they are usually short and more or less equal. The abdomen might or might not have tergites, but there is always a tergite on segment IX. They do not have abdominal gills. The case can have different shapes depending on the genera and even the species, but they are usually laterally compressed. The basic building material is silk, which in some genera is the sole material, but in others, sand grains or fragments of filamentous algae can be added as well to form the case (Fig. 2.21c and Fig. 3.16d–f).

Biology

Hydroptilidae are also known as "microtrichopterans", as the smallest species belong to this family, with larvae of 2–3 mm long. Larvae build and carry (only the last instar) a case that makes them more conspicuous. Due to their small size, they go otherwise unnoticed in previous stages. The cases are very characteristic of each genus. Some cases are flat (e.g. *Hydroptila* Dalman 1819, *Tricholeiochiton* Kloet and Hincks 1944, *Agraylea* Curtis 1834, *Allotrichia* McLachlan 1880), bottle-shaped (*Oxyethira* Eaton 1873) or resemble pumpkin seeds (*Ithytrichia* Eaton 1873) or oat seeds (*Orthotrichia* Eaton 1873 and *Stactobia* McLachlan 1880). Larvae from the genera *Agraylea* and *Allotrichia* build cases with filamentous algae arranged concentrically, while others use only silk (e.g. *Stactobia*). Some use silk and small sand grains arranged as to cover the external side of the case (e.g. *Hydroptila*), and others, such as *Ptilocolepus* Kolenati 1848 species, arrange oval fragments of moss and hepatics slightly overlapping at the edges of the case. One of the most noticeable aspects of the biology of this group is the existence of hypermetamorphosis. While the first four stages develop as campodeiform larvae, without a case, when the fifth larval stage occurs, the membranous parts (especially on the abdomen) increase notably in volume by accumulating as many energy reserves as possible, as a strategy to prepare for the pupal stage. Nymphs develop inside the case. Larvae live both in standing waters with plenty macrophyes, and in all sorts of permanent running waters, feeding on the periphyton and fine organic particles. Some genera *Hydroptila*, *Orthotrichia* and *Agraylea*, are specialized to feed on filamentous algae. Trichopteran life cycles are strongly influenced by water temperature and multivoltine cycles are frequent.

Lepidostomatidae

Description

Lepidostomatidae species have a brown or dark brown head, with some lighter areas that can be more or less large and oblong (Fig. 3.16g, h). The pronotum is completely sclerotized and the mesonotum is covered by two large sclerites. The metanotum is membranous, but it bears six small sclerites. The first pair of thoracic legs is shorter than the other two pairs, which are similarly sized. The antennae are located near the anterior margin of the eye. The first abdominal segment does not have dorsal protuberances but it has two lateral ones. They can have simple abdominal gills. The ninth abdominal segment has a sclerotized dorsal plate on its anterior area.

Biology

Lepidostomatidae live in river reaches with fresh waters, in areas with lower velocity where the detritus is deposited (Wallace et al. 1990). Sometimes they can also be found on lake shores or standing waters of large rivers. Some species initially build cases of mineral elements, to which vegetable particles are incorporated as the larva grows, to finally build cases of vegetal fragments with a more or less quadrangular cross-section. The species *Lasiocephala basalis* (Kolenati 1848) builds tubular, slightly curved cases with mineral particles. Representatives of this family are detritivorous organisms associated with leaves and other deposits of vegetal nature (González and Cobo 2006). Thus, their populations are affected when the riverbank vegetation that supplies these materials to the river is affected. In general, this species is considered to be an indicator of clean waters due to its low tolerance to pollution and its high oxygen requirements (Puig 1999). It also indicates good quality riverbanks. In the Iberian Peninsula, three species have been recorded.

Leptoceridae

Description

Leptoceridae final instars have a cephalic capsule with a marked ecdysis line (Fig. 2.22e3). The antennae are close to the edge of the head and they are relatively long (except in some species of the genus *Ceraclea* Stephens 1829, which have short antennae, but which can be easily differentiated from other trichopterans by two dark lines on the posterior end of the mesonotum). The mandibles are asymmetrical. The pronotum and the mesonotum are sclerotized, although the mesonotum is quite pale, which can be misleading. The metanotum is almost entirely membranous, at most having a few reduced sclerites. The meso- and metathoracic femurs are subdivided in a short proximal section and a distal longer one in all stages. The third pair of legs is longer than the rest, three times longer than the first pair of legs (Fig. 2.22e_{1-2}). The first abdominal segment has two lateral protuberances and a dorsal one. When gills are present, these are branched. The ninth abdominal segment has a dorsal sclerite, sometimes very pale. Anal appendages are short, with short anal claws.

Biology

Species of this family can live in current areas of headwater small streams, but they are more common in more sheltered waters of low current velocity or even standing waters. In any case, they are always associated with submerged vegetation (both aquatic macrophytes and submerged roots). Several species can swim among plants, using their slender and setaceous hind legs as paddles. Their case is tubular, conical, straight or curved and longer than the larva itself (González and Cobo 2006) (Fig. 3.16i, j). Building materials are very diverse, from silk-only cases to cases made with mineral or vegetal particles of variable complexity. Predator species exist, but most species are shredding organisms that feed on vegetal matter or even sponges (Vieira-Lanero 2000). In the Iberian Peninsula, 38 species have been recorded. Although some species can tolerate moderate organic matter discharges, in general their presence is considered as an indicator of adequate water quality (Puig 1999).

Limnephilidae

Description

Limnephilidae have medium to large-sized larvae (Peterson 1960; Fig. 3.16k–l). The antennae are usually located mid-way between the eyes and the anterior margin of the cephalic capsule. The mandibles are short and sturdy, with a brush of setae on their inner margin. The pronotum is completely sclerotized, with two big sclerites separated by a medial longitudinal suture. The mesonotum dorsal surface is almost entirely covered by two large and separated sclerites. The metanotum has six small sclerites (sometimes five) separated between them. The prothoracic legs are a bit shorter than the meta- and mesothoracic legs. The first abdominal segment has two lateral protuberances and a dorsal one. The rest of the abdomen has a circular cross-section with gills of variable morphologies depending on the species. The ninth segment has a dorsal sclerite. Anal appendages are short, similar to those of other case-building trichopteran families.

Biology

Limnephilidae is a very diverse group with many representatives, which allows the family to cover a great variety of habitats. They occupy both, areas with cold and fast waters, and warmer backwaters areas, as well as lakes, lagoons, pools, rivers or streams (Wallace et al. 1990). They build very diverse portable cases of tubular shape (González and Cobo 2006) (Figs. 3.16m and 3.17a–e). Generally, species that live in faster waters use mineral fragments, while species on slower waters use vegetal fragments. In fast reaches, and to avoid being swept by the current, they incorporate heavier stones on the posterior end of the case, as well as including pieces of branches on the case so they favor the dispersion of current lines. Due to the group's great diversity, the thropic spectrum is also very wide, with phytophagous, scrapers, scavengers and even predator species, although the most frequent are detritivorous species that feed on small particles of organic matter. They require high oxygen levels in the water and they only tolerate small increments of organic matter on the environment. Thus, their presence indicates good quality ecosystems (Puig 1999). In the Iberian Peninsula, 87 species have been recorded (excluding species from the genus *Apatania* Kolenati 1848, as it is considered an independent family).

Apataniidae

Description

Apataniidae have medium to large-sized larvae, very similar to Limnephilidae (for a long time, Apataniidae was considered a subfamily of Limnephilidae). Antennae are located mid-way between the eyes and the anterior margin of the cephalic capsule. They have scraping mandibles. The pronotum is convex and completely sclerotized. The mesonotum is also sclerotized, conformed by two sclerites that merge in the medial dorsal line. The metanotum is membranous, with small sclerotized plates (some very reduced), similarly to Limnephilidae. However, they can be differentiated from the latter because the anterodorsal plates are absent, and instead there is a transversal row of setae. The first abdominal segment has two lateral protuberances and a dorsal one. The abdomen has a circular cross-section and usually does not have gills. If gills are present, they only have one filament. They have a dorsal sclerite over the ninth abdominal segment with numerous setae. Anal appendages are short, similar to those of other case-building trichopteran families.

Biology

Apataniidae species usually inhabit fresh waters in headwater reaches, although some individuals have been found in cold water lakes (Vieira-Lanero 2000). They are usually found over stone substrates and in areas with moss. They are scrappers that during juvenile stages feed on periphyton and as they develop, they ingest algae and moss fragments. They build cases of mineral nature, tubular, conical and curved, with the dorsal side of the anterior aperture more prolonged than the ventral one (similar to the cases of some species of the genus *Ceraclea*). The posterior aperture is partially occluded by a pierced silk membrane which allows for water circulation (Wallace et al. 1990). Larvae of this family have a gland underneath the pronotum that secretes a repellent or paralyzing substance

Fig. 3.17 (**a**–**e**) Limnephilidae; (**f**, **g**) Odontoceridae; (**h**) Polycentropodidae; (**i**, **j**) Psychomyiidae

as a defense mechanism against predators, such as some stoneflies and caddisflies and even some fish (Wagner et al. 1990). They are considered as a group that has low tolerance to water pollution.

Odontoceridae

Description

Odontoceridae larvae (Fig. 3.17f) have a pronotum with a sharp and prolonged ventral margin that points forward (Peterson 1960). Meso- and metanotum wider than the pronotum. The metanotum has four sclerites: two transversal (anterior one large and rectangular, with the posterior margin concave; posterior one fusiform and darker in the center) and two lateral (reniform or subquadrangular) located in the pleural region. The frontoclypeal apotome has a characteristic X-shaped marking. They do not have prosternal horn. Abdominal gills have multiple digitations. The ninth abdominal segment has a dorsal sclerite with four long setae on its posterior margin. The case is tubular, conical and slightly curved (Fig. 3.17g), built with coarse sand grains that allow for the external appreciation of the thick threads of setae that bind them internally. Unlike the rest of the families, they do not have an inner silk case. The larva blocks the posterior aperture with a small stone that is strongly held to the edge of the case with thick silk threads. Water circulation is made possible thanks to the "windows" in between these threads. This type of case has certain advantages for larvae, since it is very rigid and offers great resistance to crushing.

Biology

Odontocerum Leach 1815 is the only Iberian genus of this family. Its larvae sometimes show burrowing habits. They are omnivorous, feeding on fragments of leaves, algae and invertebrate remains (crustaceans, mayflies, stoneflies, dipterans, etc.), preferably at night. They are quite stenoic, usually occupying upper reaches of mountain streams and rivers – with stone substrates and cold and well oxygenated waters – or the edges of lentic areas, where sand deposits. They are gregarious, especially during the prepupal stage. Larvae on their fifth stage can travel up to 10 m in one night to form aggregates of pupal cases that attach to the underside of stones exposed to currents. Similarly to Goeridae species (although less frequently), Odontoceridae pupae can be parasitized by the himenopteran *Agriotypus armatus* (Agryotipidae). Larvae undergo five stages and life cycles are generally univoltine.

Philopotamidae

Description

Philopotamidae (Fig. 2.22b) are trichopteran larvae that do not build cases, with a slightly dorsoventrally flattened body (Pitsch 1993). The cephalic capsule is elongated and orange, light brown or yellowish, without markings or macules from muscular insertions. Antennae are short, located on the anterior end of the head. Mandibles are asymmetric. The labrum is membranous and T-shaped, with a ciliated anterior margin. The pronotum is coloured similarly to the head, with a black posterior margin. The mesonotum and the metanotum are membranous. The legs are approximately of the same size, with small claws. The abdomen is whitish and does not bear gills. The first abdominal segment does not have protuberances and the ninth abdominal segment does not bear a dorsal sclerite. The pygopodes are formed by a proximal membranous segment and a distal, longer one, that bears a dorsolateral sclerite and ends in short and sturdy anal claws.

Biology

Philopotamidae live mainly in upper reaches of rivers with cold and oxygen-rich waters, in areas of cobbles and small blocks. Most species are mainly rheophilic, but there are some potamophilic species as well (González and Cobo 2006). They do not build a case: larvae live inside complex nets of white silk that they build on rock undersides (Edington and Hildrew 1995). They use those nets to feed. Through the silken tubes and pouches, they retain finely particulate organic matter and diatoms dragged by the current. Despite having well developed mandibles, they do not use them to catch prey but just as a defense mechanism and to ingest food: they remove the feeding particles retained on the silk with their brush-shaped labrum (Edington and Hildrew 1981; Vieira-Lanero 2000). Before pupation, the larva builds a pupal chamber under the stones with mineral or vegetal fragments in areas of high velocity currents. In the Iberian Peninsula, 19 species belonging to this family have been recorded. In general, the taxon is considered to have high oxygen requirements and therefore, its presence is associated with good quality waters (Puig 1999).

Phryganeidae

Description

Phryganeidae larvae are large when fully developed (Fig. 2.21f). The cephalic capsule is yellowish or reddish-brown, with two or three very marked dark longitudinal and dorsal stripes. Antennae are short and close to the anterior margin of the head. Mandibles have a large distal tooth and do not bear setae on their inner margin. Maxillae have elongated palpi and slender lobes. The pronotum is sclerotized, with similar colours to the head. The mesonotum and the metanotum are membranous, although in some cases some sclerotized areas can be observed. Fore- and mid-legs are similar in size, with longer hind legs. The first abdominal segment has three protuberances (or mamelons), two lateral and one dorsal. Abdominal segments are rounded in lateral view, with marked divisions between them. Abdominal segments I–VIII have simple gills and the ninth segment has a dorsal sclerite or tergal sclerotized plate. The anal appendages are short, similarly to other case-building trichopteran families.

Biology

Phryganeidae larvae preferentially live between the vegetation of standing waters, especially in pond and lake shores and marshes, as well as in river areas with weak currents (Moretti 1983; Wallace et al. 1990). They build straight and slightly conical cases with vegetal fragments bound together with silk, in which both extremes are open. They easily leave the case if threatened, and frequently use empty cases that they find in the environment (Wallace et al. 1990; Vieira-Lanero 2000). They feed primarily on aquatic insects, crustaceans and annelids, although they also eat algae and vegetal fragments (González and Cobo 2006). Their ability to catch invertebrates seems to be related with a degree of prognathism, the great mobility of their head and a first pair of legs, which are provided with spines to retain preys. In the Iberian Peninsula, two species can be found.

Polycentropodidae

Description

Polycentropodidae larvae are campodeiform (Fig. 3.17h) and similar to Philopotamidae. The whole body has roughly the same width, which makes the head appear wider than the rest of the body. They colour of the head is very characteristic: yellowish with dark spotted-patterns. Only the pronotum is sclerotized, and unlike Philopotamidae, the posterior margin is not black. They do not have abdominal gills, but they have anal gills. The claws on the legs are slender and arched, almost as long as the tarsi. The anal prolegs are quite long and have two segments of similar size, the basal one membranous and the distal one sclerotized.

Biology

Polycentropodidae species live in calm waters with low velocities, with pebble and stone substrates, both in rivers and lakes. Species of this family are carnivorous, and they spin a silk net attached to the substrate. The net looks like a pouch that collects live prey which is passively dragged by the current, but it can also act as a snare (Edington and Hildrew 1981). Polycentropodidae nets also have a silken tubular area where the larva rests. Species that live in calmer areas feed passively on rotifers, cladocerans, copepods, ostracods, oligochaetes and chironomid larvae. Specimens that live in areas with faster currents, where the passive macroinvertebrate drifting is negligible, behave as active predators of chironomids, stoneflies, mayflies and benthonic crustaceans. In the Iberian Peninsula, 23 species of this family have been recorded. They are organisms that do not tolerate decreases on the level of dissolved oxygen, which makes them indicators of relatively good quality waters (Puig 1999).

Psychomyiidae

Description

Psychomyiidae have small campodeiform larvae with a quadrangular head and a variable colour pattern (Fig. 3.17i, j). The labrum is dorsally sclerotized and the labium is long and narrow, protruding on the anterior part of the cephalic capsule. The silk gland is located apically on the labium. They do not have labial palpi and the maxillary lobe is wide and flattened, with two submental sclerites. Mandibles are asymmetrical, with only one cutting edge. Only the pronotum is sclerotized, with the meso- and metanotum completely membranous. The thoracic legs are short and similar in size, with thick and short tarsal claws. The abdomen does not have branchial filaments. The pygopodes, with short and well developed anal claws, appear to have just one segment due to the reduction of the basal membranous segment.

Biology

Psychomyiidae species are mainly found on middle and lower reaches of rivers and streams of cold waters (Puig 1999). Most species initially live as free individuals on rocks, but towards the last stages of their larval phase, they build galleries or tunnels over stones or on submerged surfaces. These galleries are spun with silk and covered with sand grains and detritus to protect the caddisfly from predators while it grazes. The galleries are also relatively long, and their width allows the larva to turn upsidedown inside. From that point onwards, they spend the rest of their larval and pupal life inside those galleries, which normally form large aggregates over rocks or wood. Larvae living on rocks are grazers of the perphyton, feeding on benthonic algae and diatoms, while larvae living on submerged wood feed on the bacteria and fungi growing on the wood (Edington and Hildrew 1981; González and Cobo 2006). In the Iberian Peninsula, 21 species of this family have been recorded. They can tolerate a certain degree of organic discharge in waters.

Rhyacophilidae

Description

Rhyacophilidae larvae are prognathous, more or less dorsoventrally compressed and with marked constrictions between abdominal segments (Solem and Gullefors 1996; Fig. 3.18a–e). Only the pronotum is sclerotized. Gills can be present or absent. The ninth abdominal segment has a dorsal sclerite. Anal appendages are prominent and the anal claws are well developed. The lateral sclerite can have an ensiform prolongation on the external posterodorsal area. They build a pupal case only when larvae are about to pupate. This case is made of stones bound with silk and it looks like a dome that attaches firmly to the substrate.

Biology

Rhyacophilidae larvae do not build portable cases or any other kind of shelter. They freely move over and between sediment particles and vegetation, sometimes using a silk thread as a safety attachment. They build a pupal case only when larvae are about to pupate, within which the larva spins a nymphal cocoon, parchment-like and yellowish-brown. After this stage, the pupa matures, and breaks the cocoon with its mandibles to swim towards the surface. Rhyacophilidae larvae are predators, although phytophagous when young. They prefer insect preys, such as the larvae of caddisflies, mayflies and dipterans (Chironomidae and Symulidae). They are clearly rheophilic insects: they do not tolerate slow currents, where they seem to suffocate after a short period. Under these conditions, they perform wavy abdominal movements to ventilate. They live mainly in clean waters of streams and small rivers of stable substrates, generally of rocks or stones. Due to their rheophilic nature and preference for cold waters, they are very frequent in headwaters of rivers and small streams. Most species are univoltine and rarely bivoltive (especially in high mountain streams and brooks).

Sericostomatidae

Description

Sericostomatidae larvae (Fig. 2.21e) had a sclerotized pronotum. The mesonotum is not very sclerotized, except for four sclerites (two larger central ones and two elongated lateral ones) on the anterior part. The metanotum is slightly sclerotized. The meso and metanotum have numerous and long secondary setae. The first abdominal segment has three protuberances (the lateral ones oblique and flat). Gills with 1–2 or 3–5 filaments can be observed on abdominal segments I–VIII. They build mineral cases, tubular and slightly curved, with a circular aperture in the posterior occlusive membrane, and an external smooth surface. The cases built by the early stages are very similar to those of Beraeidae, both in texture and shape. The cases built by the last stages are very similar to those of Odontoceridae, but in these,

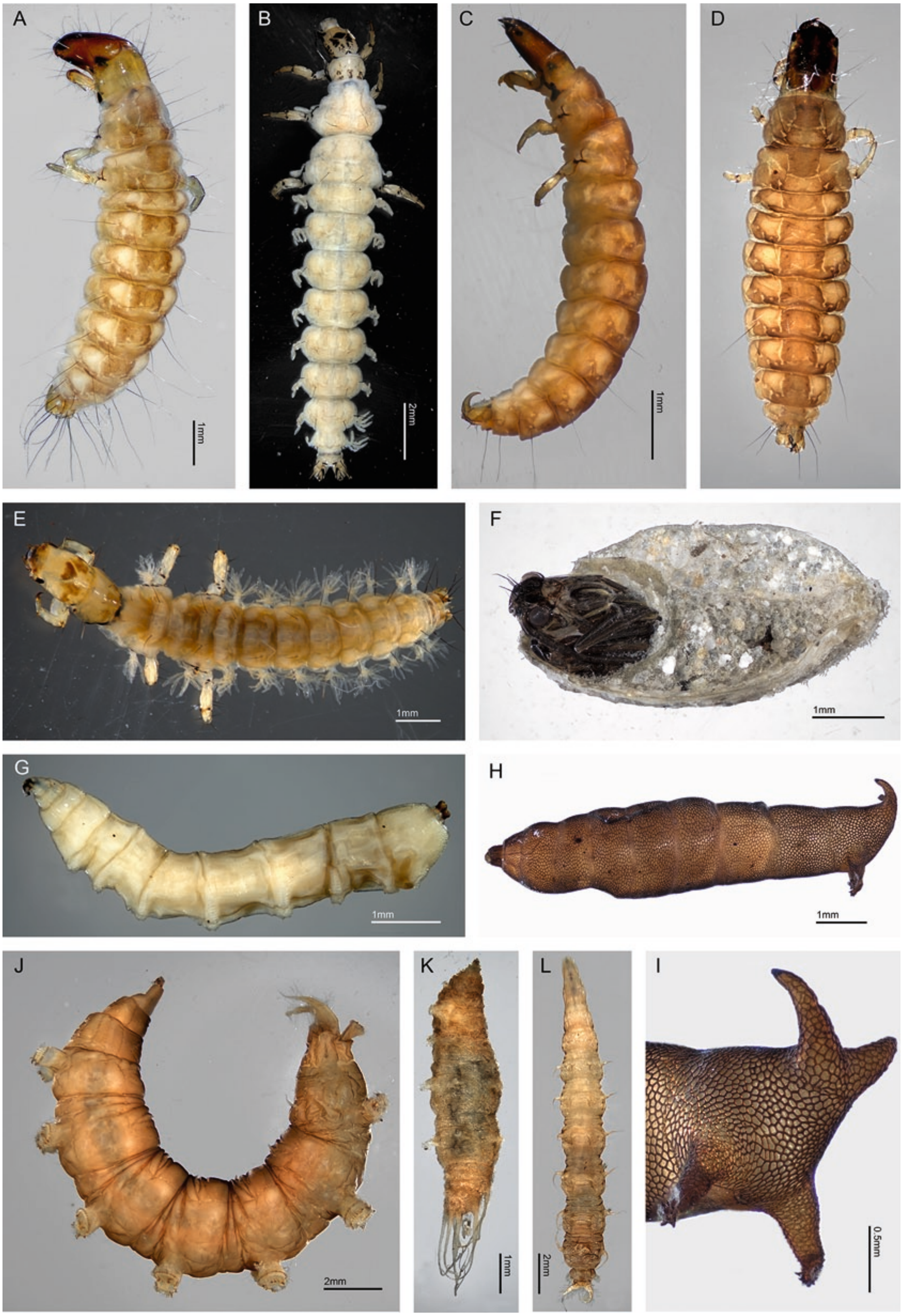

Fig. 3.18 (**a**–**e**) Rhyacophilidae; (**f**) Ueonidae pupa in its case; (**g**) Muscidae; (**h**, **i**) Anthomyiidae pupae; (**j**–**l**) Athericidae

the posterior aperture is blocked by a stone of the right size and the sand grains that form the case are not that uniform, therefore lacking the smooth texture characteristic of Sericostomatidae. Larvae can turn upside-down without leaving the case, something they do at the very least to cut the posterior part of the case in each moult and before pupation (Solem and Gullefors 1996).

Biology

Sericostomatidae larvae live in depositional lotic areas, where they wander on sand and vegetable matter. They are shredders that play an important role in the transformation of coarse particulate organic matter into fine particulate organic matter. Larvae feed usually at night on the surface of the sediment. During the day, they introduce inside the sediment, where they defecate. They are strongly gregarious during pupation: larvae group to pupate in areas of high current velocity, where they make big aggregates under stones and submerged objects (whether natural or not) to which they attach the posterior end of their cases. Unlike other caddisfly families, they first block the posterior end of the pupal case and then the anterior one. The number of larval stages varies between 6 and 7, and the life cycle seem also variable, with described cycles of one, two, three and even 5 years if the eggs undergo diapauses. They spend the winter as eggs or larvae in different stages. This complexity seems to be related to the hours of light they receive, water temperature and availability of food items with of more or less nutritional value.

Uenoidae

Description

Uenoidae larvae are very short and stout, with a very wide first abdominal segment (Fig. 2.23a). The pronotum is sclerotized, the mesonotum has three pairs of sclerites and the metanotum only bears two pairs of sclerites. The first abdominal segment has three obvious protuberances, the ventral one wide and with a pair of posterior sclerites.

They build mineral cases, tubular and conical, with the anterior aperture oblique and the posterior one narrow, partially blocked by an occlusive membrane that has a central circular orifice. Depending on the species, this basic arrangement is modified to form a case that resembles the shell of *Ancylus* (by building dorsolateral "wings") (Fig. 3.18f) or a cryptic case, dorsally and laterally covered by small balls of detritus and sand grains that the larva constantly renews.

Biology

Uenoidae larvae live in rivers and streams of cold waters, being especially abundant in headwater reaches. All the species from the genus *Thremma* McLachlan 1876 (the only European and Iberian genus) distribute in a wide range of altitudes and across the ecological spectrum. They are usually petricolid organisms that can be found forming large aggregates, mainly in springs and small water currents in the premountainous and mountainous regions, as well as in lower reaches of rivers of low flow. Studies on larval stomach content reveal that they are grazers and feed on periphyton, mostly on diatoms and fine organic particles that they scrap from the substrate and manipulate with their mandibles. Their biological cycle can be uni- or bivoltine.

Muscidae

Description

Muscidae have an elongate and subcylindrical body (third larval instar 6–22 mm) with tapering anterior and blunt posterior ends (Fig. 3.18g). They have a whitish or yellowish in colour. Their head is reduced and withdrawn into the thorax. It is also bilobate in dorsal view and posses a pair of two-segmented papillate antennae and a pair of sensory plates (maxillary palps). The internal cephalopharyngeal skeleton has slender, curved and sharply pointed mouth hooks, typical of obligate predators. The three thoracic segments usually bear a row of spinules along the anterior margin and paired bush-like groups of setae ventrally. They have eight abdominal segments with spinate ventral creeping welts, which might be more or less developed into paired prolegs depending on the species. The respiratory system is always amphipneustic in the third larval instar, comprising fan-like anterior spiracles placed laterally on the second thoracic segment, and abdominal posterior spiracles situated on two separated spiracular plates placed, in some species, on elongate spiracular processes.

The puparium retains most of the larval external features. It is usually more or less barrel-shaped with a pair of rod-like respiratory horns penetrating through the dorsal part of the first abdominal segment. Appendages are not fused to the body surface.

Biology

Muscidae is a cosmopolitan dipteran family including some 4000 species, of which 258 species have been recorded in the Iberian Peninsula (Pont and Báez 2002). The vast majority of muscid larvae are terrestrial, found amongst dung, carrion and rotting vegetable matter. However, some species have truly aquatic larvae. These can be found in running and standing waters in environments such as streams, ponds, waterfalls, lake outlets and marshes; often in decaying organic matter and moss or algal mats where they prey mainly upon other dipterans. Apart from some exceptions, the majority of larvae are obligate predators at least in the final instar. Many muscids are a nuisance to animals and man and often serve as vectors for diseases. Several species are known to cause myiasis.

Most aquatic muscids are bivoltine, overwintering in the larval stage. Muscidae are a peculiar dipteran family in that they include some viviparous species, though most are oviparous. In oviparous species, the larvae that emerge from the hatched eggs may be in the first, second or third (final) larval instar. The larvae of most aquatic species emerge from the egg as second or third instar.

Anthomyiidae

Description

Anthomyiidae larvae are whitish or yellowish, maggot-like. The head is reduced and withdrawn into the thorax (Peterson 1960). The mandibles move parallel to each other on a vertical plane. The most distinct feature of their larvae is the posterior end of the abdomen, which bears four prolongations (two dorsal and two ventral) curved towards the anterior part of the body (Fig. 3.18h, i). They present welts on the anterior ventral margin of the abdominal segments. Pupation occurs in the last larval skin (exuviae), and therefore, the external morphology is similar, without wing pads or leg-sheaths and with those characteristic curved prolongations at the end. The difference between larva and pupa is that the latter present a dark colouration and the cuticule is hardened and strongly reticulated.

Biology

Sometimes the family Anthomyiidae is included as a subfamily of Muscidae, which has generated a great deal of confusion with respect to the position and classification of some genera in both families. This also makes the available information rather confusing, as descriptions and data can be attributed indistinctly to either family. Anthomyiid larvae have different habits and some species are found in the stems and roots of various plants, while other species are regarded as aquatic or semiaquatic. They are found in both ponds and streams, where they usually prefer aquatic plants or moss as a substratum. They anchor to stems and leaves of the aquatic vegetation via the arched prolongations at the end of their abdomen. These larvae can live burrowed in any suitable material in order to avoid light. The aquatic Anthomyiid larvae are predaceous and consume a variety of invertebrates, but they mainly feed on dipteran larvae and oligochaetes. They are not particularly valuable as indicators of water quality. According to Michelsen and Báez (2002a), 173 Anthomyiidae species have been recorded in the Iberian Peninsula, although not all of them have aquatic larvae.

Athericidae

Description

Athericidae larvae have a slightly dorsoventrally compressed body (Peterson 1960; Fig. 3.18j–l). They are apneustic and hemicephalic, and the cephalic capsule can be completely withdrawn inside the thorax. Antennae are small and apically trifurcate. Mandibles are falcate and move vertically. They also have a canal to inoculate poison. Thoracic segments bear ventrally a pair of setae that can be branched. Abdominal segments 1–7 have a pair of prolegs, while the anal segment has a single ventral proleg. All have three series of quitinous hooks. They also typically present a pair of long caudal tubercles, with marginal fringes of setae (Majer 1988; Thomas 1997).

The pupae are obtect and their respiratory system is peripneustic, with a prothoracic spiracle in the shape of an inverted "3". Abdominal segments have one to seven small spiracles. They have spine-like projections on abdominal tergites (two pairs), pleurae (one pair) and sternites (three pairs). The anal segment has a crown of sturdy spines and two apical conical projections (Thomas 1997).

Imagos (7.5–10 mm) can be differentiated from those of other families because they bear antennae with a kidney-shaped third segment and a flagellum forming a slender non-annulated arista. Wings have the cell r1 closed by the vein R2+3, which meets the at the end part of the vein R1; the costa extends beyond the wing apex (Oosterbroek 2006).

Biology

Athericidae is a small, strictly aquatic family that until recently was included within Ragionidae. From the 10 European species, four have been recorded in the Iberian Peninsula (Carles-Tolrá 2002a, b). These can be found in almost all aquatic environments. *Atrichops crassipes* (Meigen 1820) lives among the mud on backwaters. The larvae of this species position on the substrate with their tracheal posterior projections protruding over the sediment surface. *Atherix ibis* (Fabricus 1798), *A. nebulosa* (Fabricius, 1798) and *Ibisia marginata* (Fabricius, 1781) are more rheophilic and penetrate in the interstitial areas of cobble substrates, exposing head and thorax to the current to catch, with a swift move, other insect larvae. They paralyze their pray inoculating an anesthetic substance that acts in a few seconds. Due to their peculiar lifestyle, they are good indicators of the stability of the substrate and do not usually appear in streams with a slope bigger than 30%. Adults can sporadically be hematophagous. Interestingly enough, adult females of *Atherix ibis* gather together in compact groups to lay eggs collectively, and die together right after (Majer 1988; Thomas 1997; González and Cobo 2006).

Dolichopodidae

Description

Dolichopodid dipterans have maggot-like larvae with a whitish cylindrical body (4–12 mm), a tapered anterior end and terminating in a blunt posterior end (Peterson 1960; Fig. 3.19b). The head capsule is incomplete (acephalic), and often retracted into the thorax. They have three thoracic and eight abdominal segments. The abdomen has ventral creeping welts on the anterior margin of the first seven abdominal segments and four pointed lobes on the posterior end. The dorsal lobes are less developed than the ventral lobes, bearing one of the two widely separated posterior spiracles. Dolichopodidae and Empididae larvae are very closely related and morphologically similar. However, they can be easily differentiated by the internal structure of the head capsule, which in dolichopodids presents a pair of metacephalic rods with distinctive swollen and spatulated posterior tips.

Dolichopodid pupae are usually enclosed within a loose cocoon made of pieces of wood, sand grains and other materials cemented together with a silken lining secreted by the larvae. Two large prothoracic respiratory horns arise dorsally just behind the eyes, projecting far in front of the head through a narrow opening at the anterior end of the cocoon.

Biology

Dolichopodidae are cosmopolitan and one of largest dipteran families, comprising about 6000 species worldwide in over 150 genera. 207 species have been cited in Spain (Ventura et al. 2002). Most dolichopodids are terrestrial in all stages, although they are often abundant in warm moist habitats, such as humid forests, salt marshes, wetlands, and shallow banks of rivers and ponds. Easy to recognise by their generally metallic green or blue body colour, the adults are predators of soft-bodied invertebrates. They have potential as biological control agents of different pest species such as bark beetles (e.g. Nicolai 1995). Many of these flies have interesting courtship rituals involving complex dance patterns.

The ecology of the immature stages (three larval instars and pupa) is still largely unknown. Probably few genera present truly aquatic larvae. Larvae are found in mud or submerged in soft sediments close to the shore of lakes and ponds and amongst rotting vegetation in springs, slow-flowing waters, stagnant pools, temporary ponds and similar environments. They are generally considered to be predators (with the exception of one plant-mining genus), feeding upon small insect larvae and annelid worms.

Fig. 3.19 (**a**) Empididae pupa; (**b**) Dolichopodidae; (**c**) Ephydridae; (**d**) Rhagionidae; (**e**–**g**) Sciomyzidae; (**h**, **i**) Blephariceridae: larva (**h**), pupa (**i**); (**j**–**l**) Stratiomyidae; (**m**) Chironomidae; (**n**) Simuliidae pupa

Empididae

Description

Larvae of aquatic Empididae (Fig. 2.19h) are not very well known and the larval stage of many genera has not been described. In general, they are apneustic and hemicephalic, small, vermiform, with well developed prolegs and 11 abdominal segments that have one pair of cylindrical prolegs in seven of their 11 segments. They also have four groups of posterior setae. The mouth pieces of aquatic species are distinctly different from those of the other subfamilies of Empididae (Vaillant 1981; Brindle 1969; Sinclair 1995; Wagner and Gathmann 1996; Wagner 1997b).

Pupae of Hemerodromiinae are easily distinguishable. They are characterised by having long projections along the lateral surface (Fig. 3.19a). These projections are slender and coiled and seem to have a double function as reparatory and anchorage structures. Unlike Hemerodromiinae, the pupae of Clinocerinae do not have projections; they are free living and have a pair of prothoracic horns with respiratory function (Wagner 1997b).

Adults (1–12 mm) have raptorial forelegs and very complex genitalia, whose size is related to body size in Hemerodromiinae. The thorax of Clinocerinae is less elongated and does not have raptorial legs. The ratio between the maximum length and width of the wing is significantly constant in these subfamilies, always between 2.8 and 3.2 (Wagner 1997b).

Biology

The family Empididae is divided in six subfamilies, with only two truly aquatic genera, Hemerodromiinae and Clinocerinae (Vaillant 1981; Vaillant and Gagneur 1998; Wagner 1997b). They colonise different environments: they can be found in the hygropetric areas of springs, streams and rivers, with fast currents and thick substrates, under rocks, over mosses, on submerged wood and even on the humid soil of riverbanks.

The larval stages of these subfamilies are active predators of other insect larvae. Their main preys are larvae and pupae of chironimid, simulids and caddisflies. Adults can form swarms for mating. They generally have sexual dimorphism, with males presenting elongated and widened tibias or femurs. During mating, the male offers a prey or a small object to the female.

Freshwater Empididae have not been very studied in the Iberian Peninsula, where 11 species or Hemerodromiinae and 30 species of Clinocerinae (Ventura and Báez 2002; Wagner and Cobo 2001; Cobo and Carreira 2003) have been recorded. In general, Empididae species richness seems to decrease as one moves away from mountainous areas.

Ephydridae

Description

Ephydridae are small to medium whitish larvae (up to 25 mm long including the respiratory tube when present), with three larval instars, usually of similar appearance within species (Fig. 3.19c). The body shape is variable, from dorsoventrally flattened to cylindrical, and usually broadest around the middle. The head is reduced and withdrawn into the thorax. The anterior part of the head is often bilobate with a pair of dorsal two- or three-segmented antennae. The facial mask around the oral opening has several rows of comb-like structures in all genera but Nostima. The internal cephalopharyngeal skeleton has mouth hooks that are curved and sharply pointed. The thorax and abdomen are variously wrinkled or annulated, tuberculate, and present numerous setae or spinules. In some genera, up to eight pairs of prolegs can be present, each with two or three rows of hooks. The last pair of prolegs is clearly larger than the rest and presents opposable hooks. The last abdominal segment is markedly tapered to a long tube-like respiratory siphon, which is at least partially retractile and bears a posterior pair of spiracles. The respiratory system is metapneustic in the first larval instar switching, with some exceptions, to amphipneustic in the second and third instars. The posterior spiracles usually bear three or four rounded openings.

Both pupae and larvae can have variable shapes, with colouration ranging from dark to light brown. Pupae retain many of the external morphological features of the larvae. The larval respiratory siphon and spiracles are fully extended.

Biology

Ephydridae are a cosmopolitan dipteran family of a mainly Holarctic distribution comprising more than

1,850 species, 145 of which have been cited in Spain (Zatwarnicki 2002). Shore flies (also known as brine flies) are intimately related to humid environments. Most of the larvae are aquatic or semi-aquatic and frequently inhabit the margins of ponds, marshes and pools, on almost any kind of substrate, frequently detritus or algal mats and mud. The family Ephydridae has been a very successful family in its adaptation to extreme habitats. The larvae can be found in very inhospitable environments, such as alkaline lakes, salt marshes or hot springs. Some species can even thrive in crude petroleum (the petroleum fly, *Halaeomyia petrolei* (Coquillett, 1899)) or urine pools. Ephydridade larvae generally require substrates with high organic content, which support rich populations of micro-organisms. They are usually grazers or filter feeders of microscopic algae, bacteria and organic detritus. Other shore fly larvae are also piercers, scavengers, predators and shredders.

Females can deposit up to 600 eggs, which are laid singly or in groups over substrates such as algal mats, plants or boulders. In temperate regions species are mostly multivoltine, each generation taking from 2 weeks to a month and a half to complete. Adult activity may be sustained throughout the year.

Rhagionidae

Description

Rhagionidae larvae (Fig. 3.19d) are very similar to Dolichopodidae, which sometimes makes differentiation of these two families difficult. Rhagionidae larvae have a white, more or less cylindrical body without an obvious head and with ventral welts on abdominal segments to facilitate locomotion. Mandibles are triangular and well developed, moving parallel to each other on a vertical plane. The larva has two lateral longitudinal furrows along the entire body, which are more or less marked. The last abdominal segment has four well differentiated lobes, two dorsal and two ventral. These lobes are somewhat foliaceous (unlike those of Dolichopodidae, which are somewhat conical) and demarcate a respiratory atrium. Usually there is a small conical and pointed tubercle between the dorsal and ventral lobes. The anal plates have a more oval-elliptical shape than in Dolichopodidae (more triangular and pentagonal). The anal plates can have a dark colouration with ferrous shades.

Biology

Most representatives of this family are terrestrial, with a single aquatic genus, *Chrysopilus* Macquart 1826, of which six species have been recorded in the Iberian Peninsula (Carles-Tolrá 2002). They can be found in lake and river shores, but also in areas where rock substrates are covered with a thin layer of water, or between aquatic bryophytes. They can also develop on humid soils. They are predators that feed on aquatic invertebrates.

Scathophagidae

Description

Scathophagidae have maggot-like larvae with a cylindrical white body (third larval instar 4–14 mm). The anterior end is pointed and the posterior end is thicker and truncated, usually with several short conical lobes surrounding the spiracular plate (Fig. 2.20a). The body comprises an undeveloped head, three thoracic segments and eight abdominal segments. The head posses a pair of small papillate, antennae and maxillary palps. The internal cephalopharyngeal skeleton has mouth hooks that are often toothed below and that vary from slender to stout depending on feeding habits. The thoracic and abdominal segments are smooth or with transverse rows of short spines. The abdominal segments present spinate ventral creeping welts. They possess an amphipneustic respiratory system. The anterior pair of spiracles is situated laterally on the second thoracic segment, and it is very broad and forked with two branches, each with many lobate structures. The posterior pair of spiracles is situated on short tubes on a spiracular disc, each with three straight respiratory silts. The puparium is barrel-shaped with some of the larval characteristics visible.

Biology

The family Scathophagidae comprises about 250 species, of which 20 have been cited in Spain (Michelsen and Baez 2002b). Scatophagids have an almost exclusive Holarctic distribution and present the most northern overall distribution among dipterans (Vockeroth 1987). Dung flies are mainly terrestrial and, as their common name suggests, the larvae live normally in the dung of mammals (e.g. cattle). They often occur in environments such as meadows, marshes and bogs, and along the shores of streams and lakes. They prey generally upon invertebrate larvae including other Diptera.

Only a few genera (e.g. *Scathophaga* Meigen 1803, *Acanthocnema* Becker 1894, *Hydromyza* Fallen 1813) present truly aquatic larvae, whose biology and ecology is still poorly described. Among them, some are leaf miners of aquatic plants such as *Hydromyza livens* (Fabricius 1974), while others have free-living larvae like those of the genus *Acanthocnema*, which live in swift streams and are predators of aquatic insect eggs. Females enter the waters of streams and ovoposit their eggs on the surface of the eggs masses of other invertebrates such as Trichoptera and other Diptera. The hatched larvae feed on the eggs and surrounding jelly of the host (Purcell et al. 2008).

Sciomyzidae

Description

Sciomyzidae fully grown larvae usually present an elongated body (2–15 mm), cylindrical or fusiform, with a tapered anterior part and covered by a wrinkled and folded integument (Fig. 3.19e–g). Colouration ranges from transparent or whitish to entirely black. The head is reduced and withdrawn into the thorax, apically rounded or bilobate. The internal cephalopharyngeal skeleton is visible through the integument. Depending on the species, the mandibles may or may not have a row of accessory teeth. They have three thoracic and eight abdominal segments, often presenting transverse rows of tubercles. The integumentary folds mark the boundaries between body segments. The ventral creeping welts on the posterior abdominal segment have transformed into anal prolegs in some species. Mature larvae posses an amphipneustic respiratory system. The anterior spiracles are located laterally on the posterior margin of the first thoracic segment in the form of round, oval or elongated stalked structures. The posterior spiracles are situated on separate, short tubular mountings on the last abdominal segment, and surrounded by fleshy lobes which might be long and have a respiratory function. Each spiracle has three slits arranged in a radiating pattern.

The puparia are ovoid to almost cylindrical with tapering ends. The original larval segmentation is usually barely visible. In aquatic sciomyzid larvae, the puparia is frequently adapted to float with the posterior end elongate and upturned forming a long respiratory tube.

Biology

Sciomyzids are a cosmopolitan family with about 506 species, of which 57 have been cited in Spain (Carles-Tolrá and Báez 2002). Aquatic and semi-aquatic species occur on a wide variety of aquatic habitats; most commonly in pools, marshes, the littoral zone of lakes and ponds, and the edges of depositional reaches of streams. The vast majority of sciomyzid larvae feed as predators or parasites of pulmonate aquatic snails and pea mussels. The truly aquatic species are active predators that within a few minutes can kill snails that are comparatively much bigger in size. A single larva can kill up to 30 snails or mussels during its development. These larvae live mainly on the water surface, often only partly submerged and frequently swallowing air bubbles to maintain buoyancy, breathing atmospheric air through their posterior spiracles. Other larvae display a partial or complete parasitic behaviour, with more or less pronounced host specificity. They feed on a single snail, which is killed after several days, and then their different larval instars develop on its decaying tissues. In some cases, full larval development and pupation take place within the host shell (puparia typically twisted) but in most cases the larva leaves the host in its second or third instar and becomes predatory until pupation. Sciomyzid larvae are important bioregulators of snails in nature and they have a potential use as biological control agents.

Larval development comprises three larval instars. Most species are multivoltine, with rapid larval development (1 month on average) and the puparia undergo winter diapause. Adult emergence occurs during the spring. Overlapping of summer generations can occur sometimes.

Stratiomyidae

Description

Stratiomyidae larvae have a well sclerotized cephalic capsule, relatively small and narrower than the body, which is quite fusiform and more or less dorsoventrally flattened (Fig. 3.19j–l). There are two different larval morphologies. The most common are easily differentiated by the coriaceous appearance of their body, due to a strong cuticular chitinization. At the end of the abdomen they have a crown of hydrophobic setae that surround the respiratory stigmas. Some other larvae do not show a cuticular thickening, and therefore they have a softer appearance, with the last abdominal segments tapered, ending up in hydrophoic setae. These setae can be numerous and arranged radially, or scarce and grouped.

Biology

An important portion of this family's larvae are terrestrial, but there are also aquatic species. The habitat of aquatic species varies depending on the two main morphologies described. The larvae whose cuticle is not thickened are frequent in quiet low flowing streams, sheltered areas of river shores, lakes and even saline pools. They are usually detritivorous, feeding on organic detritus. The larvae with thickened cuticles can be found in sheltered areas of rivers of mixed substrates of gravel and sand, where leaves and organic particles of allochthonous origin deposit. These larvae feed on leave fragments and the decomposing fauna associated with them, and also on organic remains. They are somewhat tolerant to organic pollution.

Syrphidae

Description

Syrphidae larvae are unmistakable: they have an amorphous body, sack-like, without differentiated structures and a characteristic long and telescopic respiratory siphon that allows them to breathe atmospheric air (Fig. 2.19d). The head is blunt, reduced and withdrawn into the thorax. The mandibles move parallel to each other on a vertical plane. Body segmentation is not very clear, due to numerous furrows on the tegument. They have seven prolegs, the first one on the thorax and the rest on the first six abdominal segments. The abdomen ends in the aforementioned respiratory siphon, which is at least as long as half of the body.

Biology

Syrphidae live in shallow areas in the margins of reservoirs, wetlands and sometimes rivers, usually in areas where there is a large quantity of organic matter and therefore, a reduced concentration of dissolved oxygen that they easily tolerate due to direct intake of oxygen through the siphon. They can move on the bottom of shallow areas looking for food items, mainly detritus and other organic matter, although they have been observed eating mosquito larvae and pupae. They are highly tolerant to organic pollution, and they are frequently observed in areas with wastewater discharges. The presence of this group in rivers usually indicates strong organic pollution.

Tabanidae

Description

Tabanidae larvae (Fig. 2.19f) have a subcylindrical or spindle-shaped body, broadened in the middle and tapered at both ends. Colouration patters differ depending on the species. They have numerous longitudinal wrinkle-like striations on the tegument. The head is reduced and retracted in the thorax, with mandibles that move parallel to each other on a vertical plane. Abdominal segments 1–7 have prolegs on the anterior margin, which are arranged in a ring with small hooks, which also gives these larvae a peculiar appearance. On the posterior part of the abdomen they usually have a short and more or less conical respiratory siphon.

Biology

This family has some representatives that are strictly aquatic, but most species are subaquatic. They are frequent in all sorts of aquatic systems, developing in reservoirs, wetlands and shores of rivers with weak currents. Larvae usually burrow either on backwaters or on the sands and gravel of the riverbeds where they live. They are active predators from their third developmental stage onwards, feeding on annelids and molluscs, although primarily eating other dipteran larvae. However, some species seem to feed on detritus (Puig 1999). Pupation is always terrestrial, usually in soil or mud adjacent to water. Adult females are normally hematophagous, feeding on mammals, amphibians and reptiles. In general, they are not regarded as high quality indicators, because some species can live in areas with detritus deposits, although most species in this family are found in clean reaches of rivers. The diversity of this family in areas with scarce or no riverbank vegetation can be very low (González and Cobo 2006), possibly because adults require dense vegetation (Rivosecchi 1984).

Blephariceridae

Description

The morphology of both larvae and pupae of the family Blephariceridae is very characteristic and unmistakable with that of any other invertebrate group (Fig. 3.19h, i). They have a subcylindrical body, ventrally depressed and seemingly with six segments, which bear six suckers on the middle axis. Each of these segments also bears a couple of very strong claws on each side. The first of those apparent six segments results from the fusion of the head, thorax and the first abdominal segment, while the last apparent segment results from the fusion of abdominal segments 7–10. The anterior part of the first segment is more sclerotized (corresponding with the head) and ventrally it has a circular opening enclosing the mouth pieces. Antennae are conspicuous, with one or two segments. The anterior area of each of the apparent body segments has filamentous pairs of gills with different morphology. They also have anal gills. Pupae have a semi oval body shape, dark dorsally and pale ventrally, resembling small limpets. They also have three to four pairs of adhesive discs with which they attach to rocks on current areas, and two anterodorsal sets of leaf-like thoracic gills that resemble ears.

Biology

Blephariceridae is a group specialised in strong current environments, such as waterfalls and fast mountain rivers. Their range of tolerance for different environmental conditions is also very narrow (Nicolai 1983). For example, the temperature of the waters they inhabit is usually lower than 14°C. Their suckers, strong claws and dorsoventrally flattened shape, make them especially resistant to these conditions of fast waters and strong currents, as they allow them to attach to boulders on the river bed. Their mouth pieces are specialised in feeding on the layer of diatoms, algae, bacteria and organic matter that covers rocks. Due to their high sensitivity to any type of water pollution, the presence of specimens of this family in the environment is an indicator of high water quality (Nicolai 1983; Rivosecchi 1984). In the Iberian Peninsula, 11 species have been recorded (Zwick 2002a).

Ceratopogonidae

Description

Ceratopogonidae larvae have a well differentiated head. Within this family, markedly different types of morphologies can be found (Fig. 2.18d, i). On the one hand, the subfamily Ceratopogoninae presents a filiform body, elongate and cylindrical, without the apparent presence of prolegs, body segments clearly longer than wide and an elongated cephalic capsule, orange and well sclerotized. The subfamily Leptoconopinae have a vermiform, elongated and cylindrical body, but segments are not as elongated as the in latter family, usually showing secondary divisions, and the cephalic capsule is not as strongly sclerotized (it presents two sclerotized plates over the mouth pieces). The subfamily Dasyheleinae also has a vermiform body, with well defined segments that are longer than wide, a prognathous head and a short retractile anal proleg. Finally, the subfamily Forcipomyinae have a hypognathous head with a cylindrical and vermiform body that has two anterior and two posterior prolegs, similarly to Chironomidae, but unlike these, they have several spine-like protuberances. This subfamily can also have larvae with a well differentiated head and a depressed body with lateral expansions in the form of elongated protuberances and setae, as well as the aforementioned spine-like protuberances, and they also have prolegs crowned with distinct claws.

Biology

The family Ceratopogonidae has both terrestrial and aquatic species. Due to the heterogeneity of species in the family, there are species with very diverse habits in terms of food habits and habitat preference. Larvae are frequently found on rivers, usually associated with calm river shores, over leaves and detritus accumulations, macrophytes and algae; although they can also be found in waters with a certain degree of current. They seem to prefer mixed substrates of sand, gravels and pebbles in reaches of low flow and well forested basins. In general, larvae are detritivorous, although there are also herbivorous species, as well as scrapers and predators of chironomids and oligochaetes. Pupae are mainly terrestrial. Their tolerance to large quantities of organic matter does not make them ideal candidates to be indicators of good quality waters. After Chironomidae, they are the aquatic dipterans with most species recorded in the Iberian Peninsula, with 174 (Delécolle 2002).

Chironomidae

Description

Chironomidae larvae have very diverse colour patterns. They are characterised by having a well developed cephalic capsule with multisegmented antenna (retractile or not), and a cylindrical body that has two pairs of prolegs, the first one situated on the thoracic area and the second pair on the anal area (Fig. 3.19m). The pair of thoracic prolegs can be reduced to a transversal pad with thin denticulations. Pupae have different morphologies depending on the subfamily or tribe to which species belong, although in general, they all present a flat anal lobe at the tip of the abdomen. Over the dorsum of the thoracic region there is a pair of respiratory processes of variable morphology.

Biology

The family Chironomidae is the most important and diverse family in the aquatic environment, and they often dominate the invertebrate fauna in terms of absolute numbers and sometimes even in biomass. It is a cosmopolitan family that abounds in all types of continental waters, and also covers the whole range of water qualities, from clean and cold waters to very polluted and anoxic reaches of rivers, as some species are very resistant to pollution. They have diverse lifestyles. Some species burrow galleries in the substrate, among algae mats or inside sponges; others build different types of sheltering tubes with different types of materials that even can include structures made with silk to retain suspended particles, much in the same way that caddisflies do. Many other species are free living and locomote over the substrate. They breathe dissolved oxygen in the water and some groups can have haemoglobin, which allows them to develop in habitats that, due to the lack of oxygen, would be unsuitable for other organisms. They cover all throphic spectra, from filtration to predation, free living or parasitism. In the Iberian Peninsula 480 species of Chironomidae have been recorded (Cobo et al. 2002).

Simuliidae

Description

Simuliidae larvae have a subcylindrical body with two broadened sections, one on the thorax and another one on the posterior end of the abdomen (Fig. 2.18c). They also have a cephalic capsule which is quadrangular and well developed. The premandibles are modified into combs or fan-like structures to catch food items (Fig. 3.20a). Body segmentation is not very marked. On the thorax, the larva has one single proleg with a crown of hooks. On the broadened part of the abdomen there is a sucker-like disc also with a crown of hooks by which they adhere to the substrate. The larva locomotes using this structure and the thoracic proleg. The pupa also has a peculiar shape (Fig. 3.19n), and it builds a pouch-like silk case on the surface of the substrate, from which the respiratory filaments protrude.

Biology

The family Simuliidae is strictly linked to fluvial systems, and they can be found in shallow areas of slow and strong current water courses. They use substrates such as stone slabs, pebbles, submerged trunks and stems of submerged vegetation, to which they attach with the structure at the end of their abdomen. This structure has adhesive properties and can work as a sucker, which allows them to resist the water force and feed on the suspended matter that the current drags. They are filterers and catch particles with the help of their comb or fan-shaped premandibles.

Fig. 3.20 (**a**) Simuliidae; (**b**, **c**) Culicidae: pupa (**b**), larva (**c**); (**d**) Dixidae; (**e**, **f**) Psychodidae; (**g**, **h**) Pediciidae: lateral view (**g**), ventral view (**h**); (**i**–**k**) Limoniidae: pupa (**i**), anal region of *Scleroprocta* (**j**), general view of *Scleroprocta* (**k**); (**l**–**n**) Tipulidae: dorsal view (**l**), anal region (**m**), lateral view (**n**)

Periodically, larvae bend their premandibles towards the mouth pieces to clean them and ingest the retained materials. When the water barely drags any organic matter, they can keep these structures fold and feed on the algae they scrape from the substrate. Besides, some species or some larval stages of some species feed on periphyton or detritus deposits, where they also can accidentally predate on other small invertebrates. Under favourable conditions, they can appear at high densities over the substrate. Adult females of this family can transmit some parasites to different vertebrate groups, such as humans or cattle (Rivosecchi 1978). In the Iberian Peninsula, 49 species belonging to this family have been recorded (González et al. 2002).

Thaumaleidae

Description

Thaumaleidae larvae have a very similar morphology to larvae of the family Chironomidae and to some representatives of the family Ceratopogonidae. The head is clearly differentiated and they body is vermiform and cylindrical. Their head is the most distinguishing feature: Thaumaleidae have a hipognathous head with a series of protuberances over the surface of the cephalic capsule (Fig. 2.18e). Mandibles and maxillae are toothed and bear setae. Antennae are reduced. Besides, unlike Chironomidae, both the thoracic and abdominal prolegs are not pair structures. The anterior spiracles are located on short stalks, and the posterior spiracles open into a transverse cleft between the processes on abdominal segment VIII. On the last abdominal segment, a pair of anal gills can also be present.

Biology

Thaumaleidae are usually found in hygropetric environments of headwater areas, springs, streams and humid mountain forests. Although they can be found burrowed in the substrate, they are usually found living in a very thin film of water, such as wet surfaces of rocks and the sides of vertical walls. In these habitats they feed on the biofilm covering those substrates, scraping the surface with their mouth pieces. In the Iberian Peninsula, 11 species of this family have been found (Wagner and Báez 2002).

Chaoboridae

Description

Larvae of the genus *Chaoborus* Lichtenstein 1800 and the first instars of *Mochlonyx* Loew 1844 are extraordinarily transparent. They are eucephalic larvae that can have larval eyes (Fig. 2.18g). Developing adult eyes are visible in the last stage. They have strong mandibles and prehensile antennae, with their basal segments close to each other (*Chaoborus*) or widely separated (*Mochlonyx*). The mouth opens to a muscular esophagous that bears teeth on its posterior half and ends on a sturdy sphincter. Thoracic segments are fused. There are two pairs of pigmented air-sacs, one on the thorax and one on abdominal segment VII. These structures have hydrostatic function and are connected to the tracheal respiratory system. Abdominal segment X has four anal tubuli, two dorsal groups of setae on tubercules and fan-like ventral setae. The posterior end expands to form a lobe with ventral hooks (Wagner 1990; Saether 1997).

Pupae are obtect and mobile. They possess a characteristic fusiform respiratory horn. Abdominal segments are especially long in *Chaoborus* and each anal lobe bears two wide swimming paddles, round and segmented, in which a mid rib and strong marginal ribs can be observed (Wagner 1990; Saether 1997).

Adults (2–10 mm) have very long and slender legs. They do not have ocelli. Antennae have 15 segments and they are feathery on males. Mouth pieces are conspicuous, but less so than in Culicidae. They have two pairs of stripes on the thorax without setae. Wing venation is similar to that of Culicidae (Oosterbroek 2006).

Biology

The family Chaoboridae includes three European genera: *Chaoborus*, *Mochlonyx* and *Cryophila* Edwards 1930, the latter restricted to Northern Europe. In the Iberian Peninsula, only two species belonging to the genus *Chaoborus* have been recorded, but it is very likely that *Mochlonyx* (Wagner 2002) is also present. *Chaoborus* larvae and pupae constantly appear on the limnetic areas of lakes, whether permanent or temporary, and reservoirs. Although species of this genus are very plastic from an ecological point of view, they are particularly abundant on euthropic environments. They are very active predators that spend the day the deep into the hypolimnion feeding on benthonic organisms such as oligochaetes. At night, they migrate towards the surface of the water. When they reach the limnetic zone they feed on zooplankton and at dawn, they descend again (González and Cobo 2006).

Culicidae

Description

Culicidae larvae are eucephalic and metapneustic (Fig. 3.20c). The head is mobile and very sclerotized. Eyes vary with developmental stage. Antennae only have one segment and insert on the anterolateral cephalic margin. In all European species, the feeding labral brush has numerous and very thin hairs. Due to segment fusion, the thorax is broad and round. Prothoracic setae are a diagnostic character. They have nine abdominal segments with specific dorsal and ventral patterns of setae. The last segments are functionally different in Anophelinae and Culicinae. The anal segments are surrounded apically by four tracheal gills and they have spiracles on the dorsal surface of the eighth segment. These are located either on a plate slightly over the preceding segment (Anophelinae) or more commonly, at the apex of a respiratory siphon (Culicinae) (Richards and Davies 1984; Dahl 1997; Minár 1990, 2000).

Pupae are very mobile (Fig. 3.20b) and very similar to Chaoboridae and to some Chironomidae pupae. Their cephalothorax has characteristic respiratory horns and the abdomen has caudal swimming paddles (Dahl 1997).

Imagos (3–9 mm) are very slender mosquitoes. The head has reniform eyes without ocelli. Mouth pieces are prominent, with rigid and non-hanging palpi. Females have a perforating and sucking proboscis that projects forward markedly. Males have densely plumose antennae (15 segments), pilose in females. Wings have scales on the posterior margin and on the wing veins.

Biology

Culicidae is the most commonly known and most frequent family of biting mosquitoes. Sixty Iberian species are known (Eritjà et al. 2002); although the Asiatic tiger mosquito, *Aedes (Stegomyia) albopictus* Skuse 1894 is a recent invasion. Only Anophelinae, with some European species, can act as vectors of infectious diseases.

Members of this family are typically neustonic and have filtering larvae. They mainly live in lentic aquatic environments, such as ponds, lakes, etc. They are telmatophilous species and can colonise all types of deposits in which water is stored, from water troughs to fountain basins, old tires and all sorts of recipients (González and Cobo 2006). While resting and feeding, Anophelinae larvae float horizontally under the air-water interface, with the spiracular area in contact with the water surface. Culicinae larvae are angled towards the bottom, contacting the surface or the water with the tip of their siphon.

Dixidae

Description

Dixidae larvae are metapneustic, eucephalic, with a non-retractile and strongly sclerotized head (Fig. 3.20d). The antennae and mouth pieces are very developed. They are apodal larvae, although abdominal segments IV and V bear a pair of ventral prolegs armed with curved little hooks (crochets). In some species of the genus Dixa, segments 5–10 have a dorsal shield bearing setae. The posterior end of the body has a terminal complex with a pair of spiracles surrounded by a sclerotized area, a pair of long and pilose lateral paddles and a caudal appendage with numerous very long setae that help buoyancy (Richards and Davies 1984; Wagner 1997a).

Dixidae pupae resemble those of Culicidae, but they do not have swimming paddles and their caudal lobes, which can be more or less elongated, are triangular. The prothoracic respiratory horn can be a diagnostic character (Rozkosny 1990; Wagner 1997a).

Imagos (3–5.5 mm) have typical filiform and non-plumose antennae with 16 segments. The legs and the abdomen are elongated. They do not have ocelli and the mouth pieces are not functional. The wings do not have scales and they usually have pigmented spots. They are characterized by having radial and cubital forks and vein r-m, although they do not present a discal cell (Oosterbroek 2006; Wagner 1997a).

Biology

Dixidae are known as "meniscus midges", because their larvae adopt a characteristic inverted U-shape near the water meniscus. They are typically neustonic, feeding by filtering bacteria and organic matter.

In the Iberian Peninsula, two genera exist: the genus *Dixa* Meigen 1818, whose species are more rheophilic and that frequently appear in drift samples; and the genus *Dixella* Dyar and Shannon 1924, which prefers calmer environments in backwaters of rivers and streams. However, species of both genera can be abundant in running waters as well as ponds and lakes (Rozkosny 1990). Nine species have been recorded on Iberian waters (Wagner and Baez 2002).

Females hold the egg masses with their hind legs and deposit them on the water surface, near to any kind of emerging object, to which the eggs attach through surface tension. Larvae develop in that same environment and pupae can submerge as a defense mechanism or when the water surface freezes. There are not many published work on the phenology of this family, but in general they have univoltine cycles (Disney 1975, 1999; Wagner 1997a).

Psychodidae

Description

The family Psychodidae (Fig. 3.20e, f) has about 4,700 species worldwide with a mainly tropical distribution. In Spain, 84 species belonging to this family have been recorded (Wagner et al. 2002). There are two aquatic subfamilies in Europe, with remarkably different morphological features. The typical moth fly larva is that of the subfamily Psychodinae. The body (3–8 mm) is cylindrical and tapered posteriorly, with a sclerotized non-retractile eucephalic head, clearly separated from the thorax. Antennae are small and unsegmented. The body segments present secondary segmentation with two (thoracic and first abdominal segments) and three (from the second to the seventh abdominal segment) annuli, giving the appearance that the larva has a total of 26 segments. Each annulus bears a distinctive sclerotized dorsal plate and several smaller dorsal and ventral plates, each with hairs and setae in a number and arrangement that depends on the species. Creeping welts and prolegs are absent. They have an amphipneustic respiratory system. The anterior spiracles are situated on small tubercles on the second annulus of the prothorax. The posterior spiracles are situated on a short non-retractile respiratory siphon and surrounded by four elongate setose appendages.

The other aquatic subfamily, Sycoracina, has small isopod-like larvae with a broad body, dorsally convex and ventrally flattened in cross-section. The head is eucephalic and retractile, with a pair of slender four-segmented antennae that are longer than the width of the head. Creeping welts and prolegs are also absent. The last thoracic segment and the eight abdominal segments have large dorsal sclerites. Body segments bear several prominent lateral lobes fringed with long setae. The posterior spiracles are not placed on a respiratory siphon.

Biology

Psychodidae larvae prefer moist sediments and detritus at the edge of streams, ponds, drying swamps and marshes. Truly aquatic species are found along both swift and slow flowing streams, living on different substrates (e.g. mud, sand, s surface, moss carpets). Generally, the larvae can be classified as collector-gatherers, feeding on almost any kind of decaying organic matter and detritus. Larvae of some species are associated with decomposing organic matter in environments like sewage treatment facilities, drains or gutters, and are indicators of heavily organic enriched waters. As a result, they can be commonly found in bathrooms and public toilets. They are known to cause diseases like myiasis or bronchial infections by inhalation of the hairs of dead adults during maintenance operations in sewage plants.

Pre-imaginary development comprises the egg, larval (four instars) and pupal stages. Moth flies include both univoltine and multivoltine species. A complete life cycle can take from a week to over a month, depending on the species and the surrounding environmental conditions (temperature and resources).

Ptychopteridae

Description

The body of Ptychopteridae is long (10–25 mm without extended breathing tube) and slender, spindle-shaped, with prominent intersegmental rings between the first and the sixth abdominal segments. They have prolegs on the first three abdominal segments, each of them with a single strong apical claw. They have a small sclerotized eucephalic head, triangular in shape and clearly separated from the thorax. Antennae are also small and the eyes are located near the anterior margin. They have three small thoracic segments and nine abdominal segments. Body segments usually present numerous warts bearing hairs. The last abdominal segment is short and bears a pair of retractile anal papillae or tracheal gills. The abdomen terminates in a long retractile respiratory tube (often withdrawn into the thorax in dead specimens) with two apical tracheal trunks ending in a pair of spiracles (metapneustic respiratory system).

The pupa is usually inactive and can be found facing up in the mud in vertical position. The head appendages, wings and legs are visible, gathered inside sheaths that are attached to the body. The thoracic breathing horns have unequal length, with the right one usually much longer, exceeding the body in length, and developed into a long siphon which is kept in contact with the atmospheric air.

Biology

The Ptychopteridae are a small and mainly Holarctic dipteran family of about 64 species divided amongst three genera. Only two species have been cited in Spain (16 in Europe) belonging to a single genus (Ptychoptera) (Zwick 2002b). These flies get their common name (phantom crane flies) from the adult flying behaviour, which involves very little movement wing movement. The larvae and pupae are found in muddy areas with large accumulations of organic matter or amongst decaying vegetation in shallow waters along the margins of ponds, lakes and marshes, and in the depositional reaches of streams. The larvae are saprophagous, feeding on mud and plant detritus as well as decaying organic matter and associated microorganisms, such as algae and bacteria. Ptychopteridae larvae are hence resistant to organic pollution, which can be even favourable to some species. The larvae are generally not very active, burrowing face-down into the soft sediments and breathing by siphoning atmospheric air from the water surface through their long retractile respiratory tube.

Adult emergence occurs from spring to autumn. Eggs are laid on suitable habitats for the larvae, hatching after about a week. The duration of the larval development, comprising four larval instars, is not exactly known. Hibernation is frequently done as fourth larval instar. The development time of the pupae is very variable (from less than a week to a month). It is common to find populations with overlapping generations.

Limoniidae

Description

Limoniidae larvae (Figs. 2.19a and 3.20j, k) are hemicephalic, with cephalic sclerites differently developed depending on the subfamily considered. In general, they have two lateral sclerites and a dorsal one, all well sclerotized. The mandibles of detritivorous species are robust with broad teeth, while mandibles of carnivorous species are slender and falciform. They are metapneustic, rarely apneustic, and the terminal segments bear disc-shaped and sometimes pigmented spiracles. These are covered by a hydrophobic secretion and surrounded by five lobate projections, more or less elongated. They generally have four partially sclerotized and pigmented anal lobes, with a variable number of setae of different sizes (Savchenko et al. 1992; Reusch and Oosterbroek 1997).

Pupae are obtect, elongated, with clearly marked eyes and variable respiratory horns (simple, branched, cylindrical, spherical, etc.) (Fig. 3.20i). The antennal sheaths are long. Abdominal segments frequently bear setae, spines or tubercules. Anal segments have prominent spines (Savchenko et al. 1992; Reusch and Oosterbroek 1997).

Imagos (2–11 mm) have the last segment of the maxillary palpi as long as the preceding two together, antennae with 14–16 segments and no ocelli. The thorax has a mesonotal transverse V-shaped suture. Wings are long, although sometimes they can be reduced. They have two anal veins that reach the wing margin and vein Sc1. Legs are very long and slender, and they can have tibial spurs (Oosterbroek 2006).

Biology

Limoniidae is one of the most diverse and cosmopolitan dipteran family, with a great variety of habitats. Species of this family are aquatic or semiaquatic and colonise habitats that go from deposit areas to vegetal detritus in the shores of rivers and lentic environments, and also hygropetric surfaces. In the Iberian Peninsula, 97 species have been found (Eiroa and Báez 2002a). Characteristic of this family are the larvae, which are capable of inflating the penultimate segment as a means to anchor their body to the substrate. Their trophic spectrum includes shredders, detritivorous and grazers of the periphyton, also including predator species.

Pediciidae

Description

Until recently, some authors considered Pediciidae (Fig. 3.20g–h) as a subfamily within the family Limoniidae. However, there is a recent general consensus to consider this group as the fourth family within Tipuloidea, especially after the work of Stary (1992). Larvae of this family are hemicephalic and metapneustic, with a quite elongated cephalic capsule (in general narrower than other Tipuloidea families). The mandibles are relatively thin and pointy (typical of carnivore species), and the maxillary palpi are similar in size or a bit smaller than the mandibles. They usually have five pairs of prologs (some species have four pairs of prolegs or locomotory pads). The body is normally covered by dark setae and their density determines the overall colouration. The tip of the abdomen projects into two lobes bearing some setae (similarly to the genus *Antocha* Osten Sacken 1860, Limoniidae). Unlike *Antocha*, Pediciidae have two spiracles at the base of the terminal lobes (Fig. 2.19c). The only larvae that do not have these features are specimens from the subfamily Ulinae: larvae of this subfamily have five lobes at the end of the abdomen. They have two pairs of ventral and segmented tracheal gills.

Biology

Most species of this family have aquatic or semiaquatic larvae, except for the subfamily Ulinae, whose larvae are terrestrial and inhabit on the fungi they feed on. Larvae of the other subfamilies can be usually found in headwaters or small brooks and streams with good arboreal cover. They live on aquatic moss and reaches with sand, gravel or pebble substrates with leaf deposits, where they search for preys. They prey on different invertebrates (such as acari, oligochaetes or other aquatic insect larvae). Pupation occurs within a silk tube In the Iberian Peninsula, 10 species have been recorded (Eiroa 2002).

Tipulidae

Description

The first larval instar of Tipulidae species is different from the rest and only described for a few species. Larvae (Fig. 3.20l–n) are hemicephalic, with the head markedly withdrawn into the prothorax. The body is elongated, with eight abdominal segments. The anal segment is frequently truncate and divided into a dorsal spiracular field and an anal ventral field where three to four finger-like papillae are present. They are metapneustic. There are six lobes surrounding the spiracles, grouped in three pairs that, in aquatic species, bear fringes of hairs (Hofsvang 1997).

Pupae are obtect, very elongated and with prominent respiratory horns. Abdominal segments bear spines on the posterior margin. The anal segment is truncated in males and pointy in females (Theowald 1967; Hofsvang 1997).

Imagos (3–35 mm) are characterised by a well developed rostrum, sometimes with a nasus. They do not have ocelli and the antennae have 13 or more segments. Legs are always long and deciduous, and the mesonotum as a V-shaped suture. The wings have two anal veins and a discal cell (Oosterbroek 2006).

Biology

Representatives of the family Tipulidae usually develop on terrestrial or semiaquatic environments, although some aquatic species also exist (Oosterbroek and Theowald 1992). Best known species are those associated with prairie environments, where they can become pests. In the Iberian Peninsula, 143 species have been recorded (Eiroa and Báez 2002b). Aquatic species are shredders of fallen leaves and inhabit a wide range of environments, from fast current and very oxygenated streams, to temporary lakes and ponds, where they generally colonise the areas with vegetal detritus.

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Taxonomic Index

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