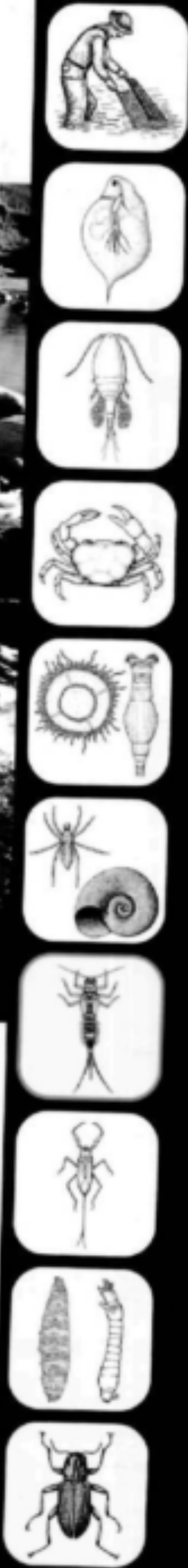
Guides to the

Freshwater Invertebrates of Southern Africa



Volume 7: Insecta I

Ephemeroptera, Odonata & Plecoptera

Editors: IJ de Moor, JA Day & FC de Moor

TT 207/03

Water Research Commission

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Since there is a possibility that revised editions of this series of guides may be printed in the future, we welcome constructive suggestions, particularly in relation to keys used to identify various taxa. These suggestions should be submitted in writing to the Executive Director, Water Research Commission (address given above). All such correspondence must be marked 'For the attention of Project K5/916/0/1').

CONTENTS

PREFACE

This identification guide is one of a series of ten books that include keys to most of the fresh- and brackish-water invertebrates in southern Africa. The paucity of identification guides suitable for non-specialists has become a yawning gap in the tools available to scientists, managers and scholars concerned with the assessment and management of water resources. It is hoped that the present guides will be of value to these and other users, and that the environment will benefit as a result. The principle aim of this series is to synthesize much of the existing knowledge on the identification of freshwater invertebrates into a standard format that is accessible to users who wish to identify taxa beyond their field of expertise.

It is a truism that identification guides are perpetually out of date, particularly in terms of nomenclature, due to advances in systematics. To keep abreast with some of the changes in nomenclature, readers are referred to the *Checklist of Aquatic Insects and Mites* (http://www.ru.ac.za/ aquatalogue). There is also a possibility that the present series will be revised periodically, but this is contingent on future funding.

Identification of taxa to species level is the ideal to which we would like to strive, but for a number of reasons this is not always possible: the present knowledge of taxa does not often permit such detailed identification, and in instances where taxa are well-known, identification to such a fine resolution is usually constrained by space considerations and cost effectiveness. In some instances, particularly for small, relatively well-researched groups such as the freshwater molluscs, taxa have, however, been identified to species level. Since new species are constantly being discovered, users of these guides are cautioned against attempting to 'make' unusual specimens 'fit' existing keys to species level. Users are encouraged to inform experts of such specimens, to take note of new distribution records, and to lodge all collections with well-known museums, particularly those that are depositories for collections of freshwater invertebrates (e.g. the Albany Museum, the South African Museum and the Transvaal Museum).

This series includes an initial introductory volume containing general information and a key to the higher invertebrate taxa. Subsequent volumes contain keys to different invertebrate groups, most often logically clustered together, but in some instances the need for cost-effectiveness has resulted in the creation of some uncomfortable 'bedfellows', such as the arachnids and molluscs that are combined in Volume 6.

It should be noted that references have, in most cases, been limited to key publications that will assist the reader in finding valuable sources of information. More extensive references have, however, been provided for the Ephemeroptera and Odonata, principally in support of the extensive checklists of taxa that have been provided with these chapters. Reference lists may include some publications not cited in the text.

The books in the series are the culmination of years of effort by a large number of people and organizations: Shirley Bethune, Jenny Day, Barbara Stewart, Nancy Rayner and Maitland Seaman started the project in 1986; Jenny Day, Bryan Davies and Jackie King initiated contact with authors and began the editing process, and Barbara Stewart and Elizabeth Louw later became involved in editing the Crustacea chapters. A decade later, Chris Dickens successfully obtained funding from the Water Research Commission (WRC) for the completion of the project, and later took on the job of Project Leader; Steve Mitchell managed the project from the WRC; Jenny Day took on the role of senior scientific editor, and Irene de Moor was contracted as managing editor from 1998. All of those above (with the exception of Nancy Rayner and Elizabeth Louw) as well as Mark Chutter, Ferdy de Moor, Lil Haigh, Arthur Harrison, Rob Hart, and Martin Villet, are part of the Editorial Board that was initially formed in 1998.

Numerous authors, including those in this book, have contributed time and expertise towards the drafting of the keys. The authors have not been paid for their efforts, which were given in the true spirit of science and a love of their work. A small donation from the Zoological Society of South Africa helped to initiate this project, but the series is largely a product of the Southern African Society of Aquatic Scientists (SASAQS), whose members are acknowledged for their support.

Umgeni Water, the Albany Museum, the Freshwater Research Unit (University of Cape Town), the South African Museum and the WRC have given organizational support at various stages of the publication.

Chris Dickens, Steve Mitchell & Irene de Moor

ACKNOWLEDGEMENTS

The publication of this series of guides would not have been possible without the enormous effort and dedication of a number of people and organizations who have been mentioned in the Preface.

The following people and organizations are also acknowledged for their assistance in the production of this volume: Ferdy de Moor, Fred Gess, Sarah Gess and Helen Barber-James of the Albany Museum for providing constant advice on editorial and technical details relating to the systematics of freshwater invertebrates; Nikki Köhly, Nancy Bonsor and Sylvia de Moor for their scientific illustrations and their assistance in tracing and touching up existing figures; Bronwyn Tweedie, Debbie Brody and John Keulder of the Graphics Services Unit, Rhodes University, for drawing the maps and producing bromides, and Drinie van Rensburg of the WRC for her advice on printing and text layout.

Further acknowledgements pertaining to particular chapters in this volume are given at the end of the chapters concerned.

GEOGRAPHICAL REGION COVERED BY THIS GUIDE

This series of invertebrate guides covers the southern African region, defined as 'south of (and including) the Cunene Catchment in the west and the Zambezi Catchment in the east' (Fig. 1). Distribution records from further afield are sometimes included for various reasons, particularly in cases where keys to particular groups have historically been composed to cover a wider region in Africa. The greatest collection effort has, however, focused on catchments south of the Limpopo River (Fig. 2), so the emphasis has naturally fallen on this region.

Chapter 2, on Ephemeroptera, represents a departure from the above convention as it covers the whole Afrotropical region (see Fig. 2.1, p. 17).

Collection efforts relating to most groups of freshwater invertebrates fall far short of adequate coverage. Consequently, locality records of many taxa are patchy and cannot be regarded as a good reflection of actual

Fig. 1. Southern Africa: the region covered by this series of invertebrate guides.

KEY: The dark dashed line represents the northern boundary of the Cunene Catchment in the west and the Zambezi Catchment in the east.

distributions. For this reason the term 'records' has been used in preference to 'distribution'.

It is hoped that this series of guides will stimulate a greater collection effort, which will in turn lead to the upgrading of geographical information on the diversity of freshwater invertebrates in southern Africa. In order to avoid meaningless references to place-names such as the ubiquitous 'Rietfontein', all records are related to countries, provinces or acceptable regional names. To avoid the confusion that often arises in association with regional names, a 'Glossary of place-names' has been compiled (see page 270), and a map of the new provincial boundaries in South Africa is given below (Fig. 2).

Fig. 2. The new provincial boundaries of the Republic of South Africa

ABOUT THE AUTHORS AND EDITORS

Jenny Day is the Director of the Freshwater Research Unit and Head of the Zoology Department, University of Cape Town, Western Cape.

Irene de Moor is a freelance scientific editor, currently working at the Albany Museum, Grahamstown, Eastern Cape.

Ferdy de Moor is the Curator of Freshwater Invertebrates at the Albany Museum, Grahamstown, Eastern Cape.

Helen Barber-James is the Assistant Curator of Freshwater Invertebrates at the Albany Museum, Grahamstown, Eastern Cape.

Carlos Lugo-Ortiz, who spent a year at the Albany Museum on a post-doctoral fellowship, is currently based in Puerto Rico, USA.

Mike Picker is a senior lecturer in the Zoology Department of the University of Cape Town. His special interests are insect ecology and systematics.

Michael Samways is Professor of Entomology at the University of Stellenbosch. He has a special interest in invertebrate conservation.

Duncan Stevens is a veterinarian who undertakes part-time research on Notonemouridae. He is currently completing his PhD on the phylogeny and systematics of South African Notonemouridae.

Brian Wilmot, formerly Director of the Albany Museum, is Director of the National Festival of Science, Engineering & Technology ('Sasol SciFest'): Grahamstown, Eastern Cape.

CHAPTER 1

INTRODUCTION

by

F.C. de Moor & J.A. Day

Many of the insects regarded as 'aquatic' only spend the immature phases of their lives in the aquatic environment, the adults being terrestrial. Some beetles and bugs do, however, remain in the aquatic environment throughout their lives, except for brief flights from river to river or wetland to wetland. Volumes 7–10 of this series deal with the insects of inland waters. The two orders of insects best known in inland waters are the Coleoptera (beetles), and the Diptera (flies and mosquitoes). Volume 9 is devoted to the Diptera and Volume 10 to the Coleoptera. Volume 7 deals with the Ephemeroptera (mayflies), the Odonata (dragonflies and damselflies) and the Plecoptera (stoneflies). Volume 8 deals with the Hemiptera (bugs), the Megaloptera (dobson- and alderflies), the Neuroptera (lacewings), the Lepidoptera (moths) and the Trichoptera (caddisflies).

General morphology of insects

It is relatively easy to place most adult insects in their respective orders, but at first sight some larvae and nymphs are rather confusing. Indeed, some dipteran larvae have virtually no obviously insectan features at all. Insects such as mayflies and stoneflies serve to illustrate the basic morphological features in relatively unmodified form (Figs 1.1 & 1.3A), most other orders exhibiting varying degrees of modification to the general plan.

Adults

Adult insects have three body divisions or **tagmata**: a **head**, which appears to consist of a single unit but is derived from the fusion of six or seven embryological segments; a **thorax**, which consists of three segments; and an **abdomen**, which primitively consists of eleven segments, although most insects appear to have ten segments, the last two being fused. The brief description below serves to introduce the reader to

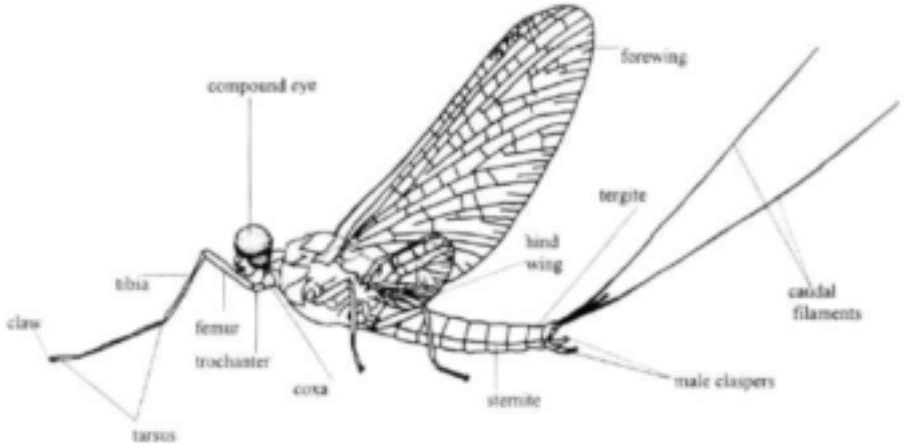

Fig. 1.1. Ephemeroptera: 'typical' adult showing the distinctive anatomical features of insects.

the external morphological structure of insects. For details of the modifications of each of the parts described below, see the individual chapters. We have tried as far as possible to use the same terms in each of the following chapters and have alerted the reader where authors have insisted on using different terms to describe the same features in the different insect orders.

The head bears a number of pairs of appendages, which may be variously modified and which provide some useful ordinal characters. Starting at the anterior end, the **antennae** represent the first pair of appendages: they are sensory and may be long or short, and bead-like, comb-like or greatly reduced. The antennae are followed by three medial structures and three pairs of mouthparts (Fig. 1.2), all used in feeding. First comes the **labrum** (Fig. 1.2B), or upper lip, which is a median flap-like structure that forms the upper border of the mouth. This is followed by the paired **mandibles** (Fig. 1.2 C–D) or jaws, used for crushing, cutting, scraping, or piercing the food. Next come the paired **maxillae** (Fig. 1.2 E–F), which are mostly sensory in function; each often bears a long segmented palp. Medial to these mouthparts is the unpaired **hypopharynx**, (Fig. 1.2H), which is sometimes modified to form a tongue-like structure. The second maxillae—which also bear palps—represent the last pair of mouthparts. These fuse with the lower lip to form a complex structure usually known simply as the **labium** (Fig. 1.2G). The maxillary and labial palps are usually used for touching, tasting and manipulating the food. In addition to these appendages, the head also bears a pair of **compound eyes** and, in some groups, two or three raised, light-sensitive **ocelli.**

The three segments of the thorax are known as the **prothorax**, the **mesothorax** and the **metathorax**. Each bears a pair of jointed **legs**. From proximal to distal, the segments are named the **coxa, trochanter, femur, tibia** and **tarsus**. The tarsus may in turn be divided into 1–5 **tarsal segments** or **tarsi**. The legs normally end in one or two **tarsal claws**. With

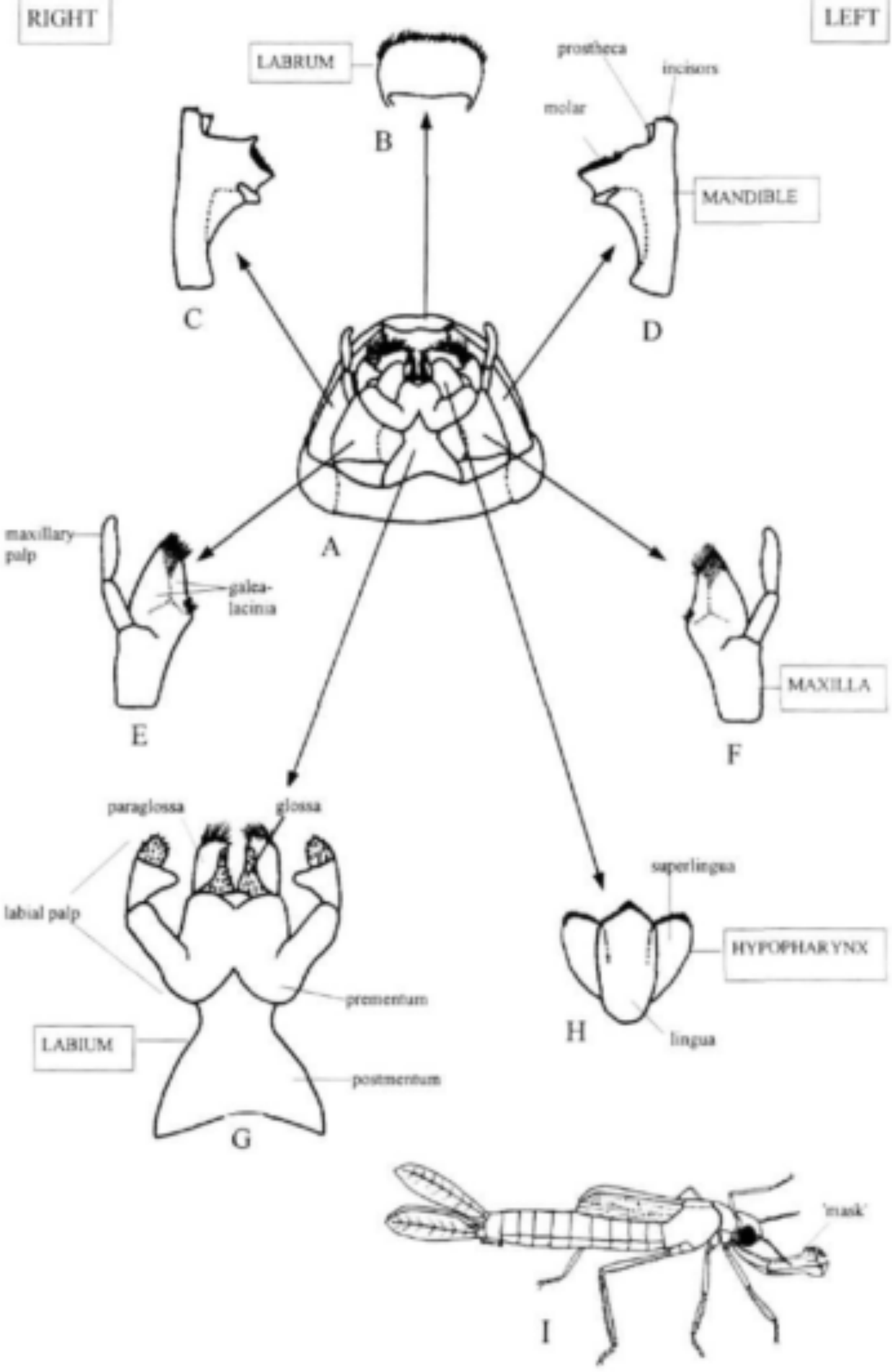

Fig. 1.2. **A**, head of a typical ephemeropteran nymph, in ventral view, indicating the position of the various typical mandibulate mouthparts. **B–H**, mouthparts, in ventral view: **B**, labrum; **C**, right mandible; **D**, left mandible; **E**, right maxilla; **F**, left maxilla; **G**, labium; **H**, hypopharynx (removed from its position beneath the labium). **I**, odonatan nymph in dorso-lateral view, showing modified labium ('mask') in extended position.

few exceptions (including some Ephemeroptera and all Diptera, which have one pair), insects have two pairs of wings, one each on the mesothorax and the metathorax. The structure of the wings, and their venation (details of the veins) are of taxonomic importance.

The **abdomen** bears no true segmented appendages but terminally may carry a pair of multi-segmented **cerci**, and sometimes a third multisegmented median filament. Posteriorly the abdomens of males and females may be quite different. Details of the male **claspers** and **aedeagus**, or intromittent organ, are often of great importance when identifying insects to species, while the egg-laying organs or **ovipositors** of the females may also be of use for identification in some cases.

Nymphs[1] (Fig. 1.3)

The morphology of nymphs (juveniles of insects that undergo incomplete metamorphosis) is very similar to that of the adults, except that the wings and other appendages are not fully developed (e.g. Figs 1.3A–H). It is often possible to identify late-instar nymphs using keys to adults.

Larvae (Figs 1.4 & 1.5)

Larvae (juveniles of insects that undergo complete metamorphosis) are often very different from adults of the same taxon, and it may be impossible to correlate larvae to the adults of the same species, unless they are reared out. The heads of most larval insects bear typical insectan mouthparts and may have ocelli, but not compound eyes; the thorax is typically three-segmented, with three pairs of normal jointed legs (e.g. Figs 1.4A–I, K, L), and the abdomen is legless but may bear one or more pairs of unjointed **prolegs** (e.g. Fig. 1.4L). Dipteran larvae (e.g. Fig. 1.5) and some coleopteran larvae (Hydrophilidae and Curculionidae: Fig. 1.4J), do not follow this pattern: they never have jointed thoracic legs (although unjointed prolegs may be present). Mouthparts may be entirely lacking, even the mandibles being replaced by a pair of **mouth hooks** (e.g. Figs 1.5H).

Pupae (Figs 1.7 & 1.8)

In insects with complete metamorphosis the pupa is the stage between the larva and the adult. Many pupae are relatively featureless (e.g. Fig. 1.8B) or enclosed in cocoons (e.g. Figs 1.8A,E). In others the future limbs and wings can be seen through the thin cuticle (e.g. Figs 1.7 A–E; Figs 1.8 C–E). Individuals of many aquatic insect groups tend to pupate out of water, often in the soft mud, or under stones on the banks of rivers and ponds.

[1] The terms 'nymph' and 'larva' traditionally refer to juveniles of insects that (respectively) undergo incomplete and complete metamorphosis. There have, however, been a number of departures from this convention, with 'larva' sometimes being used to describe juveniles in certain orders that undergo incomplete metmorphosis. In this chapter we have followed the traditional convention, whereas a different convention has been adopted in Chapter 3.

Insect taxonomy

Until recently the arthropods were considered to form a single monophyletic phylum. Over the last few decades, however, various authorities have questioned the validity of the group, suggesting that arthropods are not monophyletic but merely share a number of common features—such as a chitinous exoskeleton (which in turn dictates features such as jointed limbs) and metamerism—in the same way that 'worms' share features such as cephalisation and an elongated body. If this is true, then the term 'arthropod' merely describes a grade of organization and not a taxonomic unit. The following is a simple arrangement of the arthropods based on the fundamental structure and arrangement of the limbs and mouthparts.

Subphylum TRILOBITA (a group of extinct marine animals): biramous limbs, a single pair of antennae and mandibles developed from gnathobases.

Subphylum CRUSTACEA (the crabs, lobsters, etc.): biramous limbs, two pairs of antennae and mandibles derived from gnathobases.

Subphylum CHELICERATA (the spiders, mites, scorpions and horseshoe 'crabs'): apparently uniramous limbs and lacking both mandibles and antennae.

Subphylum UNIRAMIA (insects, myriapods and onychophorans): uniramous limbs, one pair of antennae, and the biting tips of the mandibles derived from the tip of the limb.

The Uniramia in turn are divided into three superclasses: the Onychophora (velvet worms), the Myriapoda (millipedes and centipedes) and the Hexapoda (the insects and their allies). The Hexapoda, in turn, consist of three classes of primitive, wingless forms (the Protura, the Diplura and the Collembola), plus the Insecta, which includes the subclasses Pterygota (all the familiar winged and secondarily wingless forms), and the Apterygota (the fishmoths and firebrats). One version of the higher taxonomy of the Uniramia is shown below for the taxa treated in these volumes. The reader should be aware, though, that—as is the case with the higher taxonomy of many groups—details are still argued by entomologists and consensus has yet to be reached on virtually all taxa above that of Order.

Superclass HEXAPODA: three body tagmata (head, thorax and abdomen); thorax three-segmented, each segment with one pair of legs: see key below for details and for means of distinguishing between the classes and orders.

Class COLLEMBOLA[1]: minute; wingless; no distinct larval or pupal stages; springtails (Volume 1).

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[1] The Collembola are sometimes regarded as a 'terrestrial' group since members of this class breathe air and, when found in association with water, occur only above, or on, the surface of the water.

Class **INSECTA**

Subclass PTERYGOTA: two pairs of wings (*note* that most pterygote taxa include some secondarily wingless species). For the purpose of the present publication we have adopted a 'traditional' classification in which this subclass is divided into two superorders, the Exopterygota and the Endopterygota, both of which contain orders (listed below) to which some aquatic or semi-aquatic taxa belong. Readers are however referred to Mackerras (1970) for a more taxonomically-rigorous classification based on the fossil record and evolutionary considerations relating to wing morphology.

Superorder **EXOPTERYGOTA**: no pupal stage; immatures (usually known as nymphs) similar to adults but wings incomplete (i.e. develop in external sheaths), visible externally as wing buds in later instars.

Order EPHEMEROPTERA: mayflies (this volume).
Order ODONATA: damselflies and dragonflies (this volume).
Order PLECOPTERA: stoneflies (this volume).
Order ORTHOPTERA[1]: grasshoppers and crickets (Volume 1).
Order HEMIPTERA: true bugs (Volume 8).

Superorder **ENDOPTERYGOTA**: larval and pupal stages in the life cycle; larvae very different from adults; wing buds visible externally in pupae but not in larvae.

Order MEGALOPTERA: alderflies and dobsonflies (Volume 8).
Order NEUROPTERA: lacewings (Volume 8).
Order LEPIDOPTERA: moths (Volume 8).
Order TRICHOPTERA: caddisflies (Volume 8).
Order DIPTERA: true flies, mosquitoes, midges (Volume 9).
Order COLEOPTERA: beetles (Volume 10).

KEY TO THE ORDERS OF AQUATIC HEXAPODA IN SOUTHERN AFRICAN INLAND WATERS

This is a key to truly aquatic forms of insects only, with the exception of some terrestrial adults that are frequently collected in samples.

1. Thorax possessing three pairs of segmented legs (e.g. Figs 1.1;1.3; 1.4A–I & K–L; 1.6; 1.7; 1.8A,C–E); legs may be minute or adhering to the body (e.g. Fig. 1.7B) 2
– Thorax lacking three pairs of segmented legs (Figs. 1.4J: 1.5A–H), but unsegmented prolegs or protuberances may be present (Figs 1.5A,B,D, F–H)..........24

2. External wings or wing-pads present (e.g. Figs 1.1; 1.3; 1.6B–G), may be vestigial (e.g. Fig. 1.3F & 1.6G), membranous (Figs 1.1) or hardened and plate-like (Fig. 1.6J)..3
– External wings or wing-pads completely absent (Figs 1.4; 1.5; 1.6A, D; 1.8B).....17

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[1] Only very few orthopterans are found in association with water, and these, like the Collembola, are sometimes regarded as being 'terrestrial' since they breathe air and occur on, or above, the water surface.

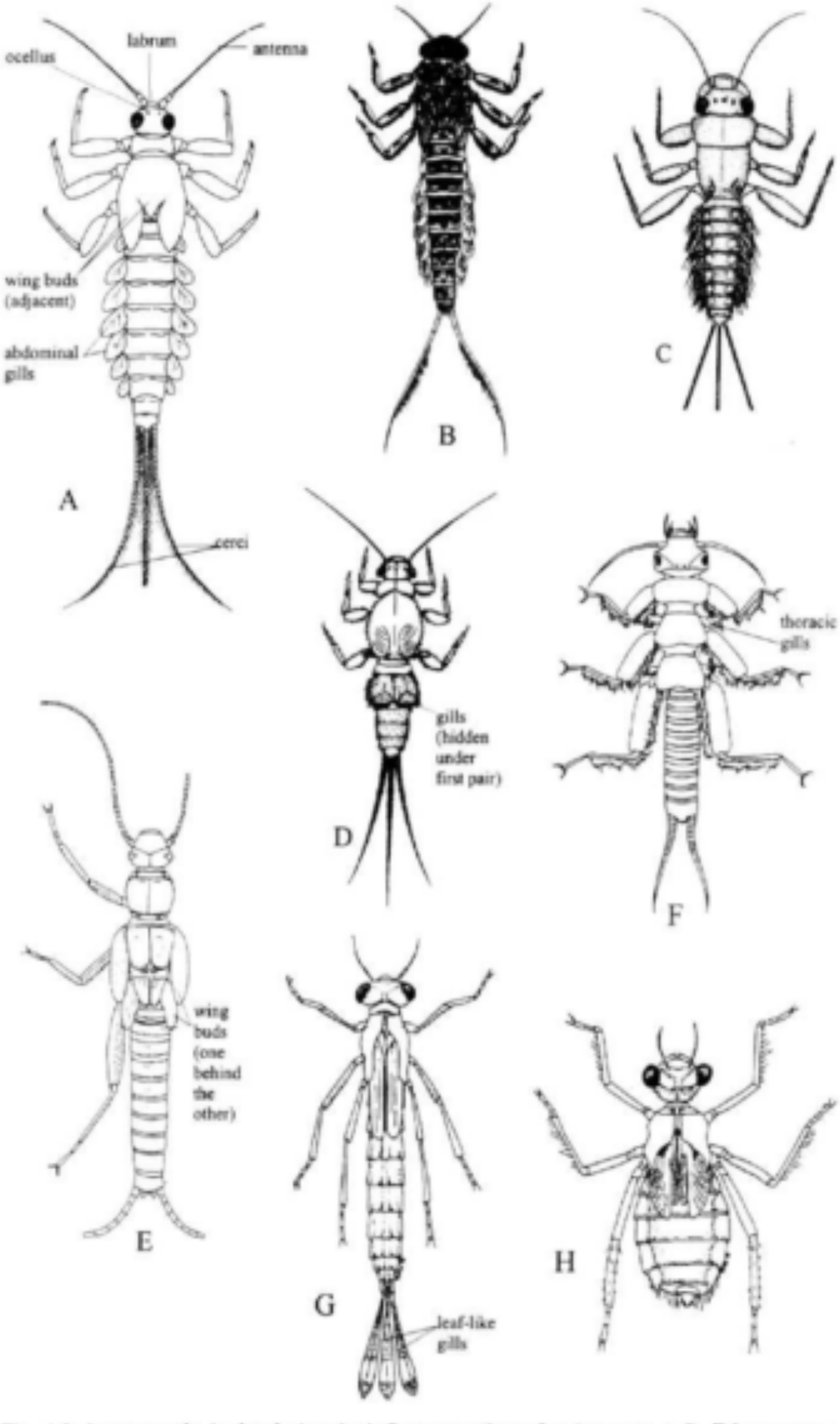

Fig. 1.3. Insect nymphs in dorsal view: 'typical' representatives of various taxa. **A–D**, Ephemeroptera. **A–B**, Baetidae: **A**, a three-tailed species; **B**, a two-tailed species. **C**, Leptophlebiidae. **D**, Caenidae. **E–F**, Plecoptera: **E**, Notonemouridae (nymph with right appendages truncated); **F**, Perlidae. **G–H**, Odonata: **G**, Zygoptera; **H**, Anisoptera.

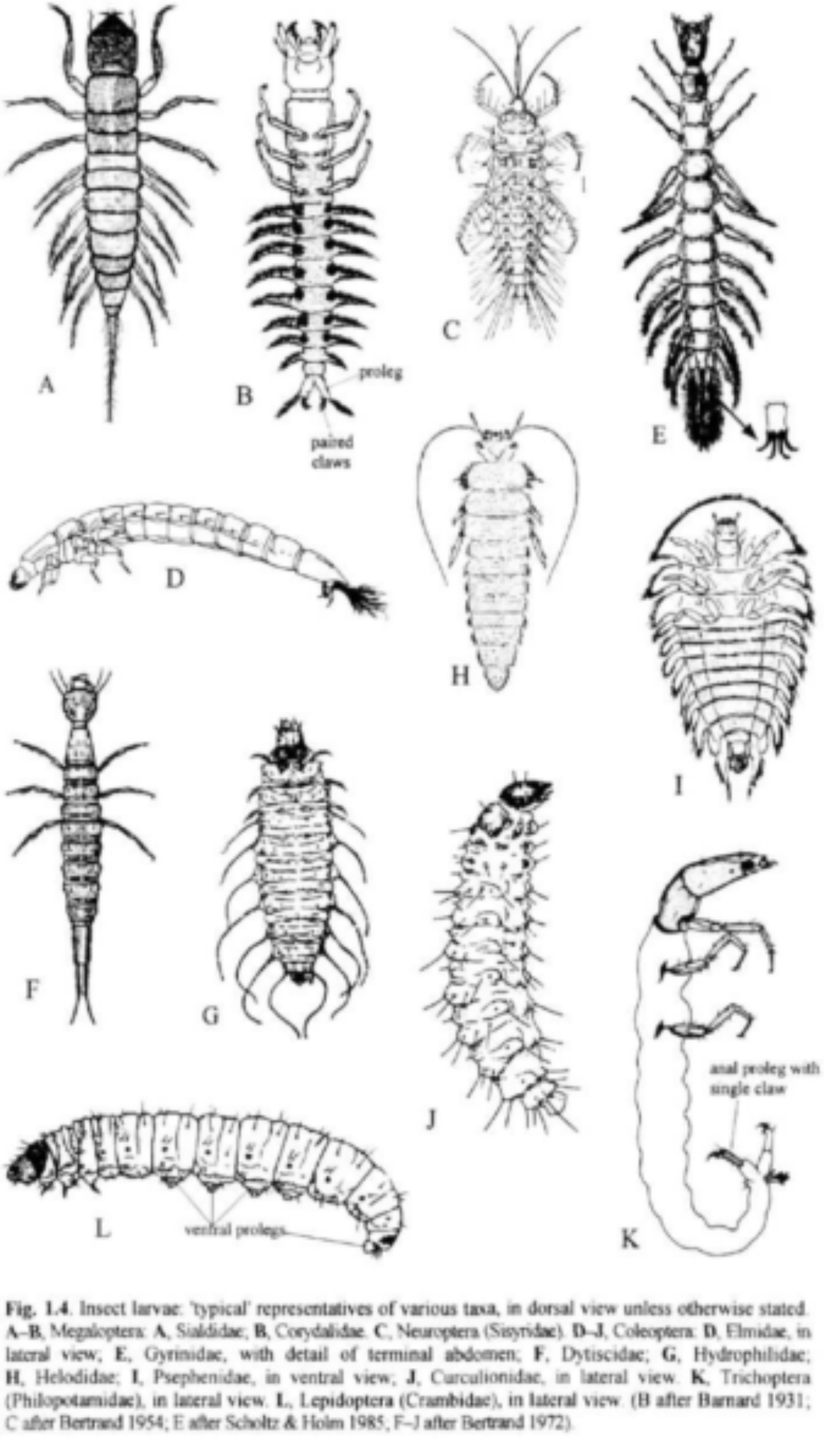

Fig. 1.4. Insect larvae: 'typical' representatives of various taxa, in dorsal view unless otherwise stated. **A–B**, Megaloptera: **A**, Sialidae; **B**, Corydalidae. **C**, Neuroptera (Sisyridae). **D–J**, Coleoptera: **D**, Elmidae, in lateral view; **E**, Gyrinidae, with detail of terminal abdomen; **F**, Dytiscidae; **G**, Hydrophilidae; **H**, Helodidae; **I**, Psephenidae, in ventral view; **J**, Curculionidae, in lateral view. **K**, Trichoptera (Philopotamidae), in lateral view. **L**, Lepidoptera (Crambidae), in lateral view. (B after Barnard 1931; C after Bertrand 1954; E after Scholtz & Holm 1985; F–J after Bertrand 1972).

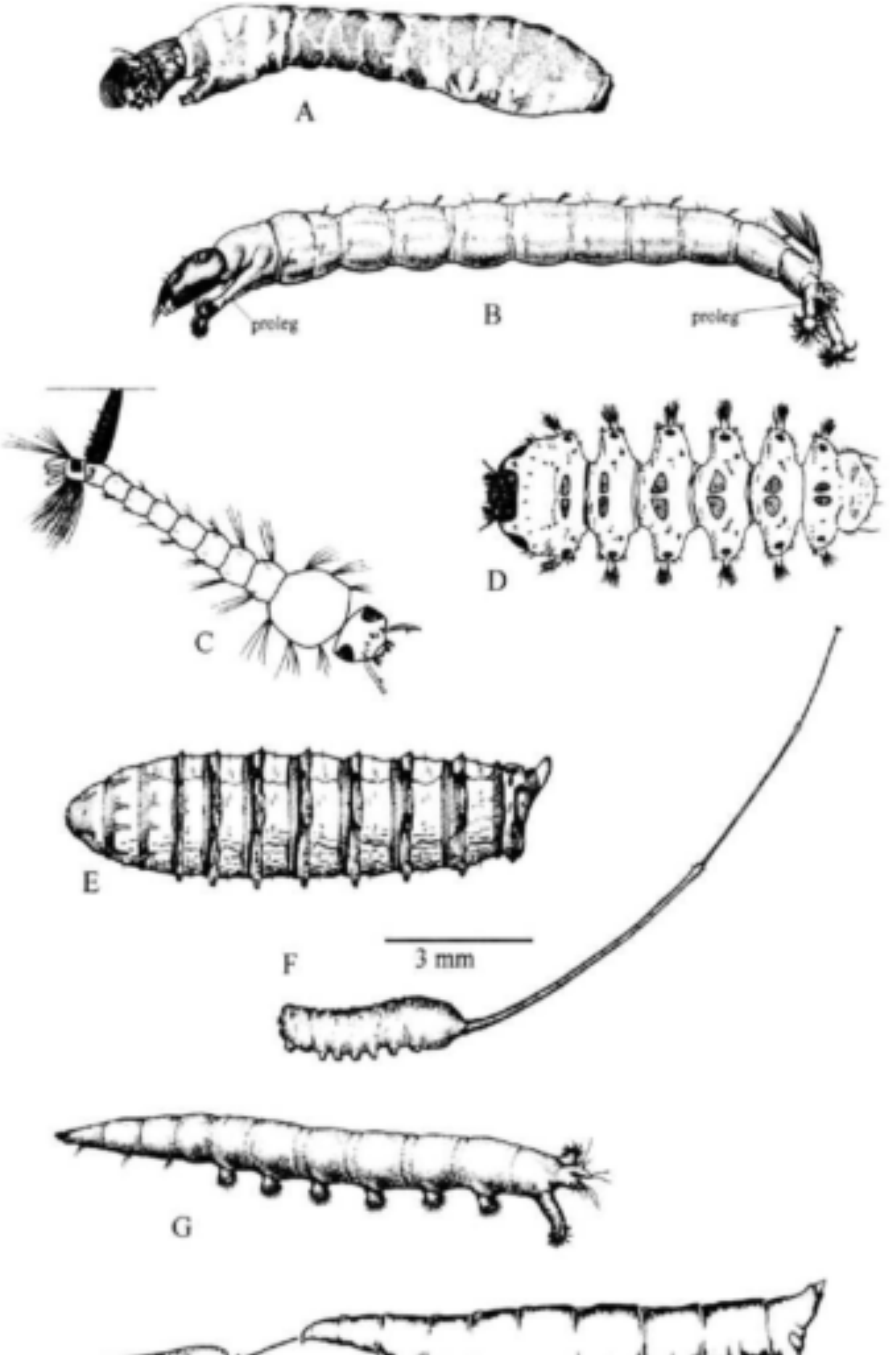

Fig. 1.5. Diptera: larvae. 'Typical' representatives of various taxa (in lateral view unless otherwise stated). **A–D**, Nematocera: **A**, Simuliidae; **B**, Chironomidae; **C**, Culicidae; **D**, Blephariceridae (in dorsal view). **E–H**, Brachycera: **E**, Tabanidae; **F**, Syrphidae; **G**, Empididae; **H**, Muscidae (showing detail of mouth hooks).

3. Thoracic legs fused to the body in an encasement (Figs 1.7B; 1.8C–E)......4
– Thoracic legs freely moving (Figs 1.1; 1.3; 1.6B,C,E,G,H,J,K) or held in an encasement separate from the body (i.e. not fused to the body) (Figs 1.7A, C, D, E)..5

4. Two pairs of developing wing-pads present; mouthparts form a coiled elongate proboscis visible through outer cuticle cover; always enclosed in a felt-like cocoon ....**Lepidoptera**: pupae (Fig. 1.7B)
– Only one pair of developing wing pads present; mouthparts, when visible, clearly not with elongate proboscis; body usually not enclosed in a silken cocoon...........................**Diptera (Nematocera)**: pupae (Figs 1.8 C,D, E)

5. Abdomen ends in three many-segmented tail filaments (e.g. Figs 1.1 & 1.3A, C &D)...**Ephemeroptera** (part)
– Abdomen ends not in three many-segmented tail filaments, but either in one or two many-segmented or unsegmented tails (Figs 1.3B, E & F) or in two or three leaf-like gills (Fig. 1.3G) or no tails are present (Figs 1.3H; 1.6B,C,E, G,J,K; 1.7A,C,D,E)..6

6. Mouthparts in the form of an elongated sucking beak (Fig. 1.6C) or cone-like structure (Figs 1.6F)....................................**Hemiptera** (Figs 1.6 B–H)
– Mouthparts not in the form of an elongated sucking beak or cone-like structure 7

7. Mouthparts modified into a protrusible mask-like structure (Fig. 1.2I).........
....**Odonata** (Figs 1.3 G, H)
– Mouthparts not modified into a protrusible mask-like structure..................8

8. Hindlegs enlarged and modified for jumping; forelegs sometimes modified for digging ....**Orthoptera**
– Hindlegs not enlarged and modified for jumping......................................9

9. Wings fully developed, forewing membranous, but may be covered with scales or hairs (Figs 1.1) (emerging adults or adults laying eggs under stones, often collected in water samples)...**adults**
(Ephemeroptera, Trichoptera, Chironomidae and Simuliidae)
– Forewings either reduced (Fig. 1.6G), sheathed in cases (Figs 1.3A–H), or modified into protective plate-like elytra (Figs 1.6 J, K)...........................10

10. Forewings modified into plate-like coverings (elytra) (Figs 1.6 J & K), sometimes shortened but usually covering entire abdomen........**Coleoptera: adults**
– Forewings not modified into elytra...11

11. Abdomen ends in a pair of segmented tails (Figs 1.3 B, E–F)......................12
– Abdomen does not end in a pair of segmented tails, but sometimes in a pair of unsegmented anal processes (Figs 1.7A,C,D, E; 1.8C,D)...........................13

12. Most abdominal segments possessing lateral gills (Figs 1.3 A–D); wing buds lying lateral to each other ....**Ephemeroptera** (part)
– Abdominal gills absent (Figs 1.3 E, F); filamentous thoracic gills (Fig. 1.3F) may be present; wing buds lying one behind the other............. **Plecoptera**

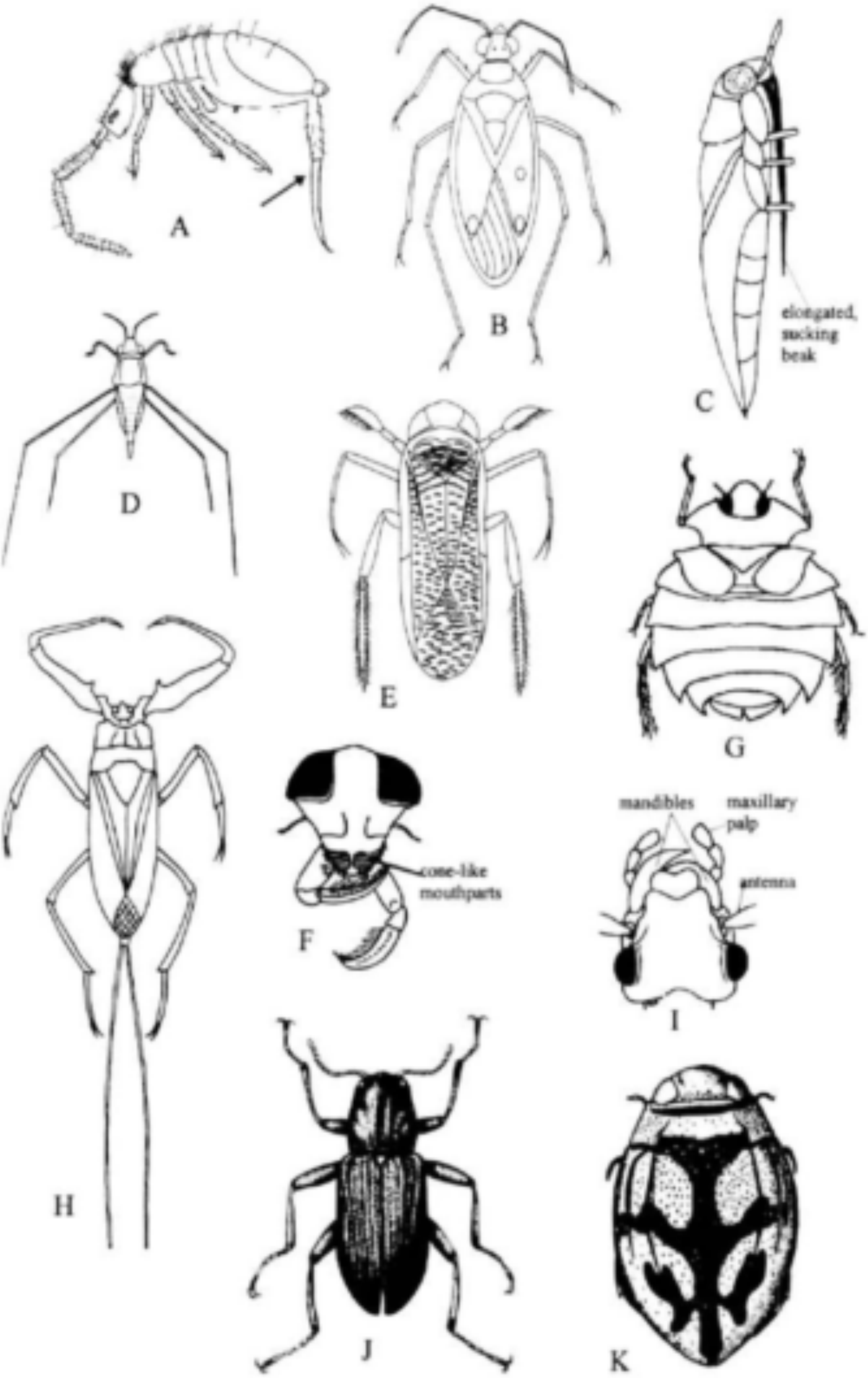

Fig. 1.6. Adult aquatic insects: 'typical' examples from various taxa, in dorsal view unless otherwise stated. **A**, Collembola, in lateral view. **B–H**, Hemiptera: **B**, Saldidae; **C**, Ochteridae, in lateral view; **D**, Veliidae (*note* absence of wing buds). **E–F**, Corixidae: **E**, whole animal; **F**, detail of head, in anterior view. **G**, Aphelocheiridae; **H**, Nepidae. **I–K**, Coleoptera: **I**, head (generalized, with antennae truncated) showing biting mandibulate mouthparts; **J**, Elmidae; **K**, Dytiscidae. (A after Coates 1974; F & G after Dethier 1981; K after Scholtz & Holm 1985).

13. Wing pads or shortened wings present only on the second thoracic segment (Figs 1.8 C–E); peg- or knob-like structures may be visible on the third thoracic segment .... **Diptera (Nematocera)**: pupae
– Wing pads or shortened wings are present on the second and third thoracic segments (Figs 1.7A, C, D, E)..14

14. Forewings thickened (Fig. 1.7E); antennae with eleven or fewer segments (Fig. 1.7E)..**Coleoptera**: pupae
– Forewings not thickened; antennae with twelve or more segments 15

15. Mid- and hind-legs with swimming hairs; antennae more than half the total length of the body................................ **Trichoptera**: pupae (Fig. 1.7A)
– No swimming hairs on mid- and hind-legs; antennae less than half the total length of the body..16

16. Body over 12 mm (total length)................**Megaloptera**: pupae (Fig. 1.7C)
– Body less than 10 mm (total length).. ....**Neuroptera (Sisyridae)**: pupae (Fig. 1.7D)

17. Mouthparts form a beak (rostrum) projecting backwards below the head; eyes are compound........**Hemiptera**: apterous forms or young nymphs (Fig. 1.6D)
– Mouthparts not in the form of a beak, and if long and slender, then projecting forwards (Fig. 1.4C); eyes absent or as groups of simple ocelli (Figs 1.4A–L; 1.6A)..18

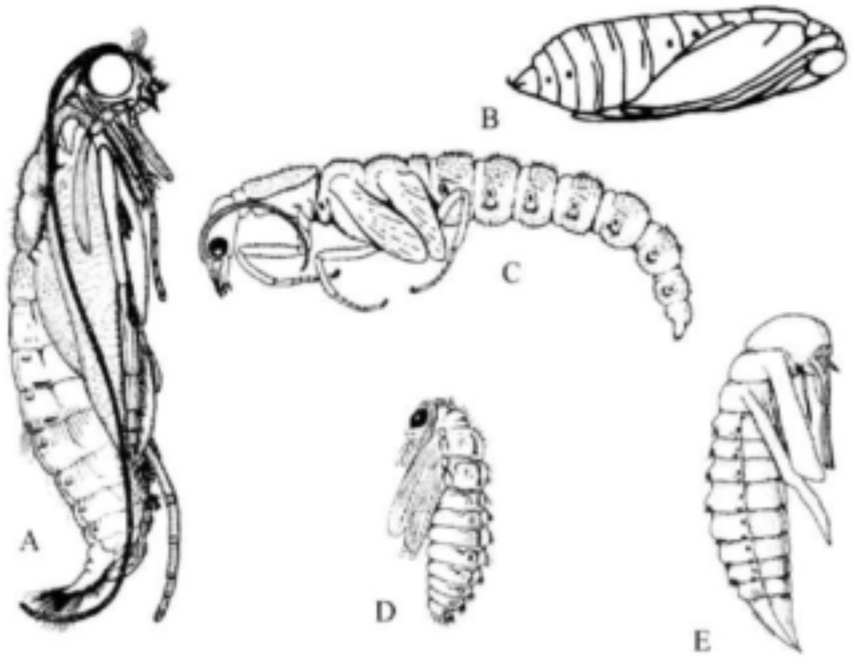

Fig. 1.7. Aquatic insect pupae: 'typical' representatives from various taxa (in lateral view). **A**, Trichoptera (Hydropsychidae); **B**, Lepidoptera (Crambidae[1]); **C**, Megaloptera (Corydalidae); **D**, Neuroptera (Sisyridae); **E**, Coleoptera (Dytiscidae). (C after Barnard 1931; D after Bertrand 1954; E after Scholtz & Holm 1985).

[1] Previously Pyralidae

18. Abdomen with forked jumping organ on the underside (Fig. 1.6A); minute surface-dwelling arthropods ....**Collembola**
– Abdomen not with a forked jumping organ on the underside 19

19. Mouthparts comprised of long, slender, forward-projecting rods forming a sucking tube when held together...
....**Neuroptera (Sisyridae)** larvae (Fig. 1.4C)
– Mouthparts consist of distinct biting mandibles plus maxillae and labia with palps (Figs 1.4A, B & E–I)..20

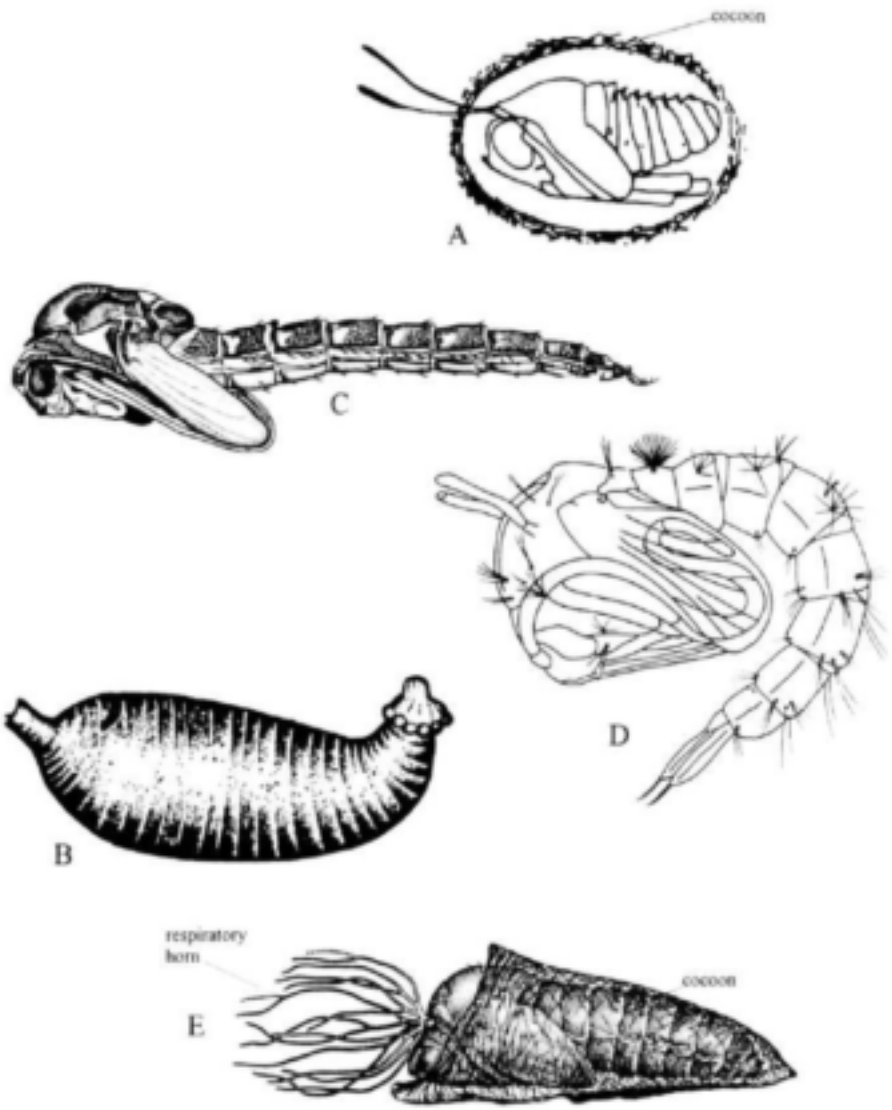

Fig. 1.8. Diptera: pupae. 'Typical' representatives from various taxa, in lateral view. **A**, Dolichopodidae; **B**, Sciomyzidae; **C**, Chironomidae; **D**, Culicidae; **E**, Simuliidae.

20. Undersides of some, but not all, abdominal segments with pairs of prolegs (Fig. 1.4L) bearing series of tiny hooks terminally (Fig. 1.4L)..**Lepidoptera**: larvae

– Abdomen lacking several pairs of fleshy prolegs on underside, but may have one pair of terminal prolegs with prominent claws (Fig. 1.4B, E K)..........21

21. Abdomen ending in a pair of prolegs, short or long, each with a single distinct sclerotized terminal claw (Fig. 1.4K)...........................**Trichoptera**: larvae

– Abdomen ends variously but never with a pair of prolegs, with a single terminal claw; terminal hooks, if present, total four (Figs 1.4A, B, D–I)...........22

22. Abdomen lacks well-developed lateral filaments or processes (Figs 1.4D, F, H), may be rounded or flattened dorsoventrally ....**Coleoptera** larvae

– Abdomen with well-developed lateral filaments or processes (Figs 1.4A, B, E, G, I)..23

23. Abdomen ends either in a single, unforked, elongated filament (Fig. 1.4A) or in a pair of prolegs, each possessing two separate hooks (Fig. 1.4B) ....**Megaloptera**: larvae

– Abdomen ends variously but never with a single, unforked elongated filament and never with a pair of prolegs each with two hooks; if four terminal hooks are present then they are grouped together (not on two separate prolegs) (Fig. 1.4E) and two pairs of terminal filaments are then also present (Figs 1.4E, G, I)..**Coleoptera**: larvae

24. Head composed of a distinct sclerotized capsule (Figs 1.4 J; 1.5 A–D); external mouthparts—which may be highly modified—visible 25

– Head indistinct, partly or entirely lacking (Figs 1.5E-H); mouthparts represented by internal sclerotized bars and rods (Fig. 1.5H).................................. .... **Diptera (Brachycera)**: larvae (Figs 1.5 E–H)

25. Prolegs often present on thorax or end of abdomen, or both (Figs 1.5A, B, D); if prolegs absent, then conspicuous hairs and/or processes are usually present at the end of the abdomen (Fig. 1.5C); body may be unsclerotized, very slender, heavily sclerotized or divided into several distinctive regions (Fig. 1.5D).. ....**Diptera (Nematocera)**: larvae (Figs. 1.5A–D)

– Prolegs not present; body either fleshy thick and C-shaped (Fig. 1.4J), or covered with sclerotized plates dorsally on the thorax and segment 8 ....**Coleoptera (Curculionidae & some Hydrophilidae)**: larvae

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CHAPTER 2

EPHEMEROPTERA

by

H. M. Barber-James & C. R. Lugo-Ortiz

The ancient insect order Ephemeroptera, or mayflies, is considered to be the most primitive surviving group of insects, dating back to the late Carboniferous or early Permian periods, about 290 m years ago. The Ephemeroptera and Odonata are the only living relicts of an ancient group, the Palaeoptera, of which another four orders (the Meganisoptera, Megasecoptera, Palaeodictyoptera and Archodonata) are extinct, being known only from the fossil record (Riek 1970). Adults ephemeropterans (Fig. 2.4A) exhibit a number of primitive traits. For example, they are unable to fold their wings flat over their bodies, instead holding them vertically, and they have long caudal filaments.

At least 2500 species of Ephemeroptera are recognized worldwide, in 23 families (CSIRO web site) and 371 genera, of which 61 are known only as fossils (Hubbard 1990). The order is well represented in the Afrotropical region, defined by Crosskey & White (1977) to include Africa south of the Sahara Desert, conveniently delimited by the 254 mm rainfall isohyets (Fig. 2.1). In this region, mayflies are represented by 13 families, 94 genera and approximately 382 species reported thus far (see Appendix, p. 143). Considering South Africa alone, the figures stand at 11 families, 47 genera and 102 species. The number of genera and species is expected to rise significantly as the mayfly fauna of the region continues to be more thoroughly documented. Although intended mainly for southern African freshwater ecologists and water-quality managers, the nymphal identification key includes all known Afrotropical mayfly genera because, in the course of our research on the mayfly fauna of the Afrotropics, we have consistently found genera previously known to occur north of the catchments of the Cunene and Zambezi rivers to extend their ranges to southern Africa. Madagascan mayflies have also been included as the region has many genera in common with Africa.

Fig. 2.1. The Afrotropical Region, including the Malagasy Subregion. The northern 254 mm y^{-1} (10 inches y^{-1}) rainfall isohyet forms a useful boundary to demarcate the border of the Sahara Desert.

Life history and biology

Mayflies undergo hemimetabolous, or incomplete, metamorphosis; that is, they hatch from eggs, grow and mature as nymphs through several moults, and transform into adults, without undergoing a pupal stage. Mayflies, however, have a unique maturation stage, called the **subimago**, between the nymph and adult. Subimagos are similar to adults but they have opaque wings and dull abdomens covered with small water-resistant hairs (**microtrichia**), which help them to leave the water after moulting from the final instar nymph. Adults of most species have shiny, transparent wings and glossy abdomens, having shed the subimaginal cuticle. In male subimagos the forelegs are considerably shorter than in the mature adults and the genitalia are not fully developed. In those families (represented in the Afrotropics by the Baetidae, Leptophlebiidae and Teloganodidae), whose male adults have compound eyes with clearly differentiated upper and lower sections (Figs 2.4B & C), the upper section appears undeveloped in the subimaginal stage. Subimagos are poor fliers and vulnerable to predation, and are often found resting in secluded areas among vegetation near the waterbodies from which they have emerged. Adult mayflies normally live from a few hours to one to two weeks or, in some rare cases, for up to a month. Male mating swarms usually form at dawn or dusk, although certain species of Leptophlebiidae swarm towards midday. The males fly rhythmically up and down and attract females. Mating occurs in flight, the males using their elongate legs to grasp females from underneath. The males may mate more than once but they die soon after mating. After they have mated, the females fly to the nearest body of water to oviposit. This is done in a variety of ways: some drop their eggs while flying low over the water; some intermittently touch down on the water surface, and some alight onto the surface and drown. Some species release their eggs as they die and others crawl under the water surface to oviposit on the substrate. Mayflies lay many eggs, from 500 to 4500, but have high mortality rates at all stages. After ovipositing, the females die. In extreme environmental conditions there is no mating and females are parthenogenetic.

Mayflies may be semivoltine (i.e. take more than a year to complete their life cycle) or univoltine, bivoltine or multivoltine, (i.e. respectively have one, two, or several generations a year). Semivoltine life cycles are more common in colder temperate climates (for example, large burrowing species in Canada take over two years to mature). In tropical and subtropical regions most species are bi- or multi-voltine. Having a very short developmental (aquatic) stage in the life cycle may be an adaptation to living in intermittent streams. The number of nymphal instars varies between 10 and 50, with the most common being between 15 and 30 (Peters &

Campbell 1991). The number of instars within a species is flexible, and correlated with temperature regimes. Development speeds up with increasing temperatures, resulting in fewer instars and smaller individuals. In populations developing in cooler conditions, individuals tend to go through more instars, grow bigger, produce larger, more darkly-coloured adults, and females tend to produce more eggs, than individuals of the same species from warmer waters. Such differences can result in taxonomic confusion. About 50 species are known to be parthenogenetic, although in most cases, parthenogenesis is not obligatory (Brittain 1982).

Eggs of most mayflies have sticky coverings, frequently with specialized anchoring devices, and often have species-specific external morphology. Embryonic development usually takes a few weeks but eggs of many species undergo diapause before hatching. Depending on the species, diapause can last from three to eleven months or longer.

Ecology and feeding

Mayflies are considered to be a primary group of aquatic insects, meaning they have always had an aquatic stage (secondary aquatic groups, such as the waterbugs, have evolved from terrestrial forms). Mayfly nymphs occur in lentic and lotic freshwater bodies and are benthic. They can be found clinging to, sprawling on, or burrowing into, a diversity of substrates (including silt, clay and wood), or climbing on the stems of submerged vegetation. Some nymphs are capable of swimming for short distances and others drift in the current periodically.

Most mayfly nymphs are deposit feeders or grazers, but some are filter feeders and a small number are predatory. Deposit feeding is accomplished mainly by browsing fine particulate organic matter and bacteria from different surfaces, whereas grazing primarily involves the scraping of periphyton (mostly diatoms) from the surfaces of rocks. Filter-feeding taxa are characterized by the presence on the forelegs of long specialized setae, which aid in the collection of fine particulate organic matter. Some burrowing filter-feeders create currents in their burrows by rhythmically moving their gills, thus stirring up organic particles, which they collect from the water. The nymphs of predatory species tend to be found facing the current on top of rocks in riffle areas. They feed mostly on other small macroinvertebrates, particularly drifting or dislodged midge larvae.

Diagnostic characters

Both nymphal and adult stages are important for identification. The keys in this chapter deal only with the nymphal stages however, because this series of volumes deals with the aquatic stages of freshwater organisms only.

Ephemeropteran nymphs (Fig. 2.2) are distinguished by the following characteristics: the presence of compound eyes, which may be particularly well developed in mature male nymphs, as these develop into the **turbinate eyes** characteristic of adult males in some families (Fig. 2.4B); slender antennae and well-developed legs; **forewing pads** (note that **hindwing pads** may or may not be present, and if they are present they are obscured from dorsal view by the forewing pads; variously-developed and variously-orientated abdominal gills; two or three elongate 'tails' or **caudal filaments** (the lateral filaments are also known as **cerci**, while the middle filament is usually known as the **medial caudal filament**: Fig. 2.2) and chewing mouthparts (Fig. 2.3), which may be variously modified.

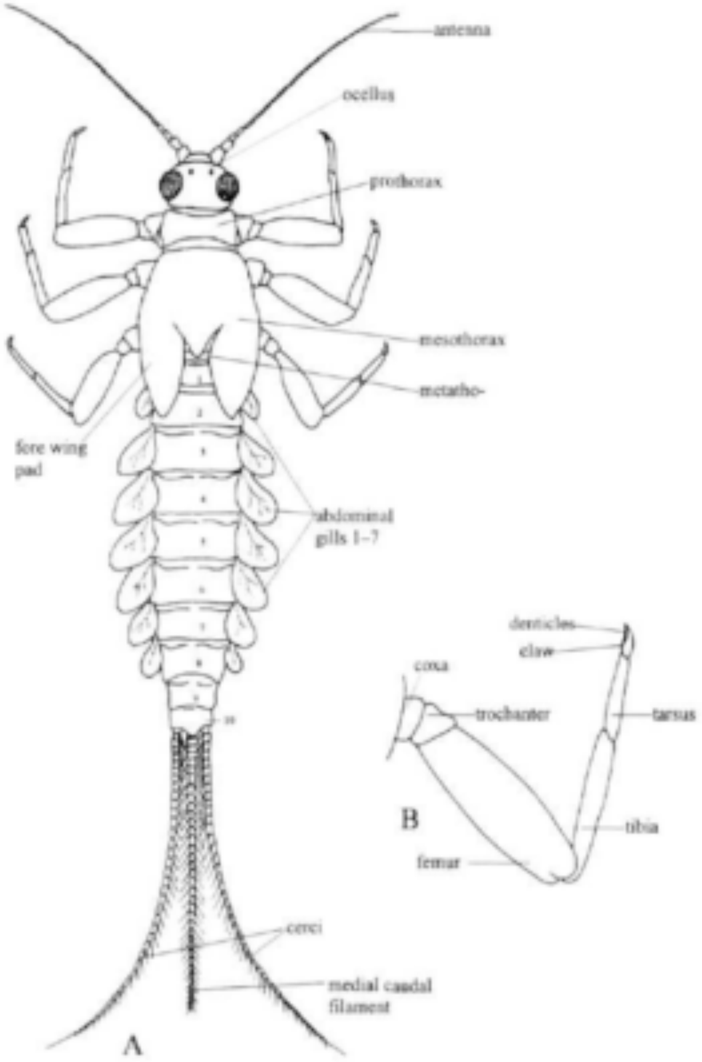

Fig. 2.2 Ephemeroptera: morphologically-important features of a baetid nymph, useful for identification. **A**, whole nymph in dorsal view; **B**, leg.

In summary, the following criteria are important for nymphal identification:

- the structure of the mouthparts (including the 'tusks' in burrowers)
- gill number, shape and size
- the presence or absence of operculate gills (Figs 2.13; 2.14A, B & C; 2.15A & 2.16A)
- the presence or absence of setae and spines on legs and other parts of the body
- the number of denticles (teeth) on the claws
- the colour and pattern of various parts of the body, although this characteristic may not always be reliable.

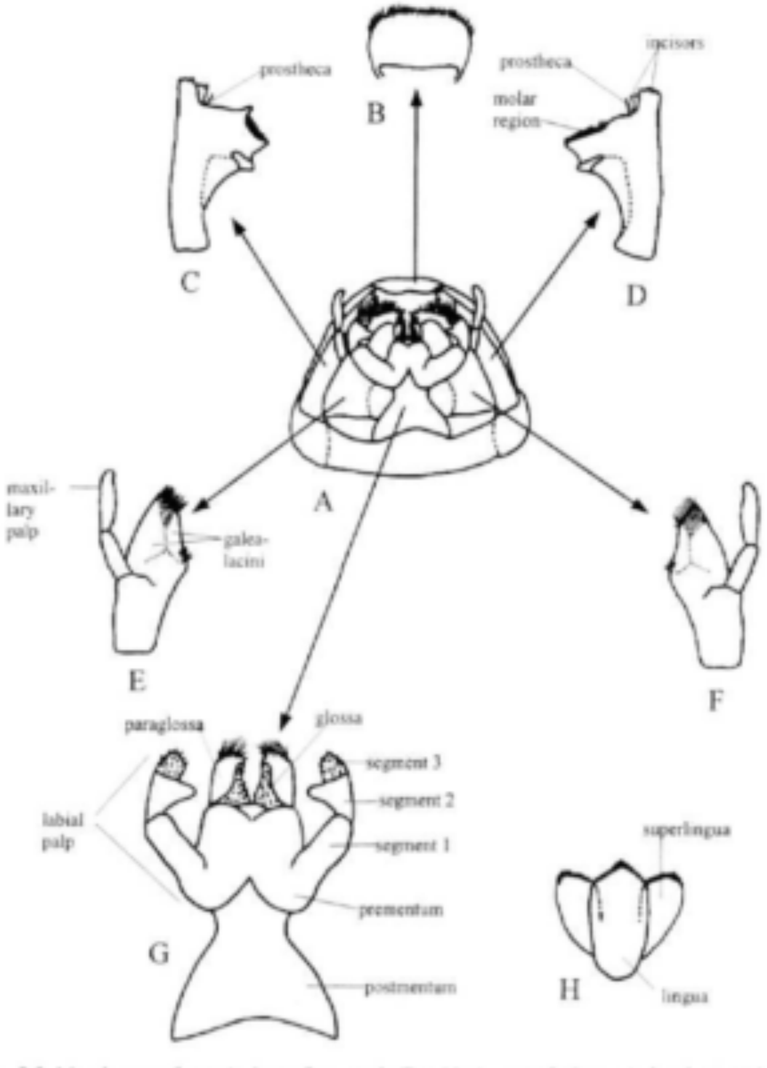

Fig. 2.3. Mouthparts of a typical mayfly nymph (Baetidae), ventral views: **A**, head, ventral view, indicating position of various mouthparts: **B**, labrum; **C**, right mandible; **D**, left mandible; **E**, right maxilla; **F**, left maxilla; **G**, labium; **H**, hypopharynx (dissected out from it's position beneath the labium).

Mayfly nymphs may be confused with stoneflies (Plecoptera); stoneflies, however, have double tarsal claws and lack dorsal abdominal gills, though may have branched gills ventrally on the thorax and/or on the first few abdominal segments. Stoneflies always have only two caudal filaments; while most mayflies have three, a few have only two. Stoneflies also always have two sets of wingpads, both of which are visible, whereas in mayflies the upper wingpads lie over the lower wingpads (if these are present). Mayfly nymphs may also be confused with immature nymphs of the order Odonata, particularly with those of the suborder Zygoptera, but odonate nymphs lack abdominal gills; zygopteran caudal gills are fleshy (as opposed to the filamentous cerci of mayflies) and their mouthparts have a mobile, hinged labium.

Mayfly adults (Fig. 2.4A) are distinguished by the presence of short antennae, well-developed compound eyes (particularly in males), atrophied mouthparts, subtriangular wings that are held dorsally, and two or three elongate caudal filaments. Mayfly eggs often have distinctive patterns, and studies of their structure using electron microscopy can be used to distinguish species.

Collection and preservation

Mayflies are fragile animals that are easily damaged, often losing gills and legs if not handled carefully. It is therefore worth taking special care during collection, since there is little point in obtaining material that is so damaged that it cannot be properly identified.

Depending on the substrate and flow regime, different techniques are required to collect mayfly nymphs. In relatively shallow riffles, the simplest collecting method is to make use of a kick-screen. This device consists of a quadrangular screen (which can be made from a variety of mesh sizes) with long handles attached to both sides. The collector faces downstream and holds the submerged screen by the handles in front of him/her while disturbing the substrate with gentle to moderate kicks. This action dislodges most benthic organisms that are then washed into the screen. The screen is then taken out of the stream at an open angle and held at the lower end (to prevent organisms from falling back into the water). It is then transported to a secure place where specimens are removed from the net. Although collection can be carried out by one person, the process is more efficient if carried out by two people, the person in the upstream position disturbing the substrate while facing downstream, while the person in the downstream position holds the net while facing upstream. A modification of this 'kick-net' method is used for the South African biomonitoring 'SASS' sampling (Chutter 1998), in which case a standardized net with 70 cm square opening and mesh size 1 mm is held downstream of the person collecting the sample. It is important to note, however, that such

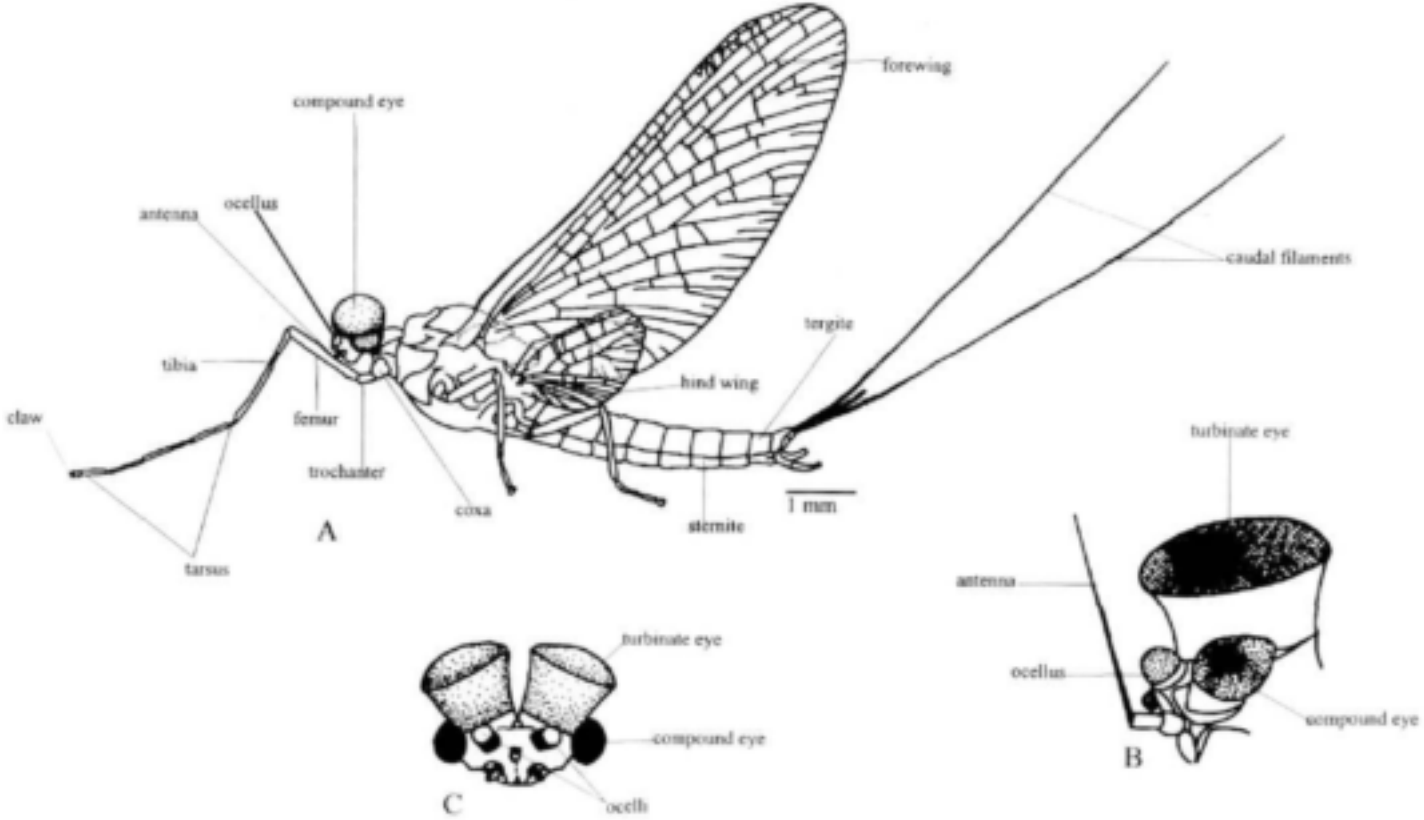

Fig. 2.4. Distinctive anatomical features of mayfly adults. **A**, adult in lateral view. **B–C**, baetid adult males showing turbinate eyes: **B**, head, in lateral view; **C**, head, in anterior view.

a coarse mesh size misses smaller individuals, and a finer mesh size is needed if the smaller instars are required.

As an alternative to the 'kick-net' method, a small hand net can be used for qualitative sampling. In this case stones are carefully picked up from the benthos, with the net held downstream to collect any escapees. Individuals are then picked off the net with forceps and preserved in a small tube that has been previously filled with ethanol.

The insertion of a small plug of cotton wool into the neck of the tube is sometimes recommended, particularly for fragile specimens. This helps to prevent air-bubble damage of the specimens during transportation back to the laboratory. In such samples it is important to ensure that the collection tube is brim-full with ethanol.

In many cases it may be necessary to identify adults, either to confirm nymphal identifications, or to link particular nymphs and adults of the same species. It then becomes necessary to collect live specimens in order to rear the final instar nymphs through to adults. It is best to select nymphs that are nearly ready to emerge. These can be recognized in the field by their dark-coloured wingbuds, which signify that the wings are tightly packed, waiting to be unfurled. The nymphs should be kept in a small container of river water in which stones and/or plants have been placed for the nymphs to cling to. An airstone with a gentle stream of bubbles must be placed into the container and the container placed in a larger container with a gauze lid on which the subimago can alight. Since the subimago does not have all of the mature adult features, it is necessary to facilitate final moulting so that the mature adult can be examined. For this purpose the subimago is gently removed and placed in a smaller, lidded container.

Light traps can be used to collect the winged stages of mayflies and other insects. There are many versions of light traps used by entomologists, but for mayflies nothing is more effective than a white sheet with a super-actinic light source (which has a stong *UV* component) suspended at the top end of the sheet. This attracts the adults and subimagos. The adults can be collected directly in a tube of ethanol, while subimagos are collected live in order to rear them through to adults. For this purpose, a lidded box with a small corked opening is used. A section of the box should be covered with gauze so that one can observe the progress of the animals inside. Care must be taken to insert specimens into the container gently, without letting them escape. A number of specimens can be temporarily kept in the same box, but must be soon separated into smaller individual containers.

Dissection of mouthparts and preparation of microscope slides

The dissection of mouthparts for nymphal identification can be accomplished with the aid of a dissecting microscope (at X50 magnification), forceps with acute tips, and a thin dissecting needle. The mouthparts are gently dislodged from the head and carefully removed with forceps or a dissecting needle. They are then soaked in Cellusolve™ for at least five minutes before being transferred to a drop of Euparal™ on a microscope slide. A direct transfer from alcohol to the Euparal™ is not advisable, as this produces a cloudy effect, obscuring the mounted pieces. A small amount of Euparal™ (one or two small drops) should be put in the centre of the microscope slide and spread evenly in a circular motion so as to cover an area equal to the size of the coverslip. The mouthparts should be then transferred from the Cellusolve (taking care to dry off drops of Cellusolve from the forceps) to the mounting medium. Once arranged in the desired position, the coverslip can be lowered carefully onto the slide by letting it drop slowly from the edge of the medium. This method lessens the chances of air bubble formation and the movement of mouthparts, but should this happen, the coverslip can be delicately tapped to expel the bubbles and reposition the mouthparts. It is best to leave the prepared slide to cure on an even surface in a dry place for at least 24 hours before examination under a compound microscope under magnifications of ×100 to ×1000. If handled with extreme care, however, the specimen can be examined immediately.

IDENTIFICATION OF MATURE MAYFLY NYMPHS

Although the keys provided in this chapter deal only with the nymphal stages of mayflies, an abundant literature deals with adults. These keys only go as far as generic level, and the primary literature has to be sought for identification to species.

Use of the identification key

In the identification key we have attempted to concentrate on the most conspicuous morphological characters that can be seen at magnifications of X50 under a dissecting microscope. The identification of most genera, particularly in the family Baetidae, relies, however, on the examination of mouthparts, claws and other small features, for which dissection and mounting on microscope slides, followed by examination under a compound microscope, may be necessary (see above). On the other hand, the identification of the genera of the Heptageniidae and Leptophlebiidae depends primarily on the morphology of the abdominal gills, which may become easily dislodged and lost while collecting and handling the specimens. If such structures are lost, it is necessary to consult specialist literature to achieve proper identifications. For the latter purpose, and for cases where identifications require further corroboration, a list of useful references is provided below the discussion of each genus.

Measurements are of assistance in identification. Note that, unless otherwise indicated, size measurements given in keys refer to the **body length** (the length excluding the antennae and cerci). The **cerci length** is also sometimes noted.

Identification should be carried out on late-instar nymphs (recognized by the fact that their developing wingpads are darker), as some of the diagnostic features are less apparent in the immature stages. Note that these keys are meant for identification purposes only and are in no way intended to reflect phylogenies. In the generic keys, if a genus occurs in the Malagasy subregion (Madagascar, Comores or Seychelles) this is indicated in parenthesis in the key. If it occurs in Africa only, then this is not noted in the key.

Useful general references

Allan (1995); Brittain (1982); Chutter (1998); Demoulin (1981); Edmunds et al. (1976); Edmunds & McCafferty (1988); Ward (1992); McCafferty (1981); Merritt & Cummins (1996); Wang & McCafferty (1996);

KEY TO FAMILIES OF MATURE MAYFLY NYMPHS

1. Nota fused, forming a dorsal carapace-like structure covering the legs and gills, giving nymphs an ellipsoid appearance (Fig. 2.5); minute (≤ 4 mm)…. ………………………………………………Prosopistomatidae, *Prosopistoma*
– Nota not fused as above, legs and gills visible in dorsal view; length of nymph > 4 mm ……………………………………………………………2

2. Head with compound eyes on short, dorsally-oriented protruberances (Fig. 2.6B); terga 3–7 dorsally expanded, forming open V-shaped compartment protecting gills (Fig. 2.6A)………………..Machadorythidae, *Machadorythus*
– Head with compound eyes not raised on protruberances; terga not modified as above…………………………………………………………………3

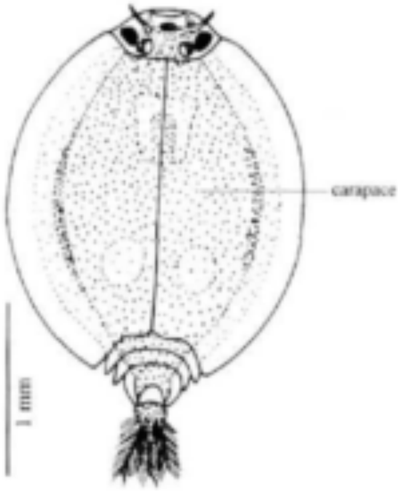

Fig. 2.5. *Prosopistoma*, whole nymph, dorsal view.

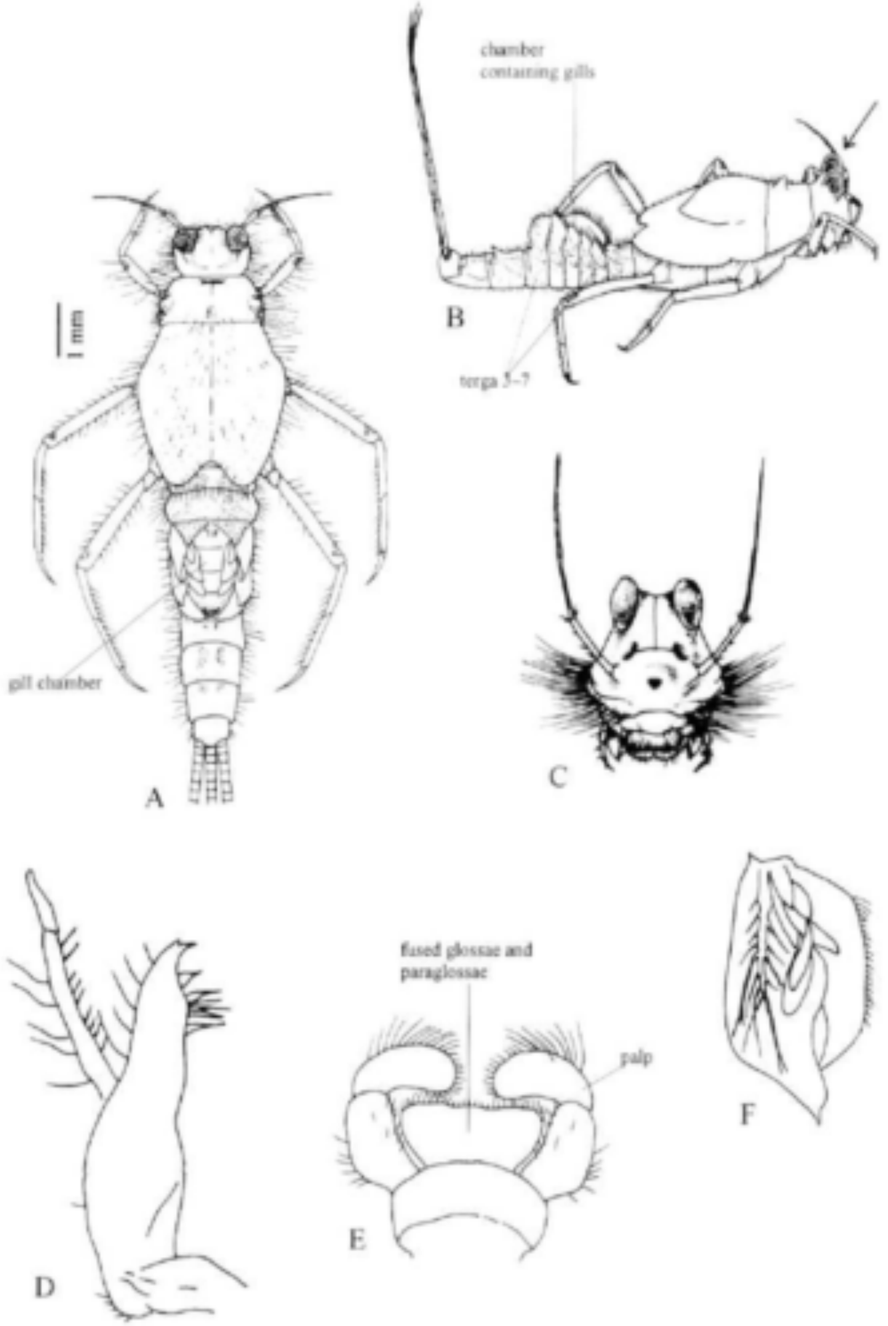

Fig. 2.6 *Machadorythus* sp.: **A**, whole nymph in dorsal view; **B**, whole nymph, in lateral view, indicating protruding eyes (arrowed); **C**, head, anterior view; **D**, maxilla; **E**, labium; **F**, gill 4. (A & C–F redrawn from McCafferty & Wang 2000; B redrawn from Demoulin 1959).

3. Nymph usually with seven simple gills including gill 1 (Fig. 2.7A); head with lateral ocelli located above lateral branches of epicranial suture (Fig. 2.7B); femoral apices with a ventrally-oriented dorsal lobe (Fig. 2.7D)..Baetidae

– Nymphs with variously developed gills, gill 1 present or absent; head with lateral ocelli located anterior to (i.e. in line with or below) lateral branches of epicranial suture (Fig. 2.7C); femoral apices without ventrally-oriented dorsal lobe (Fig. 2.7E) 4

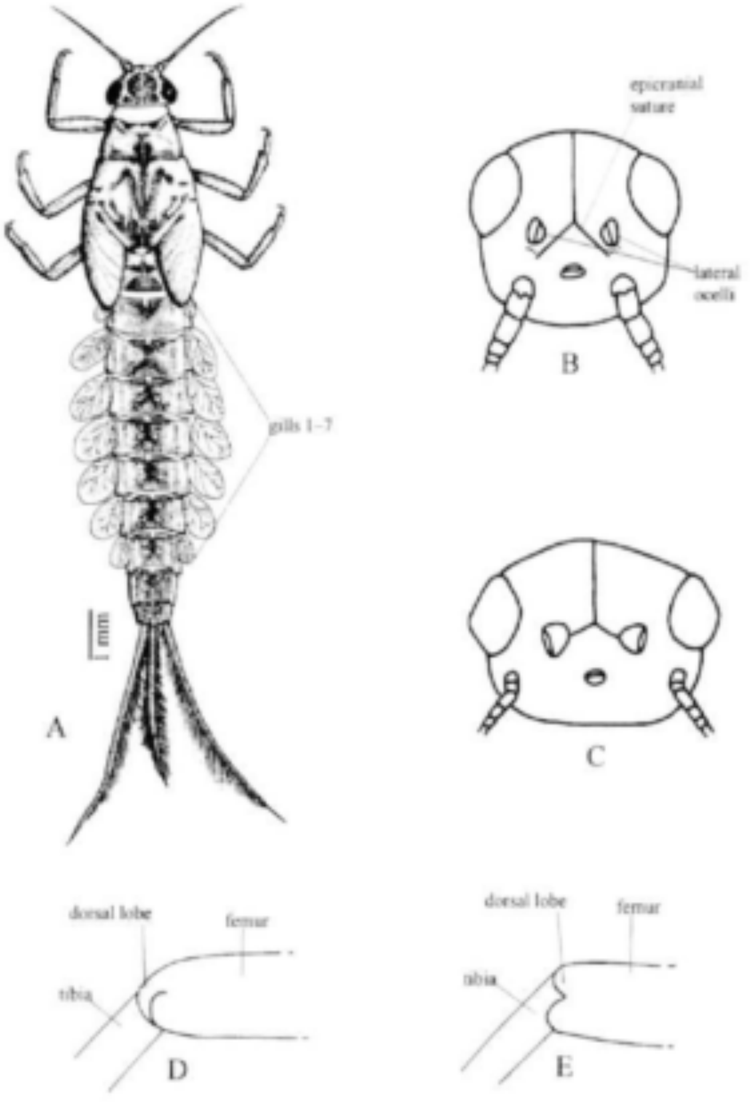

Fig. 2.7. Mayfly nymphs, showing distinctive characteristics. **A**, baetid nymph, in dorsal view. **B–C**, anterior views of the head showing epicranial sutures: **B**, of a baetid, showing lateral ocelli above the lateral branches of the suture; **C**, of a non-baetid, showing lateral ocelli that connect with the lateral branches of the suture, or may be situated below the suture. **D–E**, distal apices of femora: **D**, of baetids, showing a ventral orientation of the dorsal lobe of the femoral apex; **E**, of non-baetids indicating a different orientation. (B–D after Wang & McCafferty 1996).

4. *Gill 1 ventrally oriented, lamellate section reduced, fibrilliform section pronounced* (Fig. 2.8C); gills 2–7 laterally-orientated, lamellate, with fibrilliform tufts on ventral surface (Fig. 2.8D); labium fused, forming a plate-like structure (Fig. 2.8E); base of maxillae with fibrilliform tufts (Fig. 2.8F), maxillary palps two-segmented; forelegs with rows of long setae along margin of femur and tibia (Figs. 2.8A, B) ....Oligoneuriidae

– Gills 1 present or absent; if present, laterally, dorsally, or dorsolaterally oriented, and variously developed; gills 2–7 not as above; labium not fused; maxillae without fibrilliform extensions; forelegs without filtering setae......5

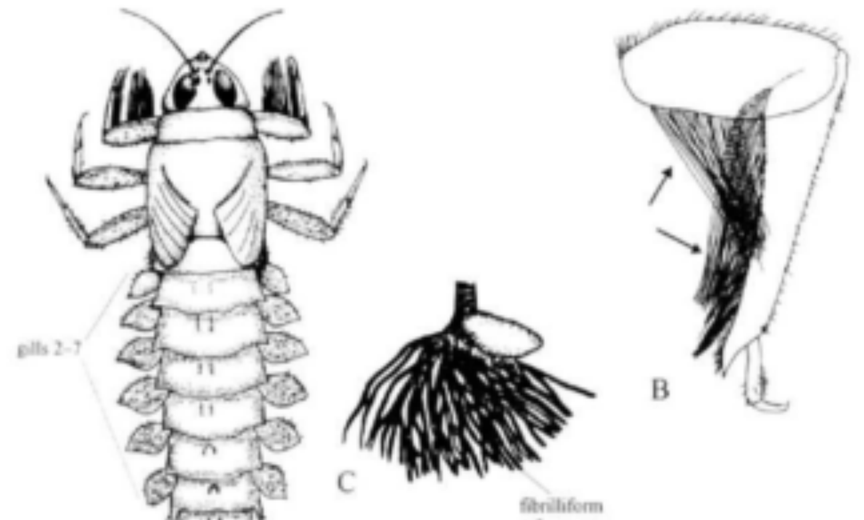

Fig. 2.8 Oligoneuriidae: generalized figures, showing distinctive morphological characters of the family: **A**, a whole nymph, dorsal view; **B**, details of foreleg; **C**, gill 1; **D**, gill 4; **E**, labium, showing fusion of parts; **F**, maxilla, showing fibrilliform tuft.

5. Head with long mandibular tusks projecting forward and arising from lateral margin (Figs. 2.9A,B; 2.10E) or, if tusks short, frontal process pronounced (Fig. 2.10A,B); gill 1 reduced, not feather-like or fringed; gills 2–7 fold upwards over the abdomen, each consisting of two elongate lamellae with fringed margins (Figs 2.9C, 2.10C)..6
– Head without mandibular tusks; gills 2–7 not as above..............................7

6. Mandibular tusks apically convergent (Figs. 2.9A,B); frontal process absent, or reduced; posterior legs (Fig. 2.9D) without tibial process ....Polymitarcyidae
– Mandibular tusks apically divergent, frontal process present (Fig. 2.10B,E); posterior legs (Fig. 2.10D) with tibial process .... Ephemeridae

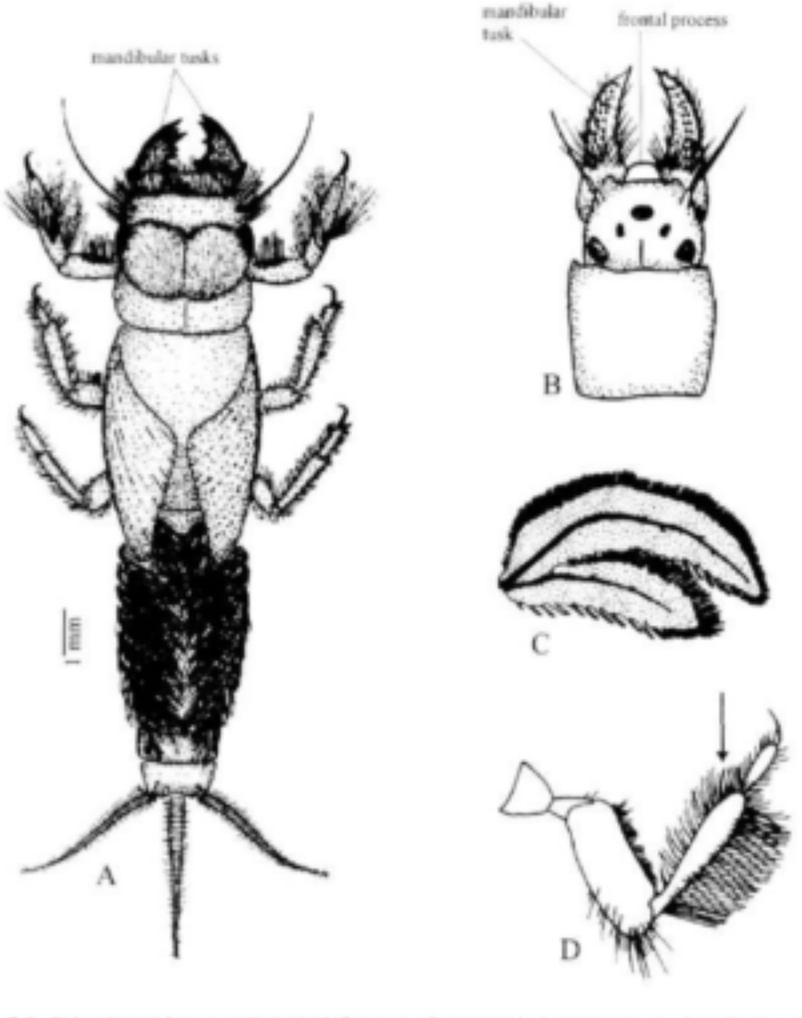

Fig. 2.9. Polymitarcyidae: morphological features of taxonomic importance. **A**, *Povilla* sp., whole nymph in dorsal view. **B–D**, *Ephoron*, sp., **A**, head and prothorax, in dorsal view, showing detail of tusks; **C**, gill 4; **D**, hind leg (*note* the absence of a tibial extension—arrowed). (A & B redrawn from Agnew 1980; C & D redrawn from Crass 1947).

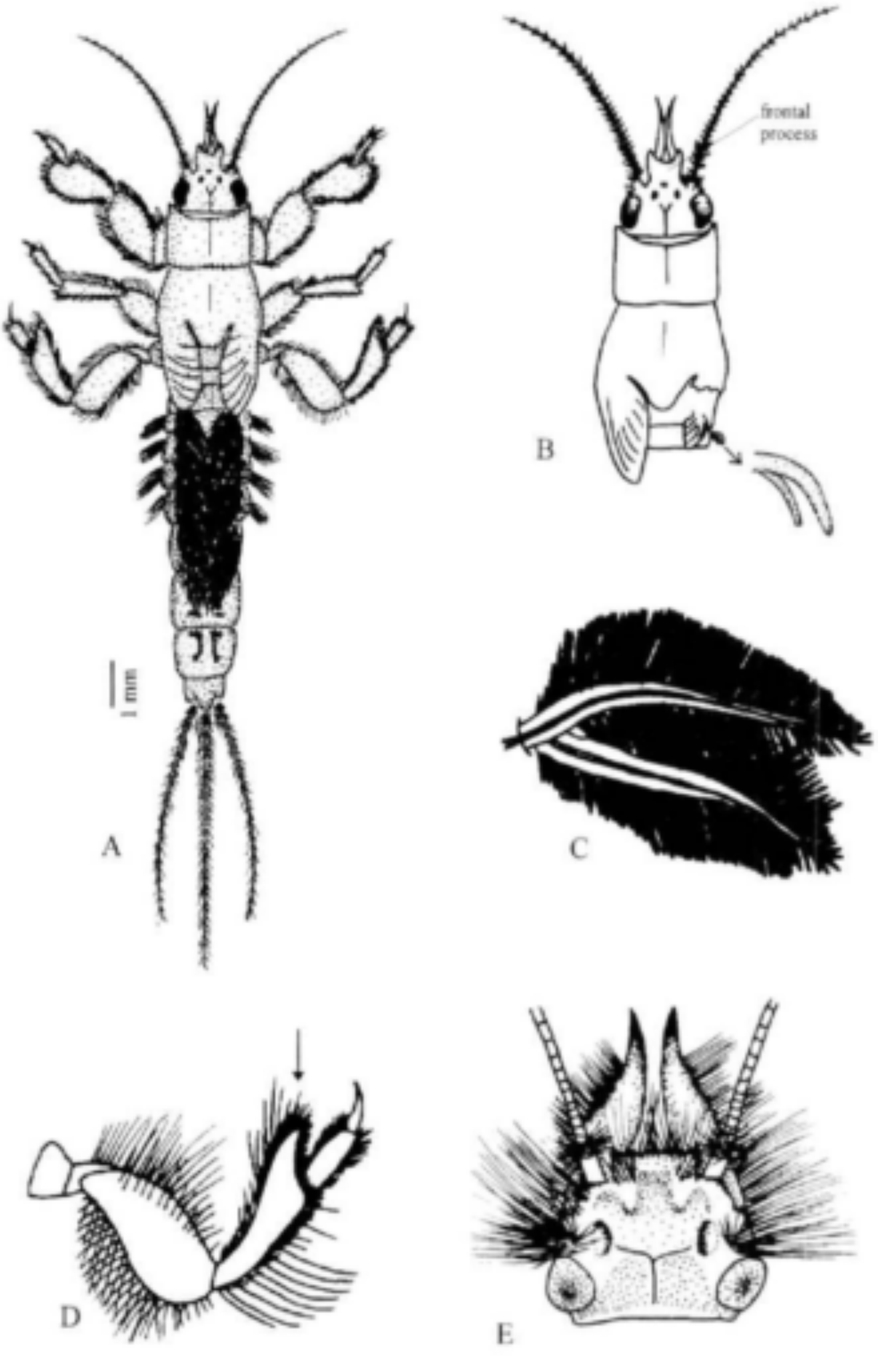

Fig. 2.10. Ephemeridae: morphological features of taxonomic importance. **A–D,** *Ephemera* sp.: **A**, whole nymph in dorsal view; **B**, head and thorax with right forewing pad removed to show small hindwing pad and detail of gill 1 (enlarged); **C**, gill 4; **D**, hindleg (note pointed tibial extension—arrowed). **E**, *Cheirogenesia* sp., detail of head showing tusks; (A redrawn from Agnew 1980; C redrawn from McCafferty & Edmunds 1976; B, D & E redrawn from Crass 1947).

7. Forewing pads freely extending beyond fusion to thorax for more than half their length (Figs. 2.11A, 2.12A,B); gill 1 may be operculate (Fig. 2.12B); gill 2 never operculate...8

– Forewing pads freely extending beyond fusion to thorax for less than half their length (Figs 2.13A, 2.14A, 2.15A, 2.16A); gill 1 never operculate; operculate gills present on abdominal segment 2 (Figs 2.13A, 2.14A, 2.15A & 2.16A) or absent 9

8. Head capsule more or less semi-circular, covering mouthparts from dorsal view (Fig. 2.11A); gills 1–6 consisting of a plate-like dorsal lamella with a fibrilliform ventral portion (Figs. 2.11B,C,D); gill 7 lamellate, without the fibrilliform portion (Fig 2.11E); maxilla without a prominent brush of long setae on the apicolateral margin (Fig. 2.11F)............................ Heptageniidae

– Head capsule more or less quadrangular, not covering mouthparts from dorsal view (Figs. 2.12A,B); gill 1 may be operculate (Fig. 2.12B & I), at least partly covering the other gills, which are bilamellate (Fig. 2.12J), or gill 1 may be simple, usually unilamellate (Fig,. 2.12E), lanceolate (Fig. 2.84A) or filamentous (Fig. 2.85A); gills 2–7 bilamellate (Figs 2.12 D, F–H), consisting of similar, separate, dorsal and ventral lamellae; apicolateral margin of maxilla with a brush of dense setae (Fig. 2.12K)..................Leptophlebiidae

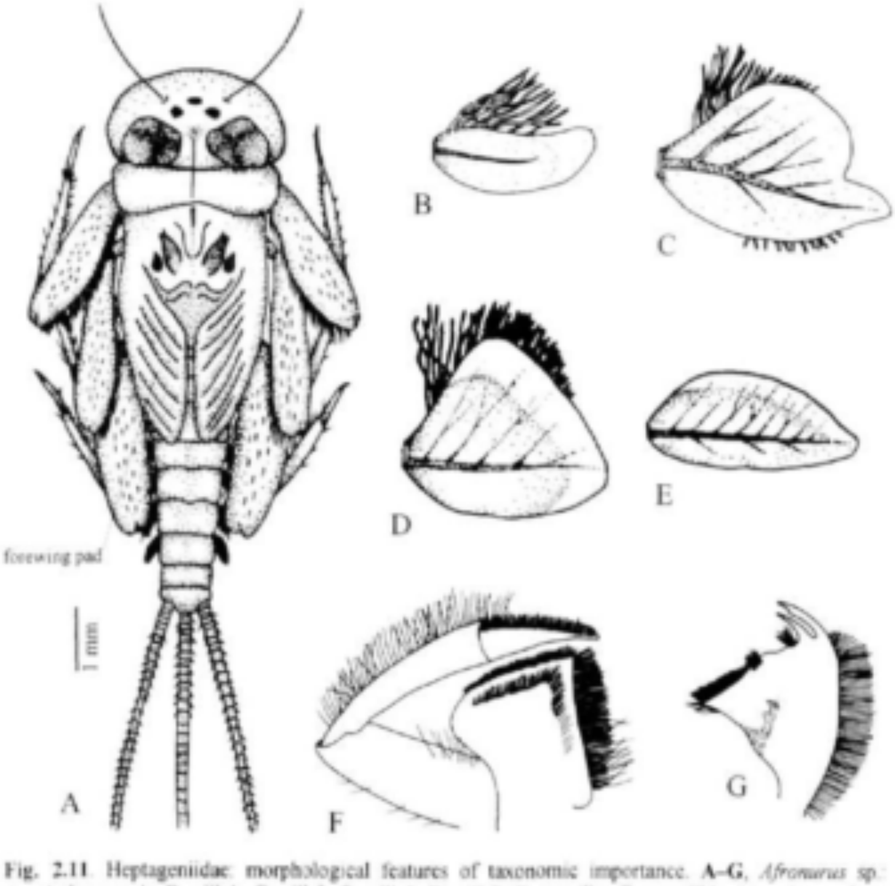

Fig. 2.11. Heptageniidae: morphological features of taxonomic importance. **A–G**, *Afronurus* sp.: **A**, whole nymph; **B**, gill 1; **C**, gill 3; **D**, gill 5; **E**, gill 7; **F**, maxilla; **G**, mandible. (A redrawn from Agnew 1980; B–G redrawn from Schoonbee 1968).

Fig 2.12. **A**. Leptophlebiidae (*Adenophlebia* sp.), whole immature nymph (with cerci truncated) in dorsal view, showing double lamellate gills. **B**, *Adenophlebiodes* sp., whole nymph (with cerci truncated), in dorsal view, showing operculate gills 1 covering the lower gills. **C–J**, variety of gill types in Leptophelbiidae: **C**, *Adenophlebia* sp., gill 4; **D**, lanceolate, bilammelate (*Castanophlepia* sp., gill 4); **E**, unilamellate (*Choroterpes* sp. gill 1); **F**, bilamellate (*Choroterpes* sp. gill 4); **G**, bilamellate (*Euthraulus* sp. gill 4); **H**, bilamellate with finger-like projections (*Thraulus* sp. gill 4); **I**, operculate (*Adenophlepiodes* sp. gill 1); **J**, bifid (*Adenophlebiodes* sp. gill 4). **K–L**, typical leptophlebiid mouthparts: **K**, maxilla, showing apicolateral margin with brush of dense setae. **L**, left mandible. (A redrawn from Agnew 1980); B redrawn from Peters & Edmunds 1964; C–L redrawn from Peters & Edmunds 1964).

9. Gill 1 always present, filamentous (Fig. 2.13A); gill 2 operculate, large and quadrangular or broadly rounded, with variously-developed Y-shaped ridges on dorsal surface, touching or overlapping medially, covering the remaining gills (Figs. 2.13A,B) ....Caenidae

– Gill 1 present or absent, if present, filamentous (Fig. 2.14A,B); gill 2 operculate (Fig. 2.14B), semi-operculate (Fig. 2.14C), or not operculate; if operculate, smaller than above and generally oval, without Y-shaped ridge on dorsal surface, never overlapping 10

10. Posterior margin of mesonotum, between wingpads, with prominent V-shaped notch, and generally slightly lobed basally (Fig. 2.14D); lateral, simple, filamentous gills generally present on abdominal segment 1 (Fig. 2.14A); gill 2 operculate (Fig. 2.14B) or semi-operculate (Fig. 2.14C); mature male nymphs with subdivided compound eyes (Fig. 2.14E); maxillae without palps (Fig. 2.14F); medial caudal filament may be present or reduced; claws with denticles ....Teloganodidae

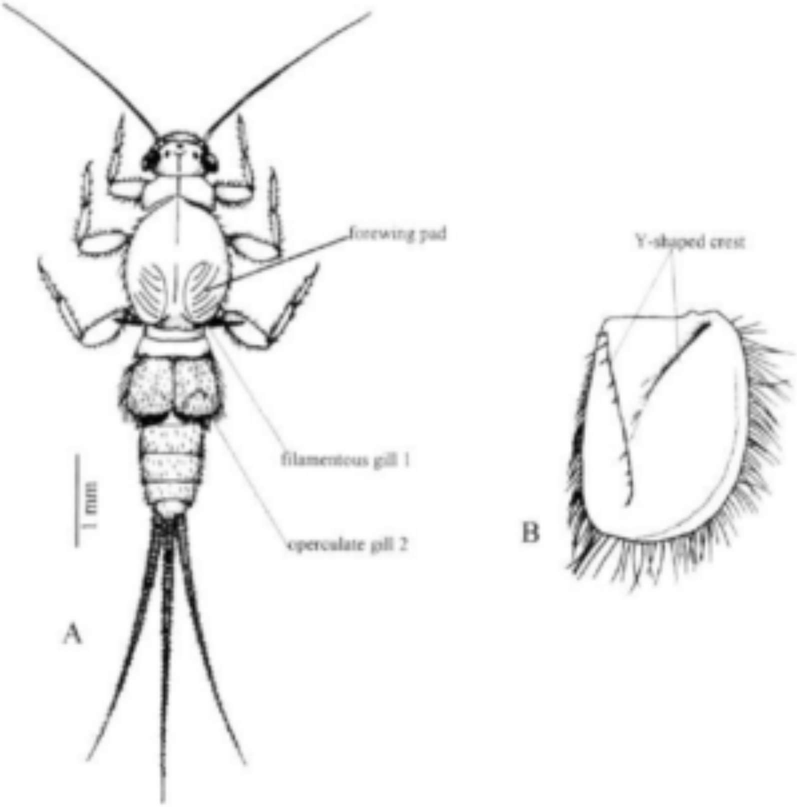

Fig. 2.13. Caenidae. **A**, whole nymph; **B**, dorsal view of operculate gill. (A redrawn from Agnew 1980).

– Mesonotum posteriorly without V-shaped medial notch and submedial lobes (Figs 2.15A, 2.16A, F); lateral, simple, filamentous gills present (like Fig. 2.14A) or absent on abdominal segment 1 (Figs 2.16A, F); gill 2 semi-operculate or not operculate; mature male nymphs without subdivided compound eyes; maxillae with or without palps; claws with or without denticles 11

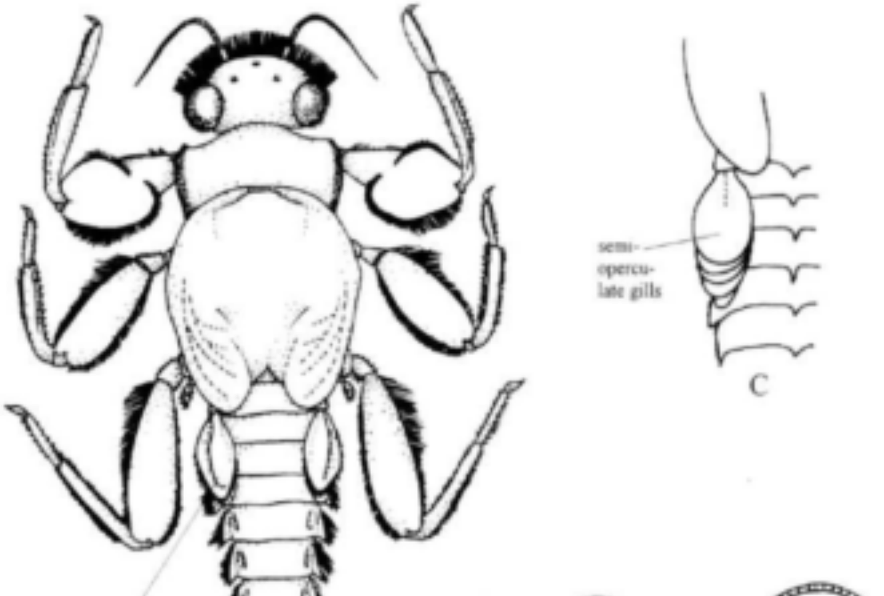

Fig. 2.14. Teloganodidae. **A–B**, *Lestagella penicillata*: **A**, whole nymph (with cerci truncated), in dorsal view; **B**, dorsal view of left posterior thorax and anterior segments of the abdomen, showing detail of filamentous gill 1 and operculate gill 2. **C–F**, *Ephemerellina* sp.: **C**, semioperculate gills; **D**, posterior margin of the mesonotum, in dorsal view; **E**, subdivided eyes of male, in dorsal view; **F**, maxilla (*note* absence of palps—arrowed). (All figures redrawn from McCafferty & Wang 1997).

11. Filamentous gill 1 present; lamellate gills present on segments 2–5, gill 2 operculate (Fig. 2.15A); maxillae without palps (Fig. 2.15B); medial caudal filament developed; claws without denticles (Madagascar only)..Teloganellidae, *Telagonella*

– Filamentous gill 1 absent; claws with denticles (Fig 2.16E)....................12

12. Gill 2 operculate, narrow-elongate (Fig. 2.16A); gill 6 absent; maxillary palps absent..Ephemerythidae, *Ephemerythus*

– Gill 2 not operculate (Fig. 2.16F); lamellate gills present on abdominal segments 2–6 (Fig. 2.16G); maxillary palps present (Fig. 2.16H)..Tricorythidae

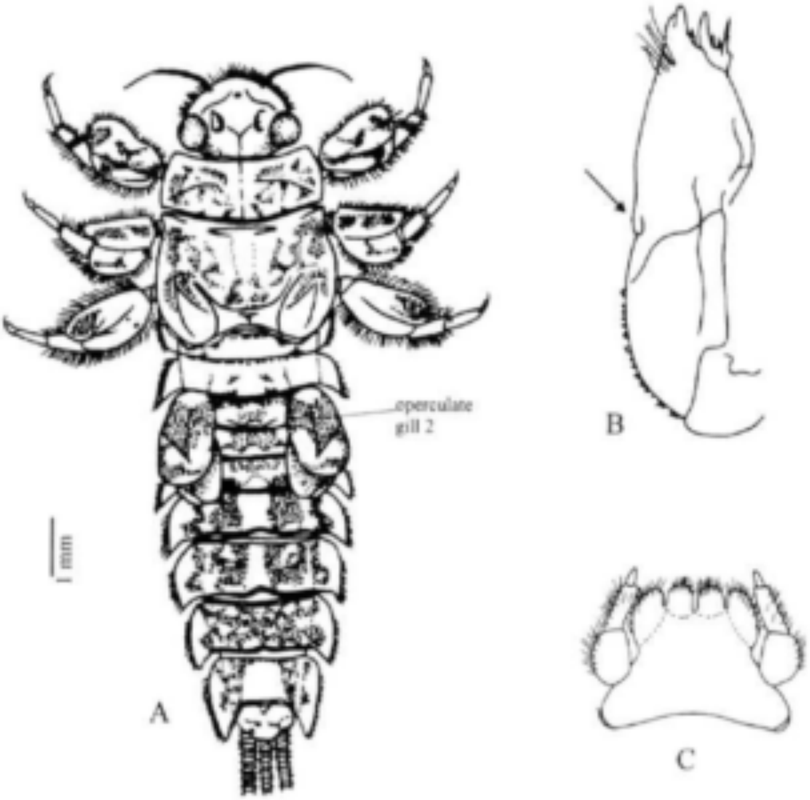

Fig. 2.15. Teloganellidae: distinctive characteristics (generalized figures): **A**, whole nymph; **B**, maxilla (*note* absence of palps); **C**, labium. (Redrawn from McCafferty & Wang 2000).

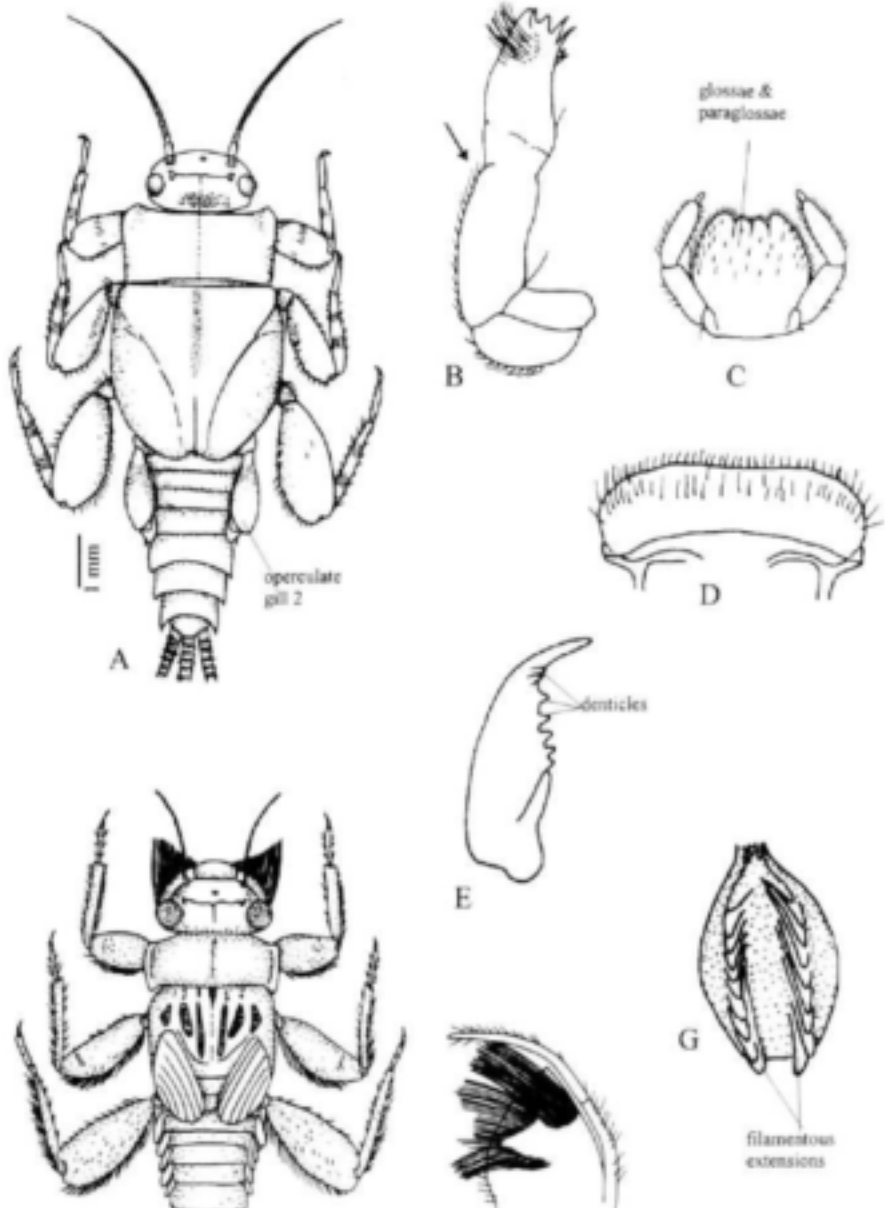

Fig. 2.16. Ephemerythidae and Tricorythidae. **A–E**, Ephemerythidae (*Ephemerythus* sp.): **A**, whole nymph, with cerci truncated; **B**, maxilla (*note* absence of palps); **C**, labium; **D**, labrum; **E**, claw showing prominent denticles. **F–H**, Tricorythidae (*Tricorythus* sp.): **F**, whole nymph; **G**, gill 4, in ventral view; **H**, maxilla. (A–D redrawn from McCafferty & Wang 2000; E redrawn from Demoulin 1964).

BAETIDAE: KEY TO GENERA

1. Nymphs with two cerci, medial caudal filament reduced to a small conical point (Fig. 2.17A). 2
– Nymphs with three cerci, medial caudal filament may be shorter than the lateral cerci (Fig. 2.17B), or subequal in length (Fig. 2.17C).....................10

2. Gills orientated ventrally (Figs. 2.17D, 2.18A), six pairs 3
– Gills orientated dorsolaterally (e.g. Fig. 2.2A), usually seven pairs.................4

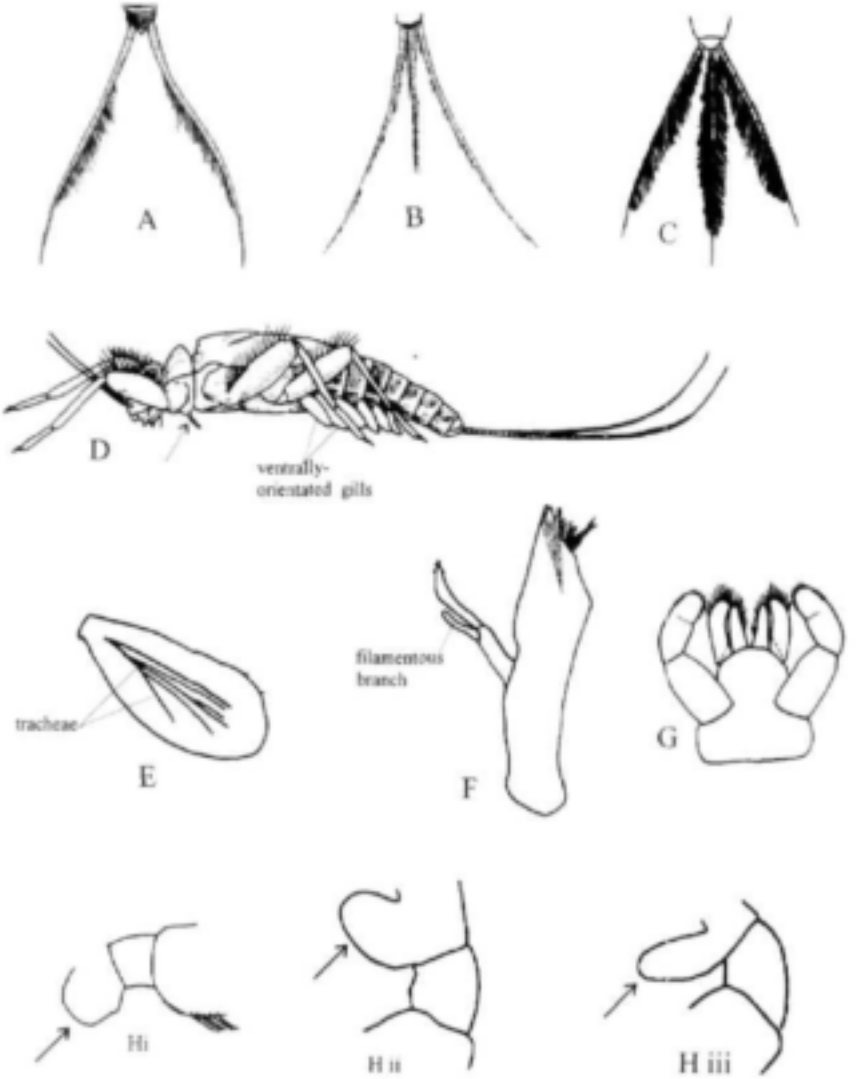

Fig. 2.17. **A–C**, cerci and median caudal filaments in baetid nymphs: **A**, no median caudal filament (e.g. *Acanthiops tsitsa*); **B**, median caudal filament shorter than lateral cerci (e.g. *Pseudocloeon glaucum*); **C**, median caudal filament and cerci subequal in length (e.g. *Cloeon* spp.). **D–H**. *Afrobaetodes* sp.: **D**, lateral view of nymph (arrow indicates small thoracic gill). **E**, abdominal gill 4 (*note* subparallel trachcation); **F**, maxilla; **G**, labium; **H**, coxal spurs on (i) the foreleg (ii) the midleg (iii) the hindleg. (D redrawn from Kimmins 1955; E–G redrawn and adapted from Gillies 1991).

3. Gills on abdominal segments 1– 6, all with entire margins and with multiple unbranched tracheae arising from the base of each gill (Fig. 2.17E); abdomen with weak dorsal tubercles or no tubercles; one small filamentous gill ventrolaterally on each side of prosternum (Fig. 2.17D); coxal spur present (Fig. 2.17H); maxillary palp two-segmented, segment 1 with filamentous branch (Fig. 2.17F) (Africa & Madagascar) .... *Afrobaetodes* (p. 93)

– Gills on abdominal segments 2–7 elongate, apically fringed with filamentous projections, devoid of trachea (Fig. 2.18B); abdomen with prominent dorsal tubercles (Fig. 2.18A); thorax without ventrolateral filamentous gills; coxae without spurs; maxillary palp (Fig. 2.18C) three-segmented, segment 1 without filamentous branch, segment 3 very small...*Thraulobaetodes* (p. 110)

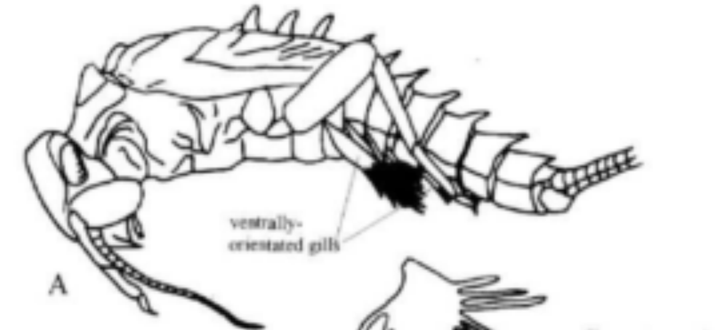

Fig. 2.18. *Thraulobaetodes*: **A**, whole nymph, lateral view; **B**, abdominal gill 4; **C**, maxilla; **D**, labium. (Redrawn from Elouard & Hideux 1991b).

4. Tarsal claws with denticles in a single row (e.g. Fig. 2.19B)..................... 5

– Tarsal claws with two rows of denticles, one row of which may be more well developed than the other (Fig. 2.20B)...7

5. Small tubercles present dorsally on abdominal terga 1–7 or 1–8 (Fig. 2.19A); metanotum with blunt dorso-median tubercle; maxillary palps two-segmented, short and stout, shorter than galea-lacinia (Fig. 2.19C); labial palp with segments 2 and 3 partially fused, segment 3 broadly rounded (Fig. 2.19D); labrum basally broad, well developed medial lobe (Fig. 2.19E), ventral margin with strong marginal and submarginal setae (Fig. 2.19E)....... ....*Tanzaniella* (p. 109)

– Dorsal abdominal tubercles absent; metanotum without tubercles; maxillary palp two- or three-segmented; labium and labrum variously developed, not as above. 6

6. Tarsal claws with subapical pair of setae (Fig. 2.20B); mandibles without tuft of setae between incisor and molar region; labial palp segment 3 narrowly rounded (Fig 2.20D) or clublike (Fig. 2.20E); villopore present (Fig. 2.20F) ....*Demoreptus* (p. 98)

– Tarsal claws without a subapical pair of setae (Fig. 2.21A); only right hand mandible with tuft of setae between incisors and molar (Fig. 2.21B); labial palp segment 3 broadly rounded, somewhat produced medially (Fig 2.21C); villopore absent .... *Micksiops* (p. 103)

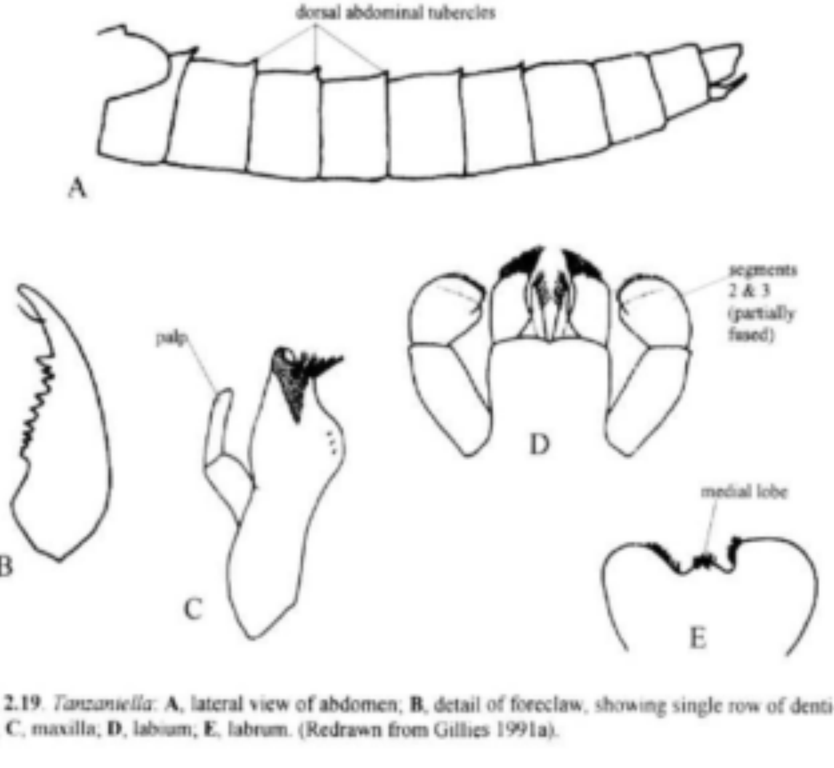

Fig. 2.19. *Tanzaniella*: **A**, lateral view of abdomen; **B**, detail of foreclaw, showing single row of denticles; **C**, maxilla; **D**, labium; **E**, labrum. (Redrawn from Gillies 1991a).

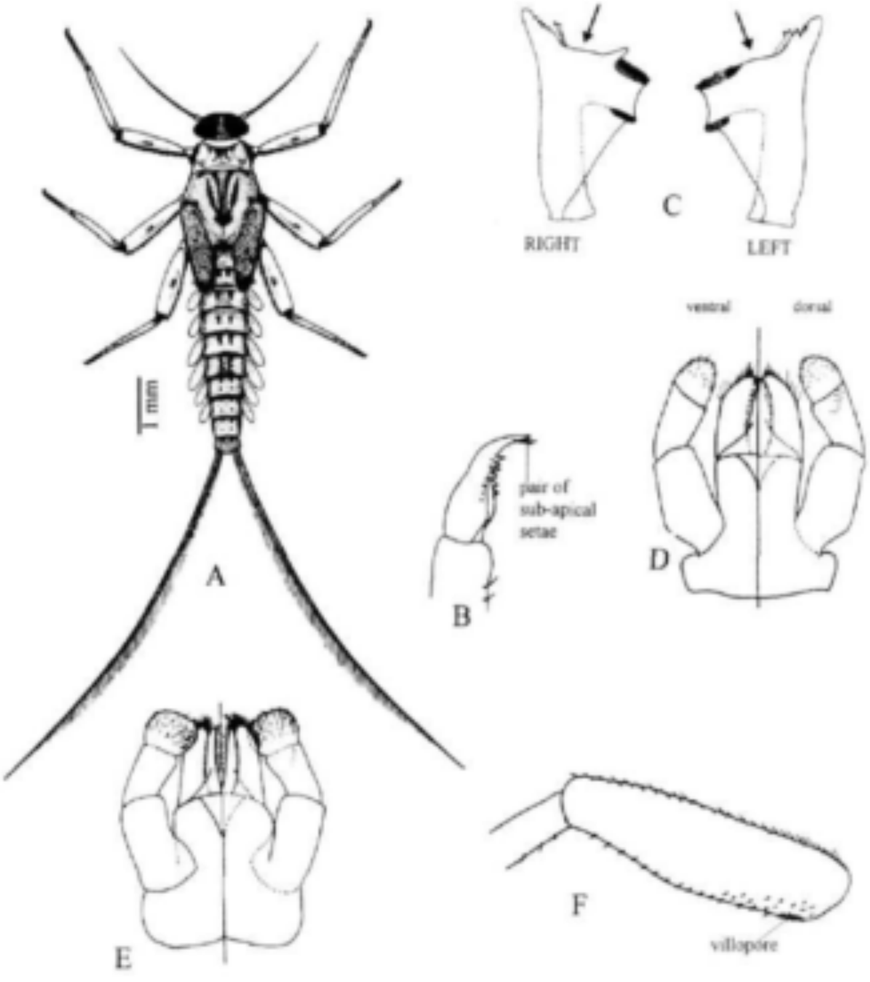

Fig. 2.20. *Demoreptus sp.* **A**, dorsal view of whole nymph; **B**, claw, showing double row of denticles and subapical setae; **C**, right & left mandibles, in ventral view (*note* lack of tufts of setae between molar and prosthecae—arrowed); **D**, labium (of *D. capensis*), in ventral view on the left and in dorsal view on the right; **E**, labium (of *D. monticola*); **F**, femur. (Redrawn from Lugo-Ortiz & McCafferty 1997b).

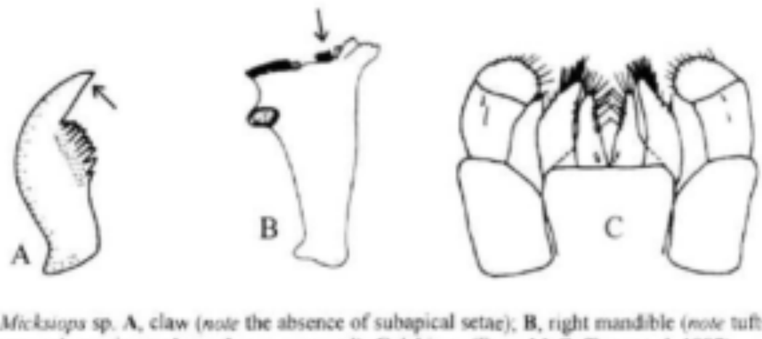

Fig. 2.21. *Micksiops* sp. **A**, claw (*note* the absence of subapical setae); **B**, right mandible (*note* tufts of setae between molar region and prostheca—arrowed); **C**, labium. (From McCafferty et al. 1997).

7. Prothorax broadly expanded laterally, giving a carapace-like appearance (Fig. 2.22A); pro- and mesothorax covered with small warts; forewing pads well developed; transverse row of setae on femora (Fig. 2.22B) (Madagascar only) .... *Scutoptilum* (p. 108)

– Prothorax not expanded in this way, no warts present, forewing pads not as prominent, no row of transverse setae on femora.................................8

8. Mandibles (Fig. 2.23A) with strongly curved lateral margins, well-developed, broad-based incisors, no setae between incisors and molar region; segment 3 of labial palp narrow-ovoid (Fig. 2.23B); hypopharynx broad, superlinguae apically raised relative to apex of lingua (Fig. 2.23C)........... .... *Barnumus* (p. 95)

– Lateral margins of mandibles not curved as above; incisors not well developed, tuft of setae present between incisors and molae of mandibles; segment 3 of labial palp narrow-ovoid or rounded (Figs. 2.24K, 2.25E); hypopharynx with linguae prominent apically above superlinguae (Figs. 2.24L, 2.25F)..9

9. Pronotum anteromedially emarginate, laterally expanded or flattened (Fig. 2.24B); abdomen with variously-developed dorsal tubercles (Figs. 2.24C,D,E); gills asymmetrical, well to poorly tracheated, often with ventrally-orientated trachea (Figs. 2.24F, G,H); maxillary palp (Fig. 2.24I) two-segmented, sometimes with small nipple-like projection apically, giving the appearance of a third segment; labrum (Fig. 2.24J) distally with deep, narrow notch, sometimes with a small antero-medial lobe; segment 3 of labial palp small, basally narrower than apex of segment 2 (Fig. 2.24K); cerci not markedly longer than body length (Fig. 2.24A) (Africa and Madagascar)................ .... *Acanthiops* (two-tailed group) (p. 92)

– Pronotum not expanded or anteromedially emarginate, gills ovoid, untracheated; no dorsal tubercles on abdominal segments (Fig. 2.25A); maxillary palp (Fig. 2.25C) three-segmented, segment 3 very small; labrum with distal margin almost straight (Fig. 2.25D); segment 3 of labial palp broadly rounded, slightly asymmetrical (Fig. 2.25E); cerci longer than length of body (Fig. 2.25A) (Madagascar only) ....*Rheoptilum* (p. 108)

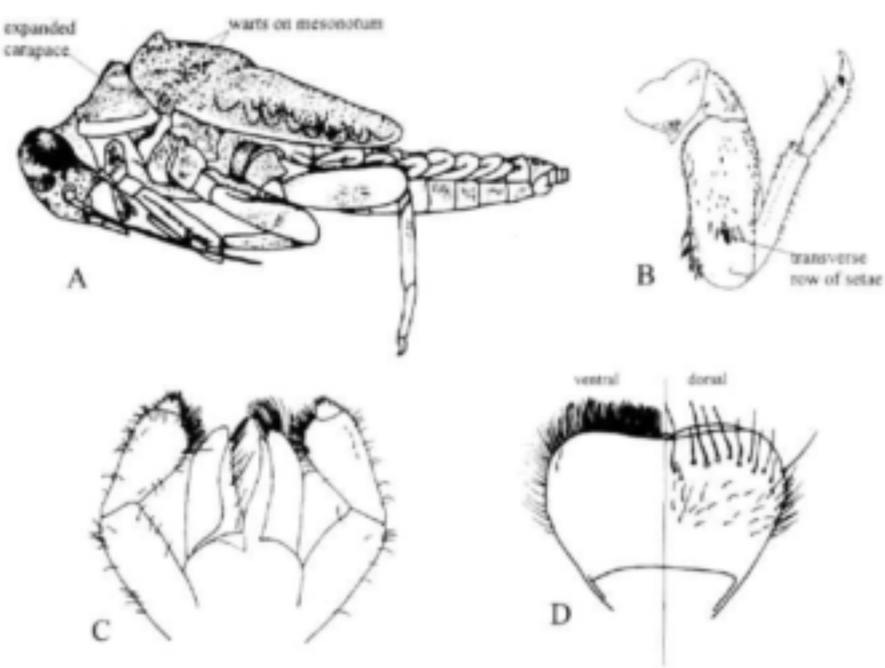

Fig. 2.22. *Scutoptilum*: **A**, whole animal, lateral view; **B**, foreleg; **C**, labium; **D**, labrum, in ventral view on the left and dorsal view on the right. (Redrawn from Gattolliat 2002b).

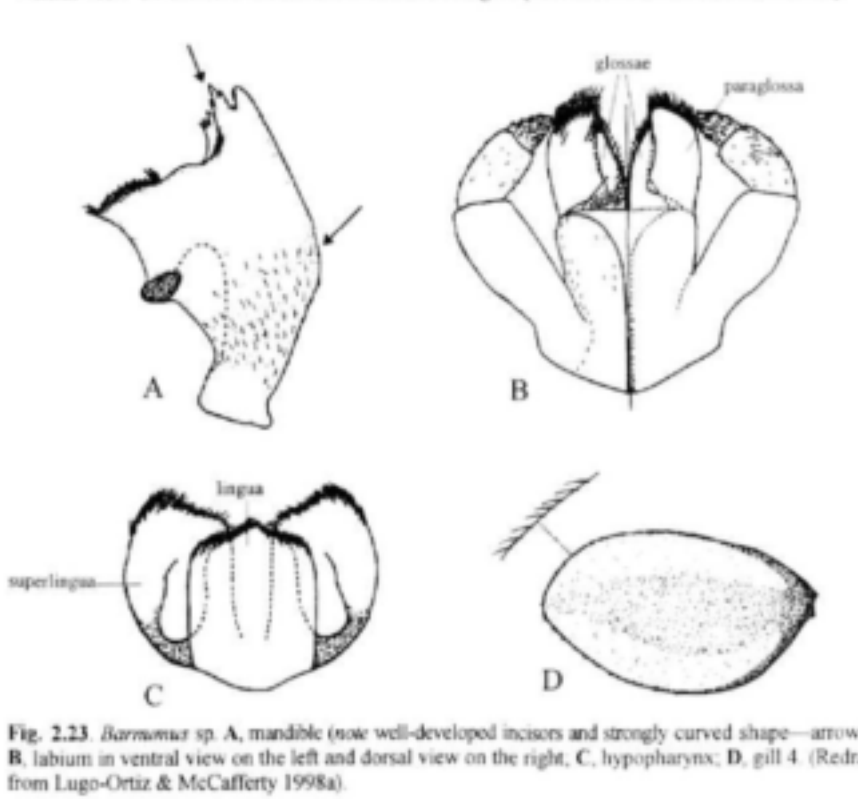

Fig. 2.23. *Barnumus* sp. **A**, mandible (*note* well-developed incisors and strongly curved shape—arrowed), **B**, labium in ventral view on the left and dorsal view on the right, **C**, hypopharynx; **D**, gill 4. (Redrawn from Lugo-Ortiz & McCafferty 1998a).

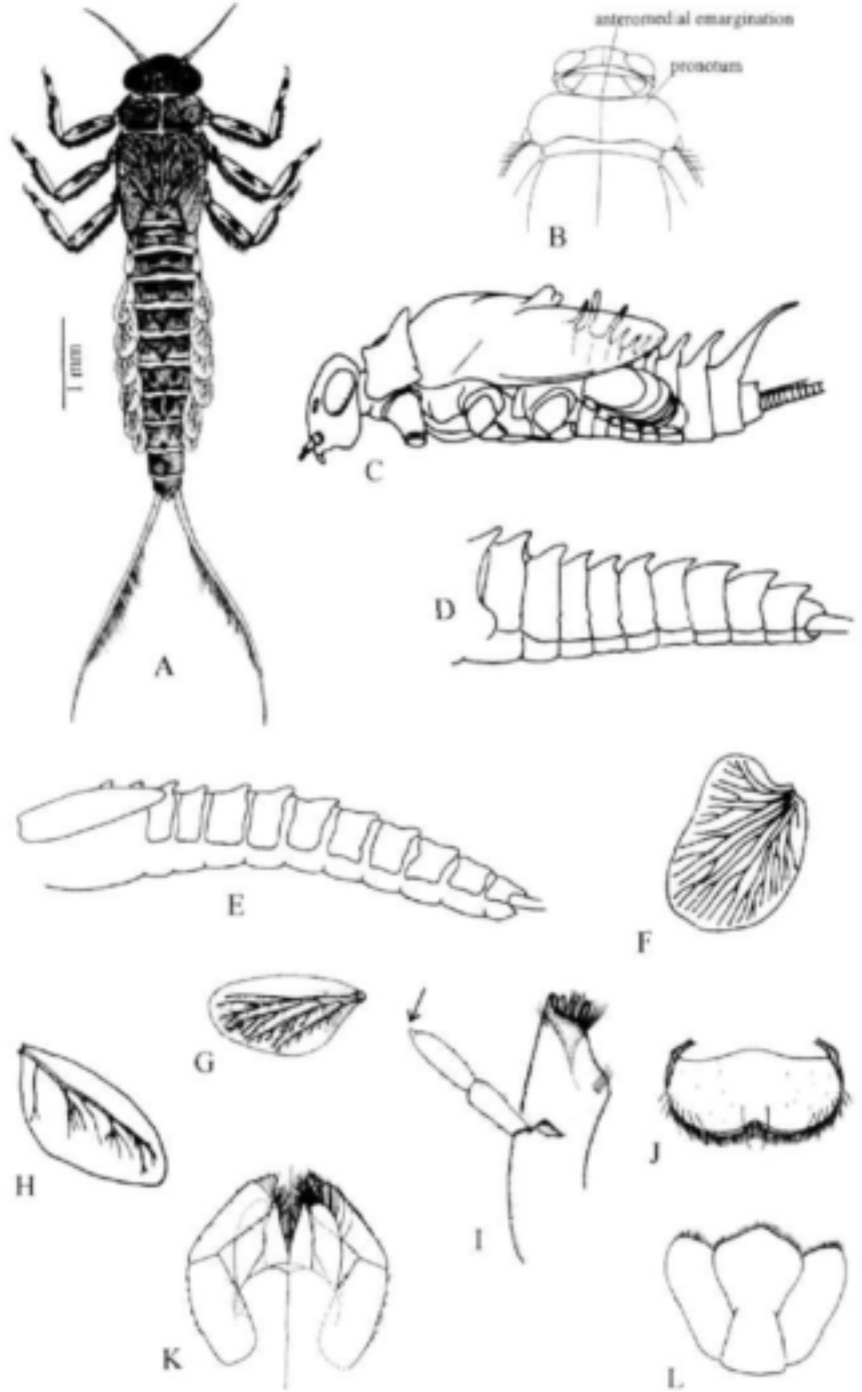

Fig. 2.24. *Acanthiops* spp. **A**, *A. tsitsa*, whole nymph, dorsal view; **B**, typical *Acanthiops* pronotum, in dorsal view. **C–E**, dorsal abdominal tubercles, lateral views: **C–E**, abdomens in left lateral views: **C**, *A. marlieri*, **D**, *A. io*; **E**, *A. tsitsa*. **F–H**, gills 4: **F**, *A. marlieri*; **G**, *A. io*; **H**, *A. tsitsa*. **I–K**, diagnostic features of *A. io*: **I**, maxilla, showing nipple-like tip at end of palpal segment 2 (arrowed); **J**, labrum; **K**, labium, in ventral view on the left and dorsal view on the right. **L**. *A. tsitsa*, hypopharynx. (A, E, H,& L from Barber-James & McCafferty 1997; C from Demoulin 1967; B,D & F from Lugo-Ortiz et al. 2001).

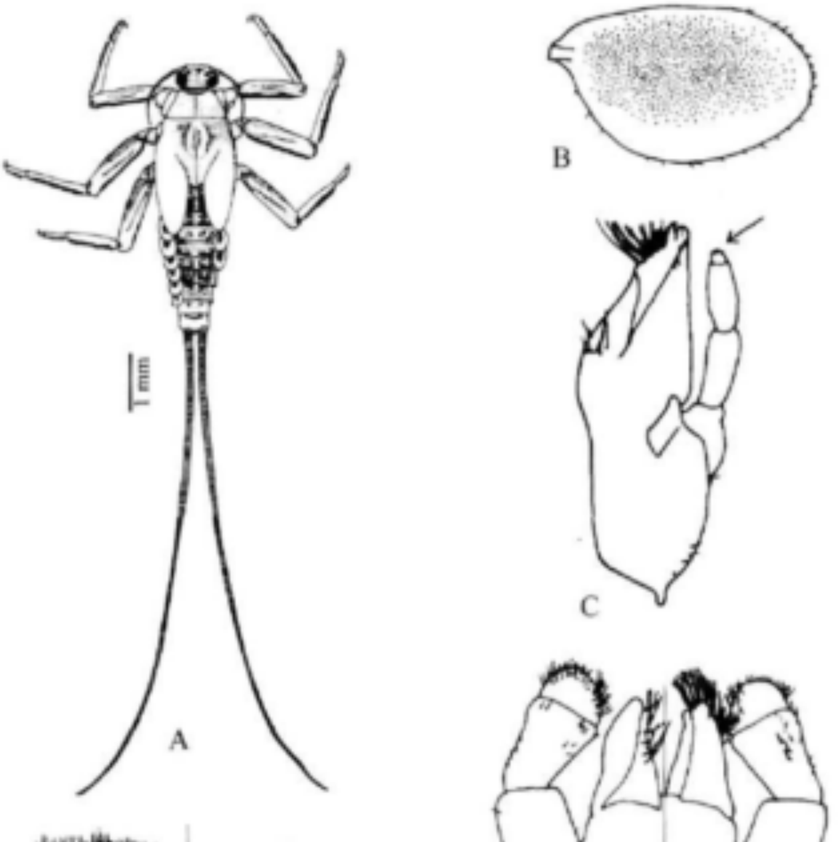

Fig. 2.25. *Rheoptilum* sp. **A**, whole nymph in dorsal view; **B**, gill 4; **C**, maxilla (*note* small size of segment 3 on palp—arrowed); **D**, labrum, in ventral view on the left and dorsal view on the right; **E**, labium, in ventral view on the left and dorsal view on the right; **F**, hypopharynx; **G**, leg with detail of claw. (Redrawn from Gattolliat 2001b).

10. Medial caudal filament half to two thirds the length of lateral cerci (Fig. 2.26A), may bear medial pairs of spines ventrally (Fig. 2.26B) (visible only with compound microscope); abdominal terga 1–3, 1–4, or 1–8 medially with small tubercles; segment 3 of labial palp reduced, basally narrower than apex of segment 2 ....*Acanthiops* (three-tailed group) (p. 92)

– Medial caudal filament as long as, or slightly shorter than, lateral cerci, ventrally without medial pairs of spines; abdominal terga without tubercles; labial palp variously modified 11

11. Gills with double lamellae (Figs 2.27A & C) on segments 1–5 or 2–6.........12

– Gills always single 13

12. Gills with double lamellae on segments 1–5 or 2–6, tracheation distinct, dendritic (Figs. 2.27A, 2.27B–D); tarsal claws gently curved, with small, fine denticles (Fig. 2.33E); labium with glossae and paraglossae tusk-shaped, glossae slightly shorter than paraglossae, labial palps three-segmented, with teminal segment more or less trapezium-shaped (Fig. 2.27F), or tapering (Fig 2.27G); maxillae (Fig. 2.27H) with slender three-segmented palps, longer than, or subequal in length to, galea-lacinia (Africa and Madagascar) ....*Cloeon* & *Procloeon* (p. 97)

– Gills with double lamellae on segments 1–5, tracheation asymmetrical (Figs. 2.28A,B,C); tarsal claws long and slender, edentate (Fig. 2.28D); labium with greatly expanded paraglossae, small glossae fused basally for half their length, labial palps two-segmented, with terminal segment wedge-shaped and with setose distal margins (Fig. 2.28E); maxillae with stout two-segmented palp, considerably longer than galea-lacinia (Fig. 2.28F)........... ....*Potamocloeon* (p. 105)

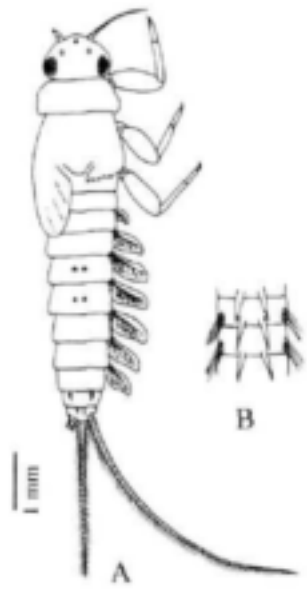

Fig. 2.26. *Acanthiops erepens*: **A**, whole nymph (with left appendages truncated), in dorsal view; **B**, detail of ventral surface of median caudal filament. (A redrawn from Crass 1947; B redrawn from Lugo-Ortiz et al. 2000).

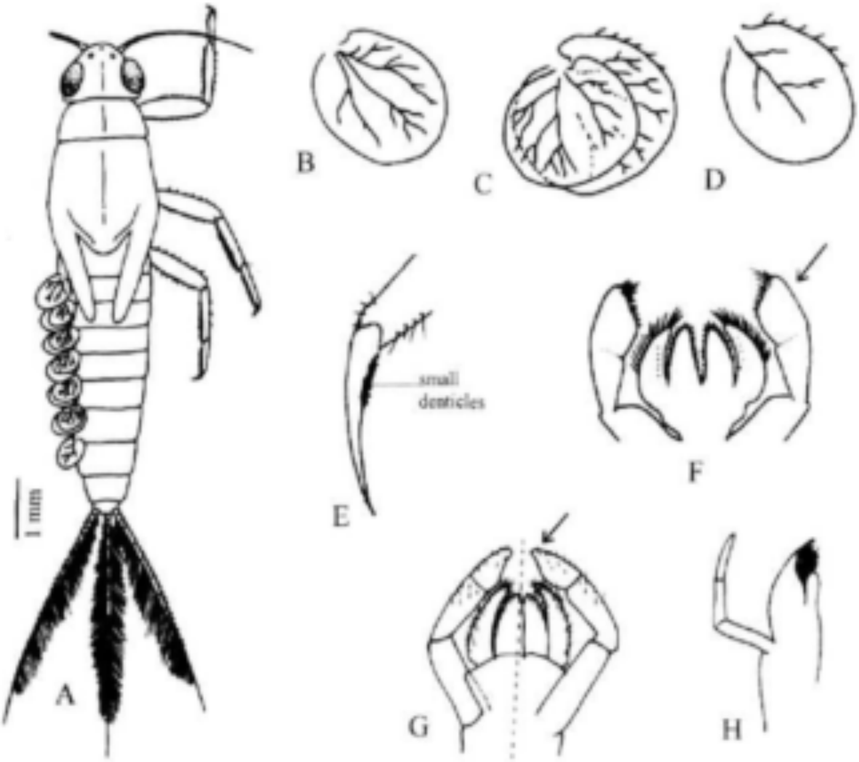

Fig. 2.27. *Cloeon* sp. **A**, whole nymph (with left legs and antenna truncated), dorsal view, **B**, gill 1; **C**, gill 3; **D**, gill 7; **E**, claw; **F**, labium (*note* wedge-shaped terminal palp—arrowed); **G**, labium, in ventral view on the left and dorsal view on the right (*note* tapering terminal palp—arrowed); **H**, maxilla. (A–D redrawn from Barnard 1932).

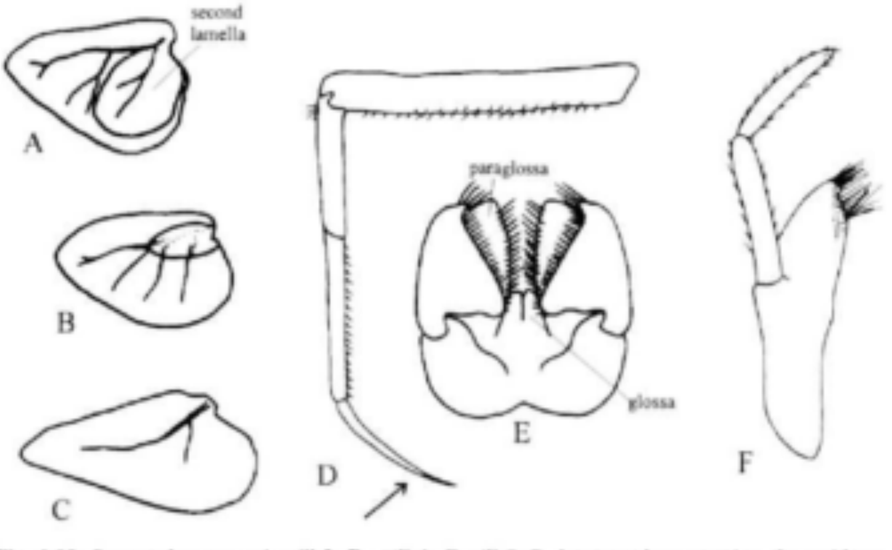

Fig. 2.28. *Potamocloeon* sp.: **A**, gill 2; **B**, gill 4; **C**, gill 7; **D**, leg (*note* long tapering claw without denticles—arrowed); **E**, labium; **F**, maxilla. (A–C redrawn from Gillies 1988; D–F from Lugo-Ortiz & McCafferty 1996).

13. Tarsal claws with denticles in two rows, second row may be less well developed than the first row (e.g. Figs. 2.29D, 2.35E, 2.36H); a pair of setae usually present subapically on claw 14

– Tarsal claws with denticles in one row (e.g. Figs 2.42A & 2.43A), or edentate (Fig. 2.38A); pair of subapical setae may or may not be present on claw.......25

14. Coxae of forelegs with pair of ventral papillae (Fig. 2.29A), inconspicuous or absent in some species; labial palps with segment 2 basally narrow, produced distomedially into rounded bulge, segment 3 short, subconical to rounded (Fig. 2.29B); labrum broader than long, with pinched-up appearance basally (Fig. 2.29C); dorsal row of long fine simple setae on tibiae and tarsi (Fig. 2.29D) (except in *D. decipiens*); hypopharynx with crest of setae on lingua (Fig. 2.29E); abdominal terga with tubercles present in some species (Africa and Madagascar) .... *Dicentroptilum* (p. 99)

– Ventral papillae never present on procoxae; mouthparts not as above; tibiae and tarsi usually without dorsal row of long fine simple setae................15

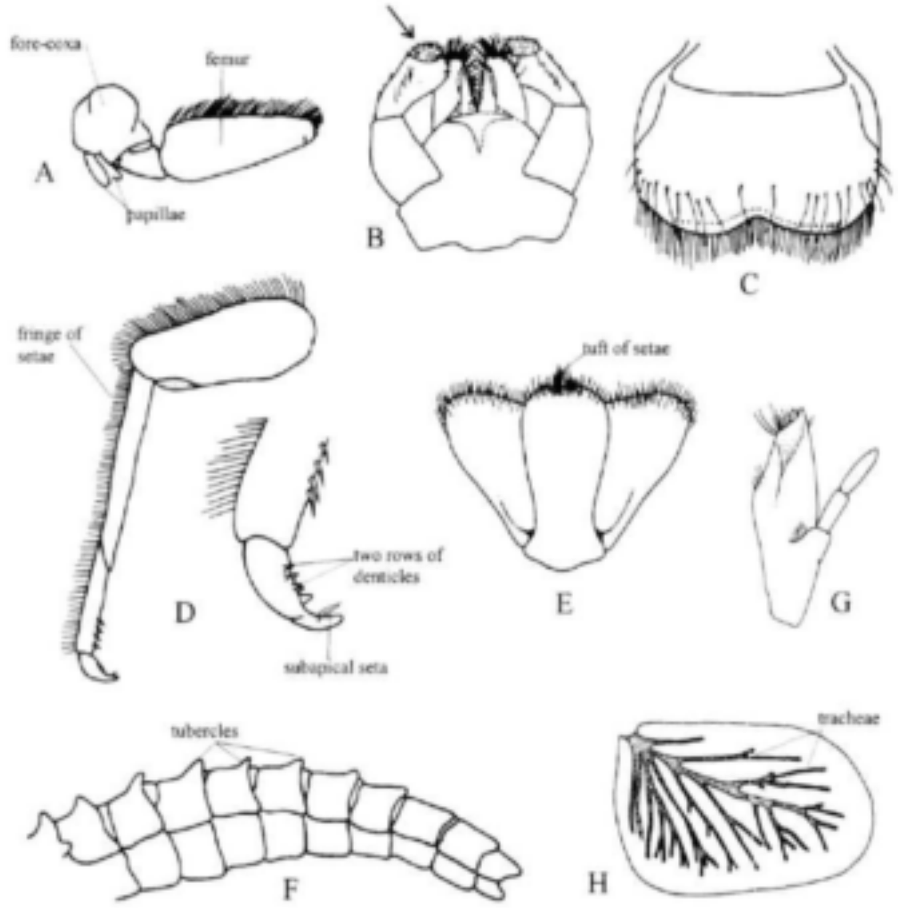

Fig. 2.29. *Dicentroptilum* sp. **A**, papillae on procoxa; **B**, labium; **C**, labrum; **D**, leg, with detail of claw; **E**, hypopharynx; **F**, abdomen, in left lateral view; **G**, maxilla; **H**, gill 4. (Redrawn from Lugo Ortiz & McCafferty 2001).

15. Labial palp segment 2 deeply falcate apically, bluntly pointed apicolaterally, rounded medioapically (Fig. 2.30A); tarsal claws with two rows of short denticles (Fig. 2.30B); gills on abdominal segments 1–7 well tracheated, narrow-elongate, gill 1 narrower that the other gills (Fig. 2.30C) (Madagascar only) .... *Delouardus* (p. 98)
– Labial palp segment 2 not falcate; tarsal claws not elongate; gills not as above..16

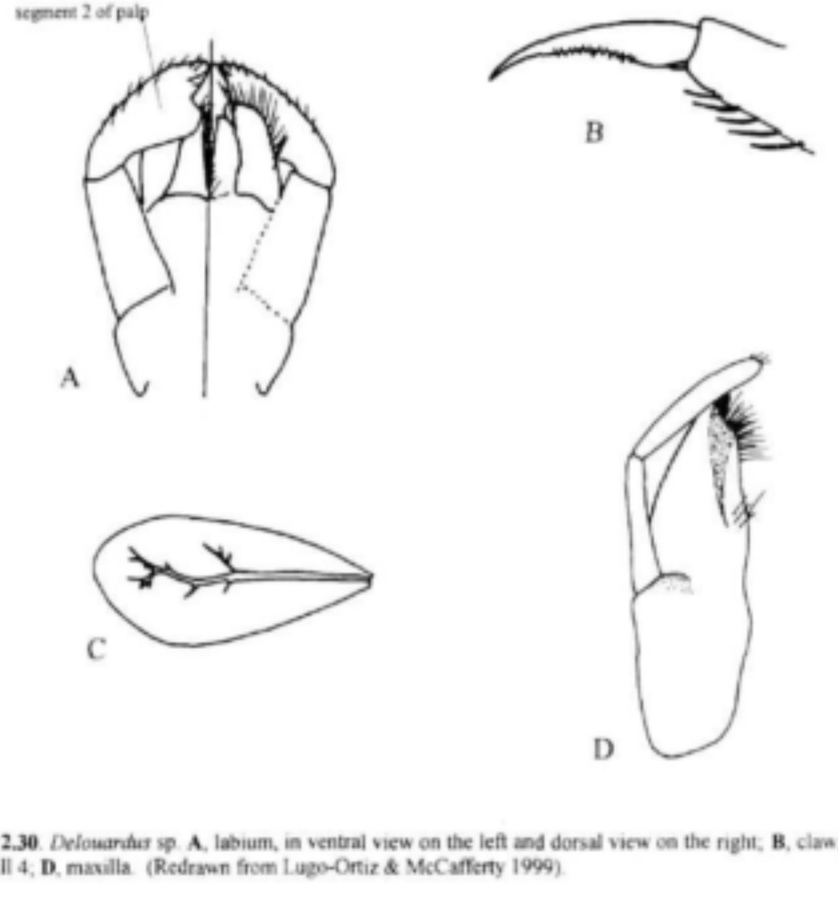

Fig. 2.30. *Delouardus* sp. **A**, labium, in ventral view on the left and dorsal view on the right; **B**, claw, **C**, gill 4; **D**, maxilla. (Redrawn from Lugo-Ortiz & McCafferty 1999).

16. Abdominal segment 1 enlarged relative to other abdominal segments (arrowed in Fig. 2.31A); gills 1 and 7 poorly tracheated, gills 2–6 well tracheated...... (Fig. 2.31B).. *Peuhlella* (p. 105)

– Abdominal segment 1 not enlarged relative to other abdominal segments; gills with other distinctive features 17

17. Head large relative to body (Fig. 2.32B); labial palp segment 2 with well-developed distomedial thumb, segment 3 subconical (Fig. 2.32C); mandibles large, robust, molar area with a few well-developed, broad-based denticles (Fig. 2.32D); tarsal claws (Fig. 2.32E) with small, evenly-sized denticles in two rows with approximately 12 denticles in each row and no subapical setae (Madagascar only)....................................... *Edmulmeatus* (p. 100)

– Head not enlarged; mouthparts with various other modifications; tarsal claws not as above 18

18. Forelegs with femora having a pronounced ventral marginal convexity (Fig. 2.33A), tibiae basally acutely produced; labrum about three times wider than long, strongly curved to formed a hooded shape, dorsally densely setose, anteromedial emargination only slight (Fig. 2.33B); labial palps three- segmented, segments 1 and 2 elongate, narrow, segment 3 narrow conical, glossae and paraglossae divergent (Fig. 2.33C); gills asymmetrical, with strong tracheation (Fig. 2.33D); tarsal claws with two rows of six to seven small denticles, and a subapical pair of long, fine, simple setae (Fig. 2.33E) (Madagascar only) ....*Nesoptiloides* (p. 103)

– Forelegs without ventral marginal convexity; labrum wider than long, with pronounced anteromedial emargination or with anteromedial lobe; labium not as above; gills asymmetrical, strongly tracheated...........................19

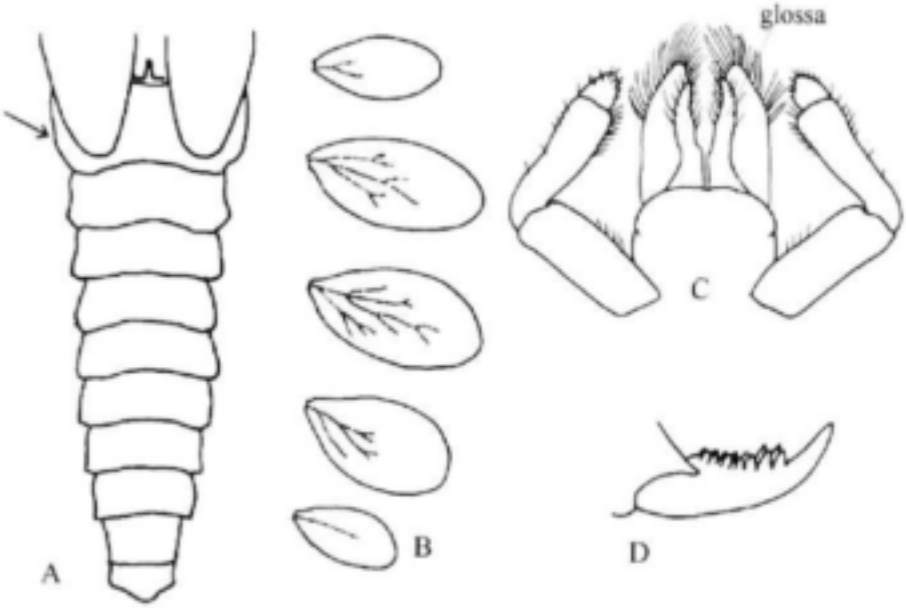

Fig. 2.31. *Peuhlella* sp. **A**, abdomen, dorsal view (*note* enlarged segment 1); **B**, gills (from top down) 1,2,3,5 & 7; **C**, labium; **D**, claw. (Redrawn from Wuillot & Gillies 1993b).

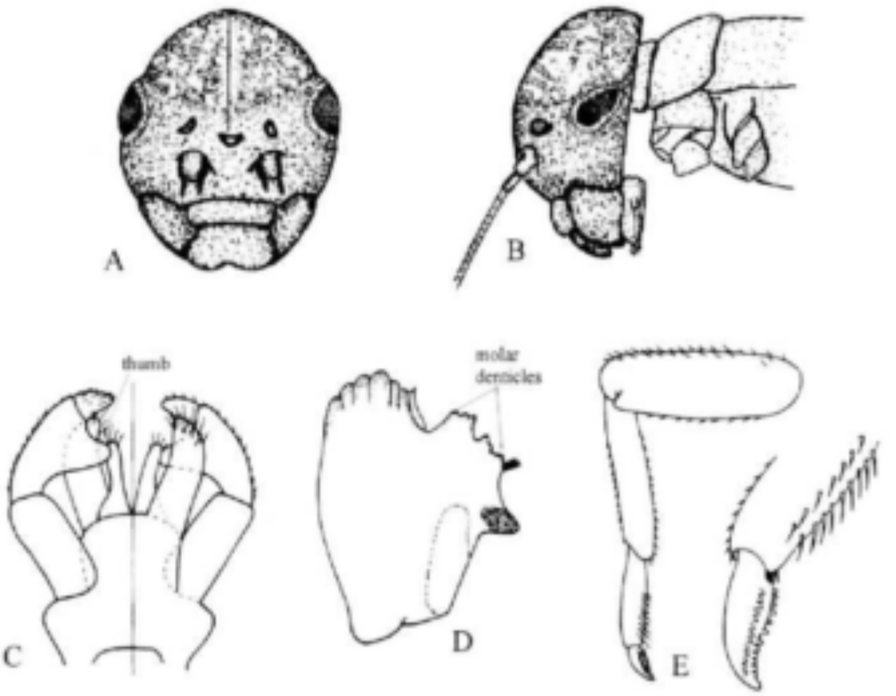

Fig. 2.32. *Edmulmeatus grandis* **A**, head, in anterior view; B, head, in lateral view; **C**, labium, in ventral view on the left and dorsal view on the right; **D**, mandible; **E**, leg with detail of claw. (Redrawn from Lugo-Ortiz & McCafferty 1997c).

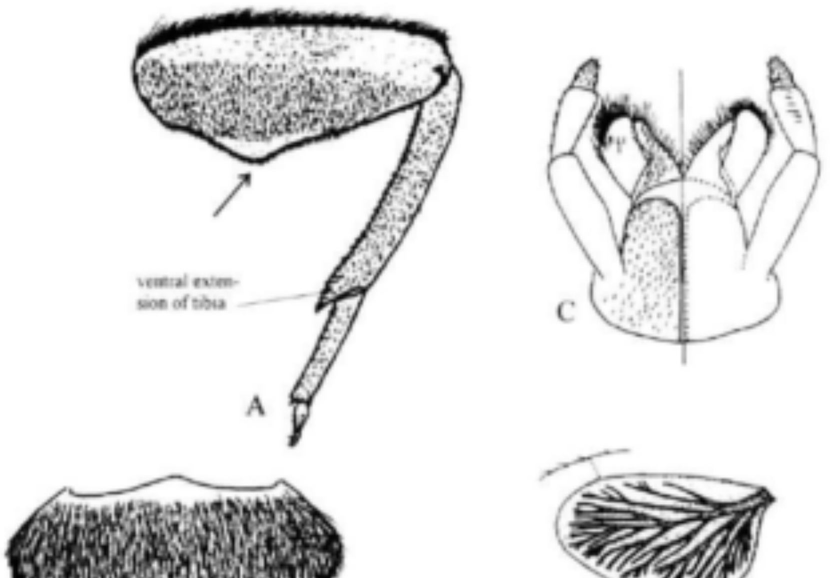

Fig. 2.33. *Nesoptiloides* sp. **A**, foreleg; **B**, labrum; **C**, labium, in ventral view on the left and dorsal view on the right; **D**, gill 4.

19. Labrum about 2.5x wider than long, dorsally setose, with small anteromedial lobe (Fig. 2.34A); labial palps three-segmented, segments 1 and 2 elongate, segment 3 very small, conical (Fig. 2.34B); mandibles long, narrow, molar region modified to form apically bifid incisor (Figs. 2.34C,D); antennae with distal segments serrate (Fig. 2.34E); tarsal claws (Fig. 2.34G) with seven to eight denticles in two rows, increasing in size towards apex, no subapical setae (Madagascar only) .... *Guloptiloides* (p. 101)
– Labrum without anteromedial lobe; labial palps two- or three-segmented; mandibles may be adapted for carnivory as above, but without the apically bifid incisor; antennal segments not serrate; subapical setae present on claws......... 20

20. Labrum about 3x wider than long, densely setose dorsally, with deep, broadly U-shaped anteromedial emargination (Fig. 2.35A); labial palps two-segmented, segment 2 tapering slightly distally (Fig. 2.35B); mandibles with modified molar area and highly developed incisors (Fig. 2.35C); gills with basal flap forming a lobed extension to the lamellae, tracheation very strong, dendritic (Fig. 2.35F)... *Centroptiloides* (p. 95)
– Labrum wider than long; other mouthparts and gills not as above 21

21. Labrum about 2.5x wider than long, with relatively deep, broad to narrow U-shaped anteromedial emargination (Fig. 2.36A); labial palps three-segmented, segments 1 and 2 approximately equal in length, segment 3 smaller, narrow-subconical (Fig. 2.36B); gills asymmetrical, strongly tracheated, but not produced basally to form a lobe (Fig. 2.36C,D) (Madagascar only)............
....*Herbrossus* (p. 101)
– Labrum only slightly wider than long (about 1.2x wider); labial glossae narrower than the paraglossae, but not more than 1.5x as wide; labial palps with variously developed distomedial projections; tarsal claws not as above.........
....22

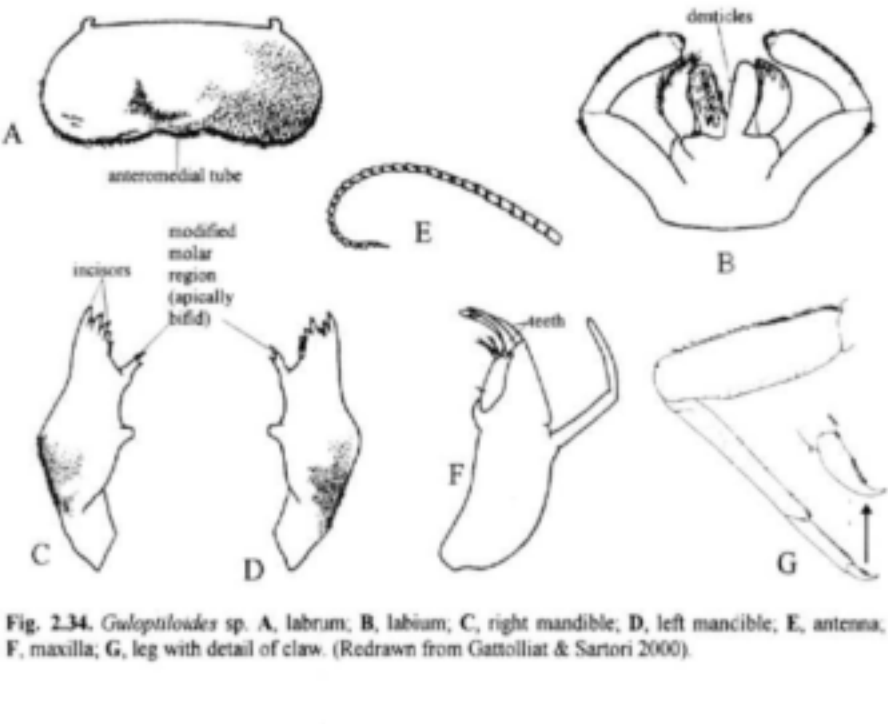

Fig. 2.34. *Guloptiloides* sp. **A**, labrum; **B**, labium; **C**, right mandible; **D**, left mandible; **E**, antenna; **F**, maxilla; **G**, leg with detail of claw. (Redrawn from Gattolliat & Sartori 2000).

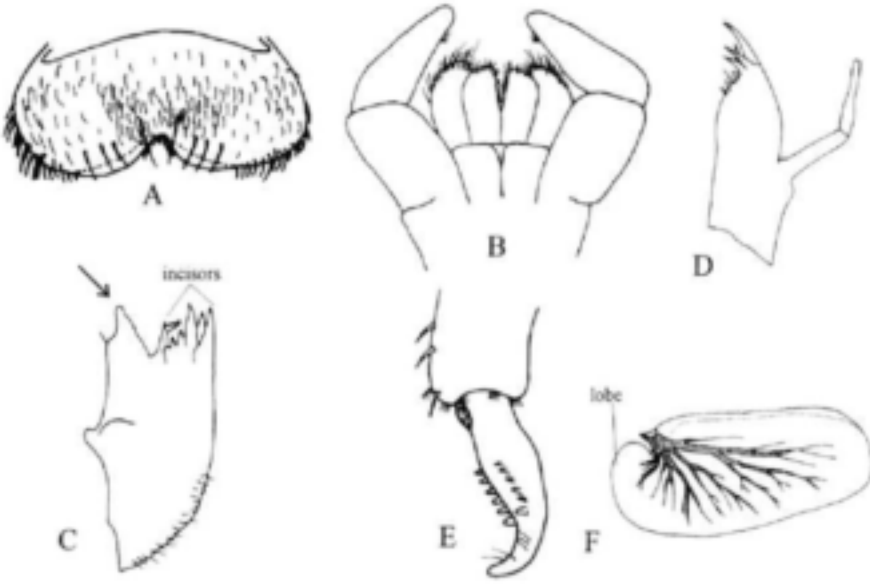

Fig. 2.35. *Centroptiloides* sp. **A**, labrum; **B**, labium; **C**, mandibles, showing modified molar region (arrowed); **D**, maxilla; **E**, claw; **F**, gill 4. (C & E redrawn from Lugo-Ortiz & McCafferty 1998a).

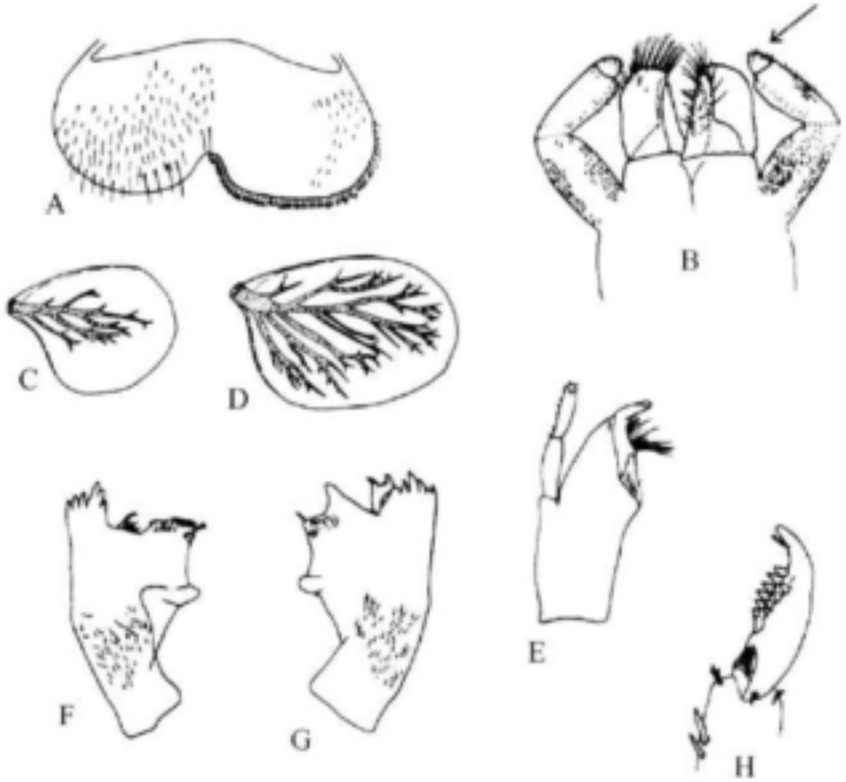

Fig. 2.36. *Herbrossus* sp. **A**, labrum, **B**, labium (*note* small palps—arrowed); **C**, gill 1; **D**, gill 3; **E**, maxilla; **F**, right mandible; **G**, left mandible; **H**, claw. (Redrawn from Gattolliat & Sartori 1998).

22. Labial palp segment 2 distally with small, upwardly-pointing, thumb-like distomedial projection (Fig. 2.37A); tarsal claws with subapical denticles conspicuously larger than the remaining denticles (Fig. 2.37B); gill 1 narrow-elongate (paddle-shaped), untracheated (Fig. 2.37C), gills 2–7 narrow-ovate with central tracheal stem only (Fig. 2.37D)................ *Susua* (p. 109)

– Tarsal claws with denticles not as above; gills not as above; labial palp not as above 23

23. Tarsal claws long, without denticles (Fig. 2.38A), with minute denticle medially in a single row (Fig. 2.38B) or in two rows (Fig. 2.38C), no subapical setae; labial palp with segment 2 having acute inwardly-produced distomedial process (Fig. 2.38D); maxilla with two-segmented palp much longer than galea-lacinia (Fig. 2.38E) (Africa and Madagascar) ....*Cheleocloeon* (p. 96)

– Tarsal claws with moderately-sized denticles in two rows, in a medial position along claw, subapical pair of setae present; second row of denticles reduced; second segment of labial palp without pronounced inwardly-produced distomedial projection, segment 3 small; maxillary palp approximately equal in length to galea-lacinia 24

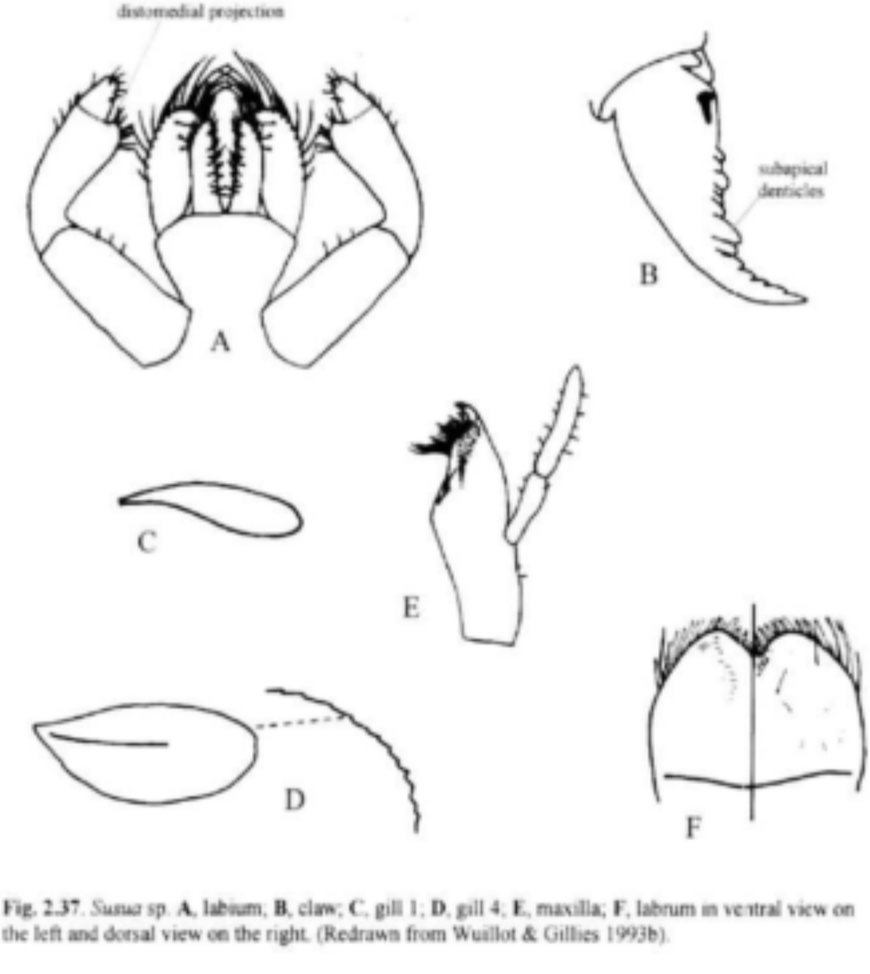

Fig. 2.37. *Susua* sp. **A**, labium; **B**, claw; **C**, gill 1; **D**, gill 4; **E**, maxilla; **F**, labrum in ventral view on the left and dorsal view on the right. (Redrawn from Wuillot & Gillies 1993b).

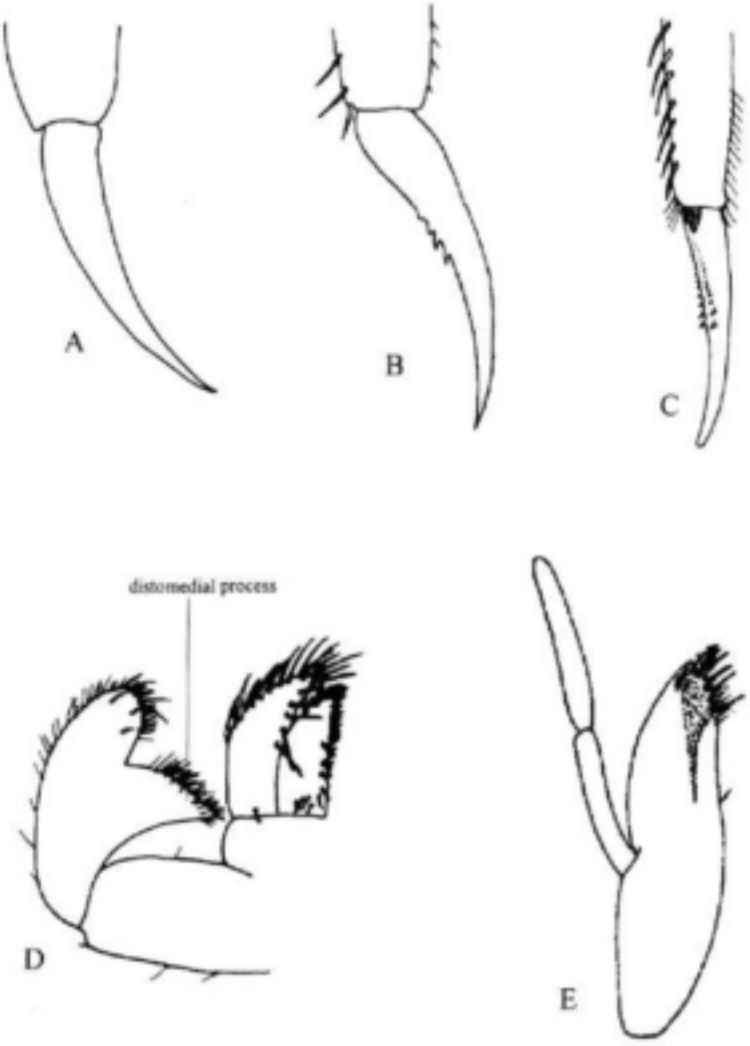

Fig. 2.38. *Cheleocloeon* sp. **A–C**, claw types: **A**, edenate claw of *C. yolandae*; **B**, with small, single row of denticles (*C. excisum*); **C**, showing two rows of minute denticles (*C. mirandei*). **D**, labium; **E**, maxilla. (B & E redrawn from Lugo-Ortiz & McCafferty 1997a; A & D redrawn from Wuillot & Gillies 1993a).

24. Forefemur with transverse arc of long, stout, blunt setae subapically on the dorsal side (Fig. 2.39A); hypopharynx covered apically with numerous fine setae, *but without bristle tuft, lingua trilobate* (Fig. 2.39B); labrum as wide as long (Fig. 2.39C) (Madagascar only)........................ *Echinopus* (p. 100)

– Femora without subapical transverse arc of long setae; hypopharynx covered apically with numerous fine setae, but also with well-developed bristle tuft at apex of lingua (Fig. 2.40A); labrum slightly wider than long (Fig. 2.40B) (Africa and Madagascar) .... *Afroptilum* (p. 93)

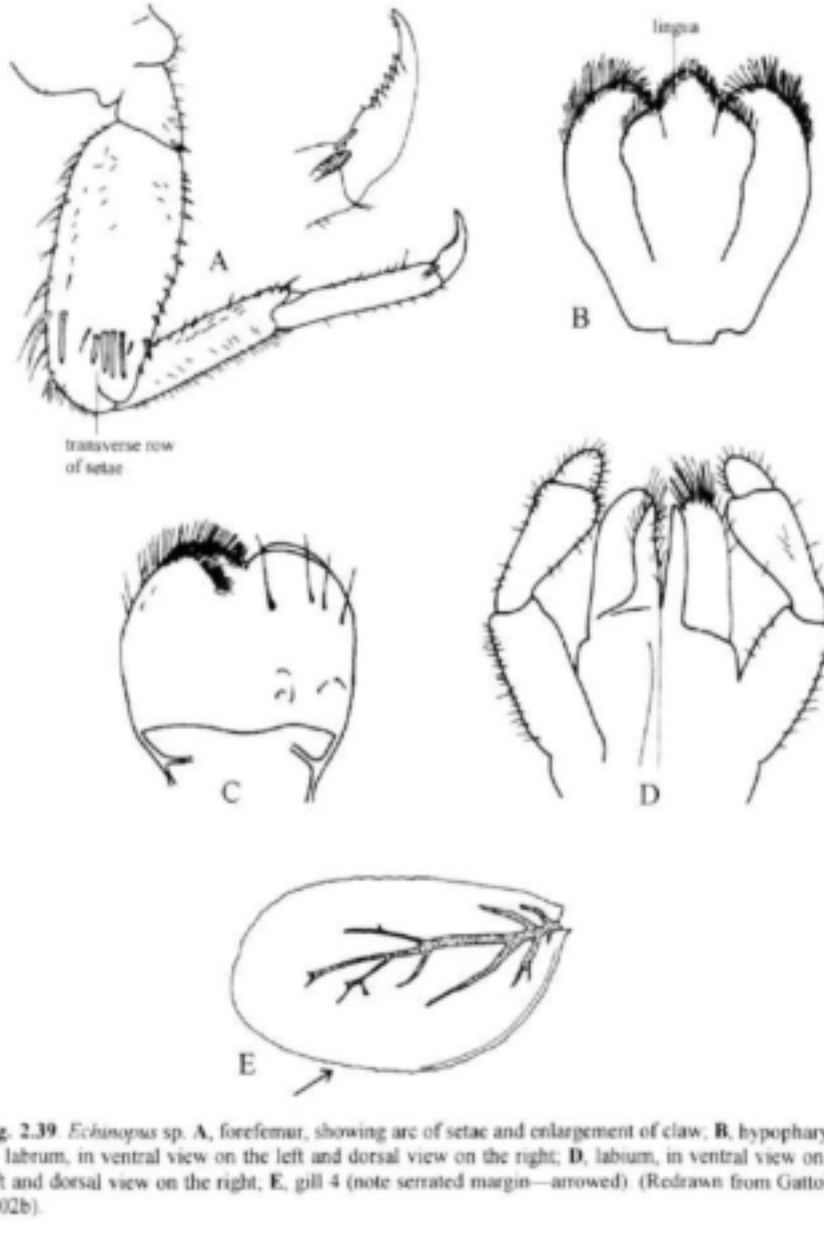

Fig. 2.39 *Echinopus* sp. **A**, forefemur, showing arc of setae and enlargement of claw; **B**, hypopharynx; **C**, labrum, in ventral view on the left and dorsal view on the right; **D**, labium, in ventral view on the left and dorsal view on the right; **E**, gill 4 (note serrated margin—arrowed). (Redrawn from Gattolliat 2002b).

25. Tarsal claws usually stongly hooked, with small to well-developed denticles in a single row 26
– Tarsal claws edentate, or with a single row of minute denticles.............. 36

26. Mouthparts highly modified, labium with glossae and paraglossae divergent, greatly elongate, slender, terminally with a fringe of long, fine, simple setae (Fig. 2.41A); labial palps segments 2 & 3 fused into slender club, angled inwardly at base of club (Fig. 2.41A); tarsal claws with four to six large denticles basally (Fig. 2.41B) ....*Ophelmatostoma* (p. 105)
– Mouthparts not modified as above 27

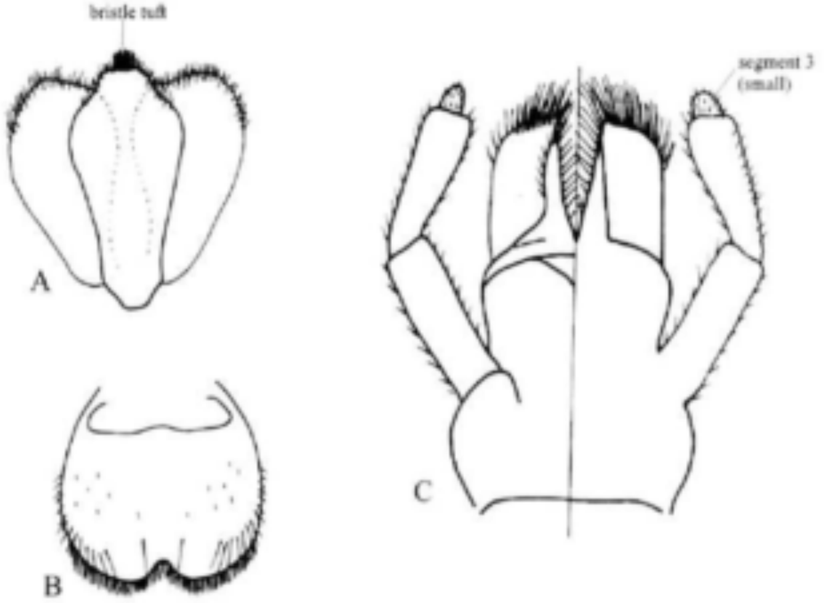

Fig. 2.40. *Afroptilum* sp. **A**, hypopharynx; **B**, labrum; **C**, labium. (Redrawn from Lugo-Ortiz & McCafferty 1998a).

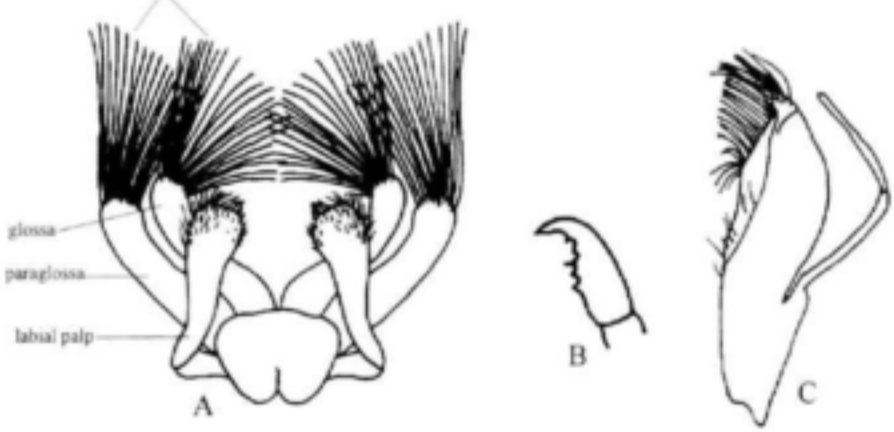

Fig. 2.41. *Ophelmatostoma* sp. **A**, labium; **B**, claw; **C**, maxilla. (Redrawn from Gillies et al. 1990).

27. Tarsal claws with four stout, broadly-based denticles (Fig. 2.42A); mandibles with incisors fused, elongate, bladelike (Fig. 2.42B); labium (Fig. 2.42C) with glossae very narrow, paraglossae narrow, labial palp segment 2 basally narrow, distomedially bulbous, segment 3 very short, rounded, offset from center to the outside; gills strongly tracheated (Fig. 2.42E) (Africa and Madagascar) .... *Xyrodromeus* (p. 110)
– Tarsal claws with few or many denticles; mandibles without blade-like incsors 28

28. Tarsal claws with well-developed denticles, smaller basally, larger towards apex (Fig. 2.43A); labium with glossae much shorter and narrower than paraglossae, paraglossae very broad; labial palp three-segmented, segments 1 and 2 narrow-elongate, segment 3 narrowly rounded (Fig. 2.43B); maxilla with two-segmented palp, segment 2 elongate, extending beyond galea-lacinia, slightly bulbous terminally in one species (Fig. 2.43C); terga without posterior marginal spines (Fig. 2.43D).................. *Glossidion* (p. 100)
– Tarsal claws with few to several denticles; mouthparts not as above 29

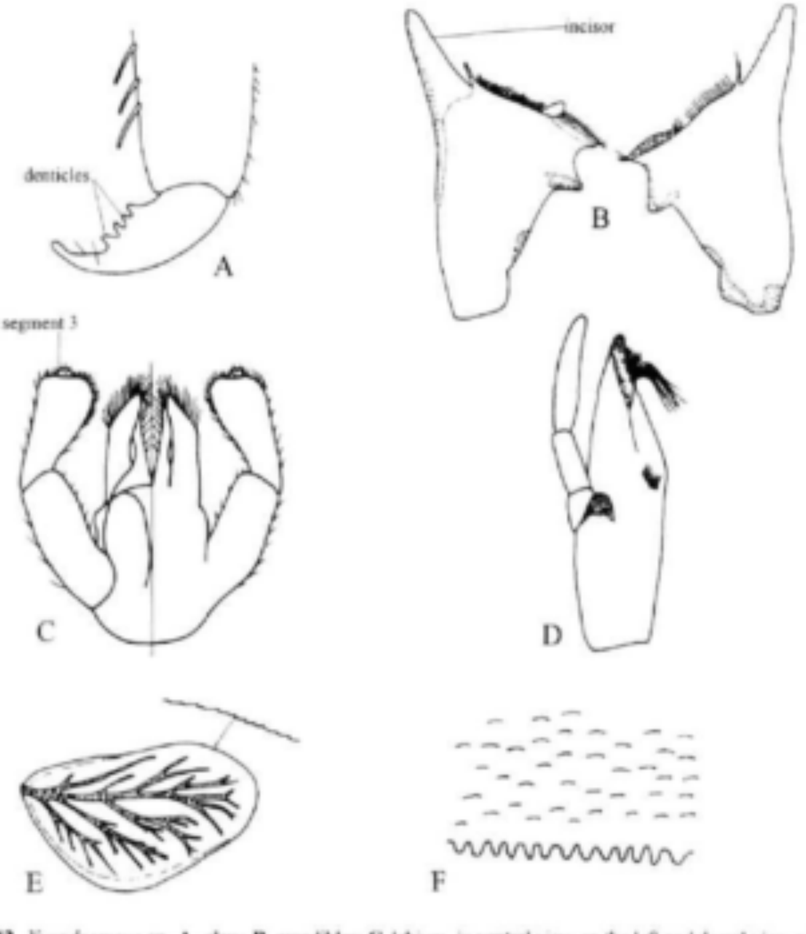

Fig. 2.42. *Xyrodromeus* sp. **A**, claw; **B**, mandibles; **C**, labium, in ventral view on the left and dorsal view on the right; **D**, maxilla; **E**, gill 4; **F**, terga with spines. (Redrawn from Lugo-Ortiz & McCafferty 1997f).

29. Maxillary palps three-segmented, extending well beyond galea-lacinia (Fig. 2.44A); labium with glossae and paraglossae broad, usually rounded apically, labial palps two-segmented, segment 2 apically expanded or bulbous, all fringed with long fine setae (Fig. 2.44B); tarsal claws hooked, with few to several large denticles (Fig. 2.44C) (Africa and Madagascar) .... *Pseudopannota* (p. 107)

(Thorax with forewing pads fused for more than half their length (Fig. 2.44D: subgenus *Pseudopannota*) or less than half their length (Fig. 2.44E: subgenus *Hempannota*))

– Maxillary palps two-segmented; labium not as above; tarsal claws with numerous denticles of variable size...... 30

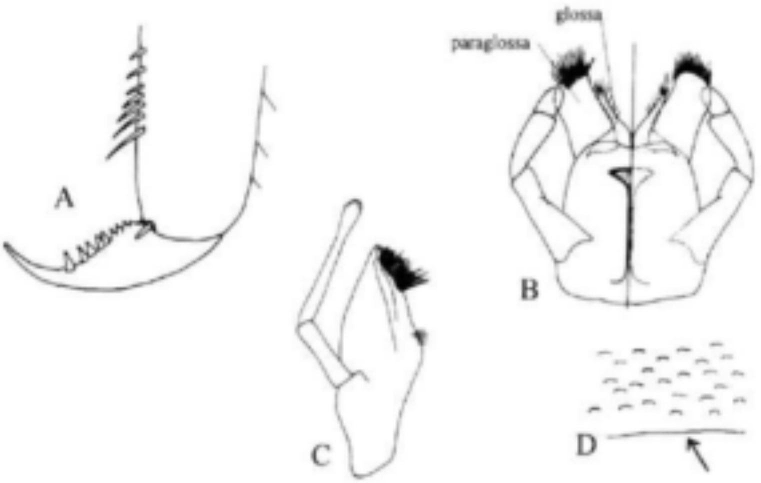

Fig. 2.43. *Glossidion* sp. **A**, claw; **B**, labium, in ventral view on the left and dorsal view on the right; **C**, maxilla; **D**, detail of posterior portion of tergite, showing lack of spines on posterior margin (arrowed). (Redrawn from Lugo-Ortiz & McCafferty 1998b).

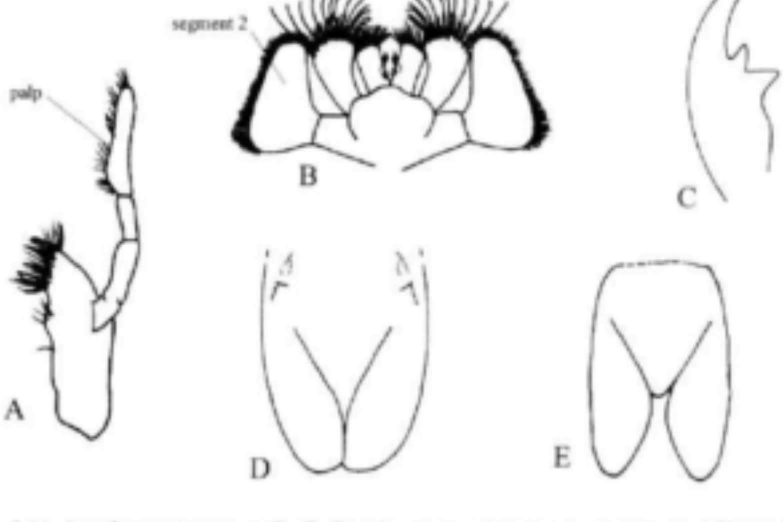

Fig. 2.44. *Pseudopannota* spp. **A–D**, *P. Pseudopannota* subgenus: **A**, maxilla; **B**, labium; **C**, claw; **D**, thoracic forewing pads. **E**, *P. Hempannota* subgenus, thoracic forewing pads. (Redrawn from Elouard et al. 1990).

30. Segment 2 of labial palp with variously-developed, thumblike, distomedial process (Fig. 2.45A), segment 3 rounded to subconical; maxillary palp segment 2 distomedially concave (Fig. 2.45B) or constricted (Fig. 2.45C); antennal scapes distolaterally with notch (Fig. 2.45D), chamfered (Fig. 2.45E) or unmodified (Fig. 2.45F); villopore present (Fig. 2.45G), reduced, or absent; tarsal claws with numerous denticles that may be evenly sized, or may increase in size towards the apex, (Africa and Madagascar) .... *Pseudocloeon* & *Labiobaetis* (See discussion on pp. 102 & 106)

– Labial palp segment 2 variously developed: if thumb-like, then maxillary palp segment 2 without constrictions or concavities............................... 31

31. Head with small carina present between antennae; (Fig. 2.46A); labial palps clearly three-segmented, segment 3 bluntly pointed apicolaterally (Fig. 2.46B); maxillary palp segment 2 without distomedial constriction (Fig. 2.46C); tarsal claws narrow-elongate, with 13–15 slender, sharp denticles, increasing in length apically (Fig. 2.46D).................. *Nigrobaetis* (p. 104)

– Frontal carina absent; labial palp with various modifications................. 32

32. Labial palp segment 2 basally narrow, broadly rounded and produced distomedially; segment 3 partly fused with segment 2, nipple-like (Fig. 2.47A); maxillary palp constricted in apical upper quarter of terminal segment, sometimes giving the appearance of two segments, fringe of small setae on apex of palp (Fig. 2.47B); gills (Fig. 2.47C) present on abdominal segments 2–7; tarsal claws with about six small denticles subapically (Fig. 2.47D)............ ....*Rhithrocloeon* (p. 107)

– Labial palp segment 3 not fused; maxillary palp not constricted as above; gills usually on abdominal segments 1–7, tarsal claws with denticles variously modified 33

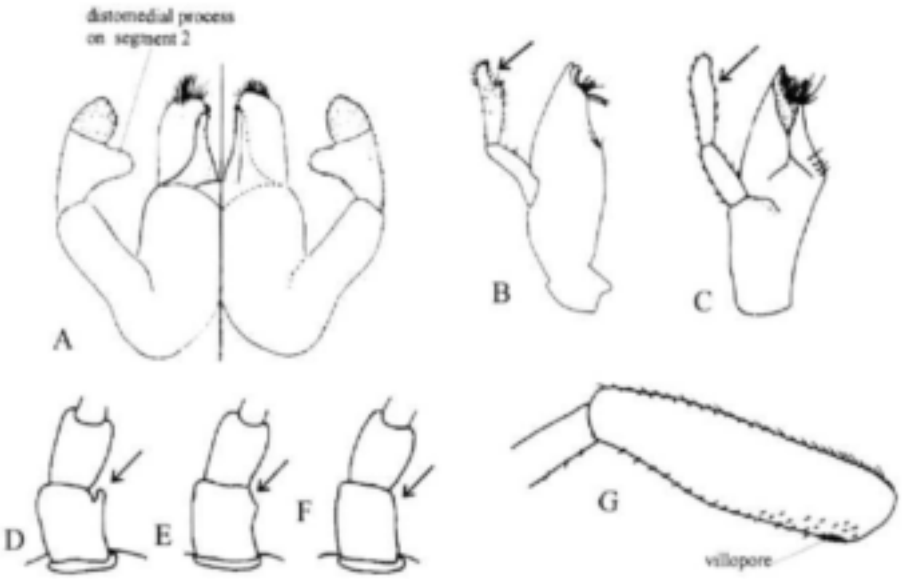

Fig. 2.45. *Labiobaetis* sp. and *Pseudocloeon* sp.. **A**, labium, in ventral view on the left and dorsal view on the right; **B**, maxilla, with concave palpal segment (arrowed); **C**, maxilla, with constricted palpal segment (arrowed); **D**, antenna, with notched scape (arrowed); **E**, antenna, with chamfered scape (arrowed); **F**, antenna, with unmodified scape (arrowed); **G**, femur, showing villopore. (A–F redrawn from Lugo-Ortiz & McCafferty 1997d).

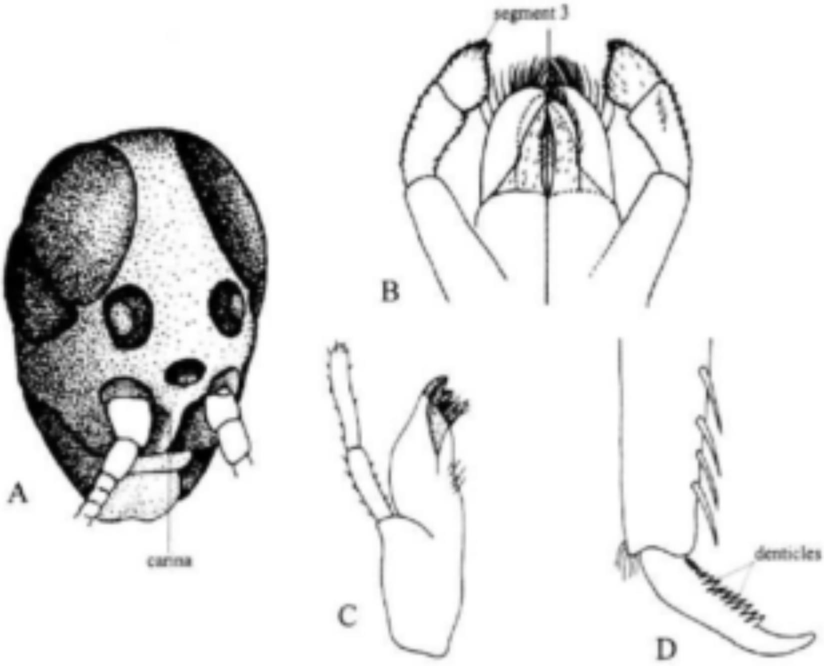

Fig. 2.46. *Nigrobaetis* sp.: **A**, head, in anterolateral view; **B**, labium, in ventral view on the left and dorsal view on the right; **C**, maxilla; **D**, claw. (From Lugo-Ortiz & de Moor 2000).

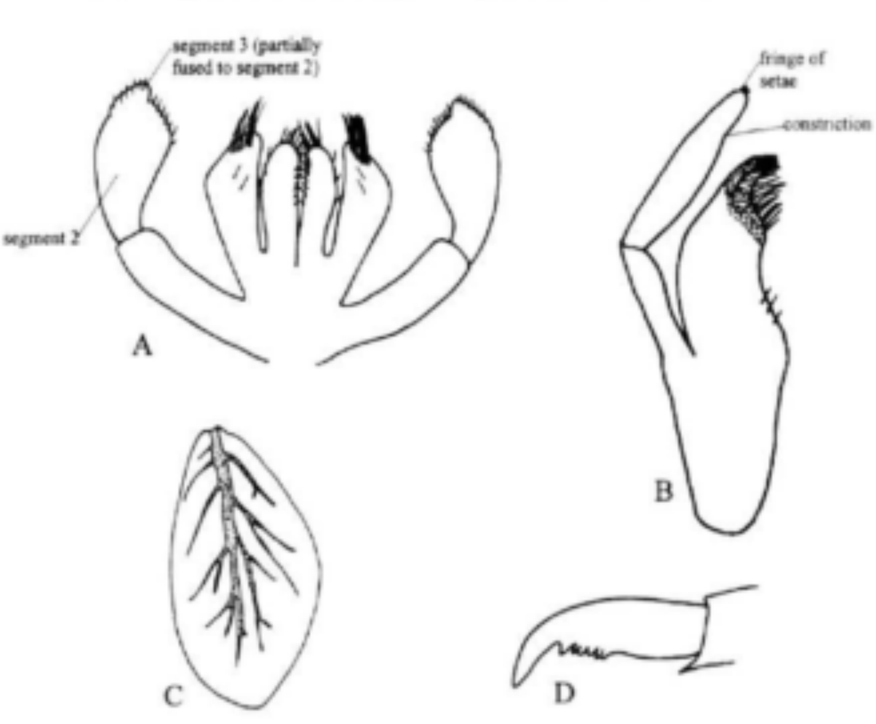

Fig. 2.47. *Rhithrocloeon* sp.: **A**, labium, in ventral view ; **B**, maxilla; **C**, gill 4; **D**, claw. (Redrawn from Gillies 1988).

33. Tarsal claws with up to about 10 strong denticles, increasing in size from base to apex (Fig. 2.48A); labial palp segment 2 with slight anteromedial emargination, segment 3 broadly rounded, (Fig. 2.48B); maxillary palp two-segmented, shorter than galea-lacina; (Fig. 2.48C); tibia without proximal arc of setae (cf. Fig. 2.49A)... *Baetis* (p. 94)

– Labial palp segment 2 with variously developed, anteromedial emargination, segment 3 may be ovoid to rounded; tibiae may have proximal arc of setae.. 34

34. Tarsal claws with two enlarged subapical denticles and four to six small basal denticles (Fig. 2.49A); labial palp with second segment strongly produced distomedially, forming thumb-like projection, and with third segment ovoid and apically rounded (Fig. 2.49B); tibiae with small subproximal arc of setae (Fig. 2.49A) .... *Crassabwa* (p. 97)

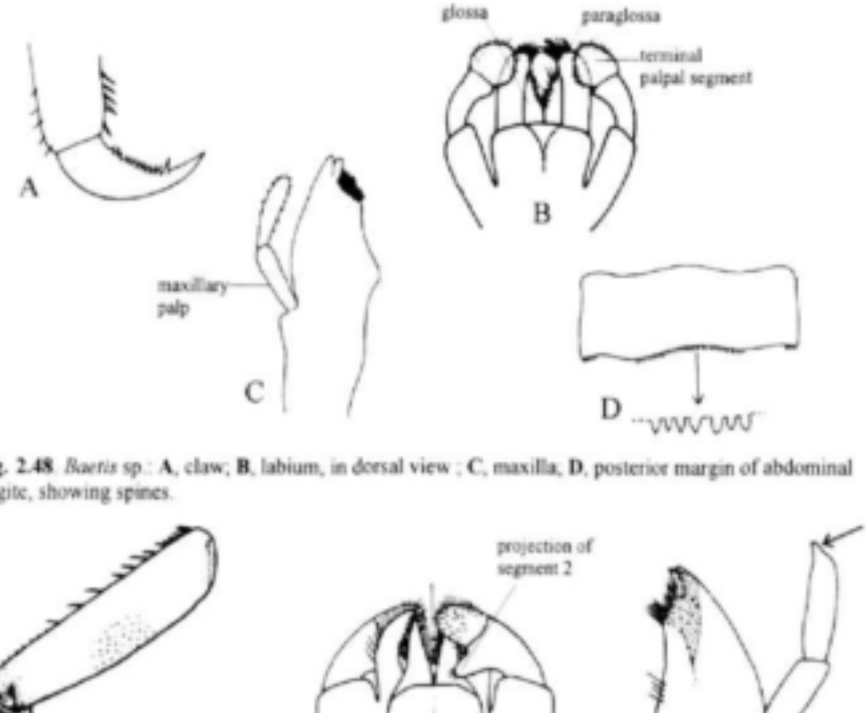

Fig. 2.48. *Baetis* sp.: **A**, claw; **B**, labium, in dorsal view ; **C**, maxilla; **D**, posterior margin of abdominal tergite, showing spines.

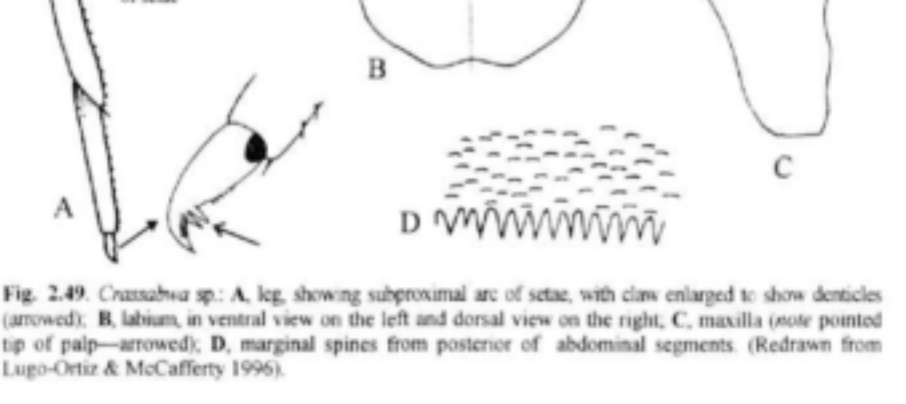

Fig. 2.49. *Crassabwa* sp.: **A**, leg, showing subproximal arc of setae, with claw enlarged to show denticles (arrowed); **B**, labium, in ventral view on the left and dorsal view on the right; **C**, maxilla (*note* pointed tip of palp—arrowed); **D**, marginal spines from posterior of abdominal segments. (Redrawn from Lugo-Ortiz & McCafferty 1996).

– Tarsal claws may have enlarged subapical denticles or, if not notably enlarged, then a gradation from smaller denticles basally to larger ones subapically; labial palp with second segment without inwardly-produced thumb (e.g. Figs. 2.50B, 2.52D) and with third segment bulbous.............35

35. Tarsal claws (Fig. 2.50A) with few to numerous denticles, usually weak basally and stronger apically; maxillary palp segment 2 usually apically rounded but apically papilliform in some species (Fig. 2.50B) (Africa and Madagascar)... *Dabulamanzia* (p. 98)

– Tarsal claws (Fig. 2.50E) with poorly developed denticles basally, and pair of enlarged denticles medially; maxillary palp segment 2 apically papilliform (Fig. 2.50F) (Madagascar only) ....*Nesydemius* (p. 104)

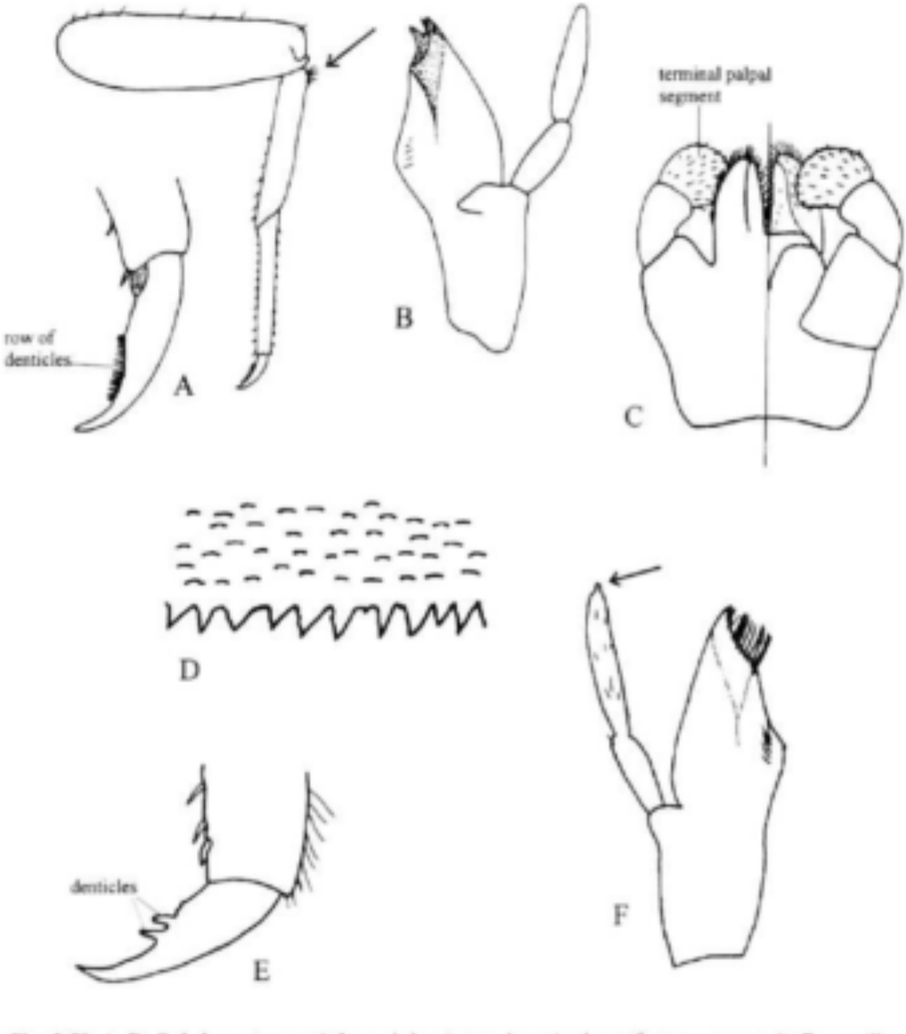

Fig. 2.50. A–D, *Dabulamanzia* sp.: **A**, leg and claw (*note* subproximal arc of setae—arrowed); **B**, maxilla, showing palps with unmodified rounded tips; **C**, labium, in ventral view on the left and dorsal view on the right; **D**, posterior margin of abdominal tergite, showing spines. **E–F**, *Nesydemius* sp.: **E**, claw; **F**, maxilla showing palp with papilliform tip (arrowed). (Redrawn from Lugo-Ortiz & McCafferty 1996).

36. Tarsal claws short, edentate or with minute denticles subapically 37
– Tarsal claws usually elongate, edentate or with small to minute denticles in one row.. 38

37. Tarsal claws short, blunt, edentate (Fig. 2.51A); legs devoid of setae except for posterior margin of hind tibiae; antennae short (only slightly longer than width of head); cerci short; maxilla with very short two-segmented palp (Fig. 2.51B); labium with glossae and paraglossae subequal, paraglossae with apicolateral emargination (Fig. 2.51C), palps two-segmented, terminal segments large, bulbous; nymphs living in association with freshwater mussels (Africa and Madagascar) .... *Mutelocloeon* (p. 103)
– Tarsal claws short, pointed, edentate or with minute subapical denticles (Fig. 2.52A); tibiae and tarsi with long row of distinctive setae (Fig. 2.52A); antennae very long in some species; abdominal sterna 2–6 with sublateral tufts of long, fine, simple setae (Fig. 2.52B); maxillary palps narrow, shorter than galea-lacinia, segment 2 bent near tip (Fig. 2.52C); labial palp segments 2 and 3 subequal in length, segment 2 simple, segment 3 ovoid ovoid with rounded to slightly squared margins (Fig. 2.52D) (Africa and Madagascar) ....*Cloeodes* and *Maliqua* (see discussion, pp. 96 & 102)

38. Tarsal claws (Fig. 2.53A) long and slender, approximately two thirds length of respective tarsi, edentate or with minute denticles in basal third; gills strongly asymmetrical, palette-shaped, strongly tracheated (Fig. 2.53B); labial palp segment 2 with subrectangular medial process, broadly rounded apically, segment 3 conical (arrowed in Fig. 2.53C); maxilla with long, slender two- or three-segmented palp (Fig. 2.53C) (Africa and Madagascar) ....*Demoulinia* (p. 99)
– Tarsal claws (Fig. 2.54A) not long, approximately a quarter the length of respective tarsi, with single row of weakly-developed denticles; gills (Fig. 2.54B) not strongly asymmetrical; labial palp segment 2 basally narrow, slightly produced distomedially, segment 3 partly fused with segment 2, broadly rounded (Fig. 2.54C); maxillary palp with abrupt constriction in apical upper quarter of terminal segment (Fig. 2.54D)..........*Bugilliesia* (p. 95)

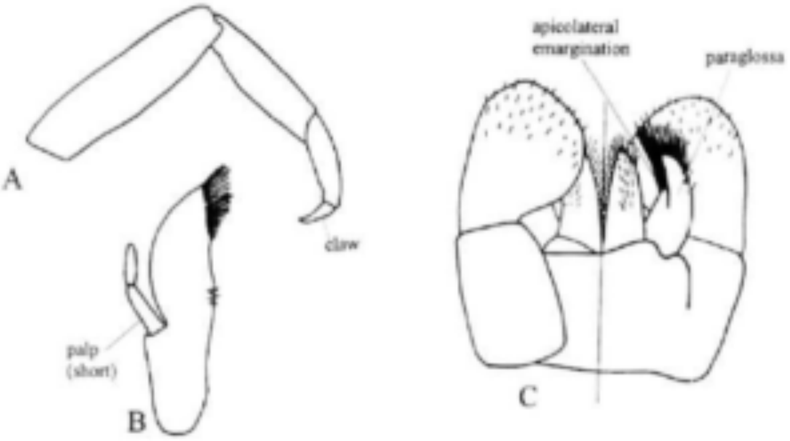

Fig. 2.51. *Mutelocloeon* sp.: **A**, leg and claw; **B**, maxilla; **C**, labium, in ventral view on the left and dorsal view on the right. (Redrawn from Gillies & Elouard 1990).

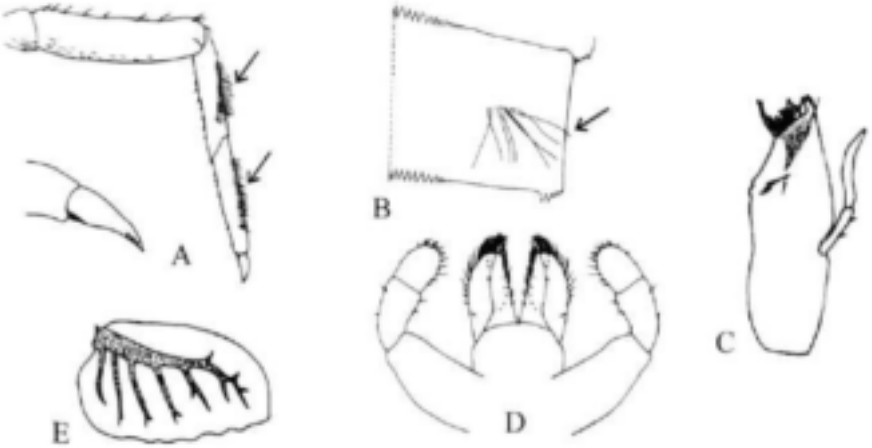

Fig. 2.52 *Cloeodes* sp. and *Maliqua* sp.: **A**, foreleg and claw; **B**, ventral abdominal setal tuft; **C**, maxilla; **D**, labrum; **E**, gill 4. (See p. 96 for a discussion on the systematics of these two genera). (A redrawn from Waltz & McCafferty 1994; C–E from Lugo-Ortiz & McCafferty 1997e).

Fig. 2.53. *Demoulinina* sp.: **A**, claw; **B**, gills; **C**, labium in ventral view; **D**, maxilla. (Redrawn from Crass 1947).

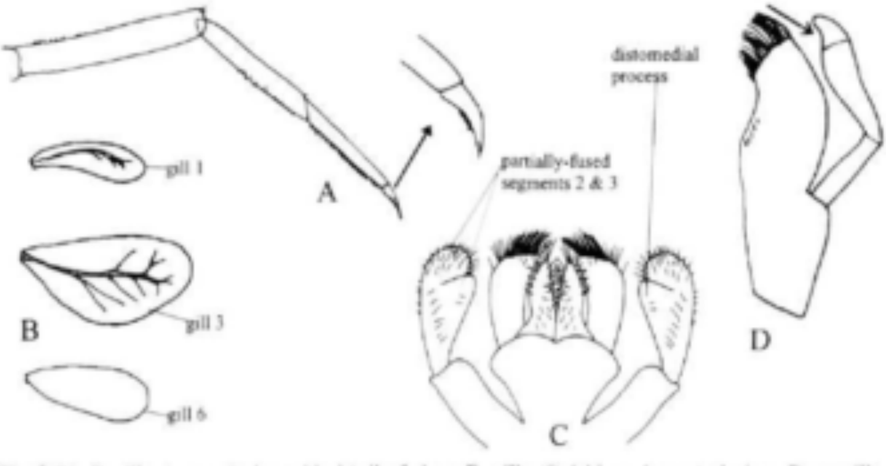

Fig. 2.54. *Bugilliesia* sp.: **A**, leg with detail of claw; **B**, gills; **C**, labium, in ventral view; **D**, maxilla (*note* constriction in palp—arrowed). (Redrawn from Gillies 1990a).

HEPTAGENIIDAE: KEY TO GENERA

1. Supracoxal spurs absent; gills apically rounded (Figs. 2.55A,B,D) or weakly pointed (Figs. 2.55C,E–H) (Africa & Madagascar)........... *Afronurus* (p. 111)

– Supracoxal spurs well-developed (Fig. 2.56A); gills apically pointed (Figs 2.57A–D); nymphs often with distinctive purplish coloured markings (which may fade with time on alcohol) (Africa & Madagascar)...........................
....*Thalerosphyrus* & *Compsoneuria*
(see pp. 110 & 112 for a discussion on the systematics of these genera)

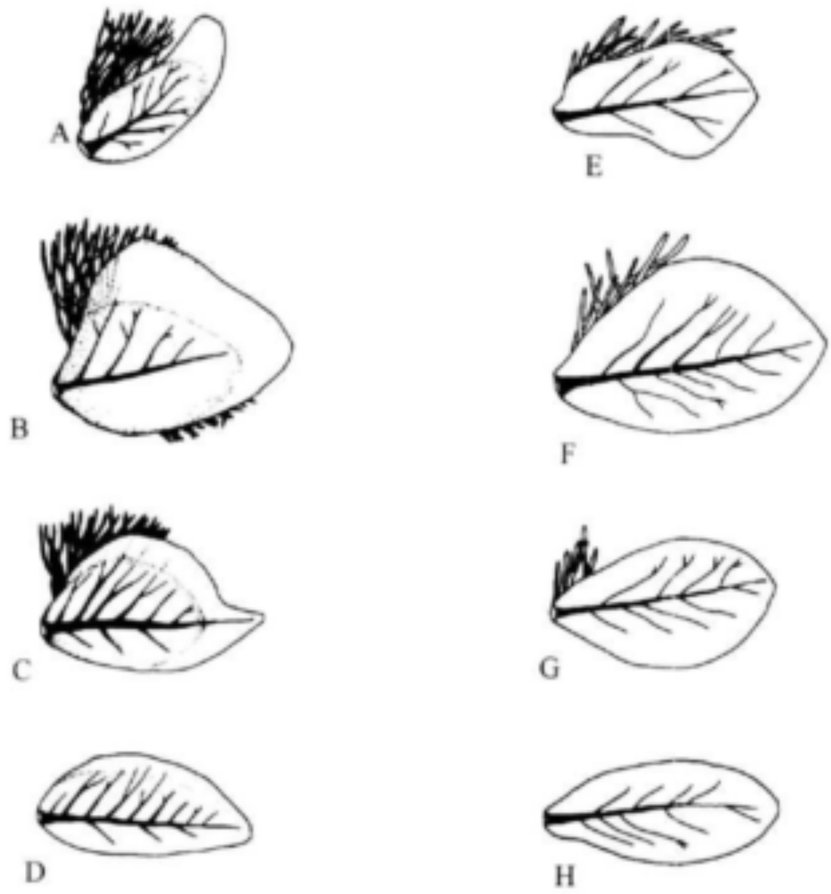

Fig. 2.55. **A–D**, *Afronurus barnardi* gills: **A**, gill 1; **B**, gill 3; **C**, gill 6; **D**, gill 7. **E–H**, *A. matitensis* gills: **E**, gill 1; **F**, gill 3; **G**, gill 6; **H**, gill 7. (A–D redrawn from Schoonbee 1968; E–H redrawn from Sartori & Elouard 1996).

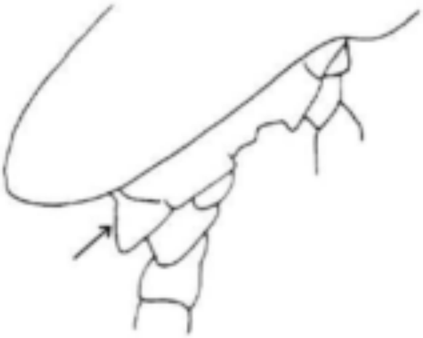

Fig. 2.56. *Compsoneuria bequaerti*, supra coxal spurs (arrowed).

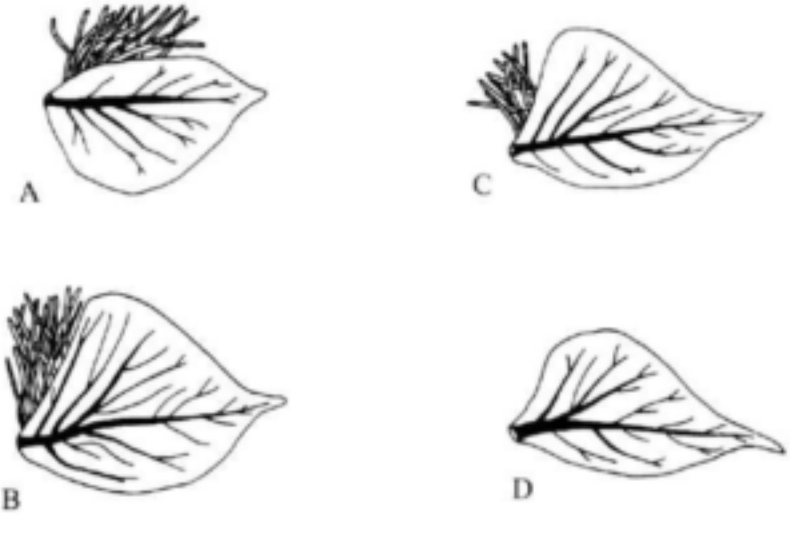

Fig. 2.57. **A–D**, *Thalerosphyrus josettae* gills 1, 3, 6 and 7. (Redrawn from Sartori & Elouard 1996).

OLIGONEURIIDAE: KEY TO GENERA

1. Head with distinct frontal carina, extending from base of antennae to the margin of the head (Figs. 2.58A); gill 1 with or without well developed lamella, gills 2–7 slightly pointed apically, each lamella longer than the segment from which it arises (Fig. 2.598) (Madagascar: subgenus *Madeconeuria*)... *Elassoneuria* (p. 112)

– Head (Fig. 2.59A) without frontal carina; gill 1 with poorly developed lamella, fibrillar portion dominant (Fig. 2.59B,C), gills 2–7 rounded apically, each lamella shorter than the segment from which it arises (Fig. 2.59D)..*Oligoneuriopsis* (p. 112)

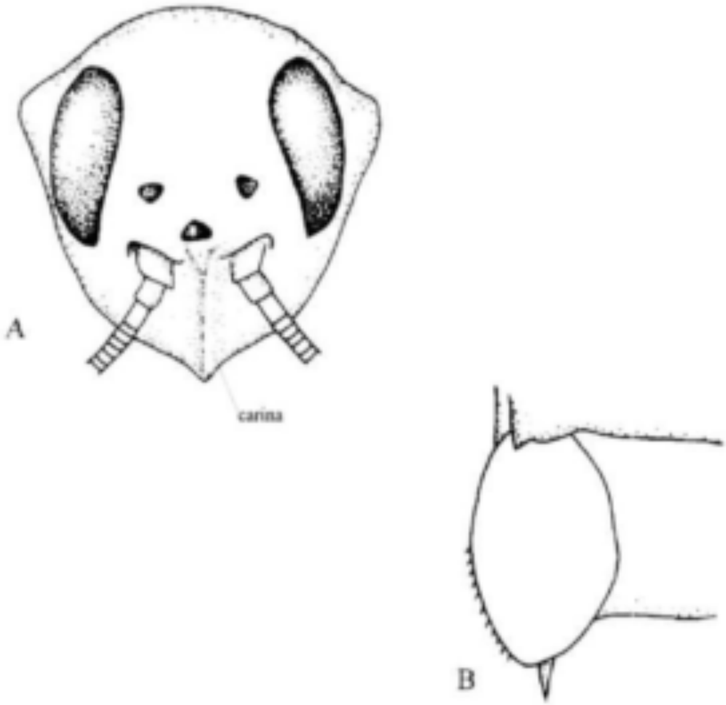

Fig. 2.58. *Elassoneuria* sp.: **A**, head; **B**, gill 7. (Redrawn from Agnew 1980).

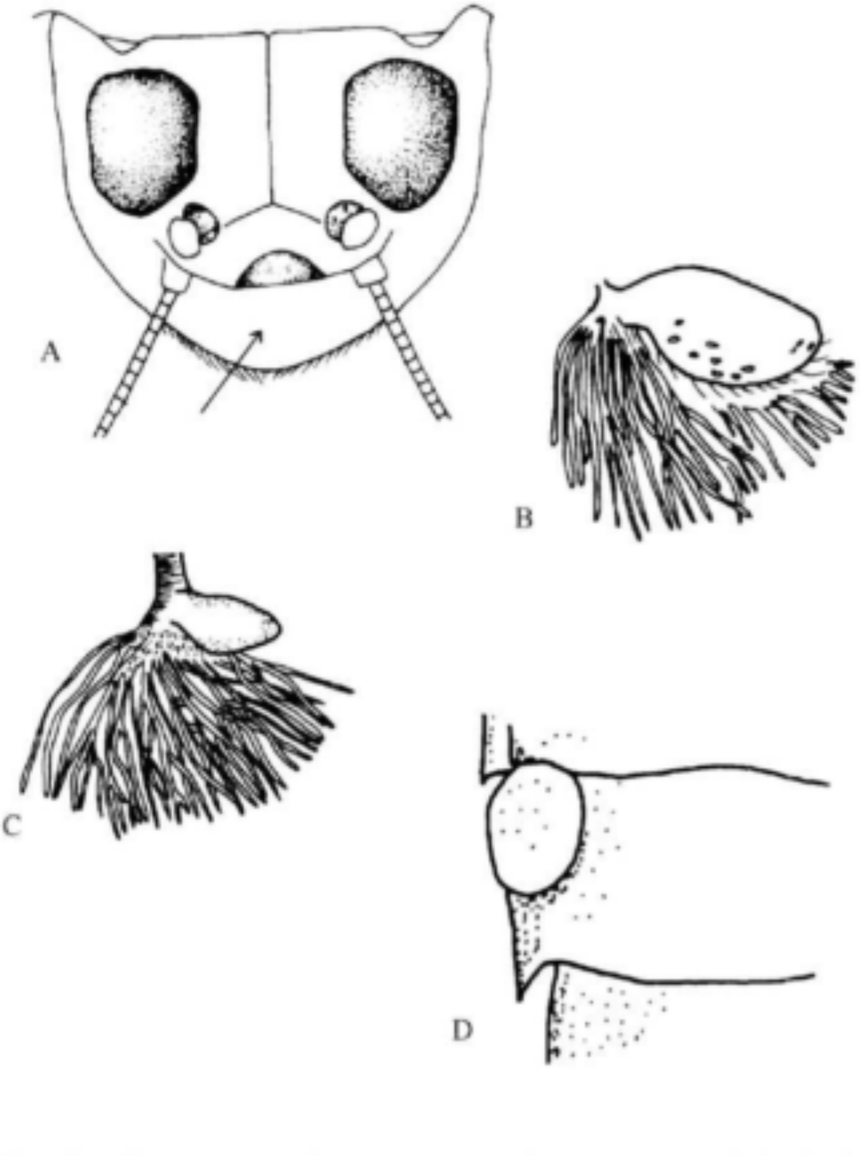

Fig. 2.59. A, *Oligoneuriopsis* sp., **A**, head (note lack of carina—arrowed). **B**, *O. elizabethae*, gill 1. **C–D**, *Oligoneuriopsis lawrencei*: **C**, gill 1; **D**, gill 7. (Redrawn from Agnew 1980).

TRICORYTHIDAE: KEY TO GENERA

1. Nymph with markedly flattened body (Fig. 2.60A); fringe of hairs on the underside of the thorax forming a sucker disc (Fig. 2.60B); legs with femora very broad and flattened (Fig. 2.60A), about 1.5x longer than broad; gills 2–6 fibrillate (Figs. 2.60C,D); fringe of setae present anteriorly on margin of head (Fig. 2.60E) .... *Dicercomyzon* (p. 113)

– Nymph with body not markedly flattened; neither ventral thorax nor anterior margin of head with fringe of hairs, though setal brushes from mouthparts visible (Fig 2.16 F); femora may be flattened, but not as broad as above; gills 2–6 (Figs. 2.61A–C, 2.62A,B) composed of two lamellae, an outer ovoid lamella and an inner bifid lamella, composed of a series of evaginations....2

2. Mature male nymphs with developing genitalia prominent; gills 2–6 progressively decreasing in size down body (Figs 2.61A–C) (Madagascar)............... ....*Madecassorythus* (p. 114)

– Developing genitalia not evident in male nymphs; gills 2–6 of similar size (Figs. 2.62A,B) (Africa & Madagascar)...................... *Tricorythus* (p. 115)

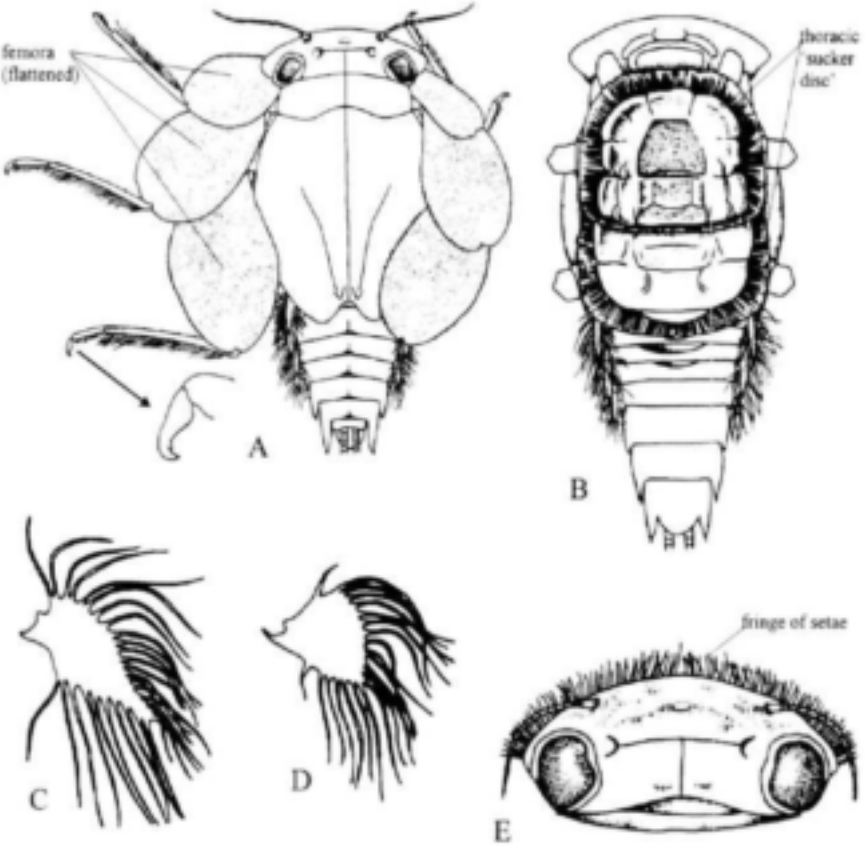

Fig. 2.60. *Dicercomyzon* sp. **A–B**, nymph with various appendages truncated: A, dorsal view, with detail of hindclaw; **B**, ventral view. **C–D**, gills: **C**, gill 2; **D**, gill 6. **E**, head, in dorsal view. (A–D redrawn from Demoulin 1964; E redrawn from McCafferty & Wang 2000).

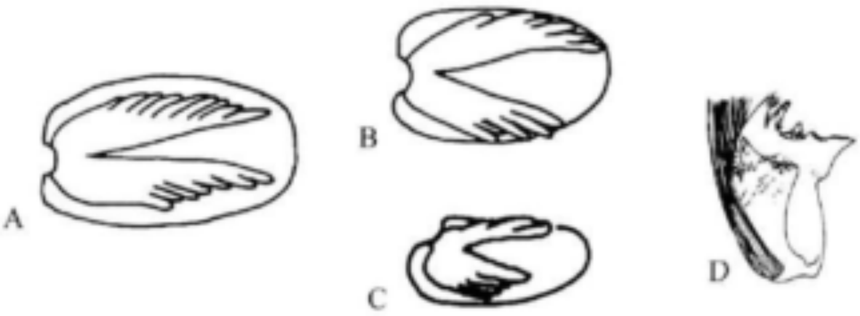

Fig. 2.61. *Madecassorythus sp.*: **A**, gill 1; **B**, gill 3; **C**, gill 5; **D**, right mandible. (Redrawn from Oliarinony et al. 2000).

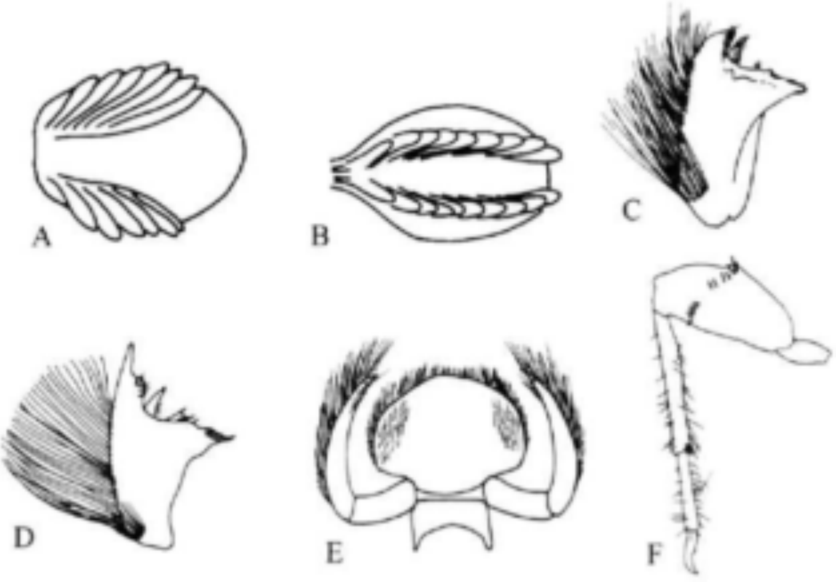

Fig. 2.62. **A**, *Tricorythus* sp., gill 3. **B–C**, *T. discolor*: **B**, gill 3; **C**, right mandible. **D–E**, *Tricorythus* sp.: **D**, right mandible; **E**, labium, in ventral view; **F**, leg. (A & D redrawn from Demoulin 1981; B redrawn from Barnard 1932; C & E redrawn from McCafferty & Wang 2000).

EPHEMERYTHIDAE

No key to genera, as only one genus currently known: *Ephemerythus*. (See Figs. 2.16A–E & p. 115).

MACHADORYTHIDAE

No key to genera, as only one genus currently known: *Machadorythus*. (See Figs. 2.6A–F & p. 116).

TELOGANELLIDAE

No key to genera, as only one genus currently known: *Teloganella*. (Madagascar only: see Figs. 2.15A–C & p. 116).

TELOGANODIDAE: KEY TO GENERA

1. Lamellate gills on abdominal segments 2–5 (Fig. 2.63A), gill 1 filamentous; claws with two rows of denticles (Fig. 2.63B); dorsal abdominal tubercles paired, or terga with broad, straight margins or at least some terga with slightly bifurcated posteromedial protuberances (Figs. 2.63C,D,E)..*Nadinetella* (p. 118)

– Lamellate gills on abdominal segments 2–4 or 2–6 (Figs 2.65A), gill 1 filamentous; claws with one row of denticles (Fig. 2.65B); abdomen with single mid-dorsal tubercles (Figs. 2.65A, 2.66A) or without tubercles (Fig. 2.64)..2

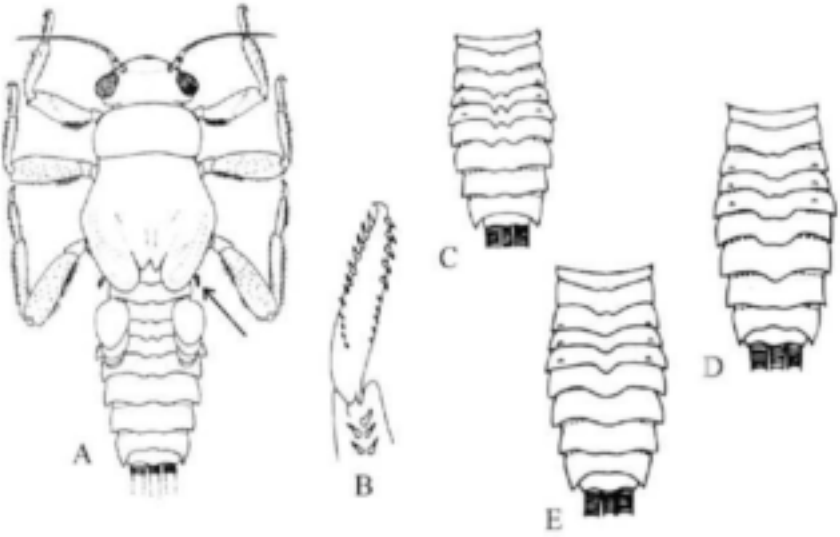

Fig. 2.63. *Nadinetella* sp.: **A**, whole nymph, with cerci truncated (*note* filamentous gills 1—arrowed—and lamellate gills 2–5); **B**, claw showing double row of denticles; **C–E**, *N. crassi*, abdomen, showing variations in types of abdominal tubercles. (Redrawn from McCafferty & Wang 1997).

Fig. 2.64. *Lestagella penicillata*, nymph with cerci truncated. (Redrawn from McCafferty & Wang 1997).

2. Head margined with long setae anteriorly (Fig. 2.64); gills on abdominal segment 2 operculate (arrowed in Fig. 2.64), covering lamellate gills on segments 3 and 4, gill 1 filamentous.......................................*Lestagella* (p. 118)

– Head not margined with long setae (Figs. 2.65A, 2.66A); gills on abdominal segment 2 semi-operculate (Figs. 2.65A, 2.66A), with part of following gill pair exposed; filamentous gill 1 present or absent 3

3. Dorsal abdominal tubercles single and sharp (Fig. 2.65A); filamentous gill 1 absent, lamellate gills on abdominal segments 2–6 (Fig. 2.65A)..*Ephemerellina* (p. 117)

– Dorsal abdominal tubercles broad and rounded (Fig. 2.66A); filamentous gill 1 present, lamellate gills on abdominal segments 2–6...... *Lithogloea* (p. 118)

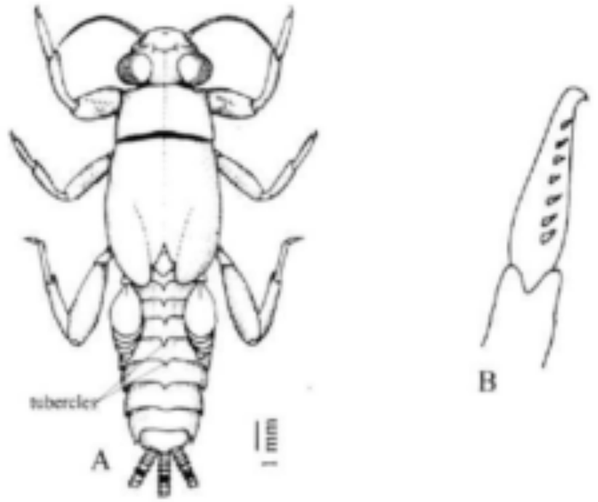

Fig. 2.65. *Ephemerellina* sp.: **A**, nymph, with cerci truncated, in dorsal view; **B**, claw, showing single row of denticles. (Redrawn from McCafferty & Wang 1997).

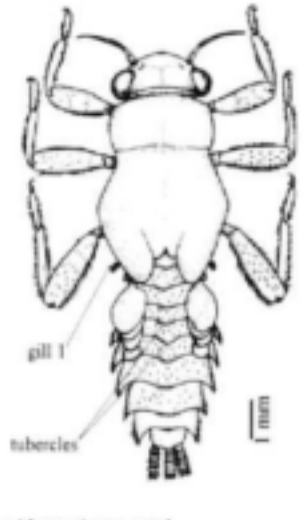

Fig. 2.66. *Lithogloea* sp., nymph with cerci truncated.

CAENIDAE: KEY TO GENERA

1. Operculate gills with Y-shaped ridge on dorsal surface (Figs. 2.68A&C, 2.69A, 2.70B, 2.71A, 2.72A); maxillary palps two-segmented (Figs. 2.71B, 2.72B), three-segmented (Figs. 2.67B, 2.69B, 2.70D) or absent (Fig. 2.68B)..........2
– Operculate gills without Y-shaped ridge on dorsal surface (Fig. 2.67A); maxillary palps 3-segmented (Fig. 2.67B) ....*Caenospella* (p. 121)

2. Maxillae without palp (Fig. 2.68F); claws hooked, without denticles (Fig. 2.68H); head, body and legs fringed with long hairs (Fig. 2.68A) (Madagascar only) .... *Madecocercus* (p. 121)
– Maxillae with two- or three-segmented palps; claws tapering or hooked, with or without denticles; body not markedly fringed with hairs...............3

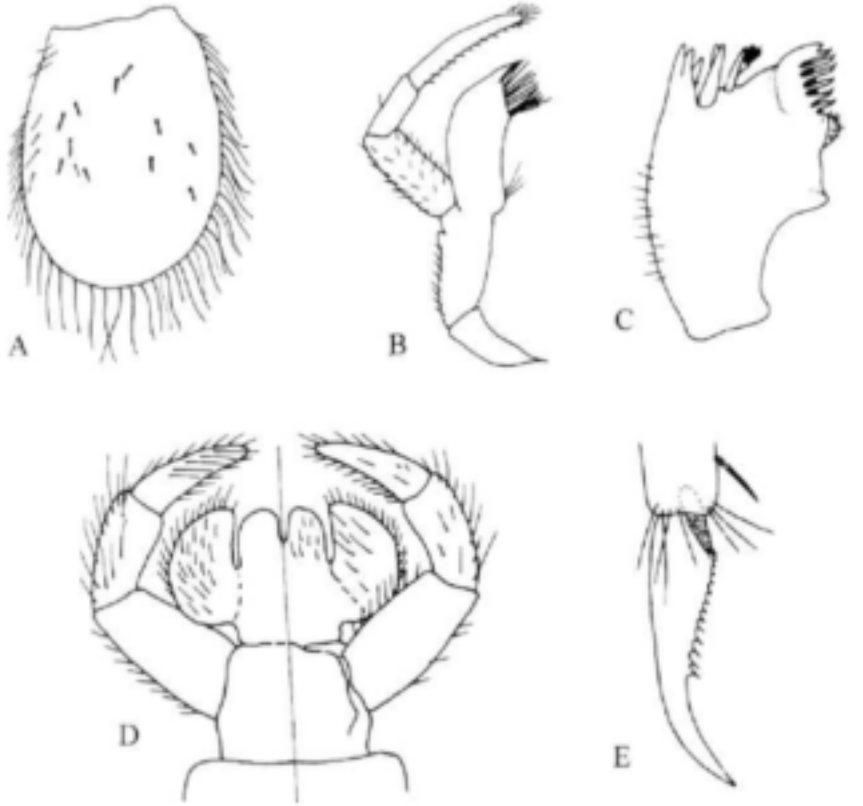

Fig. 2.67. *Caenospella* sp. **A**, operculate gill 2; **B**, maxilla; **C**, mandible; **D**, labium, in ventral view on the left and dorsal view on the right; **E**, claw. (Redrawn from Gillies 1977).

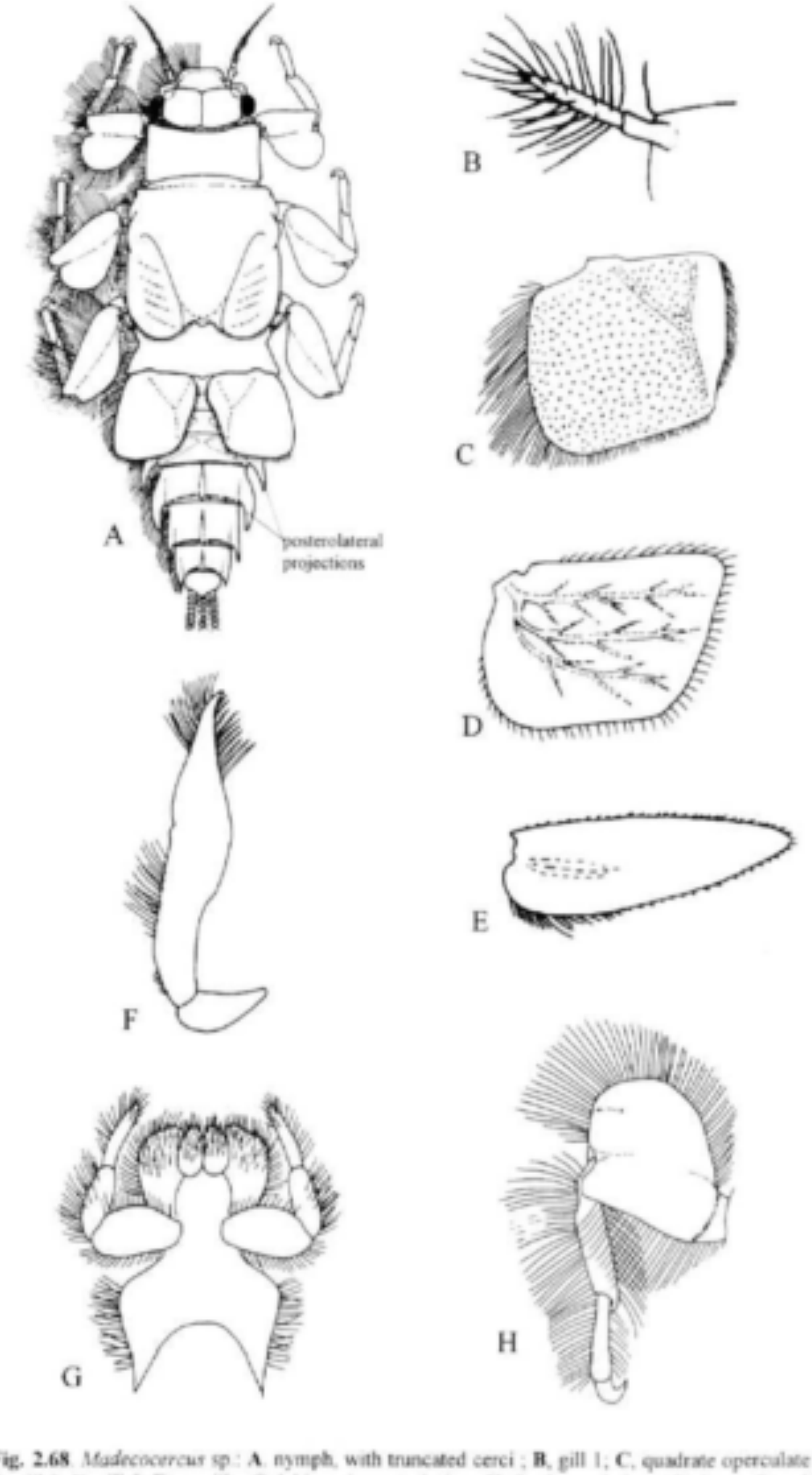

Fig. 2.68. *Madecocercus* sp.: **A**, nymph, with truncated cerci ; **B**, gill 1; **C**, quadrate operculate gill 2; **D**, gill 3; **E**, gill 5; **F**, maxilla; **G**, labium, in ventral view; **H**, foreleg and claw. (Redrawn from McCafferty & Wang 1995).

3. Claws long, slender, without denticles (arrowed in Fig. 2.69E); maxillae with three-segmented palps (Fig. 2.69B); mandibles without setation on outer margins (arrowed in Fig. 2.69C) .... *Afrocaenis* (p. 119)

– Claws usually with denticles, although these may be minute (Fig. 2.70G); maxillae with two- or three-segmented palps; at least one mandible with setae on outer margin (arrowed in Fig. 2.70E) 4

4. Maxillary palps three-segmented (Fig. 2.70D); forelegs without prominent brushes of long hair-like setae on tibiae and tarsi, although whorls of shorter setae may be present (Fig. 2.70G); tarsal claws usually tapering, with minute denticles, or no denticles (Fig. 2.70G); outer margin of operculate gills fringed with long, hair-like setae (Fig. 2.70A) (Africa & Madagascar)......... .... *Caenis* (p. 120)

– Maxillary palps two-segmented (Figs. 2.71B, 2.72B); forelegs with prominent brushes of hair-like setae on tibiae and tarsi (Fig. 2.71E, 2.72E); outer margin of operculate gills fringed with short, spatulate setae (Fig. 2.71A, 2.72A) 5

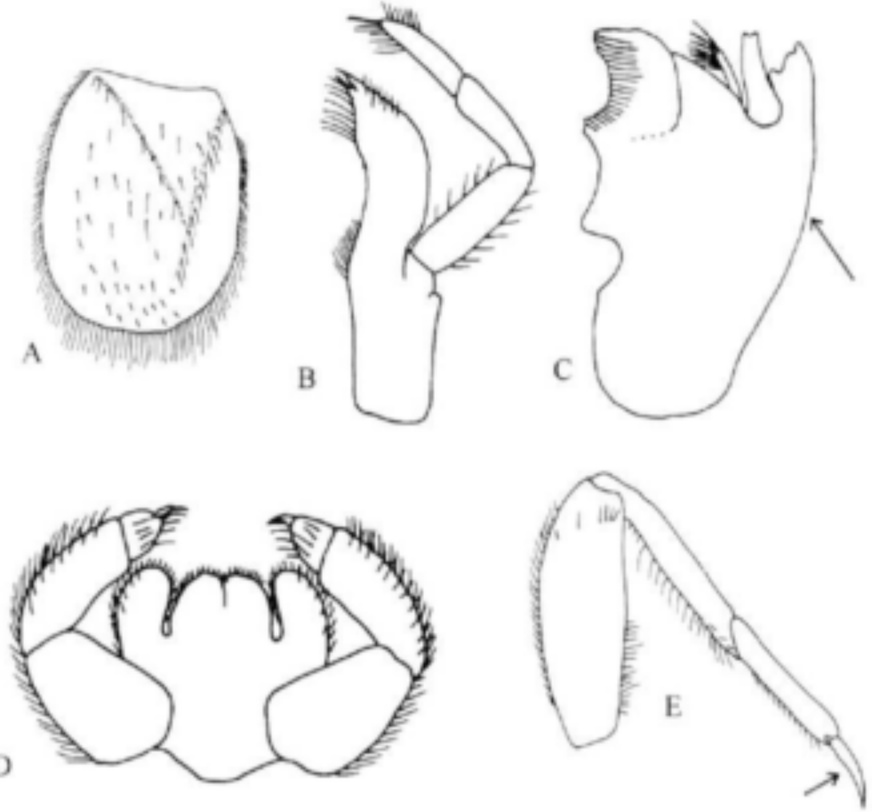

Fig. 2.69. *Afrocaenis* sp.: **A**, operculate gill 2; **B**, maxilla; **C**, mandible; **D**, labium, in ventral view; **E**, foreleg. (Redrawn from Gillies 1982).

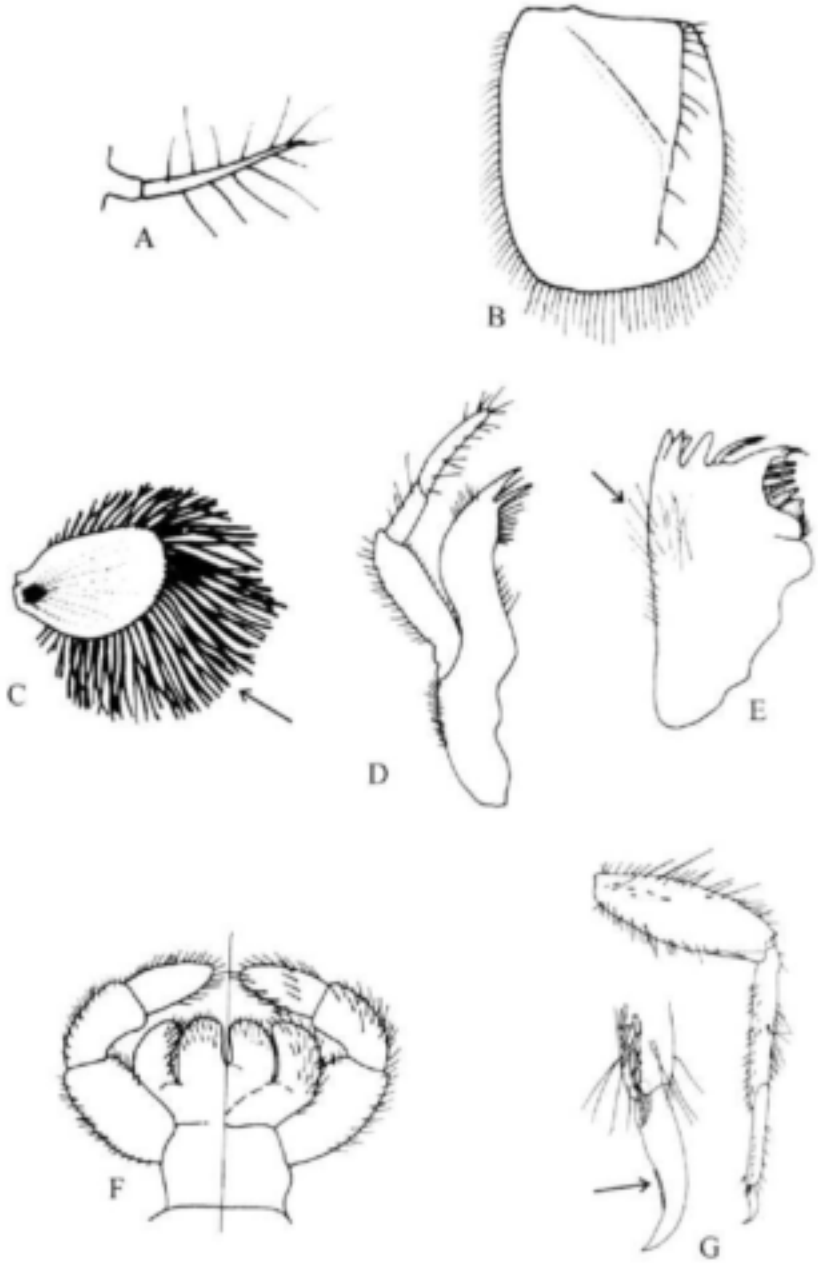

Fig. 2.70. *Caenis* sp.: **A**, filamentous gill 1; **B**, operculate gill 2; **C**, gill 3 (*note* typical fibrillar fringe-arrowed); **D**, maxilla; **E**, mandible; **F**, labium, in ventral view on the left and dorsal view on the right; **G**, foreleg, with detail of claw. (Redrawn from Provonsha 1990).

5. Setal brushes on forelegs made up of randomly-arranged, hair-like setae on dorsal surface and inner margin of tibiae and tarsi (Fig. 2.71E); mandibles with four to seven stout setae on outer margin (Fig. 2.71C); tarsal claws strongly hooked with four to five median denticles (Fig. 2.71E)..*Barnardara* (p. 120)

– Setal brushes on forelegs made up of hair-like setae arranged in distinct rows (Fig. 2.72E); mandibles with two rows of long setae on outer margin (Fig. 2.72C); tarsal claws slender, tapering, slightly curved, with five to seven minute denticles in basal half (Fig. 2.72E)................*Clypeocaenis* (p. 121)

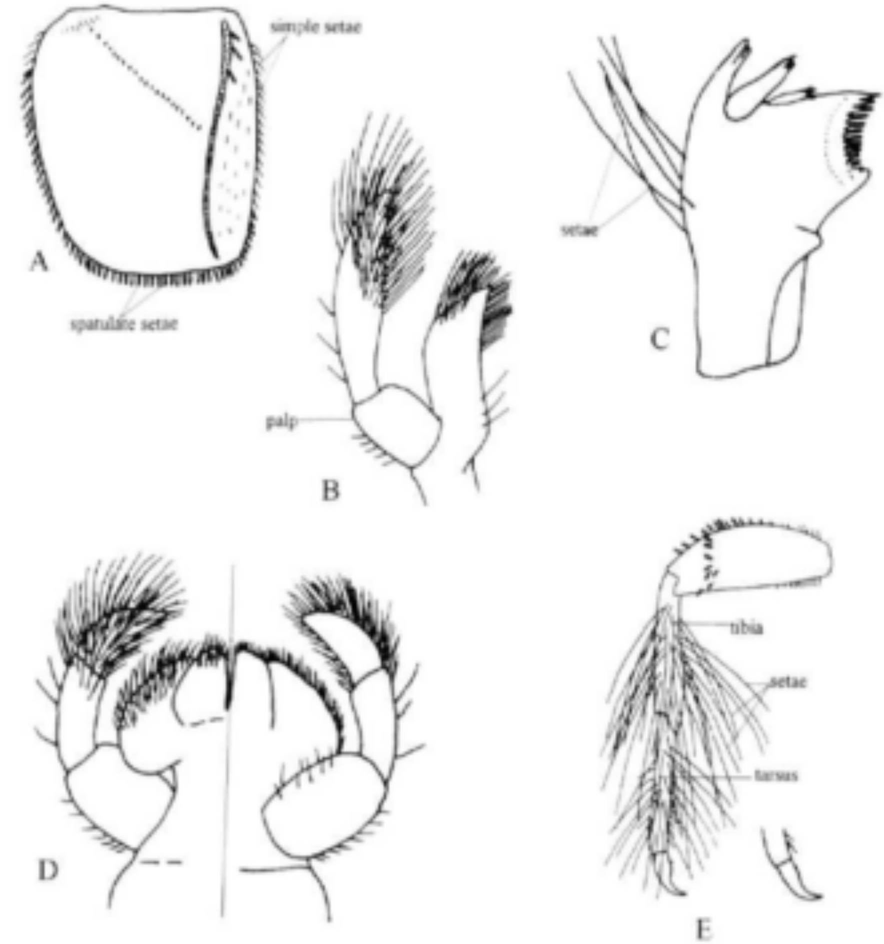

Fig. 2.71. *Barnardara* sp.: **A**, operculate gill 2; **B**, maxilla; **C**, mandible; **D**, labium, in ventral view on the left and dorsal view on the right; **E**, foreleg, with detail of claw. (Redrawn from Provonsha & McCafferty 1995).

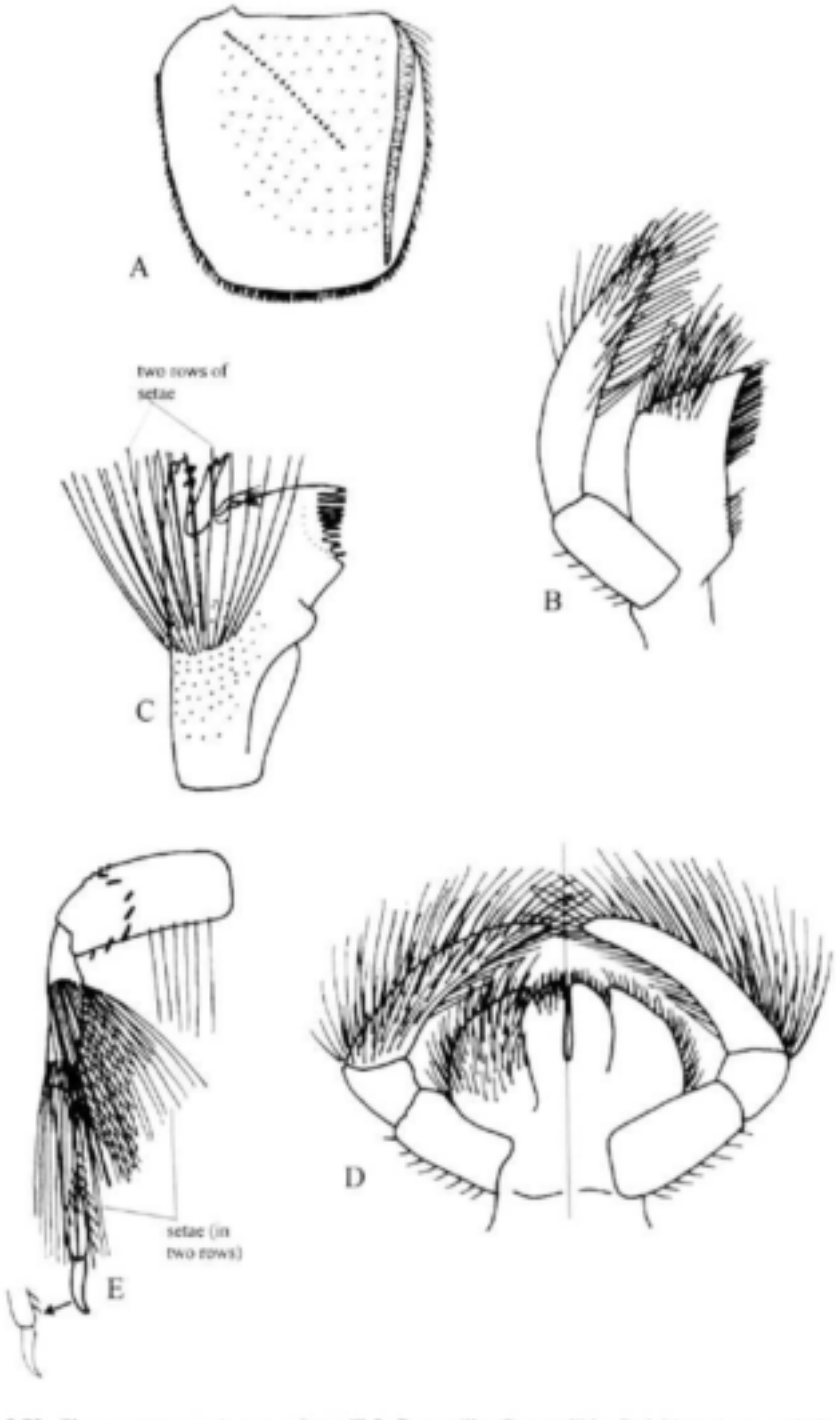

Fig. 2.72. *Clypeocaenis* sp.: **A**, operculate gill 2; **B**, maxilla; **C**, mandible; **D**, labium, in ventral view on the left and dorsal view on the right; **E**, foreleg (with detail of claw). (Redrawn from Provonsha & McCafferty 1995).

EPHEMERIDAE: KEY TO GENERA

1. Mandibular tusks with large, somewhat irregular denticles laterally (Fig. 2.73A)………………………………………………… *Palingenia* (p. 124)

– Mandibular tusks edentate (Figs 2.74B–F) or laterally with socketed spurs towards apex (Fig. 2.73C)……………………………………………………2

2. Frontal process apically serrate (Fig. 2.73B); mandibular tusks with smooth, well-sclerotized apex, and socketed spurs along lateral margin (Fig. 2.73C); (Madagascar only)………………………… ……………..*Cheirognesia* (p. 123)

– Frontal process concave or convex (Figs. 2.74A, C); mandibular tusks edentate (Figs 2.74B, C, D)……………………………………………………………3

3. Frontal process convex (Fig. 2.74A) (Africa & Madagascar)….. *Eatonica* (p. 123)

– Frontal process notched (Figs 2.74C, D, E)……………………………………4

4. Mandibular tusks poorly developed (Fig. 2.74C), not visible from dorsal view………………………………………………………… *Afromera* (p. 122)

– Mandibular tusks well developed (Fig. 2.74D), clearly visible from dorsal view…………………… ………………………………….*Ephemera* (p. 123)

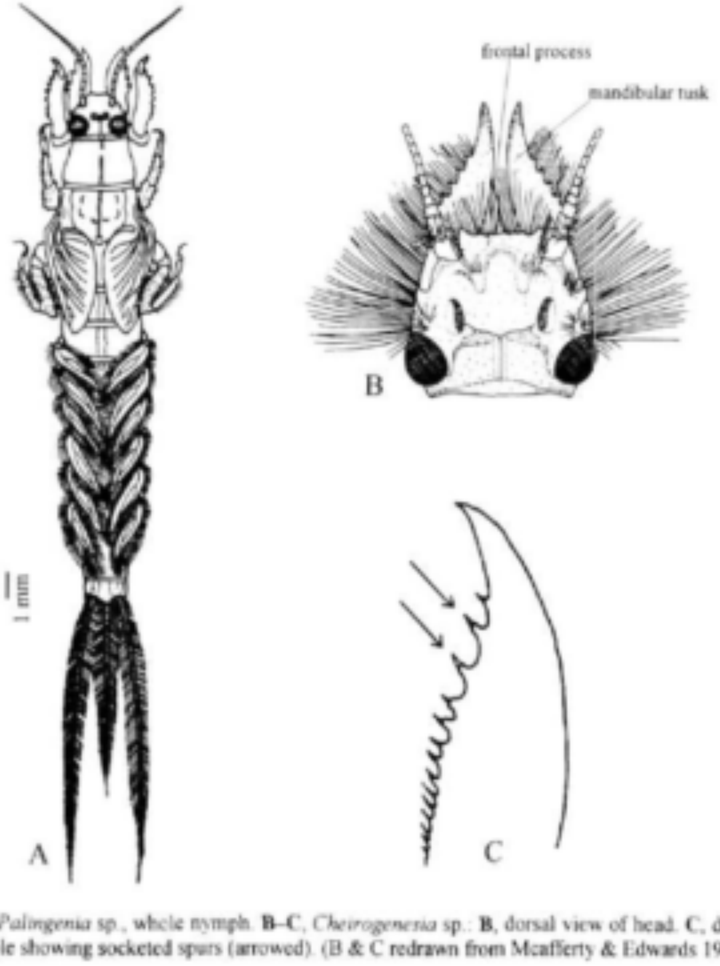

Fig. 2.73. A, *Palingenia* sp., whole nymph. B–C, *Cheirogenesia* sp.: B, dorsal view of head. C, detail of left mandible showing socketed spurs (arrowed). (B & C redrawn from Mcafferty & Edwards 1976).

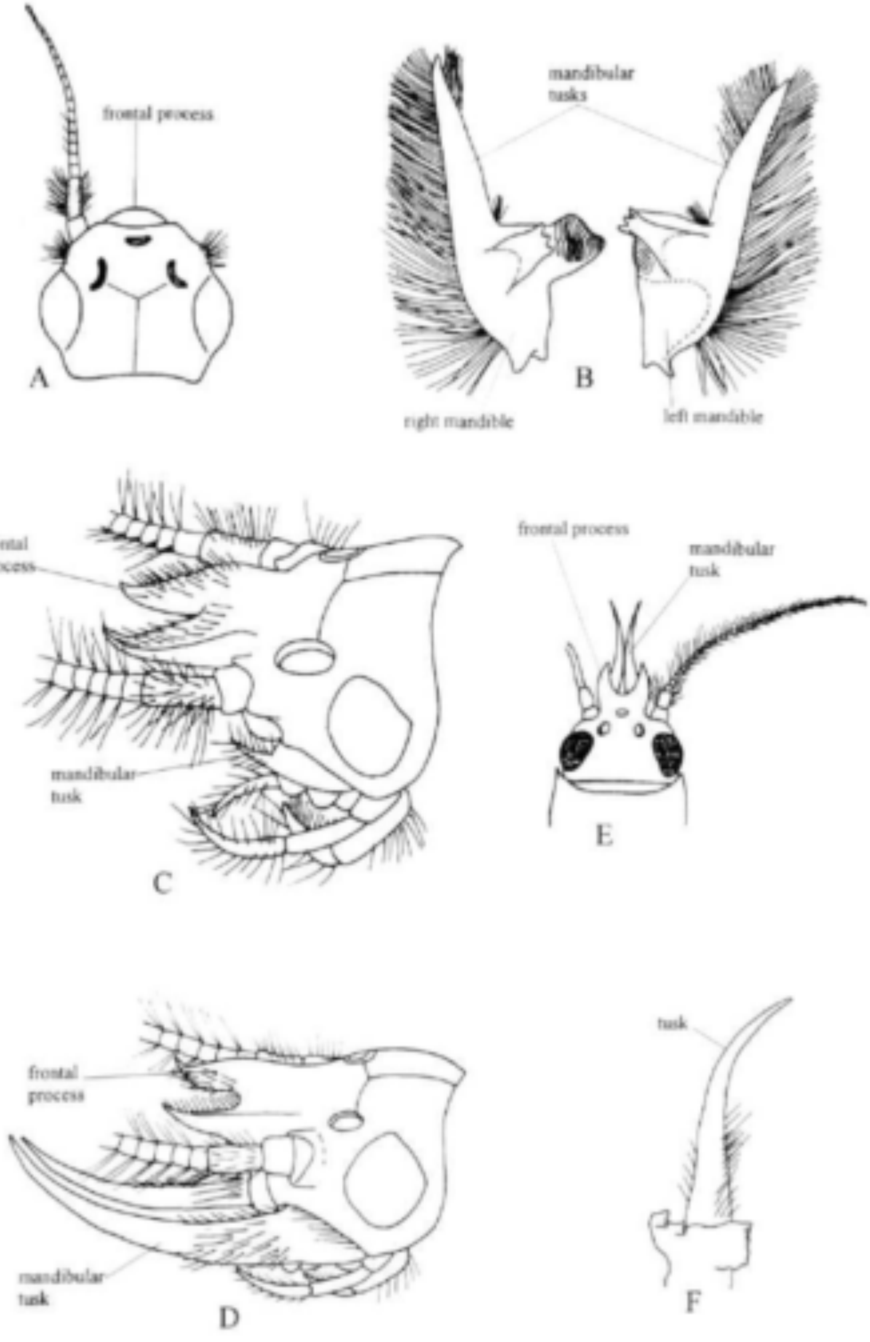

Fig. 2.74. **A–B**, *Eatonica* sp.: **A**, head, in dorsal view, with mandibles and right antenna removed; **B**, detail of mandibles, in ventral view. **C**, *Afromera* sp., head in lateral view. **D–E**, *Ephemera* sp.: **D**, head, in lateral view, showing long mandibular tusks; **E**, head (with left antenna truncated), in dorsal view; **F**, detail of left mandible. (A & B redrawn from Demoulin 1968; C & D redrawn from McCafferty & Gillies 1979; E redrawn from Crass 1947).

POLYMITARCYIDAE: KEY TO GENERA

1. Mandibular tusks elongate and slender, laterally and medially with thick rows of long setae (Figs. 2.75A); gill 1 bilamellate (Figs. 2.75B, 2.76B)……………………………………………………2

– Mandibular tusks short and robust, without continuous row of setae laterally and medially (Figs. 2.76D, H); gill 1 unilamellate (Figs. 2.76E, I)…………4

2. Mandibular tusks as long as combined length of head, thorax and first two abdominal segments (Fig. 2.75A); caudal filaments shorter than abdomen, with setae along their entire length (Madagascar only)……………………………………*Proboscidoplocia* (p. 126)

– Mandibular tusks shorter than combined length of head, thorax and first two abdominal segments (Fig. 2.76A); caudal filaments at least as long as abdomen, with setae along three quarters of their length ……………………3

3. Gill 1 with unequal lamellae (Fig. 2.75B); gills 2–7 about 1.5 X length of corresponding abdominal segment (Fig. 2.75B)…………. *Exeuthyplocia** (p. 125)

– Gill 1 with subequal lamellae (Fig. 2. 76B); gills 2–7 approximately equal in length to corresponding abdominal segment (Fig. 2.76A) ……………………………………*Afroplocia** (p. 124)

4. Mandibular tusks robust, medially denticulate (Fig. 2.76D,F,G)……………………………*Povilla* (p. 126)

– Mandibular tusks robust but more slender than above, laterally and dorsally with short, pointed nodules (Fig. 2.76H,K)………………*Ephoron* (p. 125)

* These two genera are remarkably similar as nymphs, such that one may question the validity of their separation into different genera. They are easily separable as adults, however (Demoulin 1952).

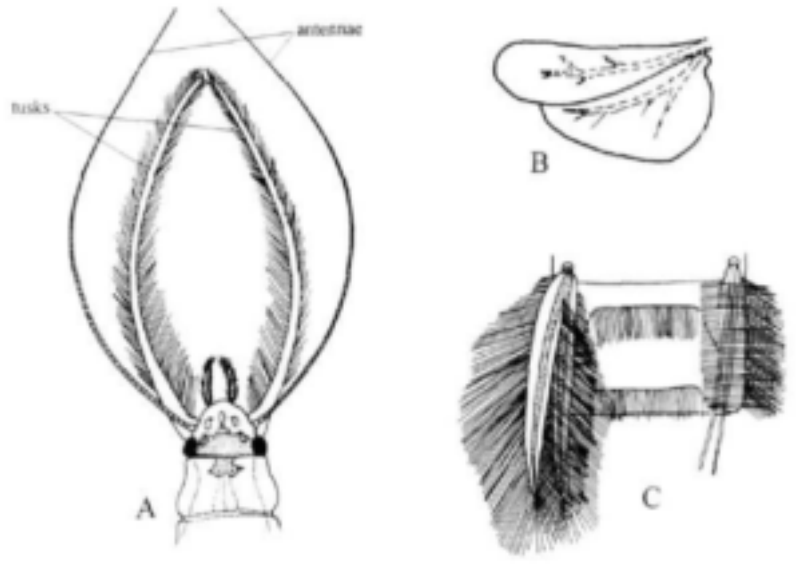

Fig. 2.75. **A**, *Proboscidoplocia* sp. dorsal view of head showing long, narrow tusks. **B-C**, *Exeuthyplocia* sp.: **B**, gill 1; **C**, abdominal segment, showing typical arrangement of setae on the right, and structure of gill 5 on the left. (A redrawn from Elouard et al. 2001; B & C redrawn from Gillies 1980b).

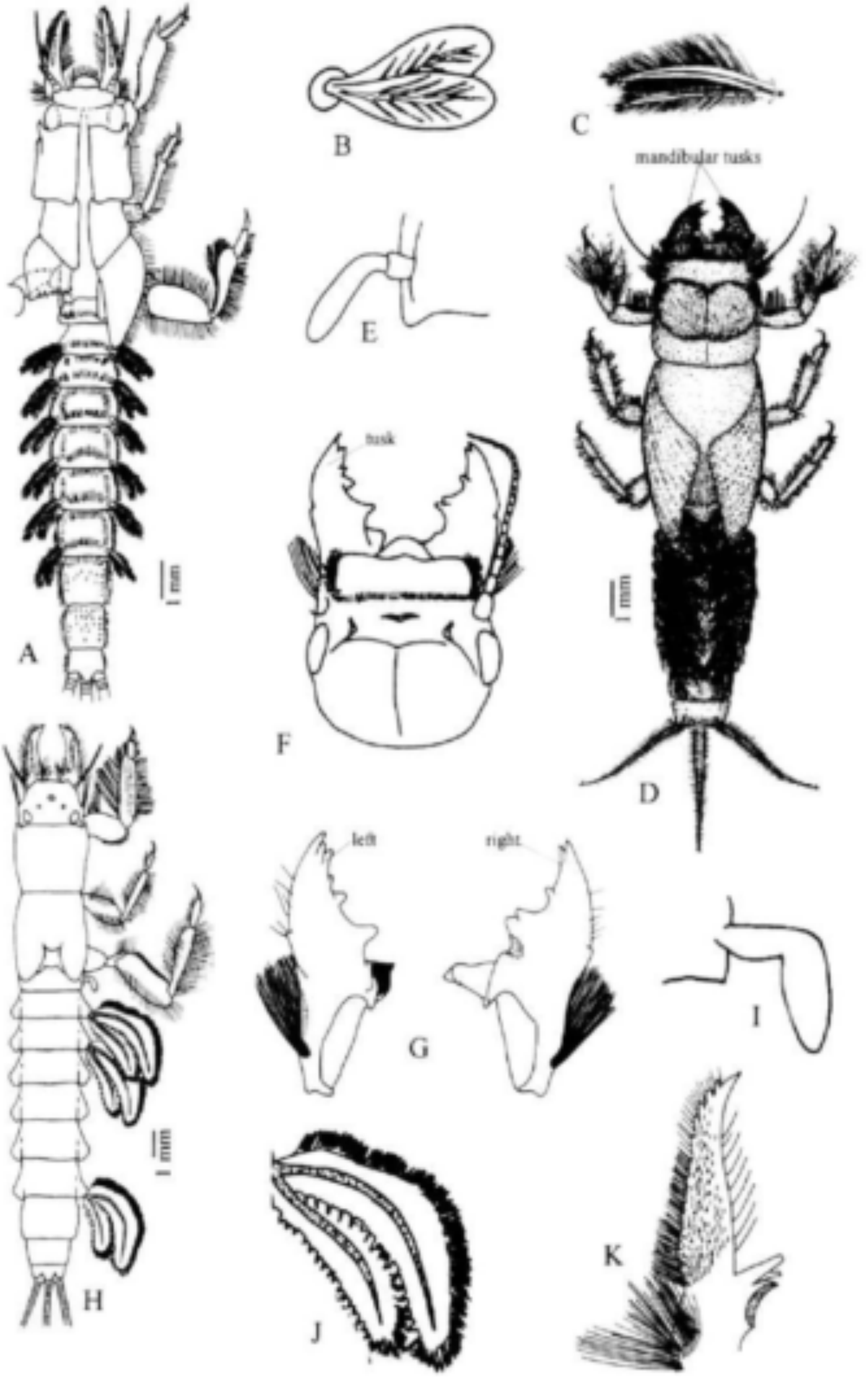

Fig. 2.76. **A–C**, *Afroplocia* sp.: **A**, nymph (with cerci truncated and left appendages removed), in dorsal view; **B**, gill 1; **C**, gill 2. **D–G**, *Povilla* sp.: **D**, whole nymph, in dorsal view; **E**, gill 1; **F**, detail of head, in dorsal view; **G**, left and right mandibles, in dorsal view; **H–K**, *Ephoron* sp.: **H**, nymph (with cerci truncated and left appendages removed), in dorsal view; **I**, gill 1; **J**, gill 2; **K**, left mandible. (A–C redrawn from Barnard 1940; D redrawn from Agnew 1980; E–G redrawn from Demoulin 1956b; H–K redrawn from Crass 1947).

LEPTOPHLEBIIDAE: KEY TO GENERA

1. Gill 1 similar to middle gills with similar dorsal and ventral lamellae (Figs. 2.77A, 2.78B, 2.79F & G, 2.80A, 2.81A–C)..2

– Gill 1 absent, or different from middle gills, operculate, or non-operculate but with single lamella (Figs 2.82A, 2.83A, 2.84A–C, 2.85A) or with different dorsal and ventral lamellae (Fig. 2.82E) 7

2. Gills long and slender, tracheae unbranched (Figs. 2.77A, 2.78A & B)......3

– Gills with broad lamellae, tracheae branched (Figs 2.79F & G, 2.80A, 2.81)......4

3. Gill lamellae narrow, terminating in long, filamentous projections (approximately equal in length to lamellate portion), inner gill only slightly shorter than outer gill (Fig. 2.77A); small posterolateral spines on abdominal segment 9 only; claws with strong denticles becoming progressively larger apically (Fig. 2.77B); mandible with fringe of setae along lateral margin, extending medially to basally (Fig. 2.77C) (Seychelles only)....................
....*Hagenulodes* (p. 129)

– Gill lamellae narrow, gradually tapering apically (Figs. 2.78A,B), inner lamella distinctly shorter than outer lamella; posterolateral margins of abdominal segments not produced to form spine-like projections; claws (Fig. 2.78C) with small, forwardly-projecting denticles basally, a large central denticle, followed by four strong denticles, gradually increasing in size towards apex; mandible without tuft of setae along lateral margin (Fig. 2.78D)................
....*Castanophlebia* (p. 128)

4. Claws edentate (Fig. 2.79A); posterolateral margins of abdominal segments 8 and 9 produced to form double spine-like processes (Fig. 2.79B); gills with upper and lower lamellae of approximately equal size, with multi-branched trachea, terminating either in a single filamentous process (Fig. 2.79F) or in three filamentous processes (Fig. 2.79G). The lateral filaments may be variously developed, being represented as mere bulges (Fig. 2.79C), through to fully-developed filaments (Fig. 2.79D & E).......................*Aprionyx* (p. 128)

– Claws denticulate (e.g. Figs 2.80A, 2.81E, 2.82D&G, 2.83C&G); posterolateral margins of abdominal segments 8 and 9 produced to form single spine-like processes (Fig. 2.81D); gills terminating in short, finger-like processes (Fig. 2.80A), single tapering filamentous processes (Fig. 2.81A–C), or in a small medial projection with the lamellae extended laterally (Fig. 2.81F)......
....5

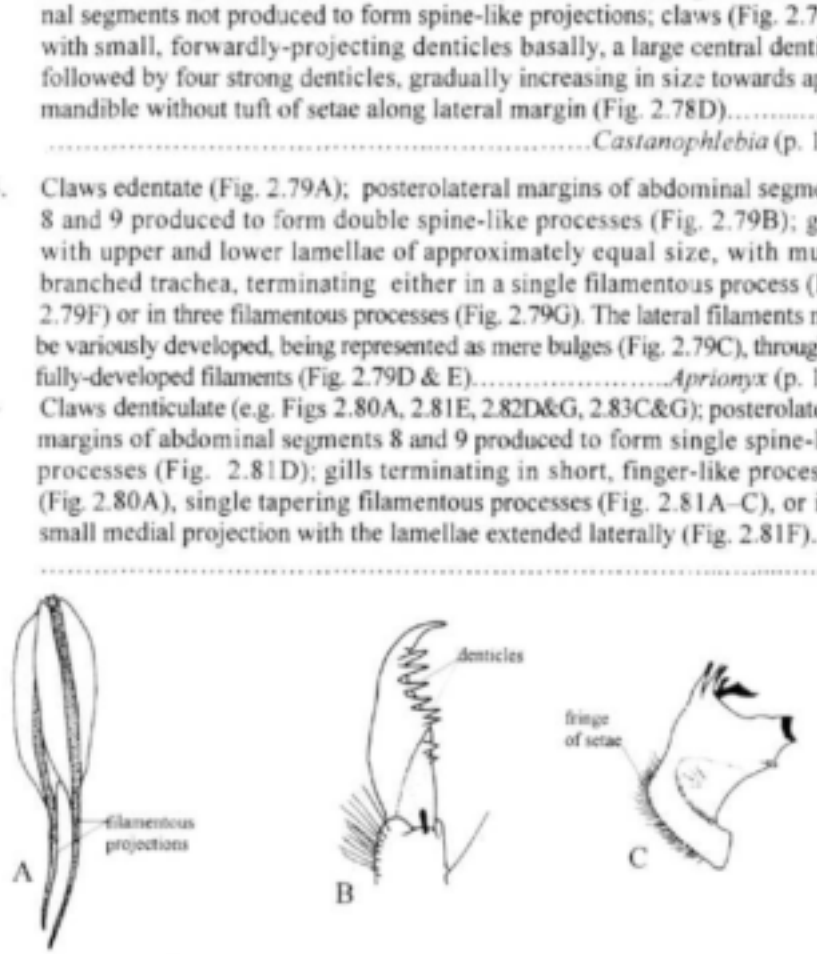

Fig. 2.77. *Hagenulodes* sp.: **A**, gill 4; **B**, claw of foreleg; **C**, left mandible. (Redrawn from Peters & Edmunds 1966).

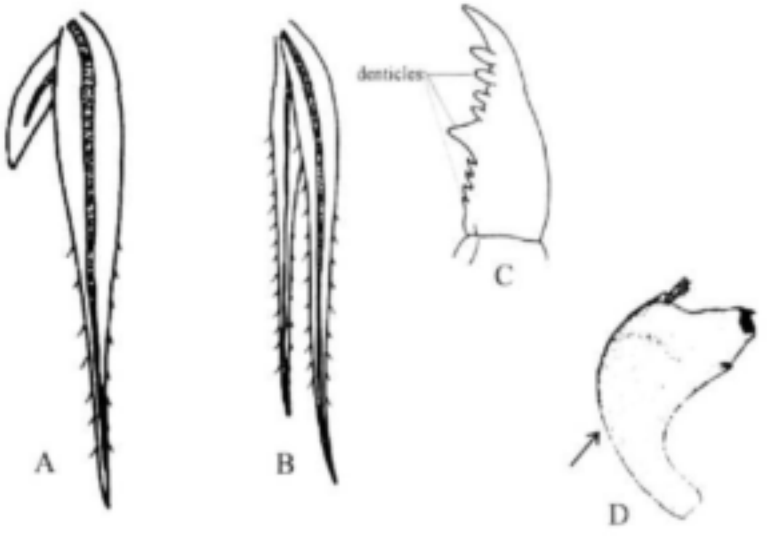

Fig. 2.78. *Castanophlebia* sp.: **A**, gill 7; **B**, gill 2; **C**, claw of foreleg; **D**, left mandible (*note* absence of setae on lateral margin—arrowed). (A-C redrawn from Barnard 1932; D redrawn from Peters & Edmunds 1964).

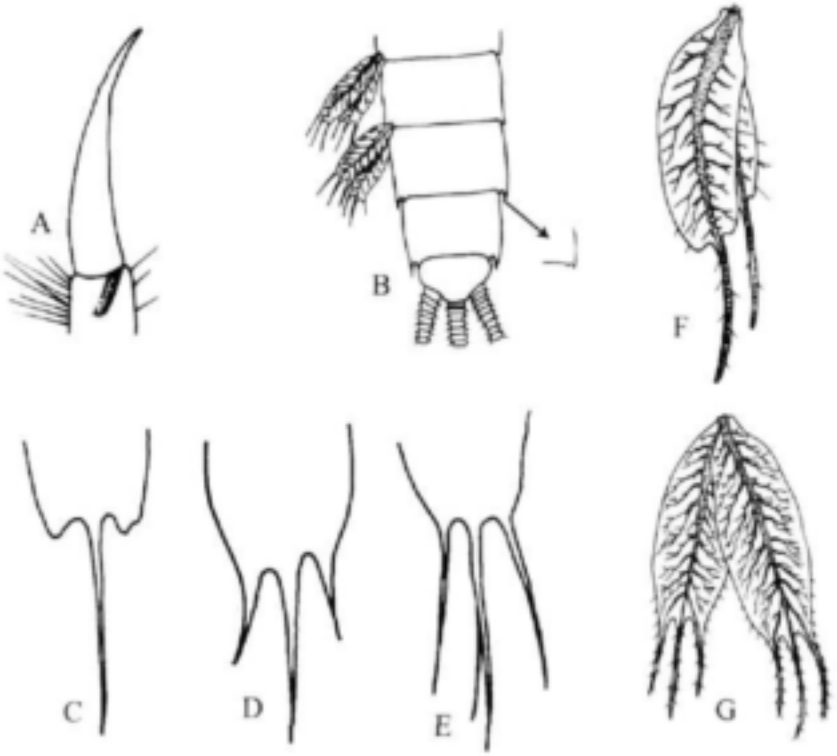

Fig. 2.79. **A–E**, *Aprionyx* sp., distinctive features of the genus: **A**, edentate claw; **B**, terminal abdomen, showing detail of biacuminate endings of lateral margins of segments 8 and 9; **C–E**, *A. tricuspidatus*, terminal sections of gills, showing variation in the development of gill filaments within this species. **F**, *A. intermedius* gill 4. **G**, *A. tricuspidatus* gill 4. (A, F & G redrawn from Peters & Edmunds 1964; B–E redrawn from Crass 1947).

5. Gills with four to six short finger-like processes distally (Fig. 2.80A), upper and lower lamellae of similar size; claws (Fig. 2.80B) with many (about 10) denticles of more-or-less even size (Madagascar only)........ *Polythelais* (p. 131)

– Gills with single tapering filamentous processes (Fig. 2.81A–C) or small medial projection with lamellae extended laterally (Figs 2.81F); claws with denticles gradually increasing in size from base to apex, with or without larger terminal denticle (Figs. 2.81E & G) 6

6. Gills apically produced to form single, slender projection; in some species, ventral lamellae are smaller than dorsal lamellae (Figs. 2.81A,B), in others the lamellae may be subequal (Fig. 2.81C); the terminal projection may not be well developed (Fig. 2.81A); small single posterolateral spines present on abdominal segments 3–7, larger single posterolateral spines on segments 8 and 9 (Fig. 2.81D); claws (Fig. 2.81E) with about 12 denticles progressively larger towards the apex, and a single much larger denticle apically.............. ....*Adenophlebia* (p. 127)

– Gills apically with a short medial process and lamellae extended to form short, rounded processes on either side (Fig. 2.81F); claws (Fig. 2.81G) with about 11 strong denticles (Madagascar only)...............*Petersophlebia* (p. 130)

7. Gill 1 absent; gills 2–7 each consisting of a single long, slender lamella, deeply forked from the basal third (Fig. 2.81H); claws (Fig. 2.81I) with about 10 denticles which gradually increase in size towards apex (Madagascar only) ....*Nesophlebia* (p. 130)

– Gill 1 present (e.g. Figs. 2.82A, C, 2.183A); gills 2–7 each consisting of a single long, slender lamella, deeply forked from basal third (Fig. 2.82B) or plate-like with variously developed processes (e.g. Figs. 2.82D, 2.83B, 2.84B)....... 8

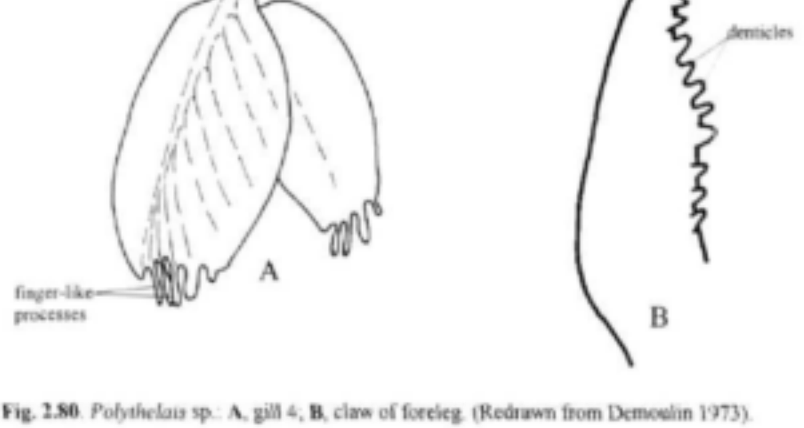

Fig. 2.80. *Polythelais* sp.: **A**, gill 4; **B**, claw of foreleg. (Redrawn from Demoulin 1973).

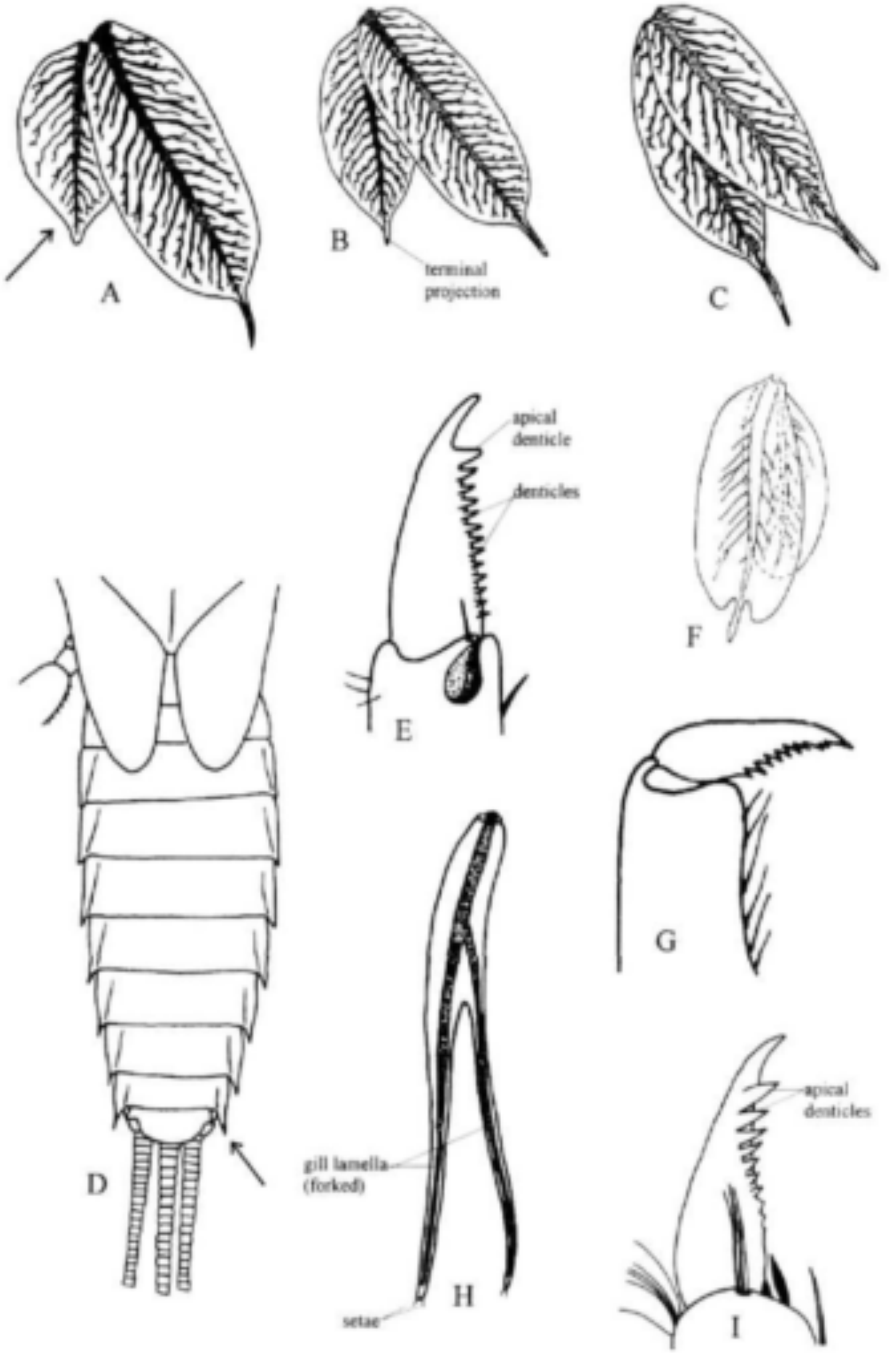

Fig. 2.81. **A–B**, *Adenophlebia auriculata*, various types of gills: **A**, gill 1 (*note* the relatively short basal lamella–arrowed); **B**, gill 4. **C–D**, *A. sylvatica* : **C**, gill 4 (*note* the subequal lamellae); **D**, posterior abdomen showing single posterolateral spines (arrowed); **E**, claw of foreleg. **F–G**, *Petersophlebia* sp.: **F**, gill 4. **G**, claw of foreleg. **H–I**, *Nesophlebia* sp.: **H**, gill 4. **I**, claw of foreleg. (A, B & C redrawn from Crass 1947; D redrawn from Demoulin 1981; E redrawn from Peters & Edmunds 1964; F redrawn from Demoulin 1973; G redrawn from Demoulin 1955b; H & I redrawn from Peters & Edmunds 1964).

8. Gill 1 long and slender, consisting of one filament (Fig. 2.82A); gills 2–7 each consisting of a single long, slender lamella, deeply forked from basal third (Fig. 2.82B); ovipositor present on mature female nymphs (Fig. 2.82C); claws (Fig. 2.82D) with around 14 denticles that gradually increase in size towards apex (Seychelles only) .... *Maheathraulus* (p. 130)
– Gill 1 consisting of two parts, or single, lamellate, lanceolate or filamentous; gills 2–7 lamellate (e.g. Figs. 2.82F, 2.83B &E, 2.84D); female nymphs without visible ovipositor 9

9. Gill 1 with dorsal lamella slender, lanceolate, ventral lamella ovoid with fringed margins (Fig. 2.82E); gills 2–7 with dorsal and ventral lamellae similar, ovoid with fringed margins (Fig. 2.82F); claws with few (5) to many (11) denticles (depending on the species), gradually increasing in size towards apex (e.g. Fig. 2.82G) .... *Thraulus* (p. 131)
– Gill 1 consisting of one lamella (Figs. 2.83A, 2.83E); gills on segments 2–6 or 2–7 without fringed margins *10*

10. Gill 1 operculate (Fig. 2.83A); gills 2–6 bilamellate with the upper lamella smaller than, but similar in appearance to, the lower lamella, each lamella being apically cleft (Fig. 2.83B); claws with denticles of more or less even size (Fig. 2.83C) .... *Adenophlebiodes* (p. 127)
– Gill 1 broad and apically cleft (Fig. 2.83D) or long and slender (Figs. 2.84A–C) to filamentous (Fig. 2.85A &B)...11

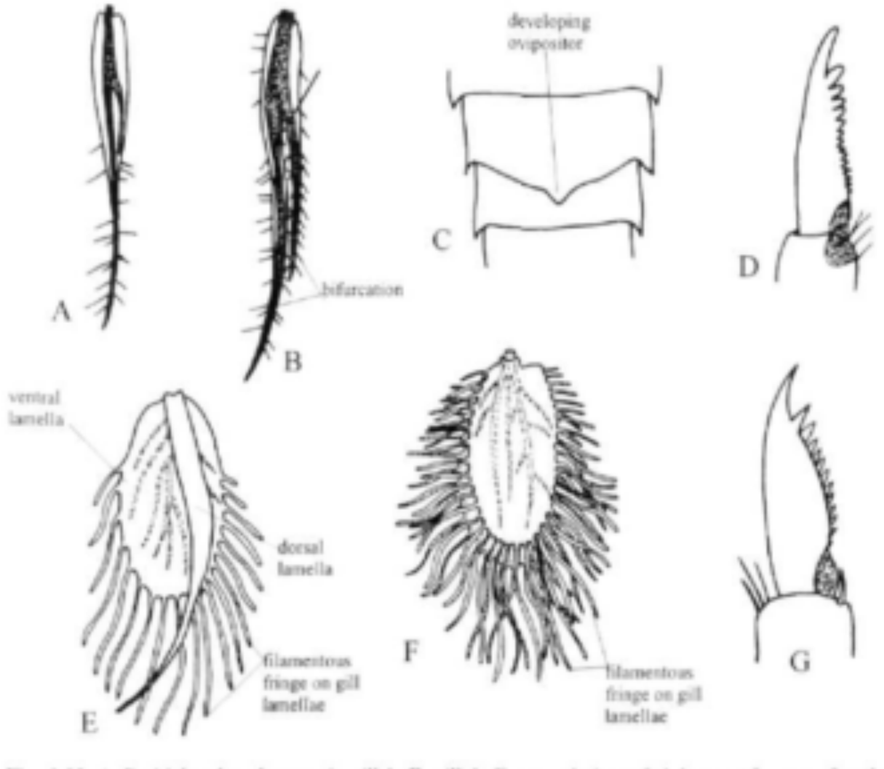

Fig. 2.82. **A–D**, *Maheathraulus* sp.: **A**, gill 1; **B**, gill 4; **C**, ventral view of abdomen of mature female nymph, showing ovipositor; **D**, claw of foreleg. **E–G**, *Thraulus* sp.: **E**, gill 1; **F**, gill 4; **G**, claw of foreleg. (A–G redrawn from Peters & Edmunds 1964)

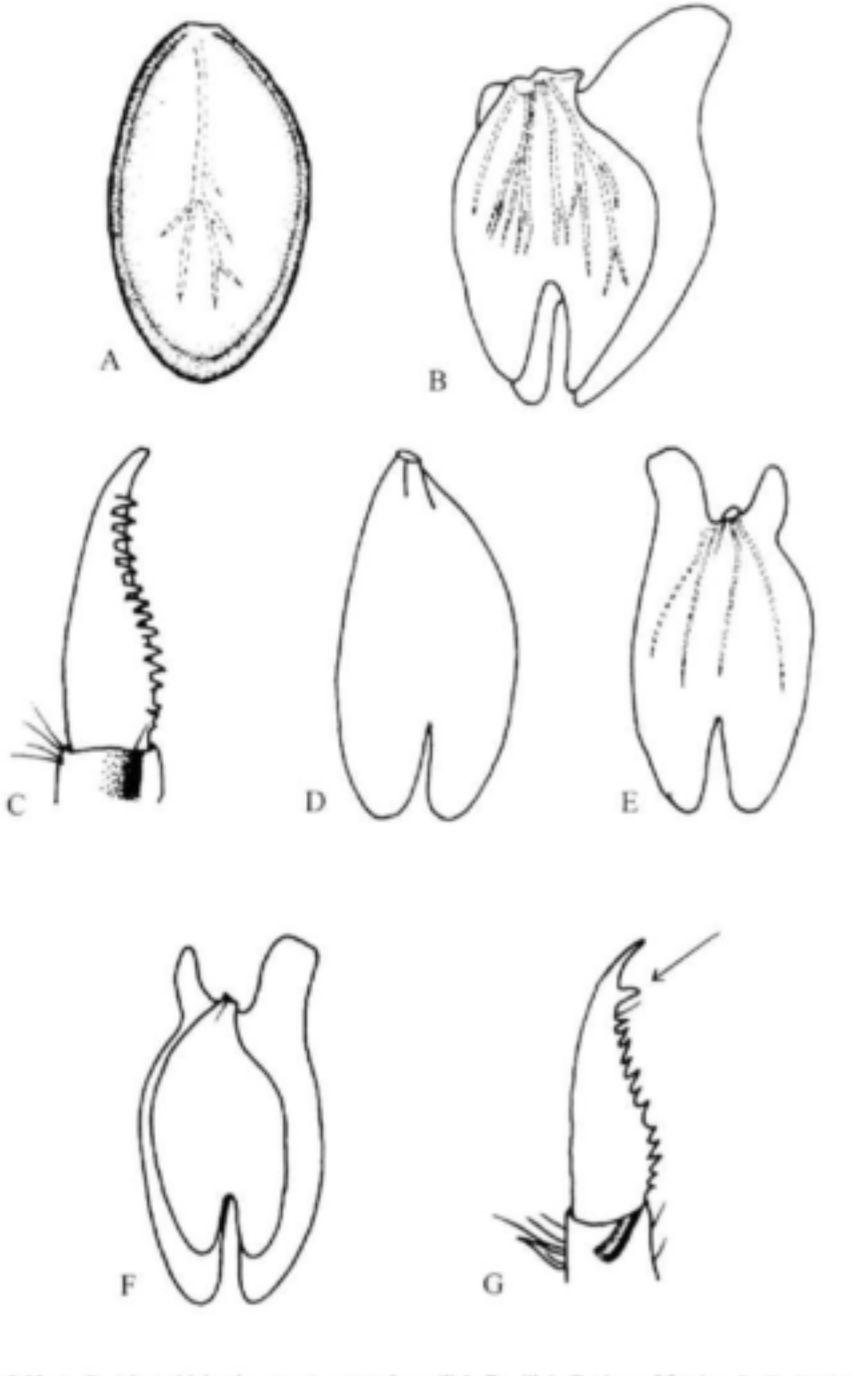

Fig. 2.83. **A–C**, *Adenophlebiodes* sp.: **A**, operculate gill 1; **B**, gill 4; **C**, claw of foreleg. **D–G**, *Hyalophlebia*: sp.: **D**, gill 1; **E**, detail of lamella of gill 4, in dorsal view; **F**, gill 4, in dorsal view, showing smaller upper lamella; **G**, claw of foreleg (*note* needle-like denticle just below last enlarged denticle) (A–C redrawn from Peters & Edmunds 1964; D–G redrawn from Agnew 1962b).

11. Gill 1 broad, made up of a single lamella, apically cleft (Fig. 2.83D); gills 2–7 bilamellate, the upper lamella smaller but similar in appearance to the lower lamella, each apically cleft (Figs. 2.83F,G); claws with denticles uniform in size except for larger apical denticle, preceded by needle-like denticle (Fig. 2.83G) .... *Hyalophlebia* (p. 130)
– Gill 1 long and slender, to filamentous (Figs 2.84A–C, 2.85A & B); gills 2–7 apically with three variously-developed processes (Figs. 2.84D, 2.85C, 2.86A) claws not as above (Figs 2.84E, 2.85D, 2.86C)........................12

12. Gill 1 lanceolate (Fig. 2.84A) or with narrow lamella and single apical process (Fig. 2.84B,C); gills 2–7 apically with three processes, medial process obviously longer than apicolateral processes on each lamella (Fig. 2.84D); claws broad in mid region, tapering abruptly to form strong hook (Fig. 2.84E); labrum with deep V-shaped notch (Fig. 2.84F).......... *Choroterpes* (p. 128)
– Gill 1 filamentous (Figs 2.85A & B); gills 2–7 apically with three slender, subequal processes on each lamella (Figs. 2.85B, 2.86A); labrum with shallow medial notch (Figs. 2.85D, 2.86D)...13

13. Posterolateral margins of abdominal segments 3–9 with poorly developed single spines; claws tapering evenly from base to apex (Fig. 2.85C); labrum laterally rounded (Fig. 2.85D) (Africa & Comores).......*Euthraulus* (p. 129)
– Posterolateral margins of abdominal segments 3–7 with well developed single spines, 8 and 9 produced to form double spines (Fig. 2.86B); claws with irregular denticles (Fig. 2.86C); labrum laterally divergent (Fig. 2.86D) .... *Fulletomimus* (p. 129)

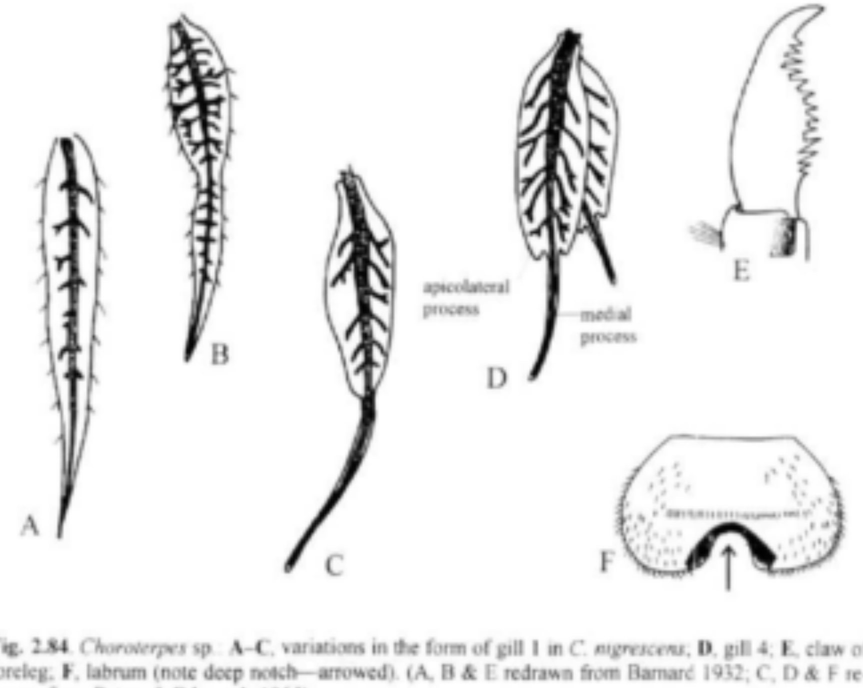

Fig. 2.84. *Choroterpes* sp.: **A–C**, variations in the form of gill 1 in *C. nigrescens*; **D**, gill 4; **E**, claw of foreleg; **F**, labrum (note deep notch—arrowed). (A, B & E redrawn from Barnard 1932; C, D & F redrawn from Peters & Edmunds 1964).

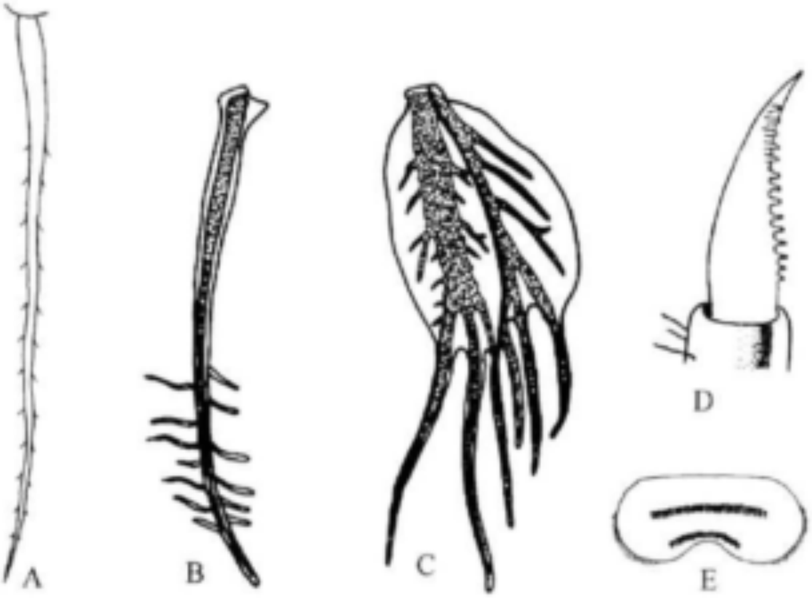

Fig. 2.85. *Euthraulus* sp. **A–B**, various forms of gills 1; **C**, gill 4; **D**, foreleg claw; **E**, labrum.

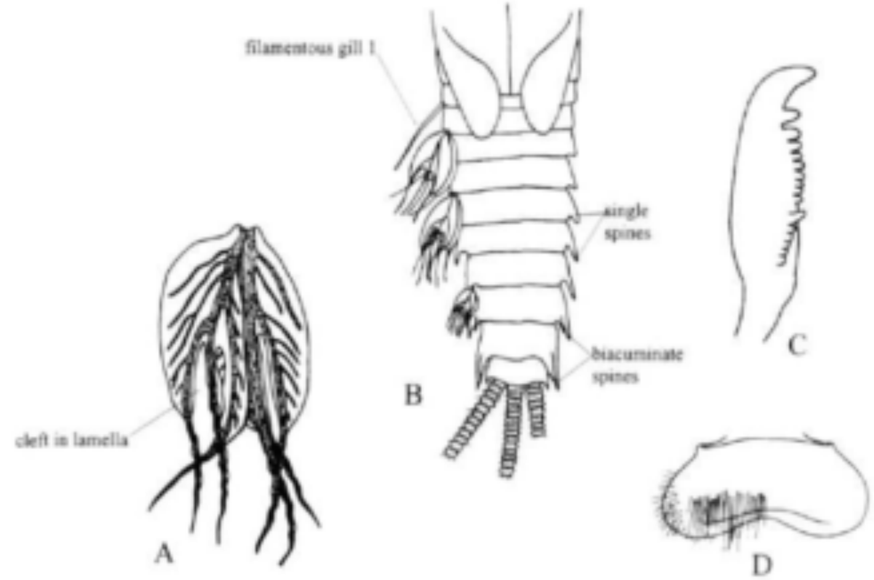

Fig. 2.86. *Fulletomimus* sp.: **A**, gill 4; **B**, dorsal view of abdomen showing filamentous gill 1 and the posterolateral biacuminate endings of abdominal segments **8** and **9**; **C**, claw of foreleg; **D**, labrum.

PROSOPISTOMATIDAE

There is no key to genera, as only one genus (*Prosopistoma:* Fig. 2.6) is currently known.

NOTES ON FAMILIES AND GENERA

BAETIDAE (Figs. 2.17–2.54)

The family Baetidae, or small minnow mayflies, is widespread in the world except in New Zealand and other remote oceanic islands. In the Afrotropics, it is a diverse and important component of the Afrotropical freshwater biota, with 40 genera currently recognized in the literature, 18 of these occuring in South Africa. It is worth noting that there is dispute over the validity of several genera, resulting in two genera keying out at the same point in a few instances (for example, *Cloeodes* and *Maliqua*; *Labiobaetis* and *Pseudocloeon*).

Nymphs of small minnow mayflies are readily distinguished by having the lateral ocelli located above the lateral branches of the epicranial suture (Fig. 2.7B) and the femoral apices with a ventrally oriented dorsal lobe (Fig. 2.7D). The head is hypognathous, the antennae are longer than the length of the head capsule, and the body is generally elongate and cylindrical. The presence or absence of hindwing pads and the degree of development of the medial caudal filament has previously been used to delineate genera. These characteristics have been shown to be inconsistent, however, even within individual genera, and are, therefore, of little diagnostic value. Mature male nymphs generally show the developing turbinate compound eyes of the adult stage (Fig. 2.4B & C). Baetid nymphs are generally found in flowing waters, but all members of certain genera (for example, *Cloeon* and *Procloeon*) are found in still waters and temporary waterbodies.

Although little is published about feeding in Afrotropical Baetidae nymphs, most are collector-gatherers, feeding generally on detritus. The nymphs of two genera (*Centropiloides* and *Guloptiloides*) are carnivorous, and others are filterers (e.g. nymphs of *Ophelmatostoma* and *Mutelocloeon*).

The sizes of nymphs, given below, are estimates at generic level, and certain species within a genus may not fit these estimates.

Acanthiops Waltz & McCafferty, 1987 (Figs. 2.24A–L & 2.26A & B)

The genus *Acanthiops* has a widespread distribution in the Afrotropics, where it is endemic and represented by 13 species, three of which are known in South Africa. Its nymphs are distinguished by its emarginate and laterally expanded and flattened pronotum (Fig. 2.24B). Other characteristics that aid in distinguishing nymphs of *Acanthiops* include the variously developed dorsal abdominal tubercles (Figs. 2.24C,D,E). With the exception of one species reported from Kenya, nymphs of *Acanthiops* have two rows of denticles on the tarsal claws (similar to Fig. 2.20B). The medial caudal filament is undeveloped in most species (Fig. 2.24A), but is well developed in *A. cooperi* and *A. erepens* (Fig. 2.26A). The body of a nymph may be up to about 7.0 mm in length, the cerci 4.0 mm. Nymphs of *Acanthiops* are primarily found under small- to medium-sized stones in fast- and moderate-flowing streams at middle to high elevations.

Useful references

Barber-James & McCafferty (1997); Gattolliat 2000; Lugo-Ortiz & McCafferty (1998a); Lugo-Ortiz et al. 2001; Waltz & McCafferty (1987).

Afrobaetodes Demoulin, 1970

(Figs. 2.17D–H)

The genus *Afrobaetodes* has been reported from western, eastern and southern Africa and Madagascar, and is endemic to the Afrotropics. There are six known species, three of which occur in South Africa. Its nymphs are distinguished by the ventrally-oriented, lamellate gills (Figs. 2.17D,E), a ventrolateral filamentous gill on each side of prosternum (Fig. 2.17D) and the presence of a distolateral process on maxillary palp segment 1 (Fig. 2.17F). With the exception of the species reported from Madagascar, nymphs of *Afrobaetodes* have one row of denticles on the tarsal claws. Dorsal abdominal tubercles are either present or absent. The medial caudal filament is undeveloped. Mature nymphs are about 3.2 mm in length, with cerci measuring 2.7 mm. Nymphs of *Afrobaetodes* are found under small- to medium-size stones or among gravel in fast- and moderate-flowing streams at moderate elevations.

Useful references

Gattolliat & Sartori (1999a); Gillies (1991b); Jacobus & McCafferty (2001); Kimmins (1955); Lugo-Ortiz & McCafferty (1996c).

Afroptilum Gillies, 1990

(Figs. 2.40A–C)

The genus *Afroptilum* has been the subject of considerable revision that has resulted in the establishment of numerous new genera. As a consequence, the concept of *Afroptilum* has been severely restricted, and it is now feasible to distinguish nymphs of the genus readily from those of other Afrotropical genera. *Afroptilum* is widely distributed in eastern and southern Africa, and it has been reported from Madagascar and the Comoros Islands. Ten species are recognized in total, of which two are known in South Africa.

Afroptilum nymphs are distinguished by the presence of a tuft of robust, stiff, simple setae apically on the lingua of the hypopharynx (Fig. 2.40A), and small terminal segments of the labial palp (Fig 2.40B). Other characteristics that aid in distinguishing nymphs of *Afroptilum* include the two rows of denticles on the tarsal claws (similar to Fig. 2.20B) and the somewhat dorsoventrally-flattened abdomen. The medial caudal filament is well developed, but may be shorter than the cerci. The body lengths of nymphs are about 6.0–8.5 mm, and the cerci lengths 4.0–6.0 mm. The common African species *A. sudafricanum* is distinguished by having only six pairs of gills, stout setae on fore-femora lying in a cross-cross pattern, and minute terminal segment of labial palp. Nymphs of *Afroptilum* are found under small- to medium-sized stones in slow- and fast-flowing streams at a wide range of elevations.

Useful references

Barnard (1932); Lugo-Ortiz & McCafferty (1998a).

Baetis Leach, 1815
(Figs. 2.48A–D)

Systematics of the genus *Baetis* is highly problematic and has undergone considerable worldwide revision. In the Afrotropics, several species originally described under *Baetis* have been transferred to *Pseudocloeon*, whereas others still assigned to *Baetis* have a dubious taxonomic status because they are known only from subimagos or adults and cannot be adequately identified. In any case, the genus is widespread on the African continent, but has not been reported from Madagascar. There are currently ten species assigned to this genus, three of which occur in South Africa.

Baetis nymphs are distinguished by the following combination of characteristics: labial glossae subequal or shorter than paraglossae, palp segment 3 broadly rounded (Fig. 2.48B); absence of a tuft of setae on the mandibles between the prostheca and molar region; presence of the villopore (Fig. 2.20F); terga with posterior marginal spines (Fig. 2.48D). The medial caudal filament is well developed, but may be shorter than the cerci. The most common species in southern Africa is *Baetis harrisoni*, mature nymphs of which measure about 6.0 mm, with cerci between 2.5 mm and 3.0 mm. Nymphs of *Baetis* are found in riffle areas under small- to medium-sized stones at a wide range of elevations.

Useful references

Barnard (1932); Soldán (1977).

Barnumus McCafferty & Lugo-Ortiz, 1998
(Figs 2.23A–D)

The genus *Barnumus* is known from only one species, *B. editus*, from South Africa (KwaZulu-Natal and Mpumalanga provinces). Apart from having an undeveloped medial caudal filament, nymphs of *Barnumus* spp. can be identified by their relatively large size and robust body, the presence of two rows of denticles on the tarsal claws (similar to Fig. 2.20B), and the untracheated gills (Fig. 2.23D). Nymphs are large, measuring between 9.5–13.0 mm. They are found under, and on top of, stones in fast-flowing streams at high elevations.

Useful references

Lugo-Ortiz & McCafferty (1998a).

Bugilliesia Lugo-Ortiz & McCafferty, 1996
(Figs 2.54A–D)

Bugilliesia is a widespread genus in the Afrotropics, represented by five species, but has not been reported from southern Africa or Madagascar. Its nymphs are distinguished by having labial palp segment 2 with a variously-developed distomedial process and segment 3 partly fused and broadly rounded (Fig. 2.54C), and the maxillary palp has an abrupt constriction in the apical upper quarter of the terminal segment (Fig. 2.54D). The medial caudal filament is well developed. Nymphs measure up to about 5.5 mm and are found in slow- and fast-flowing streams at low and high elevations.

Useful references

Gillies (1990a); Lugo-Ortiz & McCafferty (1996c).

Centroptiloides Lestage, 1918
(Figs 2.35A–F)

The genus *Centroptiloides* is known from only one species, *C. bifasciata*, that has a widespread distribution in the Afrotropics. The genus has not been reported from Madagascar. Nymphs of *Centroptiloides* are distinguished by having a labrum with a broad, deep, U-shaped anteromedial emargination (Fig. 2.35A) and two-segmented labial palps (Fig. 2.35B). Other important distinguishing characteristics include their relatively large size (body up to 14.0 mm; cerci 10.5 mm; medial caudal filament 4.5 mm) and robust body, the presence of two rows of denticles on the tarsal claws (Fig. 2.35E), and well-tracheated gills that often have basal folds (Fig. 2.35F). The medial caudal filament, although shorter than the cerci, is well developed in mature nymphs, but greatly reduced in immature nymphs. The nymphs are predatory and generally found on top of rocks in fast-flowing waters at a wide range of elevations.

Useful references

Agnew (1962a); Crass (1947); Lugo-Ortiz & McCafferty (1998a).

Cheleocloeon Wuillot & Gillies, 1993

(Figs. 2.38A–E)

The genus *Cheleocloeon* has a widespread distribution in the Afrotropics, including Madagascar, with a total of eight species known, two of which occur in South Africa. Its nymphs are distinguished by having a labial palp segment 2 with an anteriorly-convex medial process that is distally pointed (Fig. 2.38D). Denticulation of tarsal claws varies considerably between species, some having edentate claws (Fig. 2.38A), one species with a poorly-developed row of denticles (Fig. 2.38B), and other species with two rows of minute denticles (Fig. 2.38C). Dorsal abdominal tubercles are either present or absent. The medial caudal filament is well developed. Mature nymphs measure about 6.0–7.0 mm in length, with a cerci length of about 3.0 mm. Nymphs of *Cheleocloeon* are found in riffles and stony backwaters.

Useful references

Lugo-Ortiz & McCafferty (1997a, 1997g); Wuillot & Gillies (1993a).

Cloeodes Traver, 1938

(Figs 2.52A–E)

The genus *Cloeodes* is pantropical. In the Afrotropics it has been reported from southern Africa and Madagascar only, but is probably more widespread on the African continent. Five species have been described, only one from South Africa. Its nymphs are distinguished by the following combination of characteristics: the presence of a subproximal arc of setae on the tibiae and tarsi (Fig. 2.52A); sublateral tufts of long, fine, simple setae on abdominal sterna 2–6 (Fig. 2.52B); and edentate tarsal claws, with minute striations subapically (Fig. 2.52A). The medial caudal filament is well developed. Nymphs measure up to about 3.5–6.0 mm, with the cerci about 2.0–3.0 mm. Nymphs of *Cloeodes* are found in a wide range of flowing-water habitats and elevations.

Although treated as separate genera in this chapter (since this is the state of the current literature), evidence suggests that *Cloeodes* and *Maliqua* are synonyms (J-L. Gattolliat, pers. comm., Museum of Zoology, Lausanne, Switzerland). Further work is required to clarify this.

Useful references

Gattolliat (2001a); Lugo-Ortiz et al. (1999a); Waltz & McCafferty (1994).

Cloeon Leach, 1815 and *Procloeon* Bengtsson, 1915
(Figs 2.27A–H)

The genera *Cloeon* and *Procloeon* are found on all continents except South America. The systematics is in a state of flux, and it is possible that *Procloeon* is equivalent to *Cloeon*. On the African continent, reports of *Procloeon* are particularly troublesome because none of the species are known from the nymphal stage. In any case, nymphs of species currently assigned to *Cloeon* and *Procloeon* are extremely difficult to separate, and consequently in the key provided here we treat both genera together. There are 22 Afrotropical species of *Cloeon* in the literature (nine in South Africa), and three species of *Procloeon* (one in South Africa)

Cloeon and *Procloeon* nymphs are distinguished by the following combination of characteristics: gills 1–5 or 2–6 are double (Figs. 2.27A,B,C, D); the tarsal claws are less than one-half the length of the tarsi, with small denticles in the basal one-third of the claw (Fig. 2.27E), the labium has subequal glossae and paraglossae, with palp segment 3 being broad and truncate (Fig. 2.27F) or narrow and apically tapering (Fig. 2.27G). Mature nymphs range in size from about 5.0–8.0 mm in length, and cerci up to about 2.5–6.0 mm, according to species. Nymphs of both genera are primarily found in temporary waterbodies and among vegetation in ponds, dams, stream-pools and slow-flowing streams.

Useful references

Barnard (1932); Crass (1947); Gattolliat (In Press a); Gillies (1980a, 1985); Lugo-Ortiz & McCafferty (1998c).

Crassabwa Lugo-Ortiz & McCafferty, 1996
(Figs 2.49A–D)

The genus *Crassabwa* is widely distributed in the Afrotropics, represented by four species (one in South Africa), but has not been reported from Madagascar. Its nymphs are distinguished by the following combination of characteristics: a labial palp with a thumb-like distomedial process on segment 2 (Fig. 2.49B), the presence of a subproximal arc of setae on the tibiae (Fig. 2.49A), and an enlarged subapical pair of denticles on the tarsal claws (Fig. 2.49A). The medial caudal filament is well developed. Mature nymphs of *C. flava* measure 7.5–8.5 mm, with cerci 2.7–3.0 mm (Lugo-Ortiz & McCafferty 1996a). Nymphs of *Crassabwa* are found in medium-sized streams in shallow riffles at low to moderate elevations.

Useful references

Lugo-Ortiz & McCafferty (1996a).

Dabulamanzia Lugo-Ortiz & McCafferty, 1996
(Figs 2.50A–D)

The genus *Dabulamanzia* is widespread in the Afrotropics, including Madagascar, with 11 species known in total, four occurring in South Africa. The nymphs are distinguished by the following combination of characteristics: an apically-rounded maxillary palp segment 2 (Fig. 2.50C), the presence of a subproximal arc of setae on the tibiae (Fig. 2.50A), and tarsal claws with one row of denticles (Fig. 2.50A). The medial caudal filament is well developed. Body lengths vary from 4.8–7.2 mm and cerci lengths from 2.5–3.5 mm (with the exception of the larger nymphs of *D. gigantea*). Nymphs of *Dabulamanzia* spp. are found in riffle areas in streams at a range of altitudes, and could easily be confused with those of *Nesydemius* spp.

Useful references

Crass (1947); Gattiollat, et al. (1999); Gattolliat & Sartori (2000a); Gillies (1990a); Lugo-Ortiz & McCafferty (1996b, 1997g); Wuillot & Gillies (1993b).

Delouardus Lugo-Ortiz and McCafferty, 1999
(Figs 2.30A–D)

This genus, known only from Madagascar where it is represented by two species, is distinguished by having the second segment of the labial palp deeply falcate (Fig. 2.30A), weakly-pectinate setae on the legs, and elongate, weakly-hooked claws with two rows of small, evenly sized denticles (Fig. 2.30B). *D. djabala* nymphs measure 3.7 mm, with cerci 2.1 mm (Lugo-Ortiz and McCafferty 1999). Members of this genus tend to be found in slow-flowing water, in streams without aquatic vegetation that are 3–8m wide, 10–80 cm deep, and have sandy substrates (J-L. Gattolliat, pers. comm.).

Useful references

Lugo-Ortiz and McCafferty (1999).

Demoreptus Lugo-Ortiz & McCafferty, 1997
(Figs 2.20A–F)

The genus *Demoreptus* is known only from southern Africa, where there are three species. Its nymphs are distinguished by the following combination of characteristics: relatively narrow-elongate body; mandibles without tufts of setae between the prostheca and molar region; labial palp segment 3 narrowly rounded (Fig. 2.20E) or clublike (Fig. 2.58D); elongate and outstretched legs (Fig. 2.20A); the presence of a villopore (Fig. 2.20F); claws with two rows of denticles and a pair of subapical setae (Fig. 2.20B), and an undeveloped medial caudal filament. Body sizes of nymphs vary in different species, as illustrated by the following measurements: *D. natalensis* (body length about 5.0 mm; cerci length about 5.0 mm); *D. capensis* (body length about 7.0 mm; cerci length about 4.0 mm), and *D. monticola* (body length about 7.0 mm; cerci length about 6.0 mm). Nymphs are found in fast-flowing mountain streams.

Useful references

Lugo-Ortiz & McCafferty (1997b).

Demoulinia Gillies, 1990
(Figs 2.53A–D)

The genus *Demoulinia* is known from southern Africa (one species) and Madagascar (two species). Its nymphs are distinguished by having a labial palp segment 2 with a subrectangular medial process that is broadly rounded apically (Fig. 2.53C) and slender tapering tarsal claws that are approximately two-thirds the length of the respective tarsi (Fig. 2.53A). The medial caudal filament is well developed. Mature nymphs measure up to 8.0 mm with cerci 4.0 mm. Nymphs of *Demoulinia* are psammophilous (associated with sandy substrates), but are found in a wide variety of flow regimes in lowland streams.

Useful references

Gattolliat (2003); Gillies (1990a); Lugo-Ortiz & McCafferty (1998c).

Dicentroptilum Wuillot & Gillies, 1994
(Figs 2.29A–H)

The genus *Dicentroptilum* is widely distributed in the Afrotropics, including Madagascar, where it is represented by four species, with one species in South Africa. The nymphs are distinguished by the following characteristics: relatively large size (up to about 8.5 mm, with cerci 6.0 mm, up to nearly 10.0 mm) and robust body, the pair of ventral papillae on the pro-coxae (Fig. 2.29A), the presence of a dorsal row of long, fine, simple setae on the tibiae and tarsi (Fig. 2.29D), two rows of denticles on the tarsal claws (Fig. 2.29D), and the off-set terminal segment of the labial palp (Fig. 2.29B). Dorsal abdominal tubercles (as in Fig. 2.29F) are either present or absent. The medial caudal filament is well developed. Nymphs of *Dicentroptilum* are found in fast-flowing streams at high and low elevations.

Useful references

Lugo-Ortiz & McCafferty (1998a, 2001); Wuillot & Gillies (1994).

Echinopus Gattolliat (2002b)

(Figs 2.39A–E)

Echinopus is only known from Madagascar, represented by two species. The nymphs are distinguished by a relatively narrow labrum (Fig. 2.39C); the labium (Fig. 2.39D) has slender glossae slightly shorter than the apically-rounded paraglossae; the labial palp is three segmented, segment 3 being conical and longer than broad; the outer margin of the forefemur (Fig. 2.39A) has an apico-tranverse arc of three or four long setae; the villopore is absent; the tarsal claws (Figs. 2.39A) have two rows of teeth—the second row being reduced in number—and two small subapical setae; the asymmetrical gills (Fig. 2.39E) on segments 1 to 7 have serrated margins. The medial caudal filament is slightly shorter than the cerci, and has abundant setae on both margins and the cerci each have abundant setae on the inside margin. Nymphs are small: *E.giboni* measures 4.1 mm with cerci 1.8 mm (Gattolliat 2002b), while *E. minutus* measures 3.0 mm with cerci 2.3 mm (Gattolliat 2002b).

Useful references

Gattolliat (2002b).

Edmulmeatus Lugo-Ortiz & McCafferty, 1997

(Figs 2.32A–E)

The genus *Edmulmeatus* is known from only one species, *E. grandis*, which is endemic to Madagascar. Nymphs of the genus are distinguished by the relatively large size (middle instar nymphs with lengths of 7.3–7.5 mm and cerci of 4.9–5.1 mm) and robust body, enlarged hemispherical head (Fig. 2.32A), and massive mandibles with incisors and molars forming a series of large denticles (Fig. 2.32D). The medial caudal filament is well-developed. Details of the habitat requirements of the nymphs of *Edmulmeatus* remain unknown.

Useful references

Lugo-Ortiz & McCafferty (1997c).

Glossidion Lugo-Ortiz & McCafferty, 1998

(Figs 2.43A–D)

The genus *Glossidion* is known only from Uganda, where it is represented by two species, but it is probably more widespread in the Afrotropics.

In mature nymphs the body length ranges from 7.0 mm–8.3 mm. Nymphs of the genus are distinguished by the following combination of characteristics: glossae significantly shorter than paraglossae (shorter in *G. demoulini* than in *G. mysticum*) (Fig. 2.43B), presence of the villopore (similar to Fig. 2.20F), and the absence of posterior tergal spines. Nymphs are found in fast-flowing streams at high elevations.

Useful references
Lugo-Ortiz & McCafferty (1998b).

Guloptiloides Gattolliat & Sartori, 2000
(Figs 2.34A–G)

The genus *Guloptiloides* is known from only one species, *G. gargantua*, which is endemic to Madagascar. Its nymphs are distinguished by the following combination of characteristics: a large size—body length 12.0 mm, cerci 5.2 mm (Gattolliat & Sartori 2000)—and robust body; an apically serrate antennal flagellum (Fig. 2.34E); a labrum that is wider than long, with an anteromedial lobe (Fig. 2.34A), and tarsal claws with two rows of denticles (Fig. 2.24G). The medial caudal filament is well developed. Nymphs of *Guloptiloides* are predatory, and found in fast- to moderately-flowing streams at medium elevations.

Useful references
Gattolliat & Sartori (2000b).

Herbrossus McCafferty & Lugo-Ortiz, 1998
(Figs 2.36A–H)

The genus *Herbrossus* is endemic to Madagascar, where three species are known. Its nymphs are distinguished by the following combination of characteristics: a relatively large size (body length 8.5–10.0 mm, cerci 9.0–10.5 mm—Lugo-Ortiz & McCafferty 1998a) and robust body, a conspicuously wider-than-long labrum that has a relatively narrow, deep, U-shaped anteromedial emargination (Fig. 2.36A), well-tracheated asymmetrical gills (Fig. 2.36C,D) and a small third segment on the labial palp (Fig. 2.36 B). There are two rows of denticles on the tarsal claws (Fig. 2.36H). The medial caudal filament is well developed. Nymphs of *Herbrossus* are found at shallow depths in medium-sized streams at moderate elevations.

Useful references
Gattolliat & Sartori (1998); Lugo-Ortiz & McCafferty (1998a).

Kivua McCafferty & Lugo-Ortiz, 1996

Only described as adults, from the Ivory Coast and Congo, where two species are known.

Useful references

Lugo-Ortiz & McCafferty (1996c).

Labiobaetis Novikova & Kluge 1987

(Figs 2.45A–G)

This genus was originally erected as a sub-genus to incorporate several species placed in *Baetis*, but was then raised to generic level by McCafferty & Waltz (1995). Lugo-Ortiz & McCafferty (1997d) described several more species in *Labiobaetis*, but then Lugo-Ortiz et al. (1999b) transferred all *Labiobaetis* species to *Pseudocloeon*. Gattolliat (2001c) refutes this, but has not reassigned all *Pseudocloeon* species back to *Labiobaetis*. Hence the genus is in a state of flux that cannot be clarified until the nymphal stage of the type species of *Pseudocloeon* (*P. kraepelini*) is known. (See the description of diagnostic generic features below under *Pseudocloeon*).

Useful references

Gattolliat (2001c); Lugo-Ortiz & McCafferty (1997d); Lugo-Ortiz et al. (1999b); McCafferty & Waltz (1995).

Maliqua Lugo-Ortiz & McCafferty, 1997

(Figs 2.52A–E)

The genus *Maliqua* is known from two species: *M. plumosa* from Mali and Guinea and *M. abdallahi* from Lake Malawi. Its nymphs are distinguished by the following combination of characteristics: edentate claws (Fig. 2.52A); the presence of a subproximal arc of setae on the tibiae and tarsi (Fig. 2.52A) (J-L. Gattolliat, pers. comm; McCafferty 2000); labial palp segments 2 and 3 that are subequal in length, with segment 3 being somewhat elongate and apically rounded (Fig. 2.52D), and a well-developed medial caudal filament. Nymphs of *Maliqua* from West Africa were collected from rivers, while those from Malawi were from the littoral zone in the lake, where they were exposed to wave action. Nymphs measure from about 3.5–6.0 mm in length, with the cerci being about 2.0–3.0 mm.

Although treated as separate genera in this chapter (since this is the state of the current literature), evidence suggests that *Cloeodes* and *Maliqua* are synonyms (J-L. Gattolliat, pers. comm.). Further work is required to clarify this.

Useful references

Lugo-Ortiz & McCafferty (1997e); McCafferty (2000); Wuillot & Gillies (1993b).

Micksiops McCafferty, Lugo-Ortiz & Barber-James, 1997
(Figs 2.21A–C)

The genus *Micksiops* is known only from one species—*M. bicaudatum* from Guinea—but is possibly more widespread in the Afrotropics. Its nymphs are distinguished by the following combination of characteristics: medial caudal filament reduced; the right mandible has a small tuft of setae between the prostheca and the molar (Fig. 2.21B), segment 3 of the labial palp is broadly rounded and somewhat medially produced (Fig. 2.21C); the villopore is absent, and the medial caudal filament is undeveloped. Body length of the nymph is 4.5 mm. Details of the habitat requirements of the nymphs are unknown.

Useful references

McCafferty et al. (1997).

Mutelocloeon Gillies & Elouard, 1990
(Figs 2.51A–C)

The genus *Mutelocloeon* is widespread in the Afrotropics, represented by two African species, and adults of a third species have been reported from Madagascar, but since freshwater mussels do not occur in Madagascar (Gattolliat pers. comm), this is unlikely. The nymphs are unique among small minnow mayflies in that they are found in symbiosis with mutelid mussels, attached to the folds of the branchiae within the mantle cavity. They are distinguished by having two-segmented labial palps, with segment 2 being apically bulbous (Fig. 2.51C), short maxillary palps (Fig 2.51B) and edentate tarsal claws (Fig. 2.51A). The medial caudal filament is equal in length to the cerci, and varies from one sixth to one third of the length of the body (Gillies & Elouard 1990). While the body length of the nymph has not been reported, the adult male measures 10.0 mm, and the female 12.0 mm (Gillies & Elouard 1990).

Useful references

Gillies & Elouard (1990); Kimmins (1956); Lugo-Ortiz & McCafferty (1997g).

Nesoptiloides Demoulin, 1973
(Figs 2.33A–D)

The genus *Nesoptiloides* is known from only one species: *N. electroptera*, endemic to Madagascar. Its nymphs are distinguished by the following combination of characters: robust body and relatively large size (about 7.0 mm); forelegs with femora with broadly-based ventral humps (Fig. 2.33A), tibiae with ventrodistal processes (Fig. 2.33A), and tarsal claws with two rows of denticles (Fig. 2.33A). The glossae and paraglossae on the labium are divergent (Fig. 2.33C); the labrum is covered with setae; the asymmetrical gills are well tracheated (Fig. 2.33D), and the medial caudal filament is well developed. Nymphs of *Nesoptiloides* are found in riffles of fast-flowing streams at moderate elevations.

Useful references

Demoulin (1973); Gattolliat & Sartori (1999b); Lugo-Ortiz & McCafferty (1998a).

Nesydemius Lugo-Ortiz & McCafferty, 1998
(Figs 2.50E & F)

This genus is known only from one species in Madagascar. Its nymphs are distinguished by the following combination of characteristics: maxillary palp segment 2 with a papillaform apex (Fig. 2.50F); the presence of a subproximal arc of setae on the tibiae (similar to Fig. 2.50A), and tarsal claws with one row of denticles, two enlarged subapically (Fig. 2.50E). The medial caudal filament is well developed. The body length of nymphs varies from 5.0–7.0 mm and the cerci from 2.5–3.5 mm. Details of the habitat requirements of nymphs have not yet been described. Nymphs of this genus can easily be confused with those of *Dabulamanzia*.

Useful references

Lugo-Ortiz & McCafferty (1998d).

Nigrobaetis Novikova & Kluge, 1987
(Figs 2.46A–D)

This genus has a widespread distribution in the Palaearctic. In Africa members of the genus are widely separated, being known only from North Africa (Soldán 1977; Soldán & Thomas 1983) and Namibia (Lugo-Ortiz & de Moor 2000). Its nymphs are distinguished by the following combination of characteristics: the presence of a frontal carina (Fig. 2.46A); three-segmented labial palps, with segment 3 bluntly pointed apicolaterally (Fig. 2.46B); maxillary palps without a distomedial constriction on segment 2 (Fig. 2.46C), and the absence of the villopore. The medial caudal filament is well developed. Nymphs of *N. bethunae* measure 3.6–3.8 mm in length, with caudal filaments 1.9–2.0 mm (Lugo-Ortiz & de Moor 2000). Nymphs of *Nigrobaetis* are found in riffles of medium-size, fast-flowing streams.

Useful references

Lugo-Ortiz & de Moor (2000); Soldán (1977); Soldán & Thomas (1983).

Ophelmatostoma Waltz & McCafferty, 1987
(Figs 2.41A–C)

The genus *Ophelmatostoma* is widespread in the Afrotropics, represented by only one species, but has not been reported from Madagascar. Its nymphs have the following distinguishing characteristics: labium with glossae and paraglossae that are divergent, greatly elongate and slender with a terminal fringe of long, fine, simple setae; two-segmented labial palps, with segment 1 being abruptly angled towards the interior, and segment 2 being apically bulbous (Fig. 2.41A); the maxilla has a very slender, two-segmented palp (Fig. 2.41C); the tarsal claws have four to six large denticles basally (Fig. 2.41B), and the medial caudal filament is well developed and slightly shorter than the cerci. Nymphs measure about 4.0 mm, with cerci of about 1.5 mm. Nymphs of *Ophelmatostoma* are mostly found among vegetation in moderate-flowing, lowland streams.

Useful references

Gillies et al. (1990); Kimmins (1955); Waltz & McCafferty (1987).

Peuhlella Lugo-Ortiz & McCafferty, 1998
(Figs 2.31A–D)

This genus is known only from one species (*P. christinae* from Guinea), but it is possible that the genus is more widespread. Its nymphs are distinguished by the enlarged abdominal segment 1 (Fig. 2.31A) and the presence of two rows of denticles on the tarsal claws (Fig. 2.31D). The labium (Fig. 2.31C) has narrow glossae, and small terminal segments on the palps. The medial caudal filament is well developed. Nymphs measure about 4.0 mm; cerci length not known. Details of the habitat requirements of the nymphs of *Peuhlella* remain unknown.

Useful references

Lugo-Ortiz & McCafferty (1998a); Wuillot & Gillies (1993b).

Potamocloeon Gillies, 1990
(Figs 2.28A–F)

The genus *Potamocloeon* is widespread in the Afrotropics, with one species known from Africa north of the equator. A second species has been described from north-eastern South Africa. The nymph of a species from Madagascar has been described but not named. Adult male specimens have also been described, but as they have not yet been associated with the nymph, these have not yet been named either (Gattolliat 2003). *Potamocloeon* nymphs are distinguished by having elongate and edentate tarsal claws (Fig. 2.28D), a labium with glossae considerably shorter than paraglossae and labial palp segment 2 that is broadly wedge-shaped (Fig. 2.28E). Mature nymphs have a body length of about 5.5 mm and a cerci length of about 1.8 mm. Nymphs of *Potamocloeon* are found on silt/clay substrates in slow currents and shallow waters.

Useful references

Gattolliat (2003); Gillies (1988 & 1990b); Lugo-Ortiz & McCafferty (1996c).

Pseudocloeon Klapálek, 1905

(Figs 2.45A–G)

The taxonomy of this genus has a history of worldwide confusion. In the Afrotropics, several species assigned to *Baetis* and all species assigned to *Labiobaetis* were reassigned to *Pseudocloeon* (Lugo-Ortiz et al. 1999b). The genus is found on all continents except South America, and is widespread in the Afrotropics, including Madagascar.

In the Afrotropics, nymphs of *Pseudocloeon* are distinguished by the following combination of characteristics: a labial palp segment 2 with a variously developed, thumb-like distomedial process (Fig. 2.45A) and a maxillary palp segment 2 with a distomedial concavity (Fig. 2.45B) or constriction (Fig. 2.45C). Other characteristics associated with nymphs of *Pseudocloeon* elsewhere may be present or absent in Afrotropical species. These include the presence of the villopore (Fig. 2.45G) and a distolateral modification of the antennal scapes (Figs 2.45D, E, F). The medial caudal filament is well developed. Nymphs of *Pseudocloeon* are found under stones and among vegetation in a wide range of flowing water regimes and elevations.

More recent work (Gattolliat 2001c) refutes the validity of placing so many species in the all-encompassing *Pseudocloeon*, and recognizes the genus *Labiobaetis*, describing six new species from Madagascar (see discussion under *Labiobaetis* above). As the literature stands, there are 15 Afrotropical species of *Pseudocloeon*, with eight in South Africa.

Useful references

Gattiollat (2001c); Lugo-Ortiz & McCafferty (1997d); Lugo-Ortiz, et al. (1999b); Lugo-Ortiz et al. (1999b).

Pseudopannota Waltz & McCafferty, 1987
(Figs 2.44A–E)

This genus *Pseudopannota* is widespread in the Afrotropics, including Madagascar. It is represented by eight species, one of which occurs in South Africa. Its nymphs are distinguished by the following combination of characteristics: two-segmented labial palps, with segment 2 being apically expanded or bulbous (Fig. 2.44B); three-segmented maxillary palps that extend well beyond the galea-laciniae (Fig. 2.44A), and forewing pads that are generally fused for more than one half of their length. There are two subgenera, based on how far this fusion extends: subgenus *P. Pseudopannota* has a thorax with forewing pads that are fused for more than half their length (Fig. 2.44D), while subgenus *P. Hemipannota* has forewing pads fused for less than half their length (Fig. 2.44E). Nymphs of *Pseudopannota* measure up to 6.5 mm, with cerci up to 4.0 mm. The medial caudal filament is well developed, but shorter (about 2.0 mm) than the cerci. Nymphs of *Pseudopannota* are found under stones and among vegetation in moderately-flowing streams at high and low elevations.

Useful references

Elouard et al. (1990); Elouard & Hideux (1991a); Gattolliat, (2002c); Waltz & McCafferty (1987).

Rhithrocloeon Gillies, 1985
(Figs 2.47A–D)

This genus *Rhithrocloeon* is known only from eastern and central Africa, where two species are known, but it probably extends to southern Africa. Its nymphs are distinguished by having gills on abdominal segments 2–7 (Fig. 2.47C) and labial palps with segment 2 basally narrow, distomedially broadly rounded, and produced, and with segment 3 nipple-like and partially fused to segment 2 (Fig. 2.47A). The median caudal filament is well developed, about half to two-thirds the length of the cerci. Mature nymphs are about 6.0–7.0 mm long (basing this on adult measurements). Nymphs of *Rhithrocloeon* are found under medium- to small-size stones in fast- and moderate-flowing streams.

Useful references

Gillies (1985, 1988); Lugo-Ortiz & McCaffety (1996c).

Rheoptilum Gattolliat, 2001

(Figs 2.25A–G)

The genus *Rheoptilum* is known only from two species in Madagascar. These have the following distinguishing characteristics: dense rows of long setae on the dorsal margins of the femora, tibiae and tarsi (Fig. 2.25A & G); tarsal claws with two rows of denticles and a pair of subapical setae (Fig. 2.25G); very long cerci—approximately twice the length of the body— with the medial caudal filament reduced to a point (Fig. 2.25A); untracheated gills (Fig. 2.25B), and both mandibles with well-developed tufts of setae between the molar and the incisor regions. The maxillary palp has a small third segment (Fig. 2.24C). The labrum (Fig. 2.25D) is wide and densely setose submarginally, while the distal margin is only very shallowly notched. Nymphs of one species measure 6.4 mm with cerci of 12.2 mm; the second species measures 4.0 mm with cerci of 9.5 mm. The nymphs are found in fast-flowing, shallow streams, usually in areas of primary forest.

Useful references

Gattolliat (2001b).

Scutoptilum Gattolliat, 2002b

• (Figs 2.22A–D)

The genus *Scutoptilum* is known from Madagascar only, represented by one species. The nymph is distinguished by the following combination of characteristics: it is easily recognized by having a prothorax that is broadly expanded laterally (Fig. 2.22A), and a head that is subrectangular, with prominent eyes. The pro- and mesothorax are covered with small black warts (Fig. 2.22A), as are the abdominal terga, but not the sterna. The forewing pads are well developed, and hindwing pads are present. The labrum (Fig. 2.22D) is broad, with an almost-straight distal margin, and an arc of abundant long stout setae lying subparallel to the distal margin. There is a tuft of setae between the prostheca and molar region of both mandibles. The maxillary palp is two-segmented and subequal in length to the galea-lacinia. The labium (Fig. 2.22C) has glossae that are slightly shorter than the paraglossae, a three-segmented palp with the second segment being slightly produced apicomedially, and segment 3 being short and subconical. The forelegs (Fig. 2.22B) are short and stout and characterized by the presence of subapico-transverse arcs of long spatulate setae on the outer margins of the femora, the absence of a villopore, a dorsal margin with a row of stout setae, tibiae and tarsi that lack long setae on the dorsal margin, and the presence of two rows of denticles on the tarsal claws, the second row being reduced; two subapical setae present. The gills are asymmetrical (Fig. 2.22A) on segments 1–7, have tracheation that is extremely reduced or not visible, and margins that are smooth. The medial caudal filament is reduced to a single segment, the cerci have swimming setae on the last third of the inside margin. Mature nymphs measure 4.0 mm, with cerci 1.9 mm.

Scutoptilum is found in fast-flowing waters. It mouthparts are modified for scraping the tops of the stones.

Useful references
Gattolliat (2002b).

Susua Lugo-Ortiz & McCafferty, 1998
(Figs 2.37A–F)

The genus *Susua* is known only from one species (*S. niandanensis*, from Guinea), but the genus may be more widespread in the Afrotropics. The nymphs are distinguished by having the subapical denticles of the two rows of denticles of the tarsal claws conspicuously larger than the rest of the denticles (Fig. 2.37B) and gill 1 being narrow-elongate and poorly tracheated (Fig. 2.37C). The second segment of the labial palp has a small, upwardly- pointing, thumb-like distomedial projection (Fig. 2.37A). The medial caudal filament is well developed. Nymphs measure about 4.0 mm; the length of cerci is unknown. Details of the habitat requirements of the nymphs of *Susua* are unknown.

Useful references
Gillies (1985, 1988); Lugo-Ortiz & McCaffety (1998a).

Tanzaniella Gillies, 1991
(Figs 2.19A–E)

The genus *Tanzaniella* is known from only one species (*T. spinosa*, from Tanzania). Its nymphs are distinguished by the following combination of characters: a relatively narrow-elongate body; the presence of small dorsal abdominal tubercles on terga 1–7 or 1–8 (Fig. 2.19A); a labial palp with segments 2 and 3 appearing fused, and with segment 3 broadly rounded (Fig. 2.19D); outstretched legs, and the presence of a villopore (similar to Fig. 2.20F). The medial caudal filament is undeveloped. Mature nymphs measure about 5.0 mm, and the cerci are approximately as long as the body. Nymphs of *Tanzaniella* are found under stones in fast-flowing mountain streams.

Useful references
Gillies (1991a).

Thraulobaetodes Elouard & Hideux, 1991
(Figs 2.18A–D)

The genus *Thraulobaetodes* is known from only one species: *T. cumminsorum* from Guinea. The nymphs are distinguished by the ventrally-oriented, fringed gills on abdominal segments 2–7 (Figs. 2.18A,B), the presence of dorsal abdominal tubercles (Fig. 2.18A), and two rows of denticles on the tarsal claws. The maxilla (Fig. 2.18C) has a small downwardly-orientated palp with the third segment minute, and the labium (Fig. 2.18D) has the glossae fused in their basal half. The medial caudal filament is undeveloped. Nymphs of *Thraulobaetodes* are found crawling under stones in fast-flowing mountain streams.

Useful references
Elouard & Hideux (1991b).

Xyrodromeus Lugo-Ortiz & McCafferty, 1997
(Figs 2.42A–F)

This genus has been reported from Kenya and Uganda, where it is represented by one species, and Madagascar, where four species are known. It is possible that on the African continent the genus extends farther south. Its nymphs are distinguished by the following combination of characteristics: mandibles with bladelike incisors (Fig. 2.42B); labium with glossae subequal to, but narrower than, three-segmented labial palps, with segment 2 basally narrow and distomedially expanded, and segment 3 small and caplike (Fig. 2.42C); three-segmented maxillary palps, with no distomedial constriction on segment 3 (Fig. 2.42D), and the absence of a villopore. The medial caudal filament is well developed. Nymphs vary in size from about 5.0–7.0 mm, with cerci of about 6.0 mm. Details of the habitat requirements of the nymphs of *Xyrodromeus* remain unknown.

Useful references
Gattolliat (2002a); Lugo-Ortiz & McCafferty (1997f).

HEPTAGENIIDAE

The family Heptageniidae, or flat-headed mayflies, is known from all continents except Australia and South America. In the Afrotropics three genera are currently recognized, with *Afronurus* and *Compsoneuria* having a widespread distribution. *Thalerosphyrus* is found in the extreme north of the region, and has also recorded from Madagascar. As the literature stands at present, the genus *Compsoneuriella* has been put into synonymy with

Compsoneuria (Braasch & Soldan 1986), although there are conflicting opinions about the validity of this, and some papers refer, instead, to the genus *Compsoneuriella*. There is difficulty in distinguishing the Afrotropical species described as *Compsoneuria* and *Thalerosphyrus*, indicating problems with the assignment of species to these genera.

Heptageniid nymphs are distinguished by having a prognathous head capsule that is more or less circular and, from the dorsal view, covers the mouthparts (Fig. 2.11A), and gills 2–5 consisting of plate-like dorsal lamellae and fibrilliform ventral portions (e.g. Figs 2.55A–C & E–G; Figs 2.57A–C). In addition, the body is dorsoventrally flattened, and the legs are outstretched to the sides (Fig. 2.11A). Heptageniid nymphs are found at a wide range of elevations in riffle areas under stones, where they feed on periphyton.

Afronurus Lestage, 1924
(Figs 2.55A–H)

This genus is widespread in Africa and is also found in Madagascar. There are 13 species in the Afrotropical Region, with six species in South Africa. The nymphs are distinguished by the lack of supracoxal spurs (cf. Fig. 2.56) and have apically-rounded (Fig. 2.55A,B,D), or weakly-pointed to pointed gills (Figs. 2.55C, E–H). *Afronurus* nymphs are relatively large, the females being generally larger than the males (with body lengths being, respectively, up to about 11.0 mm and 10.0 mm). Nymphs of *Afronurus* are found under stones in riffle areas.

Useful references

Sartori & Elouard (1996); Schoonbee (1968).

Compsoneuria Ulmer, 1939
(Fig. 2.57A–D)

This genus is widespread in the Afrotropics. Its nymphs are distinguished by the presence of well-developed supracoxal spurs (Fig. 2.56) and apically-pointed gills (like Figs 2.57A–D). According to current literature, there are four species of *Compsoneuria*, with two species in South Africa. Nymphs of *Compsoneuria* are found under stones in riffle areas.

Useful references

Crass (1947); Sartori & Elouard (1996); Schoonbee (1967).

Thalerosphyrus Eaton, 1881
(Figs 2.57A–D)

Only one species of this genus has been described from Africa, on the extreme northern border of the Afrotropical region, in the mist oasis of Erkwit, Sudan (Soldán 1977). Edmunds (pers. comm. in Soldán 1977) reports an undescribed species from Madagascar. Subsequently, Sartori & Elouard (1996) have described a species from Madagascar. Like *Compsoneuria*, it has apically pointed gills (Figs. 2.57A–D).

Useful references
Sartori and Elouard (1996); Soldán (1977).

OLIGONEURIIDAE

Oligoneuriidae, or brush-legged mayflies, are known from all continents except Australia. In the Afrotropics, the family is represented by two genera, *Elassoneuria* and *Oligoneuriopsis*, with a distinct subgenus of *Elassoneuria*, *Madeconeuria*, in Madagascar. A new genus has recently been recognized from material collected in Tanzania (pers. obs.). The mature nymphs are large (up to about 30.0 mm) and are distinguished by the following characteristics: gill 1 is ventrally oriented and fibrilliform (Figs. 2.58B,C); the presence of fibrilliform filaments at the base of the maxillae (Fig. 2.8F), and forelegs with long setae that are used for filtering. Oligoneuriid nymphs are found in fast-flowing streams at high elevations (Figs 2.8A & B).

Elassoneuria Eaton, 1881
(Figs 2.58A–B)

This genus is widespread in the Afrotropics, where six species are known, including Madagascar. In Madagascar, the genus is represented by the subgenus *Madeconeuria*. The nymphs of *Elassoneuria* are distinguished by the presence of a distinct frontal carina on the head (Fig. 2.58A) and slightly apically-pointed gills (Fig. 2.58B), which are slightly longer than the length of the adjacent abdominal segment. Nymphs of *Elassoneuria* are found under stones in fast-flowing streams at low to high elevations.

Useful references
Demoulin (1966a); Gillies (1974).

Oligoneuriopsis Crass, 1947
(Figs 2.59A–D)

The genus *Oligoneuriopsis* is known only from Africa, with one species from East Africa, and three from Lesotho and South Africa. Its nymphs are distinguished by the absence of a frontal carina (Fig. 2.59A) and the apically-rounded gills (Fig. 2.59D), which are shorter than the length of the adjacent abdominal segment. These nymphs measure up to about 20.0 mm body length, with a cerci length of about 8.0 mm. Nymphs of *Oligoneuriopsis* are found under stones in mountain streams.

Useful references

Agnew (1973); Crass (1947).

TRICORYTHIDAE

The family Tricorythidae has recently undergone a revision (McCafferty & Wang 2000), resulting in the separation of several families (including the Afrotropical families Ephemerythidae and Machadorythidae), that were formerly part of Tricorythidae. In addition, several new genera have recently been described from Madagascar (Elouard & Oliarinony 1997; Oliarinony & Elouard 1997; Oliarinony et al. 1998a). There are currently seven genera recognized in the Afrotropics, three of which are endemic to Madagascar, with only two genera in South Africa. The nymphs of Tricorythidae (as it is now defined) do not have operculate gills. Filamentous gill 1 is absent and lamellate gills are present on abdominal segments 2–6. The maxillae are broad with well-developed apical setae. Hindwing pads are absent. Nymphs of Tricorythidae tend to be found under rocks in moderate to swiftly-flowing currents, or among plants in slower currents. The Afrotropical tricorythids generally feed by filtering. The nymphs are not known for all genera, however, and feeding behaviour may vary between species.

Dicercomyzon Demoulin, 1954

(Figs 2.60A–E)

This genus is widespread in the Afrotropics, but has not been reported from Madagascar. There are four species. The nymphs are distinguished by the dorsoventrally-flattened body (Fig. 2.60A), the enlarged and flattened femora (Fig. 2.60A), the ventral plastron that is fringed with setae, forming a 'sucker disc' (Fig. 2.60B), and the marginally-fringed gills on terga 2–6 (Figs. 2.60C, D). The anterior margin of the head is fringed with setae (Fig. 2.60E). The nymphs measure about 5.0 mm in length. Nymphs of *Dicercomyzon* are found among vegetation in slow sections of streams and among leaf litter in mountain streams.

Useful references

Demoulin (1954, 1957 & 1964); Kimmins (1957).

Madecassorythus Elouard & Oliarinony, 1997
(Figs 2.61A–D)

There are four species of *Madecassorythus*, all of which occur in Madagascar. The nymphs of this genus can be very easily confused with those of *Tricorythus*. Like *Tricorythus*, the mandibles (Fig. 2.61D) are robust and prominent, with a strong fringe of long setae along the lateral margin, which are clearly visible in dorsal view. The labrum is quadrate, with minimal anteromedial emargination. The labium has the same structure seen in *Tricorythus* (Fig. 2.62E) with the glossae and paraglossae fused with the prementum, forming a single flat surface; labial palps are three segmented with the terminal segment being very small. The three-segmented maxillary palp extends well beyond the galea-lacinia. The morphology of the adult males of the two genera is clearly different, and it is this which forms the basis for the separation of the two genera. Nymphs vary in size between 6.0 mm to nearly 9.0 mm, depending on the species.

Madecassorythus is localized in the eastern coastal forest zones and the plateau region of Madagascar.

Useful references

Elouard & Oliarinony (1997); Oliarinony, Sartori & Elouard (2000).

Manohyphella Allen, 1973*

Originally placed as a member of the Ephemerellidae (subfamily Teloganodinae) (Allen 1973), this genus was moved to the Tricorythidae by McCafferty & Wang (1995). Some authors (e.g. Elouard et al. 2001) still consider it to belong to the Teloganodidae. Occurs in Madagascar. Apparently, only the adults of this genus are known.

Useful references

Allen (1973); McCafferty & Wang (1995, 2000).

Ranorythus Oliarinony & Elouard, 1997

Occurs in Madagascar. Only the adults of this genus are known.

Useful references

Oliarinony & Elouard (1997)

Spinirythus Oliarinony & Elouard, 1998

Occurs in Madagascar. Only the adults of this genus have been described.

Useful references

Oliarinony et al. (1998a).

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*At the time of going to press it was noted that McCafferty & Wang (2000) have now placed this genus in the Teloganodidae.

Tricorythus Eaton, 1868
(Figs 2.16F–H & 2.62A–F)

The nymphs of *Tricorythus* share many similarities with those of *Madecassorythus*. The mandibles are robust and prominent, with a strong fringe of long setae along the lateral margin (Figs. 2.62C, D), which is clearly visible when viewing the nymph from above (Fig. 2.16F). The labrum is quadrate, with minimal anteromedial emargination. The labium has the glossae and paraglossae fused with the prementum, forming a single flat surface (Fig. 2.62E); labial palps are three segmented with the terminal segment very small. The maxillae (Fig. 2.16H) have strong brushes of setae laterally and apically, with a long two-segmented palp extending well beyond the galea-lacinia. The femora are broad and stout, with stong spatulate setae arranged in various patterns dorsally (Fig. 2.62F). The claws have one to a few strong denticles medially (Fig. 2.62F). It is interesting to note that the male nymphs of African *Tricorythus* species have much larger eyes than the female nymphs (personal observations), a feature which is not evident in Madagascan species of *Tricorythus* (Sartori, pers. comm., Museum of Zoology, Lausanne, Switzerland). In fact, one of the features used to separate *Madecassorythus* from Madagascan species of *Tricorythus* is that *Madecassorythus* male nymphs have larger eyes than females (Oliarinony et al. 2000). Male nymphs are generally smaller (6.0–7.0 mm) than female nymphs (9.0–10.0 mm), and cerci are about as long as the body. The nymphs are usually found on stones in fast- flowing sections of a river.

Useful references

Barnard (1932); Crass (1947); Oliarinony et al. (1998b).

EPHEMERYTHIDAE
(Figs 2.16A–E)

The family Ephemerythidae was originally placed as a subfamily within the Tricorythidae (Gillies 1960), but McCafferty and Wang (2000) raised the group to family status. The Ephemerythidae are endemic to and widespread in Africa (including Morocco), being known in the Afrotropics ss. from South Africa, Congo, Tanzania and Nigeria. The family is represented by only one genus (*Ephemerythus)* of which there are five species. Gills are only present on segments 2–5 (there is no filamentous gill 1), and gill 2 is operculate (Fig. 2.16A). The maxillae do not have palps (Fig. 2.16B), and the third segment of the labial palp is small in comparison to the other segments (Fig. 2.16C). The tarsal claws are distinctive, with larger, widely-spaced denticles basally and several smaller, closely-spaced denticles towards the apex (Fig. 2.16E). Nymphs measure up to about

6.0 mm with cerci about 4.0 mm. *Ephemerythus* nymphs are found on a variety of substrates (rocks, plants, roots, submerged logs and amongst litter in back water eddies). They occur in cool mountain streams, to warm lowland rivers, and generally prefer moderate to fast-flowing current.

Useful references

Demoulin (1964); Gillies (1960) (adult only); Kimmins (1955) (described as an unknown genus of Ephemerellidae); McCafferty & Wang (2000).

MACHADORYTHIDAE

(Figs 2.6A–F)

The family Machadorythidae (elevated to this status by McCafferty & Wang 2000), is represented by one species only: *Machadorythus maculatus*, which is widely distributed in the Afrotropics, including South Africa, but has not been reported from Madagascar. The nymphs have narrowly-set, dorsally-protruding eyes (Figs 2.6A & C) and terga 3–7 dorsally expanded, forming an open V-shaped compartment protecting the gills (Figs. 2.6 A, B). Mature nymphs are about 5.0 mm in length. Nymphs are apparently predatory and found on unstable substrates (sand, silt and organic detritus) in slow-flowing stretches of streams.

Useful references

Demoulin (1959), Elouard & Gillies (1989); McCafferty & Wang (2000).

TELOGANELLIDAE

(Figs 2.15A–C)

The family Teloganellidae is represented in the Afrotropics by an undescribed genus from Madagascar, where only a female adult has been collected. The family is also known from one species from Malaysia: *Teloganella umbrata*, the female adults of which show the same characteristics as the undescribed species from Madagascar. The Malaysian nymphs (Fig. 2.15A) apparently have a filamentous gill 1, an operculate gill 2, and lamellate gills on segments 2–5. The maxillary palps are absent (Fig. 2.15B), and the labial palps are three-segmented (Fig. 2.15C). The forefemora are expanded anteriorly and all femora are fringed with short, stout setae (Fig. 2.15A). Hindwing pads are present but small. The nymphs are moderately small (4.5–5.0 mm) (Wang et. al. 1995). Ecological information on this family is entirely lacking.

Useful references

McCafferty & Wang (2000).

TELOGANODIDAE

(Figs 2.13, 2.14A–F & 2.63–2.66)

Afrotropical members of the family Teloganodidae were originally placed as a subfamily, Teloganodinae, in the family Ephemerellidae. This was elevated to family level (McCafferty & Wang 1997). The Teloganodidae are Gondwanan in origin, and are currently represented by eight described genera from South Africa, the Orient and Australia (McCafferty & Wang 1997). In the Afrotropics the family is represented by four genera that are found primarily in the southern and southwestern region of the Cape, and an undescribed genus from Madagascar (Elouard et al. 2001). The Madagascan genus, *Manohyphella,* was originally placed in the Ephemerellidae (Allen 1973), but was subsequently moved to the Tricorythidae (McCafferty & Wang 1997). Some authors, however, still consider it to be a teloganodid (Elouard et al. 2001). In this guide it will, therefore, be considered under the Tricorythidae*.

Teloganodid nymphs are distinguished by the following characteristics: a posterior V-shaped medial notch and submedial lobes on the mesonotum (e.g. Figs. 2.14D, 2.63A, 2.64A); lateral, simple, filamentous gills that are generally present on abdominal segment 1 (Figs. 2.63A & C, 2.64A), and operculate (Fig. 2.64A) or semioperculate (Fig. 2.63A, 2.65A, 2.66A) gills 2; a hypognathous head, and a squat and somewhat dorsoventrally-flattened body. Mature male nymphs show subdivided compound eyes (e.g. Fig. 2.65A). Teloganodid nymphs are found in clean, fast-flowing mountain streams, and feed on periphyton and fine detritus (McCafferty & Wang 1997).

Ephemerellina Lestage, 1924

(Figs 2.65A & B)

The genus *Ephemerellina* is known only from one species: *E. barnardi* from the Western Cape. Its nymphs are distinguished by the presence of single, sharp dorsal abdominal tubercles (Fig. 2.65A) and semi-operculate gills on abdominal segments 2–6. Its claws have a single row of denticles (Fig. 2.65B). Mature nymphs measure up to 10.0 mm. Nymphs of *Ephemerellina* are found in moss on vertical rock faces of waterfalls of small mountain tributaries and on leaves of *Isolepis* (Cyperaceae) in swiftly-flowing acidic streams.

Useful references

McCafferty & Wang (1997).

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* At the time of going to press it was, however, noted that McCafferty & Wang (2000) have now placed this genus in the Teloganodidae. In the Appendix it has been placed in the Teloganodidae.

Lestagella Demoulin, 1970
(Fig. 2.64)

The genus *Lestagella* is known from only one species, *L. penicillata*, from the southern and Western Cape. Its nymphs are distinguished by having the head anteriorly fringed with long setae (Fig. 2.64) and operculate gills on abdominal segment 2 (Fig. 2.64). Mature nymphs are relatively small, measuring about 8.0 mm, with cerci measuring about 0.4 mm. Nymphs inhabit fast-flowing streams, clinging to the underside of stones.

Useful references
Demoulin (1970); McCafferty & Wang (1997).

Lithogloea Barnard, 1932
(Figs 2.66)

The genus *Lithogloea* is known from only one species: *L. harrisoni*, from the southern and western Cape. Its nymphs are distinguished by the presence of broadly-based dorsal abdominal tubercles (Fig. 2.66) and filamentous gills on abdominal segment 1. Mature nymphs measure about 7.0 mm. Nymphs of *Lithogloea* are found in swift mountain streams among leaves of *Isolepis* (Cyperaceae).

Useful references
Barnard (1932); McCafferty & Wang (1997).

Nadinetella McCafferty & Wang, 1998
(Figs 2.63A–E)

The genus *Nadinetella* is known from two species: *N. brincki* and *N. crassi*, both from the South Western Cape. The nymphs of this genus are distinguished by the following combination of characteristics: lamellate, semi-operculate gills on abdominal segments 2–5; claws with two rows of denticles (Fig. 2.63B) and paired dorsal abdominal tubercles (Figs 2.63A & C), or terga with broad, straight margins or at least some terga with slightly bifurcated posteromedial protuberances (Figs 2.63D & E). Mature nymphs measure about 9.0 mm. Nymphs are found in moss growing on the rock faces of waterfalls and other lower-gradient biotopes in mountain streams.

Useful references
Allen & Edmunds (1963); McCafferty & Wang (1997, 1998).

CAENIDAE

(Figs 2.13 & 2.67–2.72)

The family Caenidae is found worldwide, but like most mayflies, they are not found on oceanic islands. The family is poorly known from Africa, and it is likely that several new genera await discovery. Seven genera are currently known from the Afrotropics, with one of these endemic to Madagascar. A further Madagascan genus awaits description (Elouard et al. 2001). Only three genera are recognized in South Africa, but further research will no doubt add to this. The fact that much current literature on African species focuses only on adults, while stream surveys tend to focus on nymphs, compounds problems relating to systematics, and adult and nymphal stages need to be correlated in order to clear up some of the confusion in the literature. The genus *Caenis* has the highest diversity of species amongst the African genera.

Caenidae are renowned for being small in size, reaching up to about 2.0–9.0 mm when mature. They are characterized by gill 1 being filamentous (Figs 2.13A & 2.70A), and gill 2 being large, square-shaped and operculate, usually with a prominent Y-shaped crest (Figs 2.13B, 2.68A & C, 2.69A, 2.70B, 2.71A, 2.72A) covering the remaining gills, which are usually fine and frilly in appearance (Fig. 2.70C). They do not have hindwing pads. The nymphs are often associated with conditions where there is little or no flow, such as in pools and ponds. In streams they are often found among the silty substrates of backwaters, or among aquatic vegetation, where they feed on fine particulate detritus and periphyton. Their bodies are often covered with small detrital particles.

Afrocaenis Gillies, 1982

(Figs 2.69A–E)

This genus is known from cool streams in the East African highlands (Kenya, Tanzania and Ethiopia), and is represented by two species. Adult males and mature male nymphs have very large eyes. Tarsal claws are long and slender, devoid of denticles (Fig. 2.69E). Mouthparts are characterized by maxillary palps being three segmented (Fig. 2.69B), and by the absence of setae along the outer margins of the mandibles (Fig. 2.69C). Gills 2 (Fig. 2.69A) are operculate with Y-shaped crests and upper surfaces with many small, stout setae, but no submarginal spine-like hairs. Nymphs of some species in this genus are very large, reaching about 9.0 mm in length.

Useful references

Gillies (1982).

Afrocercus Malzacher, 1987

Known only from the male imago, from Uganda.

Useful references
Malzacher (1987).

Barnardara McCafferty & Provonsha, 1995
(Figs 2.71A–E)

Barnardara nymphs belong to the so called 'brush-legged' Caenidae, because of the long hair-like setae on their forelegs that form a brush. In *Barnardara* these are arranged in a random fashion over the dorsal surface and along the inner margins of the tibiae and tarsi (Fig. 2.71E). The mandibles have four to seven long setae along the outer margins (Fig. 2.71C). The operculate gills (Fig. 2.71A) have the lateral and posterior margins fringed with broad, spatulate setae and the inner margins fringed with short, simple setae. The nymphs are small, only 2.5–3.0 mm in length. They are only known from the north eastern regions of South Africa, found in shallow, slow-flowing reaches of rivers over cobbled substrates interspersed with alluvial deposits. Only one species is currently known.

Useful references
Provonsha & McCafferty (1995).

Caenis Stephens, 1835
(Figs 2.70A–G)

This is by far the most common genus in the Afrotropics, with 35 described species, only three of which are known in South Africa. Four species are known in Madagascar. The nymphs usually have at least some denticulation on the claws (Fig. 2.70G), although these denticles can be can be very small and may sometimes be overlooked. The inner margins of the tibiae and tarsi are edged with stout spine-like setae (Fig. 2.70G). The size of the nymphs varies considerably between species. Many of the Afrotropical species are known only as adults.

Useful references
Barnard (1932); Demoulin (1970); Malzacher (1990, 1993, 1995).

Caenospella Gillies, 1977
(Figs 2.67A–E)

This genus is easily recognized by the absence of the Y-shaped crest on the operculate gills (Fig. 2.67A). The claws have many denticles, increasing in size from the base to the mid-section, where the denticles are pronounced (Fig. 2.67E), the distal third being devoid of denticles so that the claw curves smoothly to a point. Only one species is known, from Lake Kalimawe (Tanzania), where nymphs shelter in papyrus. These are very small caenids, measuring just over 2.0 mm in length.

Useful references
Gillies (1977).

Clypeocaenis Soldán, 1978
(Figs 2.72A–E)

Clypeocaenis has a disjunct distribution, with one Africa species being known from Ghana and Upper Volta, the another being from KwaZulu-Natal. Other species are known from the Oriental region.

Like *Barnardara*, *Clypeocaenis* has 'brush-legs'. The hairs on *Clypeocaenis* are arranged in two distinct rows on the foretibiae (Fig. 2.72E), whereas those of *Barnardara* are randomly scattered (Fig. 2.71E). The mandibles of *Clypeocaenis* are also more setose than those of *Barnardara*, having two rows of long setae on the outer margin (Fig. 2.72C). The nymphs measure about 3.5–4.5 mm in length, with cerci measuring between 2.0–3.0 mm. In West Africa *Clypeocaenis* occurs in large, relatively rapidly-flowing rivers with stony bottoms (Soldán 1983). In South Africa it has been recorded from the Mgeni River (Provonsha & McCafferty 1995) from moderate- to steep-gradient reaches (determined from Brand et. al. 1967). On first describing the genus, Soldán (1978) deduced that the nymphs occur in rapidly-flowing water.

Useful references
Provonsha & McCafferty (1995); Soldán (1983).

Madecocercus Malzacher, 1995
(Figs 2.68A–H)

Known only from Madagascar, this genus has a number of distinctive characteristics: the body is covered with hairs; the margins of the head, thorax, abdomen, legs and operculate gills are fringed with long, hairlike setae (Fig. 2.68A); the tarsal claws are strongly hooked and lack denticles (Fig. 2.68H); gill 1 is filiform (Fig. 2.68B), gill 2 is operculate and trapezium-shaped (Fig. 2.68C), and gills 3–6 are without marginal filaments (Figs 2.68D & E); abdominal segments have well-developed posterolateral projections, which are particularly pronounced on segments 2, 6 & 7 in mature nymphs (Fig. 2.68A), and the maxillae are without palps (Fig. 2.68F). The cerci have well developed setae on their basal third. Nymphs measure about 5.0–6.0 mm, with cerci 2.5–3.0 mm. Nothing has been reported on the feeding behaviour or habitat preferences of nymphs in this genus.

Useful references

Elouard et al. (2001); Elouard & Sartori (2001); Malzacher (1995); McCafferty & Wang (1995, 2000).

EPHEMERIDAE
(Figs 2.10, & 2.73–2.74)

The family Ephemeridae is known from all continents except Australia. There are five known genera in the Afrotropics, but the presence of one of these is doubtful (see discussion under *Palingenia)*. At one time *Palingenia* and *Cheirogenesia* were placed in the family Palingeniidae, but McCafferty (1991) placed them in the subfamily Palingeniinae within the Ephemeridae.

Ephemeridae nymphs are similar to those of the family Polymitarcyidae (see below), but are distinguished by having apically-divergent mandibular tusks (Figs 2.10A & B), a frontal process with diverse morphologies (Figs 2.10B, 2.73B & 2.74A, C, D & E) and a process on the tibiae of the posterior legs (Fig. 2.10D). Gills 2–7 consist of two elongate lamellae with fringed margins (Figs 2.10A & C & 2.73A). Mature nymphs measure from 12.0–32.0 mm (McCafferty 1981). Ephemerid nymphs are primarily found in lentic waters, burrowing in silt, sand-silt, sand-gravel and silt-clay substrates. They feed on particles, and some may directly ingest sediment.

Afromera Demoulin, 1955a
(Figs 2.74C)

This genus is known from the Orient and the Afrotropics, but is absent from Madagascar. *Afromera* is currently represented by three species in West Africa, one in the Congo, one in Uganda and one in South Africa. Only *A. evae*, from Gambia, is known from the nymphal stage, and it is distinguished by the presence of a concave frontal process (Fig. 2.74C) and poorly-developed mandibular tusks (Fig. 2.74C). Mature nymphs measure 11.0–13.0 mm, with cerci 4.0–4.5 mm. Nymphs of *Afromera* burrow in silt substrates in perennially warm, lentic waters.

Useful references

Elouard (1986b) (adults only); McCafferty & Gillies (1979).

Cheirogenesia Demoulin, 1952
(Figs 2.73B & C)

The genus *Cheirogenesia* is endemic to Madagascar, known from three species. Its nymphs are distinguished by the presence of an apically-serrate frontal process on the head (Fig. 2.73B) and socketed spurs on the outer margins of the mandibular tusks (Fig. 2.73C) (below the heavily sclerotized apex). Nymphs measure about 20.0–23.0 mm, with cerci measuring 7.0 mm. The nymphs burrow in soft silt substrates in warm, lentic waters.

Useful references
McCafferty & Edmunds (1976); Sartori & Elouard (1999) (adults only).

Eatonica Navás, 1913
(Figs 2.74A & B)

The genus *Eatonica* is widespread in the Afrotropics, with four species from Africa and two described from Madagascar. The only described nymph is the presumed nymph of *E. schoutedeni* (Navás) from Africa, and despite considerable collecting effort, only one nymph (currently undescribed) has been found in a forest zone in Madagascar (Elouard et al. 1998). The nymphs are distinguished from those of other Afrotropical ephemerids by the convex frontal process on the head (Fig. 2.74A). Nymphal size has not been established, but an adult female of *E. schoutedeni* measures 12 mm (Barnard 1932).

Useful references
Demoulin (1968); Elouard (1986a) (adults only); Elouard et al. (1998) (adults only).

Ephemera Linnaeus, 1758
(Figs 2.74D, E & F)

Although the genus *Ephemera* is widespread in the Holarctic and the Orient, its only representative in the Afrotropics is the species *E. mooiana*, reported from KwaZulu-Natal, South Africa. Since its original description as *Eatonica schoutedeni* (in part: Crass 1947), *E. mooiana* has not been collected again, despite intensive collecting effort (Conor Cahill pers. comm., University of Natal, Pietermaritzburg). It is therefore likely that the species is extinct.

The tentative association of the nymph with the male adult has not yet been confirmed by rearing. Nymphs of *Ephemera* are fairly similar to those of *Afromera* (see above) in that they have a concave frontal process on the head (Fig. 2.74D & E), but differ in having well-developed mandibular tusks (Fig. 2.74D, E & F). The precise habitat requirements of *E. mooiana* are not known, but nymphs of *Ephemera* generally burrow in sand, sand-gravel or sand-silt substrates, and are found in waters that are not perennially warm and with more flow than those in which *Afromera* occurs. The nymphs of *E. mooiana* measure up to 29.0 mm, with cerci measuring 9.0 mm, and the median caudal filament 11.0 mm (Crass 1947).

Useful reference
Crass (1947); McCafferty (1971); McCafferty & Gillies (1979).

Palingenia Burmeister, 1839
(Figs 2.73A)

The genus *Palingenia* has a Palearctic distribution. The record from the Afrotropics consists of a doubtfully-assigned species (*P. apatris*) from Liberia, which is known only from male adults. In any case, nymphs of *Palingenia* elsewhere are distinguished by having the mandibular tusks laterally with large, somewhat irregular denticles (Fig. 2.73A). The known nymphs of *Palingenia* are among the largest mayflies, measuring up to about 32.0 mm. They burrow in clay substrates in lentic waters.

Useful references
Demoulin (1965).

POLYMITARCYIDAE
(Figs 2.9A–D & 2.75–2.76)

The family Polymitarcyidae is pantropical in distriubution, but is not found in Australia. Three genera are found in Africa, and one in Madagascar. Its nymphs are most similar to those of the family Ephemeridae, but differ in having the mandibular tusks apically convergent (Figs. 2.75A, 2.76A, F, H) and in lacking frontal process on the head and a tibial process on the posterior legs (Fig. 2.9D). Polymitarcyid nymphs are usually found in slow-flowing waters, either in burrows in hard substrates—such as wood—or interstitially in substrates such as silt, silt-gravel or clay.

Afroplocia Lestage, 1939
(Figs 2.76A–C)

The genus *Afroplocia* is known from only one species: *A. sampsoni*, from KwaZulu-Natal. Although the association of the nymphal and adult stages has not been confirmed through rearing, it appears that the assigned nymph indeed belongs to *A. sampsoni*. The nymph is distinguished from those of other polymitarcyids by the following characteristics: mandibular tusks as long as, or slightly longer than, the head and pronotum combined, with thick rows of long setae laterally and medially (Fig. 2.76A); caudal filaments at least as long as the abdomen, with setae along three-quarters of their length, and a reduced gill 1 with subequal lamellae (Fig. 2.76B).

Details of the habitat requirements of the nymphs of *A. sampsoni* remain unknown, but it appears that they are found interstitially in mixed substrates.

Useful references
Barnard (1940); Crass (1947).

Ephoron Williamson, 1802
(Figs 2.76H–K)

The genus *Ephoron* is found in the Holarctic, Orient and Afrotropics. In the Afrotropics, it is represented by only one described species: *E. savignyi*, which is apparently widely distributed throughout tropical Africa. It has been suggested, based on observation of specimens in the British Museum, that there may actually be more than one species (Conor Cahill, pers. comm.). *Ephoron* nymphs are distinguished from those of other Afrotropical polymitarcyids by having robust mandibular tusks with short spines laterally and dorsally (Fig. 2.76H & K). Mature nymphs measure about 16.0 mm, with cerci about 6.0 mm (Crass 1947). Nymphs occur in U–shaped burrows, with each arm of the U about 3.2 mm long, along river banks, among dense clay-silt substrate (F.C. de Moor pers. comm., Albany Museum, Grahamstown) where conditions are suitable.

Useful references
Crass (1947); Demoulin (1952)

Exeuthyplocia Lestage, 1918
(Figs 2.75B & C)

The genus *Exeuthyplocia* is known from one species only: *E. minima*, which is widely distributed in central Africa. Its nymphs are similar to those of *Afroplocia*, but differ from the latter species in having unequal gills 1 (Fig. 2.75B). Mature nymphs may measure up to about 15.0 mm. Details of the habitat requirements of *E. minima* remain uncertain.

Useful references
Gillies (1980b).

Povilla Navás, 1912
(Figs 2.76D–G)

The genus *Povilla* is known from one species only: *P. adusta*, which is widespread and common from central Africa south to KwaZulu-Natal. Its nymphs are distinguished by having short, robust mandibles that are medially denticulate (Figs. 2.76D, F, G). Mature nymphs measure about 10.0–16.0 mm, with cerci about 4.0–6.0 mm. Nymphs of *P. adusta* are found in lentic waters, and burrow into clay and hard substrates such as wood. Nymphs are known to secrete a silk-like substance to line their burrows. They are filter-feeders, creating a feeding current in their burrows by means of gill movements (Hartland-Rowe 1953), and feeding largely on microscopic algae (Kimmins 1949).

Useful references

Corbet (1957); Demoulin (1956a, b); Hartland-Rowe (1953, 1958).

Proboscidoplocia Demoulin, 1966

(Figs 2.75A)

The genus *Proboscidoplocia* is endemic to Madagascar. They are large mayflies, adult males reaching an average size of about 20.0 mm,although Elouard et al. (2001) indicate that some females of some species reach a length of 7.0 cm. Of the eight known species, only one—*P. sikorai*—is known from the nymphal stage. Its nymphs are similar to those of *Afroplocia* and *Exeuthyplocia*, but the mandibular tusks (Fig. 2.75A) are as long as the length of the head and thorax combined, and the caudal filaments are shorter than the abdomen and setaceous along the whole length. The nymphs occur mainly in forest streams along the east coast and the upper basins of western Madagascar.

Useful references

Demoulin (1966b); Elouard & Sartori (1997) (adults only); Elouard et al. (1999) (adults and ecology); Elouard et al. (2001); Sartori et al. (1999) (adult females and egg morphology).

LEPTOPHLEBIIDAE

(Figs 2.77–2.86)

The family Leptophlebiidae, or 'prong gills', has a worldwide distribution, but attain their highest diversity in the tropics. In the Afrotropics, the family is represented by 16 genera. The nymphs of different species within this genus are easily distinguished by their gills; gill 1 may be filamentous (Figs 2.82A; 2.85A & B), operculate (Fig. 2.83A), apically cleft (Fig. 2.83D), or entirely absent; gills 2–6 or 7 are double, and are either lanceolate (Figs 2.78A & B), or lamellate with pointed projections (Figs 2.79C–G), or lamellate with multiple finger-like projections (Fig. 2.80A). The cerci of Leptophlebiidae nymphs are usually widely spread, with the medial filament slightly longer than the cerci.

Leptophlebiid nymphs generally occur in flowing waters, but some species occur in standing water, and are associated with rocks, gravel and woody debris or roots along stream banks. Leptophlebiidae nymphs are brushers, scrapers, or collector-gatherers, feeding largely on detritus, and a few are shredders, feeding on leaf fragments (Palmer 1998).

The genera *Fulleta* and *Ulmerophlebia* are known from adults only. As a consequence, they are not considered in the key above or in the generic treatment below.

Adenophlebia Eaton 1881
(Figs 2.81A–E)

The genus *Adenophlebia* has a widespread distribution in the Afrotropics and is represented by six species, four of which occur in South Africa. It has not been reported from Madagascar. Its nymphs are distinguished by having well-tracheated gills on segments 1–7 with similar lamellae that taper off to a point in the last apical quarter (Figs 2.81A–C), claws with denticles increasing progressively in size apically, and an enlarged apical denticle (Fig. 2.81E). Mature nymphs measure between 9.0 and 13.0 mm. Nymphs usually occur on stones, and can tolerate a range of flow conditions, from still pools to more fast-flowing water.

Useful references
Barnard (1932); Crass (1947); Peters & Edmunds (1964).

Adenophlebiodes Eaton, 1881
(Figs 2.83A–C)

The genus *Adenophlebiodes* is represented by eight species in the Afrotropics, with two species in South Africa, but has not been reported from Madagascar. Its nymphs are distinguished by having large, operculate gills on abdominal segment 1 (Fig. 2.83A). Mature nymphs measure between 9.0–10.0 mm, with cerci 15–20 mm. Nymphs of *Adenophlebiodes* tend to be found in relatively deep pools with floating detritus and vegetation.

Useful references
Agnew (1961); Crass (1947); Elouard-Hideux & Elouard (1991c) (adults only); Peters & Edmunds (1964).

Aprionyx Barnard, 1932
(Figs 2.79A–G)

The genus *Aprionyx* is known from southern Africa only, where eight species are known. Its nymphs are distinguished by having edentate tarsal claws (Fig. 2.79A) and lamellate gills with branched tracheae (Figs 2.79C–G). Nymphs of *Aprionyx* can measure up to 16.0 mm with cerci up to 20.0 mm. They occur under large stones in fast-flowing water and in pools in mountain streams, and are often associated with patches of natural forest.

Useful references

Barnard (1932); Crass (1947); Peters & Edmunds (1964).

Castanophlebia Barnard, 1932
(Figs 2.78A–D)

The genus *Castonophlebia* is known from only two species: *C. albicauda* and *C. calida,* which are endemic to southern Africa. Both are common in mountain streams throughout South Africa and Lesotho. The nymphs are distinguished by having long, slender lanceolate gills that taper gradually towards the apex (Fig. 2.78A & B). Mature nymphs measure up to 11.0 mm, with cerci between 15.0 and 18.0 mm. Nymphs prefer fast-flowing waters and have been observed on the rock faces of small waterfalls.

Useful references

Barnard (1932, 1940); Crass (1947); Peters & Edmunds (1964).

Choroterpes Eaton, 1881
(Figs 2.84A–F)

The genus *Choroterpes* has a worldwide distribution. In the Afrotropics, the genus is represented by two species only, *C. ndebele* and *C. nigrescens,* both from South Africa. The nymphs are distinguished by having the shape of gill 1 varying from long and slender to narrow-lamellate with a long point (Figs 2.84A–C) and gills 2–7 apically with three processes, with the medial process being much longer than the apico-lateral processes, which appear as little more than rounded lateral extensions (Fig. 2.84D) (more pronounced in *C. ndebele*—not illustrated). Nymphs measure up to 10.0 mm, with cerci 12.5–17.5 mm. Nymphs of *Choroterpes* are found under stones in a wide variety of flowing-water regimes.

Useful references

Agnew (1962b); Barnard (1932); Peters & Edmunds (1964, 1970).

Euthraulus Barnard, 1932
(Figs 2.85A–E)

The genus *Euthraulus* occurs in Europe and Asia, and is widespread in the Afrotropics, including the Comoros Islands. It has not yet been recorded from Madagascar. There are eight known Afrotropical species, one of which (*E. elegans*) is widespread in South Africa. Its nymphs are distinguished by having gill 1 long and slender (Fig. 2.85A & B) and gills 2–7 apically with three slender, subequal processes (Fig. 2.85C). Nymphs of *Euthraulus* measure about 7.0 mm, with cerci 8.0–10 mm. They occur in stony-bottomed streams, preferring slow-flowing waters and tolerating stillwater conditions.

Useful references

Barnard (1932); Demoulin (1970); Peters & Edmunds (1964, 1970).

Fulletomimus Demoulin, 1956
(Figs 2.86A–D)

Originally described only in the adult stage from the Democratic Republic of the Congo (Demoulin 1956a), but a questionably-associated nymph has been described by Demoulin (1956b). It is distinguished by its gills having the lamellae with two deep clefts apically, terminating in three apical processes (Fig. 2.86A). The posterolateral margins of abdominal segments 3–7 have well developed single spines, while segments 8 and 9 are produced to form double-pointed biacuminate) spines (Fig. 2.86B). Nymphs measure 4.6 mm in length, and the cerci 5.5 mm (Demoulin 1956b). The nymphs of this species are considered to be lacustrine.

Useful references

Demoulin (1956b).

Hagenulodes Ulmer, 1919
(Figs 2.77A–C)

The genus *Hagenulodes* is known from one species only—*H. braueri* from the Seychelles. Its nymphs are distinguished by having gills 1–7 that have unbranched tracheae (Fig. 2.77A), the upper portion of the gill being narrow-lamellate, the lower portion being a filamentous projection. Details of the habitat requirements of *H. braueri* remain unknown.

Useful references

Peters & Edmunds (1966).

Hyalophlebia Demoulin, 1955
(Figs 2.83D–G)

The genus *Hyalophlebia* is known from central and southern Africa only. Of the four species known to date, only one (*H. patriciae*) is known from the nymphal stage. Its nymphs are distinguished by having gill 1 broad and apically cleft (Fig. 2.83D), and gills 2–7 that are similar to gill 1 in most respects, but have two lamellae (Fig. 2.83E & F). Nymphs of *H. patriciae* measure about 9.5 mm in length, and are found on stones in slow-flowing streams.

Useful references
Agnew (1962b).

Maheathraulus Peters, Gillies & Edmunds, 1964
(Figs 2.82A–D)

The genus *Maheathraulus* is known from one species only: *M. scotti*, from the Seychelles. Its nymphs are distinguished by the having gill 1 filamentous (Fig. 2.82A) and gills 2–7 long and slender, with a bifurcation in the basal one-third (Fig. 2.82B). Interestingly, unlike the nymphs of most other species, the ovipositor is visible in the female nymphs of *Maheathraulus* (Fig. 2.82C). Nymphs of *M. scotti* are found under small stones in streams with moderate flows.

Useful references
Peters & Edmunds (1964).

Nesophlebia Peters & Edmunds, 1964
(Figs 2.81H & I)

The genus *Nesophlebia* is known from one species only: *N. adusta*, from Madagascar. Its nymphs are distinguished by lacking the first pair of gills and by having gills 2–7 long and slender and deeply forked from the basal third (Fig. 2.81H), sometimes with small setae on the gill tips. Nymphs of *Nesophlebia* are found under large stones and among gravel in fast-flowing streams.

Useful references
Peters & Edmunds (1984).

Petersophlebia Demoulin, 1973
(Figs 2.81F–G)

The genus *Petersophlebia* is known from two species only: *P. inequalis* and *P. insularis*, both from Madagascar. The gills of nymphs in this genus are narrowly- or broadly-rounded apicolaterally, with short medial processes apically (Figs 2.81F). Nymphs are about 9.0 mm long. Details of the habitat requirements of the nymphs remain unknown.

Useful references
Demoulin (1955b, 1973); Peters & Edmunds (1964).

Polythelais Demoulin, 1973
(Figs 2.80A & B)

The genus *Polythelais* is known from one species only: *P. digitata*, from Madagascar. Its nymphs are distinguished by the broadly lamellate gills with four to six short processes distally and branched tracheae (Fig. 2.80A). Mature nymphs measure about 10.0 mm, with cerci about 10.0 mm. Details of the habitat requirements of the nymphs of this species remain unknown.

Useful references
Demoulin (1973).

Thraulus Eaton, 1881
(Figs 2.82E–G)

The genus *Thraulus* is known from the Afrotropical, Oriental and Palaearctic regions. In the Afrotropics, it is known from central Africa and the Comoros Islands. Its nymphs are distinguished by having gill 1 with different dorsal and ventral lamellae (Fig. 2.82E) and gills 2–7 with similar dorsal and ventral lamellae, both with fringed margins (Fig. 2.82F). Mature nymphs measure up to about 9.0 mm, males being larger than females. Nymphs of some species of *Thraulus* are found under stones in fast-flowing mountain streams, while those from other species are lacustrine, being found along lake shores.

Useful references
Peters, Gillies & Edmunds (1964); Peters & Edmunds (1964, 1970).

PROSOPISTOMATIDAE
(Fig. 2.6)

The family Prosopistomatidae is known only from one genus: *Prosopistoma*, which has been reported from the Afrotropics, Australia, the Orient and Europe. In the Afrotropics, the genus is widespread, represented by four described species, one of which occurs in Madagascar. Another four species from southern Africa await description (Barber-James In Press), one from Guinea (Elouard pers. Comm: Institute de Recherche pour le Developpment, Montpellier, France) and three from Madagascar (Elouard, pers. comm). Prosopistomatidae nymphs are minute, measuring up to about 3.0 mm, with short cerci of less than 1.0 mm. They are therefore easily overlooked in the field, but are easily distinguished by having fused nota that form a carapace-like structure covering the legs and gills from dorsal view. Prosopistomatid nymphs are found on stones at the edge of riffle areas, and under boulders on bedrock in fairly swift current.

Useful references

Barber-James (In Press); Gillies (1954).

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CHAPTER 2: APPENDIX

CHECKLIST OF AFROTROPICAL EPHEMEROPTERA

This checklist includes all known species, and their synonyms, from the Afrotropical region as defined by Crosskey & White (Fig. 2.1). Several species awaiting description have not been included. Readers are advised to check the following website for periodic revisions of the list given below:
http://www.ru.ac.za/academic/departments/zooento/Martin/EphemeropteraAfrica.html.
Note that in the list below, the current valid names of the species (indicated by •) are followed by subordinate names (indicated by ○) when these exist. The subordinate names are followed by an abbreviation in parentheses, indicating their status. All names, valid or subordinate, are followed by the actual author of that name and the date that the name was published. The authors responsible for the current names are indicated at the end of each list. (Adapted after McCafferty 2003).

Definitions of abbreviations and terms used:

(comb.) combination: a name recombined with a generic name different from the original.

(dub.) nomen dubium: a name that is of dubious status in that it cannot presently be determined what the species named as such actually is; although all nomina dubia have a generic name associated with them, some of them cannot actually be placed to any genus with confidence due to the lack, or loss of, original material on which the names were based.

(hom.) homonym: the name (as the unique combination of genus and species names) is or becomes the same as one used for another species at an earlier time; the subordinate homonym, therefore, had to be replaced with a new name.

(id.) misidentification: another valid species (not a subordinate name) with which the species has incorrectly been associated in the past.

(orig.) original: the original name, including the original name in its correct form, if it has been changed from an incorrectly formed name.

(renam.) renamed: a new name given because the original or recombination of the original is a secondary homonym (the same as that which has been given to another species previously).

(spell.) spelling: a misspelled or incorrect form of the name.

(stat.) status: represents a change from species to subspecies status within the same species.

(syn.) synonym: another name that was proposed independently for the same species. Normally, the earliest published name takes priority.

(in part): some of the members of this species were originally described as another species.

[sic]: name written as stated by author, even though incorrect

†: extinct

Suborder PISCIFORMA
Superfamily SIPHLONUROIDEA
Family **BAETIDAE**

1. Genus ***Acanthiops***
- *Acanthiops cooperi* (Gillies & Wuillot, 1997)
  - ○ *Platycloeon cooperi* Gillies & Wuillot, 1997 (orig.)
  - ○ *Acanthiops cooperi* Lugo-Ortiz & McCafferty, 1998 (comb.)
- *Acanthiops delphinae* (Gattolliat, 2000) [Madagascar]
  - ○ *Afroptiloides delphinae* Gattolliat, 2000 (orig.)
  - ○ *Acanthiops delphinae* Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (comb.)
- *Acanthiops elgonensis* Lugo-Ortiz &McCafferty 1998
  - ○ *Centoptilum* sp. no. 3. Demoulin 1964 (syn.)
  - ○ *Acanthiops elgonensis Lugo-Ortiz & McCafferty 1998 (orig.)*
  - ○ *Afroptiloides elgonensis* Gillies 1999 (comb.)
  - ○ *Acanthiops elgonensis* Lugo-Ortiz. Barber-James, McCafferty & de Moor, 2001 (comb.)
- *Acanthiops erepens* (Gillies, 1990)
  - ○ *Baetis cataractae* Crass, 1947 (in part)
  - ○ *Baetis* sp. A. Kimmins, 1955 (in part)
  - ○ *Afroptilum erepens* Gillies, 1990 (orig.)
  - ○ *Platycloeon erepens* Gillies & Wuillot, 1997 (comb.)
  - ○ *Acanthiops erepens* Lugo-Ortiz & McCafferty, 1998 (comb.)
- *Acanthiops faro* Barber-James & McCafferty, 2001
- *Acanthiops griffithsi* Lugo-Ortiz &McCafferty 1998
  - ○ *Afroptiloides griffithsi* Gillies 1999 (orig.)
  - ○ *Acanthiops griffithsi* Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (comb.)
- *Acanthiops io* Lugo-Ortiz & McCafferty, 2001
- *Acanthiops marlieri* (Demoulin, 1967)
  - ○ *Centroptilum marlieri* Demoulin 1967 (orig.)
  - ○ *Acanthiops marlieri* Waltz & McCafferty, 1987 (comb.)
- *Acanthiops namorona* (Gattolliat, 2000) [Madagascar]
  - ○ *Afroptiloides namorona* Gattolliat, 2000 (orig.)
  - ○ *Acathiops namorona* Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (comb.)
- *Acanthiops spinosum* (Gattolliat, 2000) [Madagascar]
  - ○ *Afroptiloides spinosum* Gattolliat, 2000 (orig.)
  - ○ *Acanthiops spinosum* Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (comb.)
- *Acanthiops tsitsa* Barber-James & McCafferty, 1997
  - ○ *Afroptiloides tsita* [sic] Gillies, 1999 (spell.)
  - ○ *Acanthiops tsitsa* Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (comb.)
- *Acanthiops variegatus* (Gillies, 1991)
  - ○ *Afroptilum variegatum* Gillies, 1991 (orig.)
  - ○ *Acanthiops variegatus* Barber-James & McCafferty, 1997 (comb.)
  - ○ *Afroptiloides variegatum* [sic]Gillies, 1999 (comb.)
  - ○ *Acanthiops variegatus* Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (comb.)
- *Acanthiops varius* (Crass, 1947)
  - ○ *Centroptilum varium* Crass, 1947 (orig.)
  - ○ *Acentrella* sp. Demoulin, 1956 (syn.)
  - ○ *Afroptilum (Afroptiloides) varium* Gillies, 1990 (comb.)
  - ○ *Acanthiops varius* McCafferty & de Moor, 1995 (comb.)
  - ○ *Acanthiops tsitsa* Lugo-Ortiz & McCafferty, 1998 (id.)
  - ○ *Afroptiloides varium* [sic] Gillies, 1999 (comb.)
  - ○ *Acanthiops varius* Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (comb.)
- *Acanthiops zomba* Lugo-Ortiz & McCafferty, 1998
  - ○ *Acentrella* sp. A. Kimmins, 1955 (syn.)
  - ○ *Baetis* sp. A. Kimmins, 1955 (in part) (syn.)
  - ○ *Centroptilum* sp. A. Demoulin, 1970 (syn.)
  - ○ *Afroptilum (Afroptiloides)* sp. A. Gillies, 1990 (syn.)
  - ○ *Acanthiops zomba* Lugo-Ortiz & McCafferty, 1998 (orig.)
  - ○ *Afroptiloides njombae* [sic] Gillies, 1999. (comb., spell.)
  - ○ *Acanthiops zomba* Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (comb.)

2. Genus ***Afrobaetodes*** Demoulin, 1970
- *Afrobaetodes berneri* Demoulin, 1970
- *Afrobaetodes delicatissimus* (Barnard, 1932)
  - ○ *Cloeon delicatissimum* Barnard, 1932 (orig.)
  - ○ *Afrobaetodes delicatissimus* Gillies, 1979 (comb.)

- *Afrobaetodes intermedius* Lugo-Ortiz & McCafferty, 1996
- *Afrobaetodes lenae* Gattolliat & Sartori, 1999 [Madagascar]
- *Afrobaetodes pugio* Gillies, 1991
- *Afrobaetodes pusillus* (Navás, 1930)
  - *Cloeon pusillus* Navás, 1930 (orig.)
  - *Afrobaetodes pusillus* Gillies, 1979(comb.)

3. Genus ***Afroptilum*** Gillies, 1990

- *Afroptilum barcuatum* (Kopelke, 1980)
  - *Centroptilum barcuatum* Kopelke, 1980 (orig.)
  - *Afroptilum barcuatum* Gillies, 1990 (comb.)
- *Afroptilum bicorne* (Ulmer, 1909)
  - *Centroptilum bicorne* Ulmer, 1909 (orig.)
  - *Afroptilum bicorne* Gillies, 1990 (comb.)
- *Afroptilum boettgeri* (Kopelke, 1980)
  - *Centroptilum boettgeri* Kopelke, 1980 (orig.)
  - *Afroptilum boettgeri* Gillies, 1990 (comb.)
- *Afroptilum confusum* Lugo-Ortiz & McCafferty, 1998 [Madagascar]
- *Afroptilum dicentrum* (Demoulin, 1956)
  - *Centroptilum dicentrum* Demoulin, 1956 (orig.)
  - *Afroptilum dicentrum* Gillies, 1990 (comb.)
- *Afroptilum gilberti* Gattolliat & Sartori, 1999 [Madagascar]
- *Afroptilum lepidum* Lugo-Ortiz & McCafferty, 1998 [Madagascar]
- *Afroptilum mathildae* Gattolliat & Sartori, 1999 [Madagascar]
- *Afroptilum parvum* (Crass, 1947)
  - *Centroptilum parvum* Crass, 1947 (orig.)
  - *Afroptilum parvum* Gillies, 1990 (comb.)
- *Afroptilum sudafricanum* (Lestage, 1924)
  - *Centroptilum sudafricanum* Lestage, 1924 (orig.)
  - *Centroptilum montanum* Kimmins, 1960 (syn.)
  - *Afroptilum sudafricanum* Gillies, 1990 (comb.)

4. Genus ***Baetis*** Leach, 1815

- *Baetis aeneus* Navás, 1936
- *Baetis harrisoni* Barnard, 1932
- *Baetis lawrencei* Crass, 1947
- *Baetis magae* (Barnard, 1932)
  - *Pseudocloeon magae* Barnard, 1932 (orig.)
  - *Baetis magae* Gillies, 1994 (comb.)
- *Baetis monikae* Kopelke, 1980
- *Baetis parvulus* Crass, 1947
- *Baetis permultus* Kopelke, 1980
- *Baetis pseudogemellus* Soldán, 1977
- *Baetis spatulatus* Gillies, 1994
- *Baetis tripunctatus* Gillies, 1994

5. **Genus *Barnamus*** Lugo-Ortiz & McCafferty, 1998

- *Barnumus editus* McCafferty & Lugo-Ortiz, 1998

6. Genus ***Bugilliesia*** Lugo-Ortiz &McCafferty, 1998

- *Bugilliesia grisea* (Gillies, 1990)
  - *Afroptilum griseum* Gillies, 1990 (orig.)
  - *Bugilliesia grisea* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Bugilliesia guineensis* (Gillies, 1990)
  - *Afroptilum guineensis* Gillies, 1990 (orig.)
  - *Bugilliesia guineensis* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Bugiliesia nitida* (Ulmer, 1916)
  - *Centroptilum nitidum* Ulmer, 1916 (orig.)
  - *Cloeon nigroalbum* Navás, 1932 (syn.)
  - *Cloeon bredoanum* Navás, 1933 (syn.)
  - *Centroptilum nitidum* Demoulin, 1957 (comb.)
  - *Bugillesia nitida* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Bugilliesia notabilis* (Kimmins, 1956)
  - *Centroptilum notabile* Kimmins, 1956 (orig.)
  - *Afroptilum notabile* Gillies, 1990 (comb.)
  - *Bugilliesia notabilis* Lugo-Ortiz & McCafferty, 1996 (comb.)

- *Bugilliesia sudanensis* (Ulmer, 1916)
  - ○ *Centroptilum sudanense* Ulmer, 1916 (orig.)
  - ○ *Afroptilum sudanense* Gillies, 1990 (comb.)
  - ○ *Bugilliesia sudanensis* Lugo-Ortiz & McCafferty, 1996 (comb.)

7. Genus ***Centroptiloides*** Lestage, 1918

- *Centroptiloides bifasciata* (Esben-Petersen, 1913)
  - ○ *Centroptilum bifasciatum* Esben-Petersen, 1913 (orig.)
  - ○ *Centroptiloides bifasciatus* Lestage, 1918 (comb.)
  - ○ *Centroptiloides bifasciatum* Ulmer, 1920 (renam.)
  - ○ *Haplobaetis umbratus* Navás, 1922 (syn.)
  - ○ *Centroptiloides bifasciata* Navás, 1922 (renam.)
  - ○ *Centroptiloides marginata* Lestage, 1924 (syn.)
  - ○ *Centroptiloides collarti* Navás, 1930 (syn.)
  - ○ *Centroptiloides umbratus* Lestage, 1945 (syn.)
  - ○ *Centroptiloides bifasciatum* (form *hyalinum*) Crass, 1947 (stat.)
  - ○ *Centroptiloides bifasciata* (form *marginata*) Demoulin, 1957 (stat.)

8. Genus ***Cheleocloeon*** Wuillot & Gillies, 1993

- *Cheleocloeon carinatum* Wuillot, 1993
- *Cheleocloeon dimorphicum* (Soldán & Thomas, 1985)
  - ○ *Centroptilum dimorphicum* Soldán & Thomas, 1985 (orig.)
  - ○ *Afroptilum dimorphicum* Gillies, 1990 (comb.)
  - ○ *Cheleocloeon dimorphicum* Lugo-Ortiz & McCafferty, 1997 (comb.)
- *Cheleocloeon excisum* (Barnard, 1932)
  - ○ *Centroptilum excisum* Barnard, 1932 (orig.)
  - ○ *Afroptilum excisum* Gillies, 1990 (comb.)
  - ○ *Cheleocloeon excisum* Lugo-Ortiz & McCafferty, 1997 (comb.)
- *Cheleocloeon falcatum* (Crass, 1947)
  - ○ *Centroptilum falcatum* Crass 1947 (orig.)
  - ○ *Afroptilum falcatum* Gillies 1990 (comb.)
  - ○ *Cheleocloeon falcatum* Lugo-Ortiz & McCafferty 1998 (comb.)
- *Cheleocloeon littorale* McCafferty, 2000
- *Cheleocloeon madagascariense* Gattolliat (*in press*) [Madagascar]
- *Cheleocloeon mirandei* Lugo-Ortiz & McCafferty, 1997 [Madagascar]
- *Cheleocloeon yolandae* Wuillot, 1993

9. Genus ***Cloeodes*** Traver 1938

- *Cloeodes bicoloratus* Gattolliat, 2001 [Madagascar]
- *Cloeodes inzingae* (Crass, 1947)
  - ○ *Pseudocloeon inzingae* Crass 1947 (orig.)
  - ○ *Pseudocloeon saxophilus* Agnew 1961 (syn.)
  - ○ *Baetis inzingae* Gillies 1994 (comb.)
  - ○ *Baetis saxophilus* Gillies 1994 (comb.)
  - ○ *Cloeodes inzingae* Waltz & McCafferty 1994 (comb.)
  - ○ *Cloeodes saxophilus* de Moor & McCafferty 1996 (syn.)
- *Cloeodes freitagae* Gattolliat, 2001 [Madagascar]
- *Cloeodes portabilis* Lugo-Ortiz & McCafferty, 1999 [Madagascar]
- *Cloeodes pseudogladius* Gattolliat, 2001 [Madagascar]

10. Genus ***Cloeon*** Leach 1815

- *Cloeon aeneum* Barnard, 1932
- *Cloeon agnewi* Hubbard, 1973
  - ○ *Austrocloeon exiguum* Crass 1947 (*nec* Navás 1918) (orig.)
  - ○ *Cloeon exiguum* Demoulin 1970 (comb.)
  - ○ *Cloeon agnewi* Hubbard 1973 (hom, renam.)
- *Cloeon amaniensis* Gillies, 1985
- *Cloeon areolatum* Navás, 1930
- *Cloeon bellum* Navás, 1931
- *Cloeon cambouei* Navás, 1930 [Madagascar] (*nomen dubium* - Lugo-Ortiz & McCafferty, 1998)
- *Cloeon chaplini* Barnard, 1932
- *Cloeon crassi* Agnew, 1961
  - ○ *Austrocloeon* sp. A. Allanson, 1961 (syn.)
- *Cloeon durani* Navás, 1926 [Madagascar]
  - ○ *Cloeon durani* Navás, 1926 (orig.)
  - ○ *Cloeon waterloti* Demoulin, 1966 (syn.)
  - ○ *Cloeon durani* Gattolliat & Rabeantoandro, 2002 (redescribed)

- *Cloeon elevatum* Agnew, 1961
- *Cloeon emmanueli* Lugo-Ortiz & McCafferty, 1998 [Madagascar]
- *Cloeon gambiae* Gillies, 1980
- *Cloeon irretitum* Navás, 1936 [Madagascar] (*nomen dubium* - Lugo-Ortiz & McCafferty, 1998)
- *Cloeon lacunosum* Barnard, 1932
- *Cloeon madhouae* McCafferty & Mauremootoo, 2000 [Madagascar]
- *Cloeon perkinsi* Barnard, 1932
- *Cloeon rhodesiae* Barnard, 1932
  - *Cloeon carneum* Navás, 1936 (syn.)
  - *Cloeon stigmale* Navás, 1936 (syn.)
- *Cloeon scitulum* Kimmins, 1955
- *Cloeon smaeleni* Lestage, 1924 [Africa & Madagascar]
  - *Procloeon smaeleni* Kimmins, 1960 (orig.)
  - *Procloeon fraudulentum* Demoulin, 1957 (syn.)
  - *Cloeon affine* Navás, 1930 (syn.)
  - *Cloeon incertum* Demoulin, 1957 (syn.)
  - *Cloeon punctatum* Navás, 1931 (syn.)
  - *Cloeon smaeleni* Gattolliat & Rabeantoandro, 2002 (comb.)
- *Cloeon tanzaniae* Gillies, 1985
- *Cloeon virgiliae* (Barnard, 1932)
  - *Austrocloeon virgiliae* Barnard, 1932 (orig.)
  - *Austrocloeon paludinosum* Crass, 1947 (syn.)
  - *Cloeon virgiliae* Demoulin, 1970 (comb.)
- *Cloeon viridellum* Lestage, 1923

11. Genus ***Crassabwa*** Lugo-Ortiz & McCafferty, 1996

- *Crassbwa badia* (Kopelke, 1980)
  - *Centroptilum badium* Kopelke, 1980 (orig.)
  - *Crassbwa badia* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Crassbwa flava* (Crass, 1947)
  - *Centroptilum flavum* Crass, 1947 (orig.)
  - *Afroptilum flavum* Gillies, 1990 (comb.)
  - *Crassabwa flava* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Crassbwa loweae* (Kimmins, 1949)
  - *Centroptilum loweae* Kimmins, 1949 (orig.)
  - *Crassbwa loweae* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Crassbwa vitrea* Navás, 1930
  - *Centroptilum vitreum* Navás, 1930 (orig.)
  - *Crassbwa vitrea* Lugo-Ortiz & McCafferty, 1996 (comb.)

12. Genus ***Dabulamanzia*** Lugo-Ortiz & McCafferty, 1996

- *Dabulamanzia babaora* (Wuillot, 1993)
  - *Afroptilum babaorum* Wuillot, 1993 (orig.)
  - *Dabulamanzia babaora* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Dabulamanzia concolorata* Gattolliat, 2000 [Madagascar]
- *Dabulamanzia duci* Gattolliat & Elouard, 1999 [Madagascar]
- *Dabulamanzia fica* Lugo-Ortiz & McCafferty, 1996
- *Dabulamanzia gigantea* Gattolliat, 2000 [Madagascar]
- *Dabulamanzia gladius* Gattolliat, 2000 [Madagascar]
- *Dabulamanzia helenae* Lugo-Ortiz & McCafferty, 1996
- *Dabulamanzia improvida* Lugo-Ortiz & McCafferty, 1997 [Madagascar]
- *Dabulamanzia indusii* (Crass, 1947)
  - *Centroptilum indusii* Crass, 1947 (orig.)
  - *Afroptilum indusii* Gillies, 1990 (comb.)
  - *Dabulamanzia indusii* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Dabulamanzia media* (Crass, 1947)
  - *Centroptilum medium* Crass, 1947 (orig.)
  - *Afroptilum medium* Gillies, 1990 (comb.)
  - *Dabulamanzia media* Lugo-Ortiz & McCafferty, 1996 (comb.)
- *Dabulamanzia tarsale* (Gillies, 1990)
  - *Afroptilum tarsale* Gillies, 1990 (orig.)
  - *Dabulamanzia tarsale* Lugo-Ortiz & McCafferty, 1996 (comb.)

13. Genus ***Delouardus*** Lugo-Ortiz & McCafferty, 1999 [Madagascar]
- *Delouardus djabala* Lugo-Ortiz & McCafferty, 1999 [Madagascar]
- *Delouardus vetustus* Gattolliat (*in press*) [Madagascar]

14. Genus ***Demoreptus*** Lugo-Ortiz & McCafferty 1997
- *Demoreptus capensis* (Barnard, 1932)
  - *Acentrella capensis* Barnard, 1932 (orig.)
  - *Baetis capensis* Demoulin, 1970 (comb.)
  - *Acentrella capensis* McCafferty & de Moor, 1995 (comb.)
  - *Demoreptus capensis* Lugo-Ortiz & McCafferty, 1997 (comb.)
- *Demoreptus monticola* (Crass, 1947)
  - *Acentrella monticola* Crass, 1947 (orig.)
  - *Baetis monticola* Demoulin, 1970 (comb.)
  - *Acentrella monticola* McCafferty & de Moor, 1995 (comb.)
  - *Demoreptus monticola* Lugo-Ortiz & McCafferty, 1997 (comb.)
- *Demoreptus natalensis* (Crass, 1947)
  - *Acentrella natalensis* Crass, 1947 (orig.)
  - *Baetis natalensis* Demoulin, 1970 (comb.)
  - *Acentrella natalensis* McCafferty & de Moor, 1995 (comb.)
  - *Demoreptus natalensis* Lugo-Ortiz & McCafferty, 1997 (comb.)

15. Genus ***Demoulinia*** Gillies, 1990
- *Demoulinia assimilis* Gattolliat (2003) [Madagascar]
- *Demoulinia crassi* (Demoulin, 1970)
  - *Centroptilum pulchrum* Crass, 1947 (nec Eaton, 1869) (orig.)
  - *Centroptilum crassi* Demoulin, 1970 (hom, renam.)
  - *Demoulinia crassi* Gillies, 1990 (comb.)
- *Demoulinia insularis* Lugo-Ortiz & McCafferty, 1998 [Madagascar]

16. Genus ***Dicentroptilum*** Wuillot & Gillies, 1994
- *Dicentroptilum decipiens* (Gillies, 1990)
- *Dicentroptilum papilionum* Wuillot, 1994
- *Dicentroptilum spinulosum* (Demoulin, 1970)
  - *Centroptiloides spinulosa* Demoulin, 1970 (orig.)
  - *Afroptilum spinulosum* Gillies, 1990 (comb.)
  - *Dicentroptilum spinulosum* Wuillot & Gillies, 1994 (comb.)
- *Dicentroptilum merina* Lugo-Ortiz & McCafferty, 1998 [Madagascar]

17. Genus ***Echinopus*** Gattolliat (2002) [Madagascar]
- *Echinopus giboni* Gattolliat (2002) [Madagascar]
- *Echinopus minutus* Gattolliat (2002) [Madagascar]

18. Genus ***Edmulmeatus*** Lugo-Ortiz & McCafferty, 1997 [Madagascar]
- *Edmulmeatus grandis* Lugo-Ortiz & McCafferty, 1997 [Madagascar]

19. Genus ***Glossidion*** Lugo-Ortiz & McCafferty, 1998
- *Glossidion demoulini* Lugo-Ortiz & McCafferty, 1998
- *Glossidion mysticum* Lugo-Ortiz & McCafferty, 1998

20. Genus ***Guloptiloides*** Gattolliat & Sartori, 2000
- *Guloptiloides gargantua* Gattolliat & Sartori, 2000 [Madagascar]

21. Genus ***Herbrossus*** McCafferty & Lugo-Ortiz, 1998 [Madagascar]
- *Herbrossus christinae* Gattolliat & Sartori, 1998 [Madagascar]
- *Herbrossus edmundsorum* McCafferty & Lugo-Ortiz, 1998 [Madagascar]
- *Herbrossus elouardi* Gattolliat & Sartori, 1998 [Madagascar]

22. Genus ***Kivua*** Lugo-Ortiz & McCafferty, 1997
- *Kivua elouardi* (Gillies, 1989)
  - *Rhithrocloeon elouardi* Gillies, 1989 (orig.)
  - *Kivua elouardi* Lugo-Ortiz & McCafferty, 1997 (comb.)
- *Kivua insuetum* (Kopelke, 1980)
  - *Cloeon insuetum* Kopelke, 1980 (orig.)
  - *Kivua insuetum* Lugo-Ortiz & McCafferty, 1997 (comb.)

23. Genus ***Labiobaetis*** Novikova & Kluge, 1987
- *Labiobaetis dambrensis* Gattolliat, 2001 [Madagascar]

- *Labiobaetis fabulosus* Lugo-Ortiz & McCafferty, 1997 [Madagascar]
  - *Labiobaetis fabulosus* Lugo-Ortiz & McCafferty, 1997 (orig.)
  - *Pseudocloeon fabulosum* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
  - *Labiobaetis fabulosus* Gattolliat, 2001 (comb.)
- *Labiobaetis gambiae* (Gillies, 1993)
  - *Baetis gambiae* Gillies, 1993 (orig.)
  - *Labiobaetis gambiae* Lugo-Ortiz & McCafferty, 1997 (comb.)
- *Labiobaetis gilliesi* Gattolliat, 2001 [Madagascar]
- *Labiobaetis longicercus* Gattolliat, 2001 [Madagascar]
- *Labiobaetis plumbago* Lugo-Ortiz & McCafferty, 1997 [Madagascar]
  - *Labiobaetis plumbago* Lugo-Ortiz & McCafferty, 1997 (orig.)
  - *Pseudocloeon plumbago* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
  - *Labiobaetis plumbago* Gattolliat, 2001 (comb.)
- *Labiobaetis nigrocercus* Gattolliat, 2001 [Madagascar]
- *Labiobaetis punctatus* Gattelliat, 2001 [Madagascar]
- *Labiobaetis vulgaris* Gattolliat, 2001 [Madagascar]

24. Genus ***Maliqua*** Lugo-Ortiz & McCafferty, 1997
- *Maliqua abdallahi* McCafferty, 2000
- *Maliqua plumosa* (Wuillot, 1993)
  - *Afroptilum plumosum* Wuillot, 1993 (orig.)
  - *Maliqua plumose* Lugo-Ortiz & McCafferty, 1997 (comb.)

25. Genus ***Mickiops*** *McCafferty*, Lugo-Ortiz & Barber-James, 1997
- *Mickiops bicaudatum* (Gillies, 1990)
  - *Afroptilum (Afroptiloides) bicaudatum* Gillies, 1990 (orig.)
  - *Mickiops bicaudatum* McCafferty, Lugo-Ortiz & Barber-James, 1997 (comb.)

26. Genus ***Matelocloeon*** Gillies & Elouard, 1990
- *Matelocloeon bihoumi* Gillies & Elouard, 1990
- *Matelocloeon corbeti* (Kimmins, 1956)
  - *Centroptilum corbeti* Kimmins, 1956 (orig.)
  - *Matelocloeon corbeti* Gillies & Elouard, 1990 (comb.)
- *Matelocloeon thomasorum* Lugo-Ortiz & McCafferty, 1997 [Madagascar]

27. Genus ***Nesoptiloides*** Demoulin, 1973 [Madagascar]
- *Nesoptiloides electroptera* (Demoulin, 1966) [Madagascar]
  - *Centroptilum electropterum* Demoulin, 1966 (orig.)
  - *Nesoptiloides intermedia* Demoulin, 1973 (syn.)
  - *Nesoptiloides electroptera* Gattolliat & Sartori, 1999 (comb.)

28. Genus ***Nesydemius*** Lugo-Ortiz & McCafferty, 1998
- *Nesydemius polhemusorum* Lugo-Ortiz & McCafferty, 1998 [Madagascar]

29. Genus ***Nigrobaetis*** Novikova & Kluge, 1987
- *Nigrobaetis bethunae* Lugo-Ortiz & de Moor, 2000
- *Nigrobaetis harasab* (Soldán, 1977)
  - *Baetis harasab* Soldán, 1977 (orig.)
  - *Nigrobaetis harasab* Lugo-Ortiz & de Moor, 2000 (comb.)

30. Genus ***Ophelmatostoma*** Waltz & McCafferty, 1987
- *Ophelmatostoma camerunense* (Ulmer, 1920)
  - *Pseudocloeon camerunense* Ulmer, 1920 (orig.)
  - *Pseudocloeon* sp. A. Kimmins, 1955 (syn.)
  - *Ophelmatostoma kimminsi* Waltz & McCafferty, 1987 (syn.)
  - *Ophelmatostoma camerunense* Gillies, Elouard & Wuillot, 1990

31. Genus ***Peuhlella*** Lugo-Ortiz & McCafferty, 1998
- *Peuhlella christinae* (Wuillot, 1993)
  - *Afroptilum christinae* Wuillot, 1993 (orig.)
  - *Peuhlella christinae* Lugo-Ortiz & McCafferty, 1998 (comb.)

32. Genus ***Potamocloeon*** Gillies, 1990
- *Potamocloeon dentatum* (Kimmins, 1956)
  - *Cloeon dentatum* Kimmins, 1956 (orig.)
  - *Potamocloeon dentatum* Gillies, 1990 (comb.)
  - *Potamocloeon macafertiorum* Lugo-Ortiz, 1996 (syn.)
- *Potamocloeon* sp. A Gattolliat, 2003 [Madagascar]
- *Potamocloeon* sp. B Gattolliat, 2003 [Madagascar]

33. Genus ***Procloeon*** Bengtsson, 1915

- *Procloeon africanum* (Esben-Petersen, 1913)
  - *Cloeon africanum* Esben-Petersen, 1913 (orig.)
  - *Cloeon marginale* Ulmer, 1916 (syn.)
  - *Austrocloeon africanum* Barnard, 1932 (comb.)
  - *Cloeon africanum* Demoulin, 1970 (comb.)
  - *Procloeon africanum* Gillies, 1997 (comb.)
- *Procloeon cylindroculum* Kimmins, 1955
- *Procloeon sylvicola* Gillies, 1997

34. Genus ***Pseudocloeon*** Klapálek, 1905

- *Pseudocloeon aquacidum* (Lugo-Ortiz & McCafferty, 1997)
  - *Labiobaetis aquacidus* Lugo-Ortiz & McCafferty, 1997 (orig.)
  - *Pseudocloeon aquacidum* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
- *Pseudocloeon bellum* (Barnard, 1932)
  - *Baetis bellus* Barnard, 1932 (orig.)
  - *Pseudocloeon bellum* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
- *Pseudocloeon boussoulium* (Gillies, 1993)
  - *Baetis boussoulius* Gillies, 1993 (orig.)
  - *Labiobaetis boussoulius* Lugo-Ortiz & McCafferty, 1997 (comb.)
  - *Pseudocloeon boussoulium* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
- *Pseudocloeon cataractae* (Crass, 1947)
  - *Baetis cataractae* Crass, 1947 (orig.)
  - *Acanthiops erepens* (in part) Lugo-Ortiz, Barber-James, McCafferty & de Moor, 2001 (id.)
  - *Pseudocloeon cataractae* Lugo-Ortiz & de Moor, 2001 (comb.)
- *Pseudocloeon elouardi* (Gillies, 1993)
  - *Baetis elouardi* Gillies, 1993 (orig.)
  - *Labiobaetis elouardi* Lugo-Ortiz & McCafferty, 1997 (comb.)
  - *Pseudocloeon elouardi* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
- *Pseudocloeon fastigatum* Kopelke, 1980
- *Pseudocloeon glaucum* (Agnew, 1961)
  - *Baetis glaucus* Agnew, 1961 (orig.)
  - *Baetis quintus* Agnew, 1961 (syn.)
  - *Labiobaetis masai* Lugo-Ortiz & McCafferty, 1977 (syn.)
  - *Labiobaetis nadineae* Lugo-Ortiz & McCafferty, 1997 (syn.)
  - *Pseudocloeon masai* Lugo-Ortiz, de Moor & Barber-James, 2000 (comb., syn)
  - *Pseudocloeon nadineae* Lugo-Ortiz, de Moor & Barber-James, 2000 (comb., syn)
  - *Pseudocloeon quintum* Lugo-Ortiz, de Moor & Barber-James, 2000 (comb., syn.)
  - *Pseudocloeon glaucum* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
- *Pseudocloeon grandiculum* Kopelke, 1980
- *Pseudocloeon insolitum* (Kopelke, 1980)
  - *Baetis insolitus* Kopelke, 1980 (orig.)
  - *Labiobaetis insolitum* Lugo-Ortiz & McCafferty, 1997 (comb.)
  - *Pseudocloeon insolitum* Lugo-Ortiz, McCafferty & Waltz 1999 (comb.)
- *Pseudocloeon kalengoense* (Kopelke, 1980)
  - *Baetis kalengoensis* Kopelke, 1980 (orig.)
  - *Labiobaetis kalengoensis* Lugo-Ortiz & McCafferty, 1997 (comb.)
  - *Pseudocloeon kalengoense* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
- *Pseudocloeon latum* (Agnew, 1961)
  - *Baetis latus* Agnew, 1961 (orig.)
  - *Labiobaetis aquacidus* Lugo-Ortiz & McCafferty, 1997 (syn.)
  - *Pseudocloeon aquacidum* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb., syn.)
  - *Baetis* sp. B. Harrison & Elsworth, 1958 (syn.)
  - *Baetis* sp. 2. Agnew, 1961 (syn.)
  - *Pseudocloeon latum* Lugo-Ortiz & de Moor, 2000 (comb.)
- *Pseudocloeon mtone* (Gillies, 1994)
  - *Baetis mtonis* Gillies, 1994 (orig.)
  - *Labiobaetis mtonis* Lugo-Ortiz & McCafferty, 1997 (comb.)
  - *Pseudocloeon mtone* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
- *Pseudocloeon piscis* (Lugo-Ortiz & McCafferty, 1997)
  - *Labiobaetis piscis* Lugo-Ortiz & McCafferty, 1997 (orig.)
  - *Pseudocloeon piscis* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)
- *Pseudocloeon tenuicrinitum* Kopelke, 1980

- *Pseudocloeon vinosum* Barnard, 1932
  - *Pseudocloeon vinosum* Barnard, 1932 (orig.)
  - *Baetis vinosus* Gillies, 1994 (comb.)
  - *Pseudocloeon minutum* Crass, 1947 (syn.)
  - *Baetis minutus* Gillies, 1994 (comb., syn.)
  - *Labiobaetis vinosus* Lugo-Ortiz & McCafferty, 1997 (comb.)
  - *Pseudocloeon vinosum* Lugo-Ortiz, McCafferty & Waltz, 1999 (comb.)

35. Genus ***Pseudopannota*** Waltz & McCafferty, 1987
- *Pseudocloeon camillae* Gattolliat (*in press*) [Madagascar]
- *Pseudopannota bergerardi* Elouard & Hideux, 1990
- *Pseudopannota bertrandi* (Demoulin, 1967)
  - *Pseudocloeon bertrandi* Demoulin, 1967 (orig.)
  - *Pseudopannota bertrandi* Waltz & McCafferty, 1987 (comb.)
- *Pseudopannota maculosa* (Crass, 1947)
  - *Pseudocloeon maculosum* Crass, 1947 (orig.)
  - *Pseudopannota maculosa* Elouard, Gillies & Wuillot, 1990 (comb.)
- *Pseudopannota modesta* Elouard & Gillies, 1990
- *Pseudopannota muganinani* Elouard & Gillies, 1990
- *Pseudopannota sartorii* Elouard & Hideux, 1990
- *Pseudopannota vinckei* (Demoulin, 1973) [Madagascar]

36. Genus ***Rhithrocloeon*** Gillies, 1985
- *Rhithrocloeon indicator* Gillies, 1985
- *Rhithrocloeon permirum* (Kopelke, 1980)
  - *Cloeon permirum* Kopelke, 1980 (orig.)
  - *Rhithrocloeon permirum* Gillies, 1985 (comb.)

37. Genus ***Rheoptilum*** Gattolliat, 2001 [Madagascar]
- *Rheoptilum arni* Gattolliat, 2001 [Madagascar]
- *Rheoptilum lokohensis* Gattolliat, 2001 [Madagascar]

38. Genus ***Scutoptilum*** Gattolliat, (2002) [Madagascar]
- *Scutoptilum verrucosum* Gattolliat (2002) [Madagascar]

39. Genus ***Susua*** Lugo-Ortiz & McCafferty, 1998
- *Susua niandanensis* (Wuillot, 1993)
  - *Afroptilum niandanensis* Wuillot, 1993 (orig.)
  - *Susua niandanensis* Lugo-Ortiz & McCafferty, 1998 (comb.)

40. Genus ***Tanzaniella*** Gillies, 1991
- *Tanzaniella spinosa* Gillies, 1991

41. Genus ***Thraulobaetodes*** Elouard & Hideux, 1991
- *Thraulobaetodes cumminsorum* Elouard & Hideux, 1991

42. Genus ***Xyrodromeus*** Lugo-Ortiz & McCafferty, 1997
- *Xyrodromeus africanus* Lugo-Ortiz &McCafferty, 1997
- *Xyrodromeus namarona* Lugo-Ortiz & McCafferty, 1997 [Madagascar]
- *Xyrodromeus modestus* Gattolliat (2002) [Madagascar]
- *Xyrodromeus sartorii* Gattolliat (2002) [Madagascar]
- *Xyrodromeus latipalpus* Gattolliat (2002) [Madagascar]

Suborder SETISURA
Superfamily HEPTAGENIOIDEA
Family **HEPTAGENIIDAE** Needham, 1901

1. Genus ***Afronurus*** Lestage, 1924
- *Afronurus aethereus* (Navás, 1936)
  - *Ecdyonurus aethereus* Navás, 1936 (orig.)
  - *Afronurus aethereus* Demoulin, 1965 (comb.)
- *Afronurus barnardi* Schoonbee, 1968
- *Afronurus elgonensis* Puthz, 1971
- *Afronurus gilliesi* Corbet, 1962
- *Afronurus harrisoni* Barnard, 1932
- *Afronurus matitensis* Sartori & Elouard, 1996

- *Afronurus muehlenbergi* Puthz, 1971
- *Afronurus negi* Corbet, 1960
- *Afronurus oliffi* Schoonbee, 1968
- *Afronurus peringueyi* (Esben-Petersen, 1913)
  - *Ecdyonurus peringueyi* Esben-Petersen, 1913 (orig.)
  - *Afronurus peringueyi* Lestage, 1924 (comb.)
- *Afronurus pulcher* Ulmer, 1930
  - *Adenophlebia collarti* Navás, 1930 (orig.)
  - *Afronurus collarti* Demoulin, 1970 (comb.)
- *Afronurus scotti* Schoonbee, 1968
- *Afronurus subflavus* Kopelke, 1980
- *Afronurus ugandanus* Kimmins, 1956

2. Genus ***Compsoneuria*** Eaton, 1881

- *Compsoneuria bequaerti* (Navás, 1930)
  - *Adenophelbia bequaerti* Navás, 1930 (orig.)
  - *Adenophelbia eatoni* Navás, 1931 (syn.)
  - *Adenophelbia inflexa* Navás, 1932 (syn.)
  - *Notonurus cooperi* Crass, 1947 (syn.)
  - *Notonurus bequaerti* Demoulin, 1956 (comb.)
  - *Compsoneuriella bequaerti* Gillies, 1984 (comb.)
  - *Compsoneuria bequaerti* Braasch & Soldán, 1986 (comb.)
- *Compsoneuria njalensis* (Kimmins, 1937)
  - *Afronurus njalensis* Kimmins, 1937 (orig.)
  - *Notonurus njalensis* Demoulin, 1970 (comb.)
  - *Compsoneuriella njalensis* Gillies, 1984 (comb.)
  - *Compsoneuria njalensis* Braasch & Soldán, 1986 (comb.)
  - *Thalerosphyrus njalensis* de Moor, Barber-James, Harrison & Lugo-Ortiz, 2000 (syn.)
- *Compsoneuria sinuosus* (Navás, 1931)
  - *Adenophlebia sinuosa* Navás, 1931 (orig.)
  - *Notonurus sinuosus* Demoulin, 1970 (comb.)
  - *Compsoneuriella sinuosus* Gillies, 1984 (comb.)
  - *Compsoneuria sinuosus* Braasch & Soldán, 1986 (comb.)
- *Compsoneuria tortinervis* (Navás, 1930)
  - *Adenophlebia tortinervis* Navás, 1930
  - *Notonurus tortinervis* Demoulin, 1970
  - *Compsoneuriella tortinervis* Gillies, 1984
  - *Compsoneuria tortinervis* Braasch & Soldán, 1986
  - *Thalerosphyrus tortinervis* de Moor, Barber-James, Harrison & Lugo-Ortiz, 2000 (syn.)

3. Genus ***Thalerosphyrus*** Eaton, 1881

- *Thalerosphyrus ethiopicus* Soldán, 1977
- *Thalerosphyrus josettae* Sartori & Elouard, 1996 [Madagascar]

Family **OLIGONEURIIDAE** Ulmer, 1920

1. Genus ***Elassoneuria*** Eaton, 1881

- *Elassoneuria candida* Eaton, 1913
- *Elassoneuria duneyi* Gillies, 1974
- *Elassoneuria grandis* Gillies, 1974
- *Elassoneuria insulicola* Demoulin, 1966 [Madagascar]
- *Elassoneuria kidahi* Gillies, 1974
- *Elassoneuria trimeniana* (McLachlan, 1868)
  - *Oligoneuria trimeniana* McLachlan 1868 (orig.)
  - *Elassoneuria trimeniana* Eaton, 1881 (comb.)
  - *Elassoneuria congolana* Navás, 1911 (syn.)

2. Genus ***Oligoneuriopsis*** Crass 1947

- *Oligoneuriopsis dobbsi* (Eaton, 1912)
  - *Oligoneuria dobbsi* Eaton, 1912 (orig.)
  - *Oligoneuriella dobbsi* Ulmer, 1924 (comb.)
  - *Oligoneuriella grandaeva* Navás, 1936 (syn.)
  - *Oligoneuriopsis grandaeva* Demoulin, 1965 (comb.,syn.)
  - *Oligoneuriopsis dobbsi* Kimmins, 1960 (comb.)
- *Oligoneuriopsis elizabethae* Agnew, 1973
- *Oligoneuriopsis jessicae* Agnew, 1973
- *Oligoneuriopsis lawrencei* Crass, 1947

Suborder FURCATERGALIA
Superfamily EPHEMERELLOIDEA
Family **TRICORYTHIDAE** Lestage, 1942

1. Genus ***Dicercomyzon*** Demoulin, 1954
- *Dicercomyzon costale* Kimmins, 1957
- *Dicercomyzon femorale* Demoulin, 1954
- *Dicercomyzon sjöstedti* Ulmer, 1910
  - *Caenis sjöstedti* Ulmer, 1909 (orig.)
  - *Tricorythus sjöstedti* Lestage, 1918 (comb.)
  - *Dicercomyzon sjöstedti* Demoulin 1954 (comb.)
  - *Dicercomyzon marginatum* Kimmins, 1957 (syn.)
- *Dicercomyzon verrierae* Demoulin, 1964

2. Genus ***Madecassorythus*** Elouard & Oliarinony, 1997 [Madagascar]
- *Madecassorythus hertui* Elouard & Oliarinony, 1997 [Madagascar]
- *Madecassorythus linae* Elouard & Oliarinony, 1997 [Madagascar]
- *Madecassorythus ramanankasinae* Elouard & Oliarinony, 1997 [Madagascar]
- *Madecassorythus raphaeli* Oliarinony & Sartori, 2000 [Madagascar]

3. Genus ***Ranorythus*** Oliarinony & Elouard, 1997 [Madagascar]
- *Ranorythus violettae* Oliarinony & Elouard, 1997 [Madagascar]
- *Ranorythus langrani* Elouard & Oliarinony, 1997 [Madagascar]

4. Genus ***Spinirythus*** Oliarinony & Elouard, 1998 [Madagascar]
- *Spinirythus colasi* Elouard & Oliarinony, 1998 [Madagascar]
- *Spinirythus martini* Oliarinony & Elouard, 1998 [Madagascar]
- *Spinirythus rosae* Oliarinony & Raberiaka, 1998 [Madagascar]

5. Genus ***Tricorythafer*** *Lestage, 1942*
- *Tricorythafer fugitans* (Needham, 1921)
  - *Caenopsis fugitans* Needham, 1921 (orig.)
  - *Needhamocaenis fugitans* Lestage, 1945 (in part) (comb.)
  - *Tricorythafer fugitans* Lestage, 1942 (comb.)

6. Genus ***Tricorythus*** Eaton, 1868
- *Tricorythus abyssinica* Ulmer, 1930
  - *Neurocaenis abyssinica* Demoulin, 1954 (orig.)
  - *Tricorythus abyssinica* Oliarinony, Elouard & Raberiaka, 1998 (comb.)
- *Tricorythus ambinintsoae* Oliarinony & Elouard, 1998 [Madagascar]
- *Tricorythus discolor* (Burmeister, 1839)
  - *Oxycypha discolor* Burmeister, 1839 (orig.)
  - *Cloeon discolor* Walker, 1853 (comb.)
  - *Caenis discolor* Eaton, 1871 (comb.)
  - *Tricorythus discolor* Eaton, 1884 (comb.)
  - *Neurocaenis discolor* Demoulin, 1954 (comb.)
  - *Tricorythus discolor* McCafferty & de Moor, 1995 (comb.)
- *Tricorythus fyae* Oliarinony & Raberiaka, 1998 [Madagascar]
- *Tricorythus fuscata* (Navás, 1936)
  - *Neurocaenis fuscata* Navás, 1936 (orig.)
  - *Tricorythus fuscata* Oliarinony, Elouard & Raberiaka, 1998 (comb.)
- *Tricorythus goodmani* Elouard & Oliarinony, 1998 [Madagascar]
- *Tricorythus jeanne* Oliarinony & Elouard, 1998 [Madagascar]
- *Tricorythus lanceolatus* Ulmer, 1916
- *Tricorythus latus* Ulmer, 1916
- *Tricorythus longus* Ulmer, 1916
  - *Caenis regia* Navás, 1932 (orig.)
  - *Caenis collarti* Navás, 1933 (comb.)
- *Tricorythus pierrei* Elouard & Oliarinony, 1998 [Madagascar]
- *Tricorythus poincinsi* Navás, 1926
  - *Neurocaenis poincinsi* Demoulin, 1954 (orig.)
  - *Tricorythus poincinsi* Oliarinony, Elouard & Raberiaka, 1998 (comb.)
- *Tricorythus reticulatus* Barnard, 1932
  - *Neurocaenis reticulata* Demoulin, 1954 (orig.)
  - *Tricorythus reticulatus* McCafferty & de Moor, 1995 (comb.)

- *Tricorythus rolandi* Oliarinony & Raberiaka, 1998 [Madagascar]
- *Tricorythus sylvestris* Oliarinony & Elouard, 1998 [Madagascar]
- *Tricorythus tinctus* Kimmins, 1956
- *Tricorythus variabilis* Oliarinony & Raberiaka, 1998 [Madagascar]
- *Tricorythus varicauda* (Kollar & Pictet, 1843)
  - *Caenis varicauda* Kollar & Pictet, 1843 (orig.)
  - *Tricorythus varicauda* Eaton, 1868 (comb.)
- *Tricorythus vulgaris* Raberiaka & Oliarinony, 1998 [Madagascar]

Family **EPHEMERYTHIDAE** McCafferty & Wang, 2000

1. Genus ***Ephemerythus*** Gillies, 1960

- *Ephemerythus dissimilimus* Kopelke, 1981
- *Ephemerythus kiboensis* Gillies, 1960
- *Ephemerythus niger* Gillies, 1960
- *Ephemerythus pictus* Gillies, 1960
- *Ephemerythus straeleni* Demoulin, 1964

Family **MACHADORYTHIDAE** McCafferty & Wang, 2000

1. Genus ***Machadorythus*** Demoulin, 1959

- *Machadorythus maculatus* (Kimmins, 1949)
  - *Tricorythus maculatus* Kimmins, 1949 (orig.)
  - *Machadorythus palanquim* Demoulin, 1959 (syn.)
  - *Machadorythus maculatus* Elouard & Gillies, 1989 (comb.)

Family: ***TELOGANODIDAE*** *McCafferty & Wang, 1997*

1. Genus ***Ephemerellina*** Lestage, 1924

- *Ephemerellina barnardi* Lestage, 1924

2. Genus ***Lestagella*** Demoulin, 1970

- *Lestagella penicillata* (Barnard, 1940)
  - *Lithogloea penicillata* Barnard, 1940 (orig.)
  - *Lestagella penicillata* Demoulin, 1970 (comb.)

3. Genus ***Lithogloea*** Barnard, 1932

- *Lithogloea harrisoni* Barnard, 1932
  - *Ephemerellina harrisoni* Demoulin, 1970 (orig.)
  - *Lithogloea harrisoni* McCafferty & de Moor, 1995 (comb.)

4. Genus ***Manohyphella*** Allen, 1973

- *Manohyphella keiseri* Allen, 1973

5. Genus ***Nadinetella*** McCafferty & Wang, 1998 (= *Nadinella* McCafferty & Wang, 1997 preoccupied)

- *Nadinetella brincki* (Demoulin, 1970)
  - *Ephemerellina brincki* Demoulin, 1970 (orig.)
  - *Nadinella brincki* McCafferty & Wang, 1997 (hom.)
  - *Nadinetella brincki* McCafferty & Wang, 1998 (comb.)
- *Nadinetella crassi* (Allen & Edmunds, 1963)
  - *Ephemerellina crassi* Allen & Edmunds, 1963 (orig.)
  - *Nadinella crassi* McCafferty & Wang, 1997 (hom.)
  - *Nadinetella crassi* McCafferty & Wang, 1998 (comb.)

6. Undescribed genus [Madagascar] Elouard et al., 2001

Family **TELOGANELLIDAE** McCafferty & Wang, 2000 [Madagascar]

1. Undescribed genus and species. [Madagascar] McCafferty & Wang, 2000

Superfamily CAENOIDEA

Family **CAENIDAE** Ulmer, 1920

1. Genus ***Afrocaenis*** Gillies, 1982

- *Afrocaenis browni* Gillies, 1983

- *Afrocaenis major* (Gillies, 1977)
  - *Caenospella major* Gillies, 1977 (orig.)
  - *Afrocaenis major* Gillies, 1982 (comb.)

2\. Genus ***Afrocercus*** Malzacher, 1987
- *Afrocercus forcipatus* Malzacher, 1987

3\. Genus ***Barnardara*** McCafferty & Provonsha, 1995
- *Barnardara demoori* McCafferty & Provonsha, 1995

4\. Genus ***Caenis*** Stephens, 1835
- *Caenis aethiopica* Navás, 1935
- *Caenis aliciae* Malzacher, 1990
- *Caenis antelucana* Malzacher, 1990
- *Caenis basuto* Demoulin, 1970
- *Caenis berneri* Kimmins, 1955
- *Caenis brevipes* Kimmins, 1956
  - *Caenomedea brevipes* Thew, 1960 (orig.)
  - *Caenis brevipes* Malzacher, 1993 (comb.)
- *Caenis capensis* (Barnard, 1932)
  - *Austrocaenis capensis* Barnard, 1932 (orig.)
  - *Caenis capensis* McCafferty & de Moor, 1995 (comb.)
- *Caenis cibaria* Eaton, 1879
  - *Caenis cibaria* Eaton, 1879 (orig.)
  - *Caenomedea cibaria* Thew, 1960 (comb.)
  - *Caenis cibaria* Malzacher, 1993 (comb.)
- *Caenis cincta* Demoulin, 1956
  - *Caenomedea cincta* Demoulin, 1965 (orig.)
  - *Caenis cincta* Malzacher, 1993 (comb.)
- *Caenis corbeti* Malzacher, 1990
- *Caenis douglasi* Malzacher, 1993
  - *Caenis cibaria* Ulmer, 1916 (*nec* Eaton 1879) (hom, syn.)
  - *Caenodes cibaria* Ulmer, 1924 (comb.)
  - *Caenodes ulmeri* Kimmins, 1949 (renam.)
  - *Caenis ulmeri* Malzacher, 1993 (comb.)
  - *Caenis douglasi* Malzacher, 1993 (renam.) (hom. *Caenis ulmeri* Brodsky ,1930)
- *Caenis duodecima* Malzacher, 1990
- *Caenis edwardsi* Kimmins, 1939
- *Caenis elouardi* Malzacher, 1990
- *Caenis fasciata* Navás, 1927
- *Caenis ghibana* Malzacher, 1990
- *Caenis gilliesi* Malzacher, 1990
- *Caenis inflexa* (Kolpelke, 1981)
  - *Caenomedea inflexa* Kolpelke, 1981 (orig.)
  - *Caenis inflexa* Malzacher, 1993 (comb.)
- *Caenis jinjana* (Kimmins, 1956)
  - *Caenodes jinjana* Kimmins, 1956 (orig.)
  - *Caenis jinjana* Malzacher, 1993 (comb.)
- *Caenis johannae* Malzacher, 1990 [Madagascar]
- *Caenis knowlesi* Gillies & Knowles, 1990
- *Caenis kivuensis* Demoulin, 1956
  - *Caenis kivuensis* Demoulin, 1956 (orig.)
  - *Caenomedea kivuensis* Thew, 1960 (comb.)
  - *Caenis kivuensis* Malzacher, 1993 (comb.)
- *Caenis kungu* Eaton, 1879
  - *Caenis kungu* Eaton, 1879 (orig.)
  - *Caenodes kungu* Thew, 1960 (comb.)
  - *Caenis kungu* Malzacher, 1993 (comb.)
- *Caenis libenauae* Malzacher, 1990
- *Caenis magnipilosa* (Kopleke, 1980)
  - *Caenomedea magnipilosa* Kopelke, 1980 (orig.)
  - *Caenis magnipilosa* Malzacher, 1993 (comb.)
- *Caenis margherita* Malzacher, 1990
- *Caenis namorana* Malzacher, 1995 [Madagascar]
- *Caenis nervulosa* Malzacher, 1990

- *Caenis noctivaga* Malzacher, 1990
- *Caenis occulta* Malzacher, 1990
- *Caenis pallida* Malzacher, 1990
- *Caenis rugosa* Malzacher, 1995 [Madagascar]
- *Caenis rutila* Malzacher, 1995
- *Caenis scotti* Ulmer, 1930
- *Caenis spinosa* Malzacher, 1995 [Madagascar]

5. Genus ***Caenospella*** Gillies, 1977

- *Caenospella meridies* Gillies, 1977

6. Genus ***Clypeocaenis*** Soldán, 1978

- *Clypeocaenis afrosetosa* Soldán, 1978
- *Clypeocaenis umgeni* Provonsha & McCafferty 1995

7. Genus ***Madecocercus*** Malzacher, 1995 [Madagascar]

- *Madecocercus tauroides* Malzacher, 1995 [Madagascar]
  - ○ *Provonshaka thomasorum* McCafferty & Wang, 1995 (syn.)
  - ○ *Madecocercus tauroides* Elouard & Sartori, 2001

Superfamily EPHEMEROIDEA
Family **EPHEMERIDAE** Ulmer 1920

1. Genus ***Afromera*** Demoulin, 1955 (= *Dicrephemera* McCafferty & Edmunds, 1973)

- *Afromera aequatorialis* (Kimmins, 1956)
  - ○ *Ephemera aequatorialis* Kimmins, 1956 (orig.)
  - ○ *Afromera aequatorialis* Kimmins, 1960 (comb.)
- *Afromera congolana* Demoulin, 1955
  - ○ *Ephemera congolana* McCafferty & Edmunds, 1973 (orig.)
  - ○ *Afromera congolana* McCafferty & Gillies, 1979 (comb.)
- *Afromera evae* Gillies, 1979
- *Afromera gilliesi* Elouard, 1986
- *Afromera natalensis* (Barnard, 1932)
  - ○ *Ephemera natalensis* Barnard, 1932 (orig.)
  - ○ *Afromera natalensis* Demoulin, 1955 (comb.)
- *Afromera troubati* Elouard, 1986

2. Genus ***Cheirogenesia*** Demoulin, 1952

- *Cheirogenesia decaryi* (Navás, 1926) [Madagascar]
  - ○ *Anagenesia decaryi* Navás, 1926 (orig.)
  - ○ *Cheirogenesia decaryi*, Demoulin, 1952 (comb.)
  - ○ *Fontainica josettae* McCafferty, 1968 (syn.)
- *Cheirogenesia edmundsi* Sartori & Elouard, 1999 [Madagascar]
- *Cheirogenesia laurenceae* Sartori & Elouard, 1999 [Madagascar]

3. Genus ***Eatonica*** Navás, 1913

- *Eatonica crassi* McCafferty, 1971
- *Eatonica denysae* Elouard & Sartori, 1998 [Madagascar]
- *Eatonica josettae* Demoulin, 1968
- *Eatonica luciennae* Elouard & Oliarinony, 1998 [Madagascar]
- *Eatonica patriciae* Elouard, 1986
- *Eatonica schoutedeni* (Navás, 1911)
  - ○ *Ephemera schoutedeni* Navás, 1911 (orig.)
  - ○ *Hexagenia illustris* Eaton, 1913 (syn.)
  - ○ *Hexagenia fulva* Esben-Petersen, 1913 (syn.)
  - ○ *Hexagenia reticulata* Navás, 1913 (syn.)
  - ○ *Eatonica schoutedeni* Navás, 1913 (comb.)
  - ○ *Ephemera nimia* Navás, 1915 (syn.)
  - ○ *Pentagenia schoutedeni* Umler, 1916 (comb.)
  - ○ *Eatonica illustris* Kimmins, 1960 (comb., syn.)
  - ○ *Eatonica schoutedeni* Demoulin, 1970 (comb.)

4. Genus ***Ephemera*** Linnaeus, 1758

- *Ephemera mooiana* McCafferty, 1971 †
  - ○ *Eatonica schoutedeni* (in part) Crass, 1947 (id.)
  - ○ *Afromera natalensis* (in part) Demoulin, 1968 (id.)

5. Genus ***Palingenia*** Burmeister, 1839
- *Palingenia apatris* Demoulin, 1965

Family **POLYMITARCYIDAE** Ulmer, 1920

1. Genus ***Afroplocia*** Lestage, 1939
- *Afroplocia sampsoni* (Barnard, 1937)
  - ○ *Exeuthyplocia sampsoni* Barnard, 1937 (orig.)
  - ○ *Afroplocia sampsoni* Lestage, 1939 (comb.)

2. Genus ***Ephoron*** Williamson, 1802
- *Ephoron savignyi* (Pictet, 1843)
  - ○ *Palingenia savignyi* Pictet, 1843 (orig.)
  - ○ *Polymitarcys savignyi* Eaton, 1871 (comb.)
  - ○ *Polymitarcys savignyi* Eaton, 1883 (comb.)
  - ○ *Polymitarcys capensis* Esben-Petersen, 1913 (syn.)
  - ○ *Polymitarcys temerata* Navás, 1916 (syn.)
  - ○ *Ephoron savignyi* Spieth, 1940 (comb.)

3. Genus ***Povilla*** Navás, 1912
- *Povilla adusta* Navás, 1912

4. Genus **Proboscidoplocia** Demoulin, 1966 [Madagascar]
- *Proboscidoplocia auberti* Elouard & Sartori, 1997 [Madagascar]
- *Proboscidoplocia billi* Elouard & Sartori, 1997 [Madagascar]
- *Proboscidoplocia leplatternierae* Elouard & Sartori, 1997 [Madagascar]
- *Proboscidoplocia magdeleinae* Elouard & Sartori, 1997 [Madagascar]
- *Proboscidoplocia mccaffertyi* Elouard & Sartori, 1999 [Madagascar]
- *Proboscidoplocia ruffieuxae* Elouard & Sartori, 1997 [Madagascar]
- *Proboscidoplocia sikorai* (Vassière, 1895) [Madagascar]
  - ○ *Euthyplocia sikoria* Vassière, 1895 (orig.)
  - ○ *Proboscidoplocia sikorai* Demoulin, 1966 (comb.)
- *Proboscidoplocia vayssierei* Elouard & Sartori, 1997 [Madagascar]

Superfamily LEPTOPHLEBIOIDEA
Family **LEPTOPHLEBIIDAE** Ulmer 1920

1. Genus ***Adenophlebia*** Eaton, 1881
- *Adenophlebia auriculata* (Eaton, 1871)
  - ○ *Leptophlebia auriculata* Eaton, 1871 (orig.)
  - ○ *Adenophlebia auriculata* Barnard, 1932 (comb.)
- *Adenophlebia burgeoni* Navás, 1929
- *Adenophlebia dislocans* (Walker, 1860)
  - ○ *Ephemera dislocans* Walker, 1860 (orig.)
  - ○ *Leptophlebia dislocans* Eaton, 1871 (comb.)
  - ○ *Adenophlebia dislocans* Eaton, 1881 (comb.)
  - ○ *Adenophlebia westermanni* Esben-Petersen, 1913 (syn.)
  - ○ *Esbenophlebia westermanni* Lestage, 1924 (comb., syn.)
- *Adenophlebia infuscata* Navás, 1936
- *Adenophlebia peringueyella* Lestage 1924
- *Adenophlebia sylvatica* Crass 1947

2. Genus ***Adenophlebiodes*** Ulmer, 1924
- *Adenophlebiodes adrieni* Elouard-Hideux & Elouard, 1991
- *Adenophlebiodes bicolor* (Crass, 1947)
  - ○ *Euphlebia bicolor* Crass, 1947 (orig.)
  - ○ *Habrophlebia delamarei* Verrier, 1951 (syn.)
  - ○ *Adenophlebiodes bicolor* Edmunds, 1953 (comb.)
- *Adenophlebiodes callasae* Elouard-Hideux & Elouard, 1991
- *Adenophlebiodes decoratus* (Navás, 1931)
  - ○ *Adenophlebia decora* Navás, 1931 (orig.)
  - ○ *Adenophlebiodes decorata* Marlier, 1958 (comb.)
  - ○ *Adenophlebiodes decoratus* Elouard-Hideux & Elouard, 1990 (comb.)

- *Adenophlebiodes maronella* Agnew, 1961
- *Adenophlebiodes maximus* Elouard-Hideux & Elouard, 1991
- *Adenophlebiodes ornata* Ulmer, 1916
- *Adenophlebiodes rubeus* Elouard-Hideux & Elouard, 1991

3. Genus ***Aprionyx*** Barnard, 1932
- *Aprionyx argus* Barnard, 1940
- *Aprionyx intermedius* Barnard, 1932
- *Aprionyx natalicus* (Lestage, 1924)
  - ○ *Atalophlebia tabularis* Esben-Petersen 1913 (nec. Eaton 1884) (orig.)
  - ○ *Atalophlebia natalica* Lestage, 1924 (comb., renam., hom.)
  - ○ *Aprionyx natalica* Barnard, 1932 (comb.)
  - ○ *Aprionyx natalicus* Demoulin, 1970 (spell.)
- *Aprionyx pellucidulus* (Esben-Petersen)
  - ○ *Atalophlebia pellucida* Esben-Petersen 1920 (orig.)
  - ○ *Aprionyx pellucidulus* Barnard 1932 (comb.)
- *Aprionyx peterseni* (Lestage, 1924)
  - ○ *Atalophlebia peterseni* Lestage, 1924 (orig.)
  - ○ *Aprionyx peterseni* Barnard, 1932 (comb.)
- *Aprionyx rubicundus* Barnard, 1932
- *Aprionyx tabularis* (Eaton, 1884)
  - ○ *Atalophlebia tabularis* Eaton, 1884 (orig.)
  - ○ *Atalophlebia phoenocera* Lestage, 1924 (syn.)
  - ○ *Aprionyx tabularis* Barnard, 1932
- *Aprionyx tricuspidatus* Crass, 1947

4. Genus ***Castanophlebia*** Barnard, 1932
- *Castanophlebia albicauda* Barnard, 1940
- *Castanophlebia calida* Barnard, 1932

5. Genus ***Choroterpes*** Eaton, 1881
- *Choroterpes ndebele* Agnew, 1962
- *Choroterpes nigrescens* Barnard, 1932

6. Genus ***Euthraulus*** Barnard, 1932
- *Euthraulus arabica* Sartoir & Gillies, 1990
- *Euthraulus bugandensis* Kimmins, 1956
- *Euthraulus curtus* Kimmins, 1956
- *Euthraulus elegans* Barnard, 1932
  Choroterpes elegans Peters & Edmunds, 1964 (orig.)
  Euthraulus elegans McCafferty & de Moor, 1995 (comb.)
- *Euthraulus magnaculeata* Kopelke, 1980
- *Euthraulus starmuehlneri* Peters, 1980 [Comoros]
- *Euthraulus tropicalis* Gillies, 1957
- *Euthraulus usambarae* Gillies, 1957

*7. Genus **Fulleta** Navás, 1930*
- *Fulleta dentata* Navás, 1930

8. Genus ***Fulletomimus*** Demoulin, 1956
- *Fulletomimus marlieri* Demoulin, 1956

9. Genus ***Hagenulodes*** Ulmer, 1920 [Seychelles only]
- *Hagenulodes braueri* Ulmer, 1920 [Seychelles only]

10. Genus ***Hyalophlebia*** Demoulin, 1955
- *Hyalophlebia demoulini* (Kimmins, 1960)
  - ○ *Adenophlebiodes demoulini* Kimmins, 1960 (orig.)
  - ○ *Hyalophlebia demoulini* McCafferty & de Moor, 1995 (comb.)
- *Hyalophlebia dentifera* (Navás, 1930)
  - ○ *Atalophlebia dentifera* Navás, 1930 (orig.)
  - ○ *Hyalophlebia dentifera* McCafferty & de Moor, 1995 (comb.)
- *Hyalophlebia patriciae* (Agnew, 1962)
  - ○ *Adenophlebiodes patriciae* Agnew, 1962 (orig.)
  - ○ *Hyalophlebia patriciae* McCafferty & de Moor, 1995 (comb.)

- *Hyalophlebia seydeli* (Navás, 1930)
  - ○ *Adenophlebia seydeli* Navás, 1930 (orig.)
  - ○ *Hyalophlebia seydeli* McCafferty & de Moor, 1995 (comb.)

11. Genus ***Maheathraulus*** Peters, Gillies & Edmunds, 1964 [Seychelles only]

- *Maheathraulus scotti* (Eaton, 1913) [Seychelles only]
  - ○ *Hagenulus scotti* Eaton, 1913 (orig.)
  - ○ *Maheathraulus scotti* Peters, Gillies & Edmunds, 1964 (comb.)

12. Genus ***Nesophlebia*** Peters & Edmunds, 1964 [Madagascar]

- *Nesophlebia adusta* Peters & Edmunds, 1964 [Madagascar]

13. Genus ***Petersophlebia*** Demoulin, 1973 [Madagascar]

- *Petersophlebia inequalis* (Demoulin, 1955) [Madagascar]
  - ○ *Atalophlebioides inequalis* Demoulin, 1955 (orig.)
  - ○ *Petersophlebia inequalis* Demoulin, 1973 (comb.)
- *Petersophlebia insularis* Demoulin, 1973 [Madagascar]

14. Genus ***Polythelias*** Demoulin, 1973 [Madagascar]

- *Polythelias digitata* Demoulin, 1973 [Madagascar]

15. Genus ***Thraulus*** Eaton, 1881

- *Thraulus fasciatus* (Kimmins, 1956)
  - ○ *Hagenulus fasciata* Kimmins, 1956 (orig.)
  - ○ *Marshallikella fasciata* Peters, Gillies & Edmunds, 1964 (comb.)
  - ○ *Thraulus fasciatus* Peters & Edmunds, 1970 (comb.)
- *Thraulus torrentis* (Gillies, 1964)
  - ○ *Marshallikella torrentis* Gillies, 1964 (orig.)
  - ○ *Thraulus torrentis* Peters & Edmunds, 1970 (comb.)
- *Thraulus turbinatus* (Ulmer, 1909)
  - ○ *Hagenulus turbinatus* Ulmer, 1909 (orig.)
  - ○ *Marshallikella turbinata* Peters, Gillies & Edmunds, 1964 (comb.)
  - ○ *Thraulus turbinatus* Peters & Edmunds, 1970 (comb.)

16. Genus ***Ulmerophlebia*** Demoulin, 1955

- *Ulmerophlebia succinea* Demoulin, 1955 [Madagascar]
- *Ulmerophlebia variegata* Demoulin, 1955 [Madagascar]

Suborder: CARAPACEA

Family: **PROSOPISTOMATIDAE** Lestage, 1921

1. Genus ***Protopistoma*** Latreille, 1833

- *Prosopistoma africanum* Gillies, 1954
- *Prosopistoma crassi* Gillies, 1954
  - ○ *Binoculus crassi* Demoulin, 1970 (orig.)
  - ○ *Prosopistoma crassi* Hubbard, 1975 (comb.)
- *Prosopistoma guernei* (Vayssière, 1893)
  - ○ *Prosopistoma de Guernei* Vayssière, 1893 (orig.)
  - ○ *Prosopistoma Deuernei* Ulmer, 1916 (spell.)
  - ○ *Binoculus guernei* Demoulin, 1970 (comb., spell)
  - ○ *Prosopistoma guernei* Hubbard, 1975 (comb.)
- *Prosopistoma variegatum* Latreille, 1833 [Madagascar]

CHAPTER 3

ODONATA

by

M.J. Samways & B.C. Wilmot

The insect order Odonata in Africa comprises two main suborders: the Zygoptera, or damselflies, and the Anisoptera, or true dragonflies (Fig. 3.1A, B). A third small Asian suborder, the Anisozygoptera (comprising only two species), has features of both the other suborders. The name 'Odonata' is a shortened form of 'Odognatha', which means 'toothed jaw', referring to their strong mandibles.

There are about 5000 species of Odonata worldwide, with a dozen or so new species being described each year. Important world catalogues are Davies & Tobin (1984, 1985) and Bridges (1994). The suborder Zygoptera is made up of 22 families and the Anisoptera of seven families. In South Africa, there are seven zygopteran and four anisopteran families.

Dragonflies and damselflies are abundant throughout the world except in permanently frozen or arid regions, some species reaching as far north as Alaska and northern Russia. They are generally good colonizers, although only one species has reached and colonized the world's remotest island, Easter Island (Samways & Osborn 1998).

The biology of Odonata has been reviewed by Corbet (1999). In this chapter, we shall only consider the young, growing larval stage that inhabits water. Adults represent the aerial, dispersal and reproductive stage, and do not grow after their emergence from the final instar aquatic larva (Fig. 3.2A). The term 'larva' is used for the immature stage because it is fundamentally different in form from the adult. In the older literature the term 'nymph' is used, which normally refers to young stages that are similar in form and function to the adults, which is not the case in Odonata.

Habitat preferences

Dragonflies and damselflies occur in virtually every type of freshwater body from small, very warm temporary pools on granite outcrops, where temperatures may exceed 33 °C, to large, cold lakes. Many southern African species prefer the well-lit, weedy margins of pools, streams and rivers, (Samways et al. 1996). Odonata are relatively intolerant of saline conditions above about 10% seawater, although in Canada one species tolerates the equivalent of 44.4 % seawater.

Although odonate larvae are almost always aquatic, a terrestrial species has been found in Australia (Watson et al. 1991). In South America, some species live in the water-filled tree holes and centres of bromeliad plants, where they feed on mosquito larvae. Other species live in streams and rivers or among algae and mosses at waterfalls. In Africa, some of the fastest streams and rivers are inhabited by Odonata, some larvae being surprisingly tolerant of high silt loads. In the dry winters when rivers stop flowing some species are able to survive in soft mud and await the return of the rains before completing their development.

Feeding

Odonate larvae are mostly opportunist predators, feeding on a variety of prey including insect larvae, small crustaceans, oligochaetes, and, in the case of large individuals in some species, even small fishes. Although regarded as generalists, they nevertheless have some preferences for prey type and size. They will also switch prey type as the larva grows, or when a more suitable source of food becomes available. Larval feeding patterns can be divided into 'sit-and-ambush' or 'active searching' strategies. Ambush predators wait amongst vegetation and grab prey as it passes. These larvae tend to be camouflaged and inconspicuous and are commonly found in permanent water where they may be susceptible to predation. The 'active searchers' are usually found in temporary waters where predation from fish is less likely, enabling the Odonata to search for prey with greater impunity.

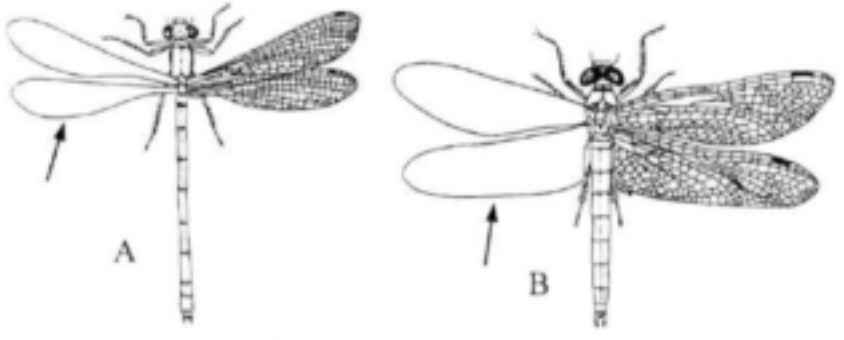

Fig. 3.1. Odonata. **A–B**, typical adults (dorsal views): **A**, zygopteran (note delicate body-form and equal-shaped wings); **B**, anisopteran (note robust body-form and differently shaped fore- and hind wings).

Odonate larvae have well-developed eyes and detect prey by sight, but sometimes also by touch or by sensing vibrations of the moving prey. There are a few records of larvae eating dead prey such as midge larvae or snails.

The way in which odonate larvae capture prey is quite remarkable. The labium is long, hinged and extensible (Fig. 3.2B, C). When prey is targeted, the labium is shot out in less than 25 milliseconds using a mechanism based on stored elastic energy. The prey is grabbed with very sharp hooks on the tip of the labium and returned to the mouth where it is masticated by strong mandibles before being swallowed.

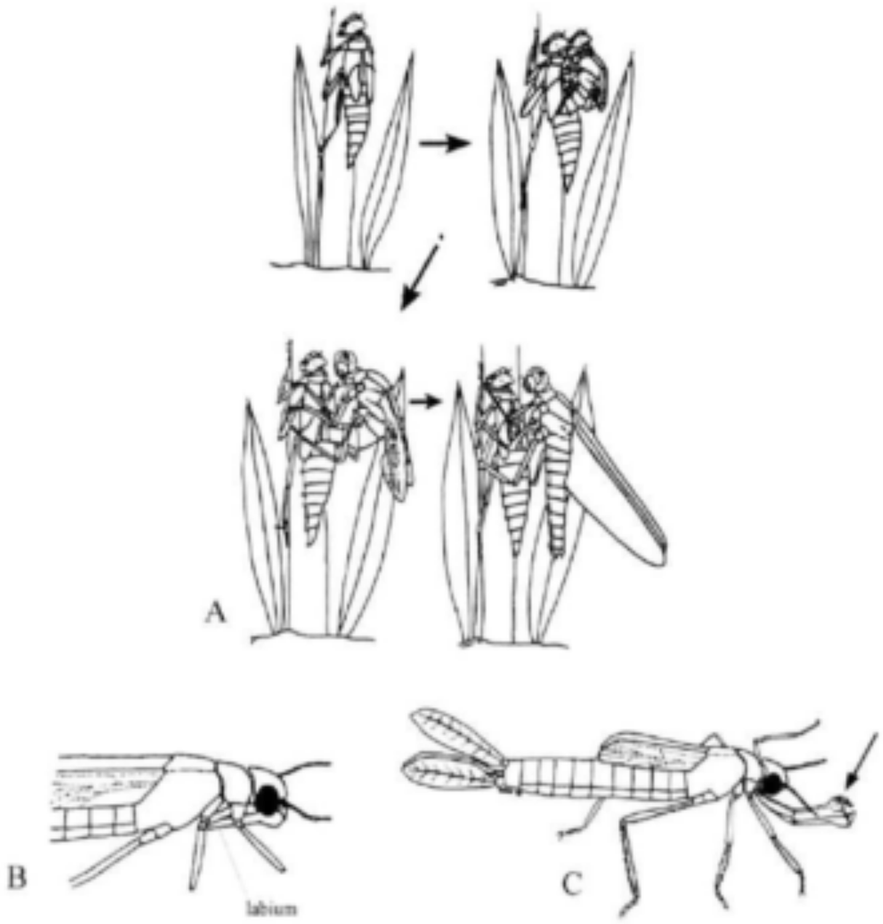

Fig. 3.2. **A**, process of emergence from larva to adult, leaving exuviae behind, with arrows indicating the sequence of the process. **B–C**, larval feeding behaviour as illustrated in a typical zygopteran larva: **B**, labium in resting position; **C**, labium in fully-extended position (arrowed). (After Samways & Whiteley 1997).

Reproduction and life cycle

Adult Odonata have a complex mating procedure. The male has secondary genitalia on the anterior undersurface of the abdomen. Before mating, sperm are transferred from the tip of the abdomen to a recess in the secondary genitalia by bending the tip of the abdomen down and forwards. Then, usually during flight, the male clasps the female behind the head (in dragonflies) or the **prothorax** (in damselflies) using the **claspers** on the tip of his abdomen. The female responds by curving her abdomen underneath until it reaches and couples with the male's secondary genitalia, and sperm is then transferred to the female. This 'wheel position' (Fig. 3.3A), in which the male and female form a circle, is often seen in the field. In some species, the male uses a small filamentous scraper at the end of his penis to remove sperm previously deposited by rival males, before intromission of his own sperm.

The eggs are laid soon after mating. During this time, the pair may remain with the male still clasping the female, and 'in tandem'. The eggs are either inserted into plant material (**endophytic oviposition**) (Fig. 3.3B) or simply cast on the surface of the water by means of the female dipping her abdomen into the water (**exophytic oviposition**) (Fig. 3.3C). Some damselflies may go several centimetres under the water to oviposit low down on plant stems, sometimes while the male is still attached to the female. In this case, a trapped air pocket, known as a 'plastron', forms around their bodies giving them a silvery sheen. Copulating couples sometimes remain submerged in this way for longer than 30 minutes.

The egg stage may last from a few days to several months, according to species and temperature. The egg hatches into the first instar larva, called

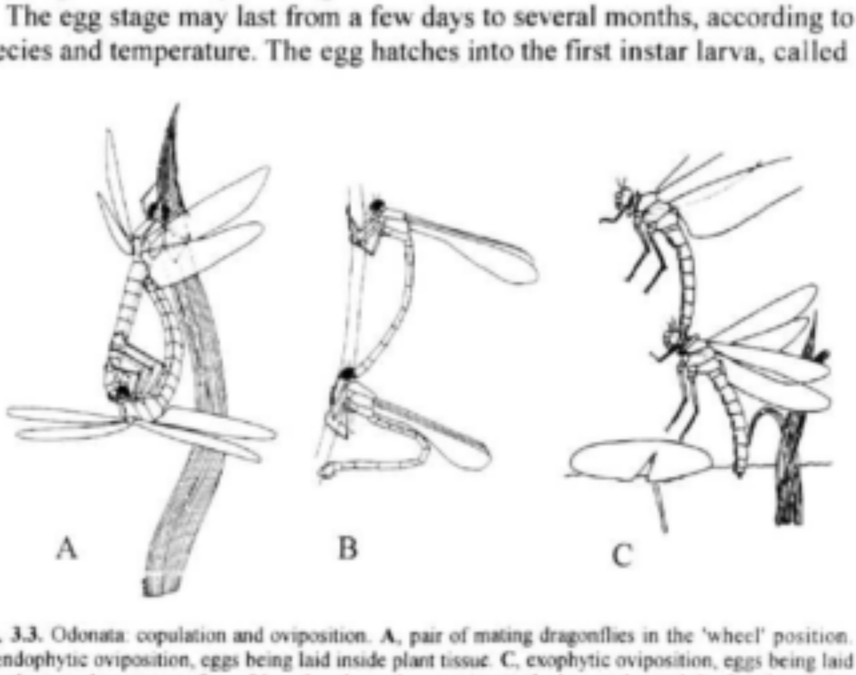

Fig. 3.3. Odonata: copulation and oviposition. **A**, pair of mating dragonflies in the 'wheel' position. **B**, endophytic oviposition, eggs being laid inside plant tissue. **C**, exophytic oviposition, eggs being laid directly onto the water surface. (Note that the males remain attached to, and guard the females during both exophytic and endophytic oviposition). (After Samways & Whiteley 1997).

the **prolarva**, which after a few seconds or minutes, moults into the second instar, the first free-living trophic larval stage. Development rate depends on the season, the particular species, whether there is diapause or not, time of year, the prevailing temperature, and food availability. Some species overwinter as eggs and others as larvae, but rarely as adults. The number of instars (counting the prolarva as number one) generally ranges from nine to seventeen.

There is no pupal stage. Often at night, when the larva is about to become an adult, it climbs out of the water and, depending on the species, onto a reed stem (Fig. 3.2A), rock or stream bank. The larva swallows air and expands its body so that its dorsal surface splits. The adult then pulls itself through the split and frees itself. Blood flows into the soft, silvery wings, expanding them into the rigid structures of the adult. In the morning, the young adult, known as the **teneral**, is ready to take to the air. At this stage, the body colour is muted and the males look very similar to the females. Both sexes then move away from the water for several days (although several weeks to months have been occasionally recorded) to mature. Once their bodies have hardened and coloured males may return to the water's edge, but females usually only return to water to mate and lay eggs.

Collection

Larvae are readily collected in most pools, impoundments, streams and rivers using a simple dip net with a long, lightweight pole. A swimming pool leaf net is ideal for most purposes, although a stouter frame may be needed for collection among thick weeds and rushes. After vigorously 'shovelling' the net back and forth among water weed, along rushes and beside banks, it is removed and examined, and the individual larvae are picked out with very soft, flexible forceps (to prevent damage to fragile structures), and placed in a shallow, white tray for sorting.

For accurate identification of the larva, it is generally necessary to rear them to adults. For this purpose, only large and, preferably final-instar larvae, should be kept. Final-instar larvae are readily recognized by the very prominent wing sheaths lying centrally and dorsally along their body, extending to beyond the third, and usually to the sixth, abdominal segment. The larvae are placed *individually* into open-top plastic or glass phials with netting, held in place with an elastic band over the opening. If more than one larva is put in a phial there is often cannibalism, with only the largest larva surviving! The phials are then immersed in a large insulated box (such as a picnic cool-box) containing water from the collecting site. A battery-driven aquarium aerator may optionally be used to oxygenate the water. It is critical not to leave the cool-box in the direct sunlight, or inside a motor vehicle.

Rearing

Larvae of most species survive and grow very well in the laboratory, preferably in an airy, shaded room. Trays are set up to contain a 2–3 cm depth of dechlorinated water (i.e. water that has been left to stand overnight). Larvae are then transferred from the collecting phials to small rearing cages made out of plastic netting (mesh size about 2–3 mm) rolled into cylinders of about 6 cm width and 15 cm height and sealed at the top with an inverted plastic petri dish (Fig. 3.4). To avoid cannibalism and to ensure the correct association of larvae and adults, only one larva should be placed into each cage. It is not necessary to put any sticks or stones inside the cage (onto which the emerging adult can climb), as the larvae of all species use the sides of cages for this purpose.

The water inside the cage must be aerated. Food is provided principally as mosquito larvae or small tadpoles netted from a nearby pool or rain barrel. Occasional small odonate larvae can be used to supplement the mosquito larvae and tadpoles. Food is placed inside the mesh cage by lifting the petri dish. Larvae should be fed daily and uneaten or rotten food must be removed from cages on a regular basis.

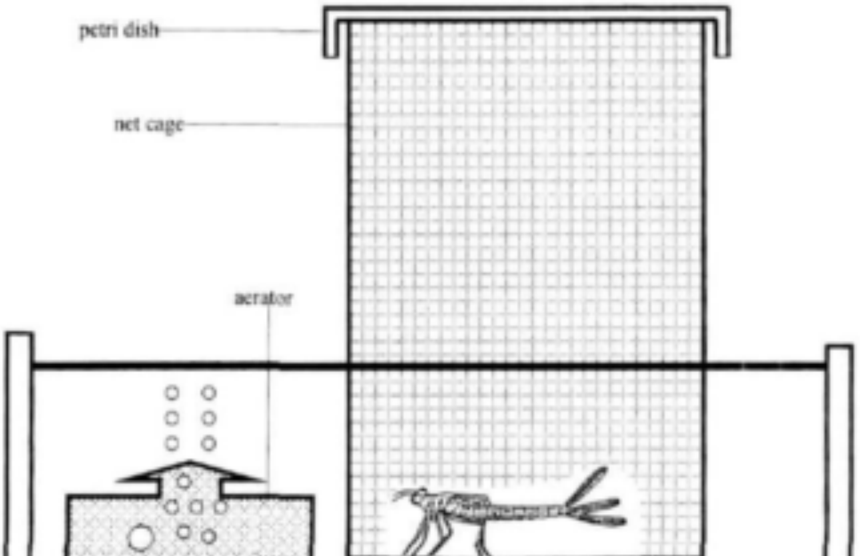

Fig. 3.4. Apparatus used for rearing an odonate larva through to the adult stage.

After several hours to days, and usually during the night or early morning, the larva will leave the water and climb up the side netting of the cage. It will stop at the highest point where it emerges. The remaining 'shuck' (or, more correctly, the **exuviae**) should be collected and retained in a phial containing 75 % ethyl alcohol. After a couple of days, the adult should also be placed in the same phial. The data label must be written in pencil and placed *inside* the phial, to ensure that it will not get lost.

MORPHOLOGICAL FEATURES OF ODONATE LARVAE

Although it is in the larval stage rather than the adult, that shows the greatest adaptive radiation in functional morphology (Corbet 1999), the body plan is the same, and the body parts bear the same names for both stages.

Compared with the adult, the head of the larva is not so freely moveable and is relatively smaller. The thorax is simpler, and the legs are further apart and adapted for walking, and not for catching prey as in the adult. The larvae of the Zygoptera are longer and more slender than those of the Anisoptera. The head is much wider than the thorax or abdomen, and the antennae relatively much longer (Fig. 3.5A, B). The antenna is composed of large first and second segments and then a series of finer segments termed the 'flagellum' (Fig. 3.5D).

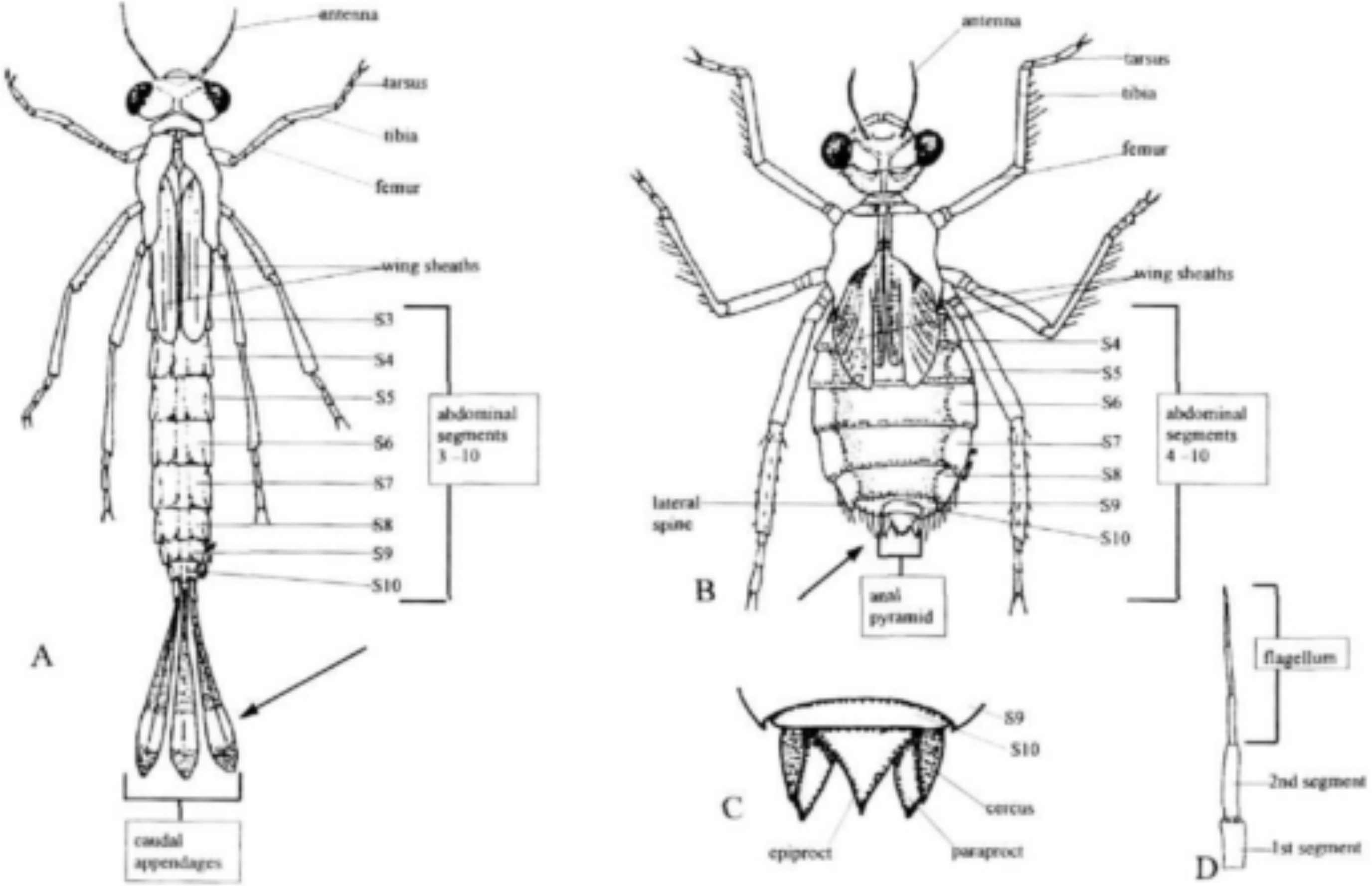

Fig. 3.5. Typical odonate final instar larvae (dorsal views). **A**, typical zygopteran (note delicate body and long, terminal caudal appendages, arrowed). **B**, typical anisopteran (note stout body and anal pyramid, arrowed). **C**, detail of anal pyramid of an anisopteran larva. **D**, detail of antenna.

The **labium** (Figs 3.2B, C & 3.6A, B) is folded upon itself at mid-length and at rest extends posteriorly to between the forelegs, or in some genera, to the middle legs or beyond. The **prementum**, which is the anterior half of the labium, varies widely in shape (Fig. 3.6). The simple, flat rectangular or triangular form typical of the Gomphidae, Aeshnidae and most Zygoptera, differs from the strongly ladle-shaped form of the Lestidae and the deeply concave form, with its broad **labial palps** forming a basket-like arrangement, of the Libellulidae and Corduliidae. (See details on features of morphological importance below).

The prementum bears a pair of strong, hinged labial palps (Fig. 3.6A). In some taxa these labial palps are armed with hooks, spines, teeth and/or setae (Fig. 3.6A, C, D). They also usually bear strong palpal setae on dorsal surface and often terminates in an apical projection, the **end hook** (Fig 3.6 D). The median lobe of the prementum, which varies with family and genus in outline, and in being incised with a median cleft (Fig. 3.6A) or not, is an important diagnostic character. Corbet (1953) gives a detailed account of the widely used terminology for the labium. An important aspect of this terminology is the formulae used for the number of main setae on the labial palp and on the prementum. Setae come in mirror-image groups, either side of the midline of the labium. For the labial palps, this means a group of setae on each palp. The number of setae on each palp is written as a number separated by an ampersand, (e.g. '3 & 3', means three large setae on each labial palp). Often there is variation between individuals and different individuals of the same species with, say, three to five setae on each palp would mean that the species as a whole would be designated 3–5 & 3–5. A similar situation prevails with the prementum, although the two groups of setae in each half are separated in the formula by a plus sign (e.g. '3+3' means three large setae in each half of the prementum). Variation between individuals with, say, three to five setae in each half of the prementum would mean that the species would be designated '3–5 + 3–5'. These setal formulae can also be applied to groups of species within one genus or one family. In this context, the formula '3–5 & 3–5' for a genus or family would mean that in that group different individuals and/or species differed in having between three and five setae on each labial palp. Similarly, '3–5 + 3–5' would mean that different individuals or species differed in having between three and five setae in each half of the prementum.

The features which are of diagnostic importance in separating the different taxa Odonata are listed from page 170–172.

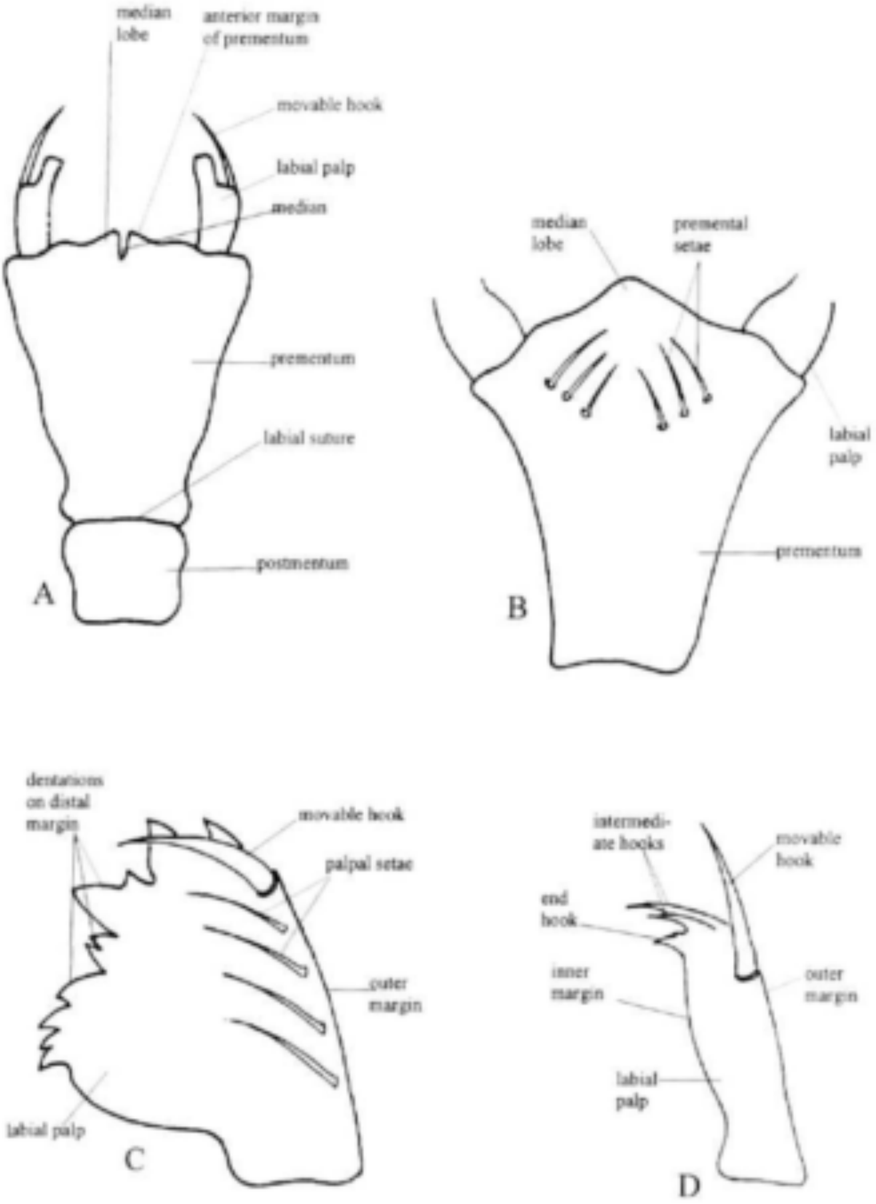

Fig. 3.6. Odonata: detail of structures associated with labium (generalized, based on Corbet 1953): **A**, ventral view of whole labium; **B**, dorsal view of prementum when labium is extended, illustrating premental setae (3 + 3 setal configuration); **C–D**, right labial palps: **C**, dorsal view of a labial palp with large dentations on the distal margin and palpal setae (4 & 4 setal configuration); **D**, dorsal view of a labial palp with a large end hook and intermediate hooks.

FEATURES OF DIAGNOSTIC IMPORTANCE

GENERAL APPEARANCE

- Slender, with **caudal lamellae** (Fig. 3.5A) or stout, or robust with an **anal pyramid** (Fig. 3.5B).
- body shape rounded (Fig. 3.12A1) or parallel-sided/fusiform (Fig. 3.12A2).

HEAD

- With angular margins (Fig. 3.10B1) or rounded margins (Fig. 3.10B2).
- Head shape rounded (Fig. 3.14A1) or more rectangular (Fig. 3.14A2).
- With **frontal horn** and **post-ocular tubercles** (Fig. 3.16A1) or without these features (Fig. 3.16A2).
- With small eyes (Fig. 3.18D1) or large eyes (Fig. 3.18D2).

Antennae

- With four segments, the last being very small (Fig. 3.11A1) or with six or seven segments and gradually tapering (Fig. 3.11A2).
- With a long third segment (Fig. 3.12B1) or a shorter third segment (Fig. 3.12B2).

Labium

The prementum:

- Anterior margin of prementum: deeply incised (Fig 3.7B1) or shallowly incised (Figs 3.7B2 & 3.10E2) or indented (Fig 3.10E1).
- Shape of prementum: ladle-shaped (Fig. 3.7D1) or triangular-shaped (Fig 3.7D2); flat and elongated (Fig. 3.11B1) or concave with palps forming a basket (Fig 3.11 B2).
- Presence of setae on moveable hook (Fig 3.7D1).
- Length of prementum: long, reaching hindlegs (Fig. 3.14B1) or shorter, reaching just beyond forelegs (Fig. 3.14B2).
- Premental setal configuration: 4+4 (Fig. 3.10D1) or 5+5 (Fig. 3.10D2), or other combinations.
- No premental setae (Fig. 3.7D1, 2).

Labial Palps

- Palpal setal configuration: 6 & 6 (Fig. 3.11C2) or 1 & 1 or 5–7 & 5–7 (Fig. 3.20 A1) or 3–4 & 3–4 (Fig. 3.20 A2) or 11–12 & 11–12 (Fig. 3.20C) or 12–14 & 12–14 (Fig. 3.20D1).
- With dentations or strong crenations (Figs 3.6C & 3.18A1) or weak crenations (Fig. 3.18A2).
- With weak crenations (Fig. 3.20D2) or smooth edged (Fig. 3.20D1).
- With spots (Fig. 3.18A2) or without spots (Fig. 3.20A1).

THORAX

- Wing sheaths parallel (Fig. 3.12C2) or divergent (Fig. 3.12C1).
- Thorax same width as head (Fig. 3.18C1) or narrower (Fig. 3.18C2).

ABDOMEN

Abdominal segments

- Segment 10 long and tapering (Fig. 3.12D1) or long and divergent (Fig. 3.12D2).
- Segment 10 short and wider (Fig. 3.12E1) or long and narrow (Fig. 3.12E1).
- Segment 9 without spines (Fig. 3.18E1) or with spines (Fig. 3.18E2).
- Segments 8 & 9 both with short spines (Fig. 3.20 E1) or with long spines (Fig. 3.20E2).
- Dorsal abdominal spines present on segments 5–9 (Fig. 3.13D) or not present on these segments (Fig. 3.13F).
- Dorsal abdominal spines very strong and pointing upwards (Fig. 3.20F1) or moderately strong and pointing backwards (Fig. 3.20F2).

Caudal appendages

- Rounded (Fig. 3.7C1) or pointed (Fig. 3.7C2).
- Banded (Fig. 3.7C1) or not banded (Fig. 3.7C2).
- Triquetral (triangular in cross section) (Fig. 3.7E1) or flattened lamellate (Fig. 3.7E2).
- With pedicel (Figs. 3.7E2 & 3.10C2) or without pedicel (Fig. 3.7C1,2).
- Wide and without node (Fig. 3.10A1) or long and narrow with node (Fig. 3.10A2).
- Long and tapering (Fig. 3.10C1) or leaf-like/lamellate (Fig. 3.10C2).

Anal pyramid

- Long and prominent (Fig. 3.18E1) or short and retracted (Fig. 3.18E2).

In Odonata the abdomen of the larva is much shorter than that of the adult, this being particularly so in most Anisoptera. The larval abdomen may be relatively long, slender and tapering in the Zygoptera (Figs 3.8 & 3.9), and in the Aeshnidae (Fig 3.15). It may be blunt-tipped, even broad and subcircular, in some Gomphidae (Fig. 3.13B) and in *Phyllomacromia* (Corduliidae: Fig 3.17A). In the Anisoptera and in a few Zygoptera, the abdominal tergites often have sharp, lateral projections, the lateral spines (Fig 3.2). There may also be variously-shaped medio-dorsal projections in the form of spines or hooks on the posterior margin of the abdominal segments. On the sternite of segment 2 of the male larva or exuviae, the rudiments of the adult genitalia can often be seen as swellings, and the developing ovipositor of the female is usually visible in the sternal region of segment 9.

The tip of the abdomen is composed of projections that are made up of a dorsal **epiproct** and two lateral **paraprocts** which surround the anal opening of the rectal chamber. Two **cerci** are also present in the final-instar larva. In the Anisoptera, these form the **anal pyramid** (Fig. 3.5B, C). In the Zygoptera, the epiproct and the paraprocts are specialized to form the three (sometimes only two) **caudal appendages** (sometimes called 'caudal lamellae' or 'caudal gills'), which are so characteristic of this group. (Fig. 3.2A & 3.5A). A variety of different larval forms are illustrated in Figs 3.8, 3.9, 3.13, 3.15, 3.17, 3.19 & 3.21.

ODONATA IN SOUTHERN AFRICA

The Appendix to this chapter (p. 201) lists the species recorded to date in southern Africa (Samways, In Press a). This list is unlikely to be complete as more exploration is needed, especially in Angola and Mozambique.

The region has several species that are threatened. These are discussed and assigned IUCN *Categories of Threat* (IUCN 2000) in Samways (1996, 1999, 2002, In Press b).

NOTES ON THE ODONATA KEYS THAT FOLLOW

The keys provided below can only be used for the final-instar larva or the exuviae since the measurements given here refer specifically to the final instar larva which can be recognized by its wing sheaths that extend beyond the third abdominal segment. These wing sheaths generally reach the posterior edge of segment 4, but, depending on the shape of the larval abdomen and the positioning of the wing sheaths, they may reach beyond this point. In order to determine the correct number of particular abdominal segments, it is often easier to count backwards from the last or tenth abdominal segment (i.e. excluding the caudal appendages or anal pyramid) since the basal segments may be difficult to distinguish.

'Body length' refers to the distance from the front margin of the head, excluding the antennae, to the posterior tip of the abdomen, including the anal pyramid in Anisoptera but excluding the caudal appendages in Zygoptera.

Although the southern African odonate fauna are well documented (Pinhey 1961, 1976, 1981, 1984a, b, 1985; Curtis, 1991; Barlow, 1996; Samways, 1999, and references therein) this is really only the case for the adults. The larvae are very poorly known, even at the generic level. For this reason, these keys are very provisional, and will hopefully provide a stimulus for more collecting, rearing and description of undescribed larvae.

Many species of Odonata have specific habitat preferences, geographical distributions, and rarity values. This helps considerably in narrowing down the possible species for the purpose of identification. A brief overview of the distributions of individual species is given in the appendix at the end of this chapter.

KEY TO SUBORDERS OF ODONATA

1. Larvae long and slender (Fig. 3.5A); head as wide as or wider than thorax or abdomen; abdomen principally cylindrical, not widening behind the base, and terminating in three (rarely two) caudal appendages that are lamellate or (rarely) triquetral (triangular in cross section) (Fig. 3.7E1) ....**Zygoptera*** (p. 173–180)
– Larvae stout and robust (Fig. 3.5B); head usually narrower than thorax or abdomen; abdomen widening from base to middle or beyond and without external caudal appendages; abdomen terminating in five (in final instar) spine-like processes making up the anal pyramid (Fig. 3.5B, C).........**Anisoptera** (page 180–197)

* Zygopteran larvae readily lose one or more caudal appendages due to injury or during capture. Also, caudal appendages lost early on are regenerated, and therefore may not be full size when the larva is captured.

KEY TO FINAL INSTAR LARVAE AND EXUVIAE OF ZYGOPTERAN FAMILIES IN SOUTHERN AFRICA

1. Antenna with long first segment, at least as long as the remaining six segments of the antenna (Fig. 3.7A1) 2
– Antenna with short first segment, shorter than remaining segments of antenna (Fig. 3.7A2)... 3

2. Antenna with first segment equal to or slightly longer than rest of antenna; prementum moderately ladle-shaped with median lobe deeply incised, and extending proximal to articulations of labial palps (Fig. 3.7B1); abdomen long and cylindrical; three caudal appendages of similar lengths and lamellate ....**Calopterygidae**
– Antenna with first segment twice the length of rest of antenna; prementum flat and triangular in outline, with median lobe only shallowly incised (Fig. 3.7B2), if at all; abdomen tends to be broad and flattened; median caudal appendage rudimentary or absent, lateral appendages triquetral (Fig. 3.7E1) ....**Chlorocyphidae**

3. Labial palps without dorsal setae; caudal appendages apically very rounded and with a broad, dark band (Fig. 3.7C1) ....**Synlestidae**
– Labial palps with dorsal setae; caudal appendages less rounded and without a broad, dark band (Fig. 3.7C2) 4

4. Prementum strongly ladle-shaped with median lobe incised (Fig. 3.7D1); movable hook with setae (Fig. 3.7D1) .... **Lestidae**
– Prementum triangular with median lobe, not incised (Fig. 3.7D2); movable hook without setae 5

5. Antenna with second segment longer than third (first flagellar segment); prementum extends back only to base of forelegs (e.g. Fig 3.14B2); 2 & 2 palpal setae; if premental setae present then caudal appendages triquetral (Fig. 3.7E1); if premental setae absent or extremely small, caudal appendages lamellate and entire; caudal appendages with pedicels (Fig. 3.7E2) .... **Platycnemididae**
– Antenna with second segment shorter than first flagellar segment; prementum extends back beyond base of forelegs (see Fig 3.14B1); palpal and premental setae always present but range in number; caudal appendages lamellate and simple or nodate, with or without pedicels 6

6. Outer edge of prementum with fine setae (Fig. 3.7F1); 3–8 & 3–8 setae on each palp and 1–6 + 1–6 premental setae; caudal appendages without pedicels ... . **Coenagrionidae**
– Outer edge of prementum with long series of stout, spiniform setae (Fig. 3.7F2); 3 & 3 palpal setae and 1+1 premental setae; caudal appendages with pedicels .... **Protoneuridae**

Synlestidae

(Fig. 3.8A)

Two genera occur in the region (see Appendix). To date, only the final-instar larvae of *Chlorolestes conspicuus* (Barnard 1921, 1937), *C. elegans* (Pinhey 1958) and *C. fasciatus* (Samways and Whiteley 1997) have been illustrated but not fully described.

Lestidae

(Fig. 3.8B)

One genus, *Lestes* (ten species), has been recorded from the region (see Appendix). The final-instar larvae of the following species have been described: *L. ictericus* (Pinhey 1961); *L. pallidus* (Pinhey 1959); *L. plagiatus* (Cammaerts 1966) and *L. virgatus* (Samways et al. 1992).

Protoneuridae

Three genera have been recorded from the region (see Appendix). The final-instar larva of *E. frenulata* has been described by Barnard (1937).

Platycnemididae

(Fig. 3.8C, D)

Four genera have been recorded from the region (see Appendix). The characters used in the following key are based on the descriptions of *Allocnemis leucosticta* by Barnard (1937) and of *Mesocnemis singularis* by Corbet (1956) (under the former name *Metacnemis valida*) and Pinhey (1959).

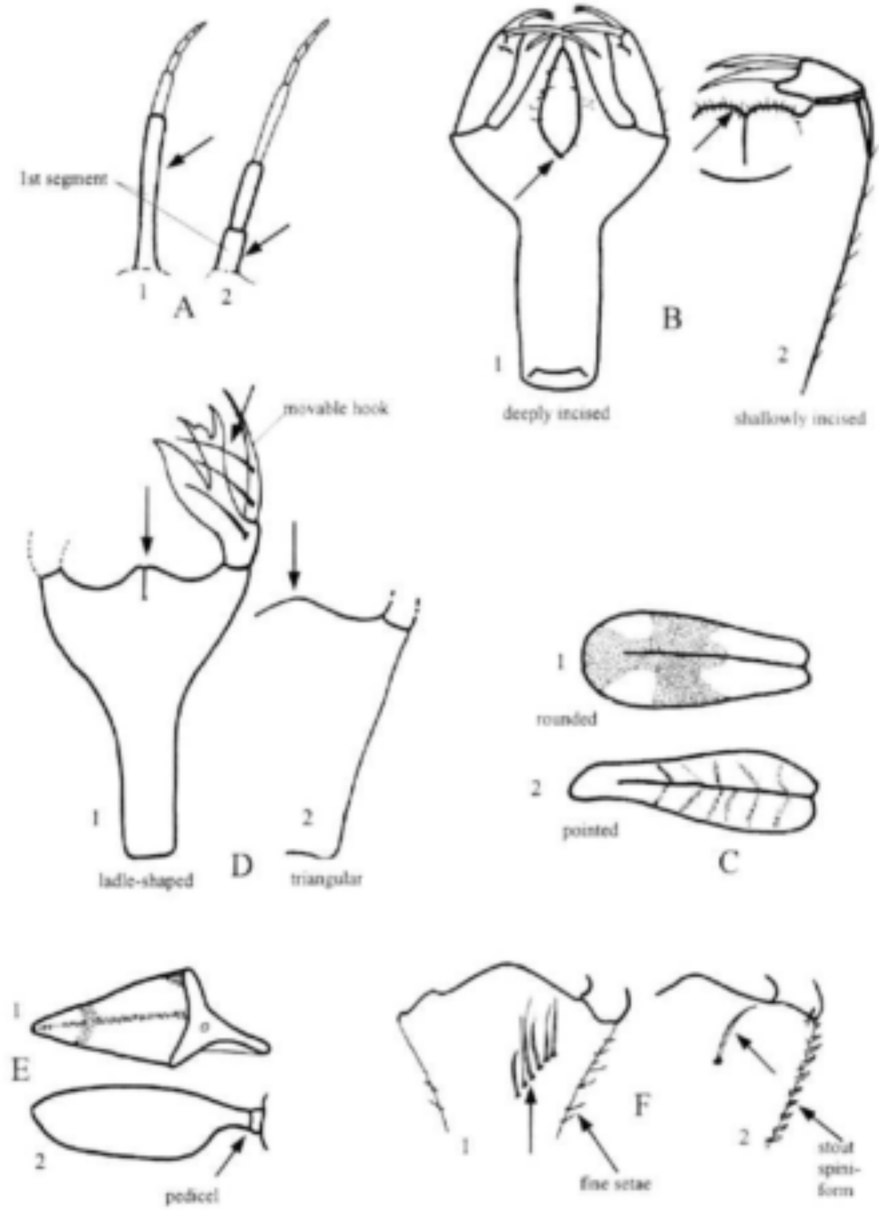

Fig. 3.7. Distinguishing features of zygopteran families and genera. **A**, antennal first segment: A1, long (arrowed), in Calopterygidae & Chlorocyphidae; A2, short (arrowed), in other zygopteran families. **B**, prementum (dorsal view): B1, deeply-incised, in Calopterygidae; B2, shallowly-incised, in Chlorocyphidae; C, caudal appendage: C1, rounded with a broad, dark band, in Synlestidae; C2, less rounded (or pointed), without dark band, in other families. **D**, prementum (dorsal view): D1 ladle-shaped with median lobe incised (arrowed), and movable hook with setae (arrowed), in Lestidae); D2, triangular without median incision (arrowed). **E**, caudal appendage: E1, triquetral-shaped, in *Allocnemis* (Platycnemididae); E2, with a pedicel (arrowed). **F**, premental setae (dorsal view): F1, with several premental setae (6+6 setal configuration–arrowed) and a margin with fine setae (arrowed), in *Agriocnemis pinheyi* (Coenagrionidae); F2, with a single, strong seta in each half of prementum (1+1 setal configuration – arrowed) and a margin of stout spiniform setae (arrowed), in *Elattoneura frenulata* (Protoneuridae).

PLATYCNEMIDIDAE FINAL INSTAR LARVAE AND EXUVIAE: KEY TO SOUTHERN AFRICAN GENERA

Introductory Note: *Metacnemis* has been omitted from this key as the larvae of neither of the two rare South African endemic species, *M. angusta* and *M. valida*, have been described.

1. Antenna with first segment half the length of second segment; 1 + 1 premental setae; caudal appendages thickened, median appendage saccoid and lozenge-shaped, laterals triquetral (Fig. 3.7E1); body length 16–17 mm; caudal appendages 5–6 mm .... *Allocnemis* (Fig. 3.8C)

– Antenna with first segment less than half the length of second segment; no premental setae; caudal appendages lamellate; body length 14–16 mm; lateral caudal appendages elongated, not triquetal; caudal appendages 6–6.5 mm .... *Mesocnemis* (Fig. 3.8D)

Coenagrionidae

(Fig. 3.9A, B, C, D)

Seven genera have been recorded from the region (see Appendix).

Introductory note on the key to Coenagrionidae: The characters used in this key are based on the generic and specific descriptions by Barnard (1937), Carchini et al. (1995), Chutter (1961, 1962), Corbet (1956b), Di Domenico et al. (1996), Gardner (1983), Pinhey (1959, 1961) and Walker (1953).

The larva of *Aciagrion* is unknown, and is not included in the following key. This preliminary key nevertheless serves for all South Africa, except at Ndumo and Cape Vidal (in KwaZulu–Natal), where *Aciogrion* spp. occur. The features for *Teinobasis* are based on those of an Asian species (*T. ariel*) described by Lieftinck (1962).

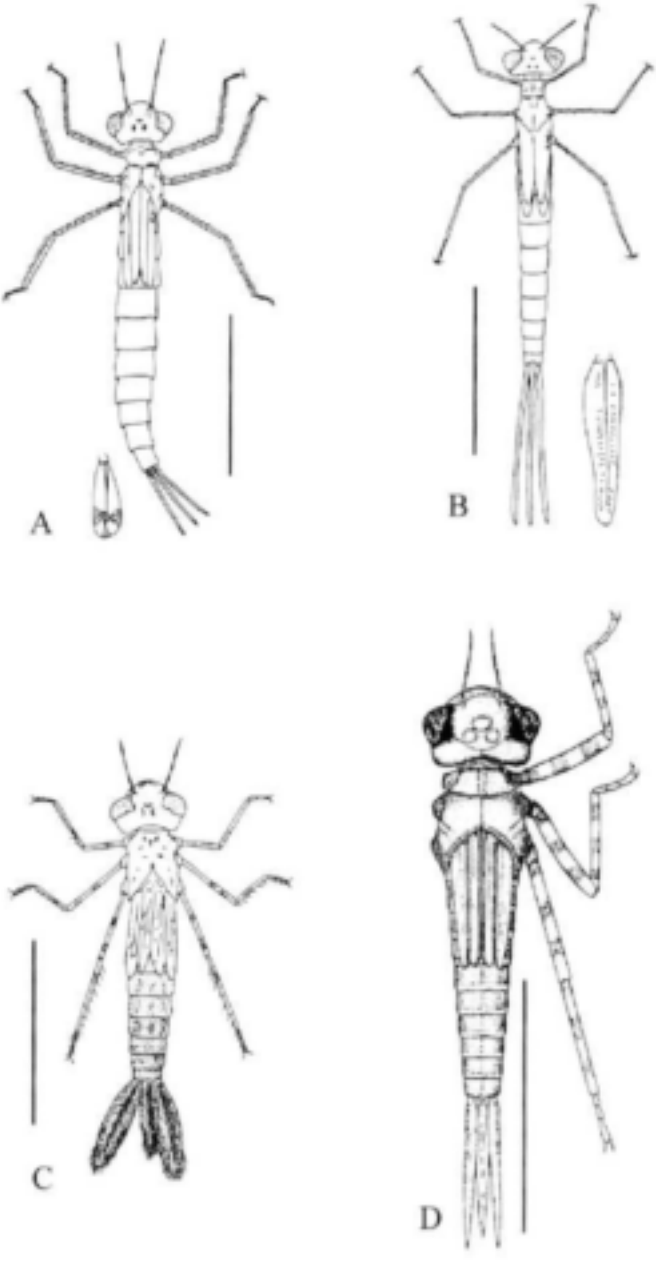

Fig. 3.8. Southern African zygopteran larvae (dorsal views, with A& B also showing detail of gills): A, *Chlorolestes fasciatus* (Synlestidae); **B**, *Lestes plagiatus* (Lestidae); **C**, *Allocnemis leucosticta* (Platycnemididae); **D**, *Mesocnemis singularis* (Platycnemididae); (A, B & C after Samways & Whiteley 1997; D after Corbet 1956b). Scale bar = 10 mm.

COENAGRIONIDAE FINAL INSTAR LARVAE AND EXUVIAE: KEY TO SOUTHERN AFRICAN GENERA

1. 1 + 1 premental setae (as in Fig. 3.7F2); caudal appendages with or without nodes (Fig. 3.10 A1, 2) 2
– 4–6 + 4–6 premental setae (Fig. 3.7F1); caudal appendages without nodes (Fig. 3.10A1) 3
2. Caudal appendages 4–5 mm long; head large relative to body length (head width/body length ratio 1: 3.5); caudal appendages simple, lamellate, broadest in distal half before obtusely pointed tip (Fig. 3.10A1) 4
– Caudal appendages 6–7 mm long; head not large relative to body length (head width/body length ratio 1: 4.5); caudal appendages elongate, nodate and usually narrow with apices shortly acute (rounded in some species) (Fig. 3.10A2).................... *Pseudagrion* (Fig. 3.9B)
3. Prementum straight to slightly concave, with maximum width less than length; palpal setae 7–9 & 7–9 .... *Ceriagrion* (Fig. 3.9A)
– Prementum convex, with maximum width equal to length; palpal setae 4 & 4.................... *Teinobasis*

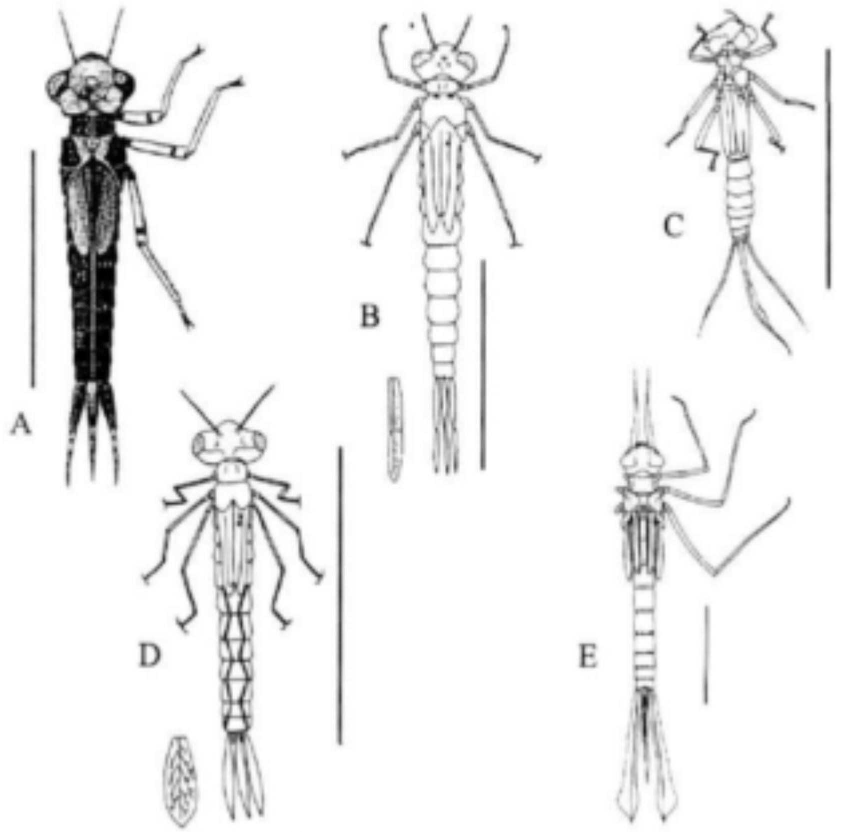

Fig. 3.9. Southern African zygopteran larvae (dorsal views, B & D also showing detail of gills). **A**, *Ceriagrion glabrum* (Coenagrionidae); **B**, *Pseudagrion spernatum* (Coenagrionidae); **C**, *Agriocnemis pinheyi* (Coenagrionidae) (with left antenna truncated); **D**, *Enallagma glaucum* (Coenagrionidae); **E**, *Phaon iridipennis* (Calopterygidae). (B & D after Samways & Whiteley 1997; A after Corbet 1956b; C after Carchini et al. 1995; E after Cammaerts 1967). Scale bar = 10 mm.

4. Larva very small (body length less than 9.5 mm); postero-lateral margins of head acutely angled (Fig. 3.10B1); caudal appendages very long and tapering (Fig. 3.10C1) ....*Agriocnemis* (Fig. 3.9C)
– Larva large (body length more than 9.5 mm); postero-lateral margins of head rounded (Fig. 3.10B2); caudal appendages wider and more leaf-like (Fig. 3.10C2) 5

5. Premental setae 4 + 4 (Fig. 3.10D1); abdomen with dark zig-zag lines (Fig. 3.9D); average body length 9–10.5 mm; caudal appendages 3–5 mm long.................. ....*Enallagma* (Fig. 3.9D)
– Premental setae 5 + 5 (Fig. 3.10D2); abdomen without dark zig-zag lines; body length 13–14 mm; caudal appendages 6–6.5 mm long ....*Ischnura*

Calopterygidae
(Fig. 3.9E)

Two genera have been recorded from the region (see Appendix). Only the larva of *Phaon iridipennis* has been described, by Cammaerts (1967).

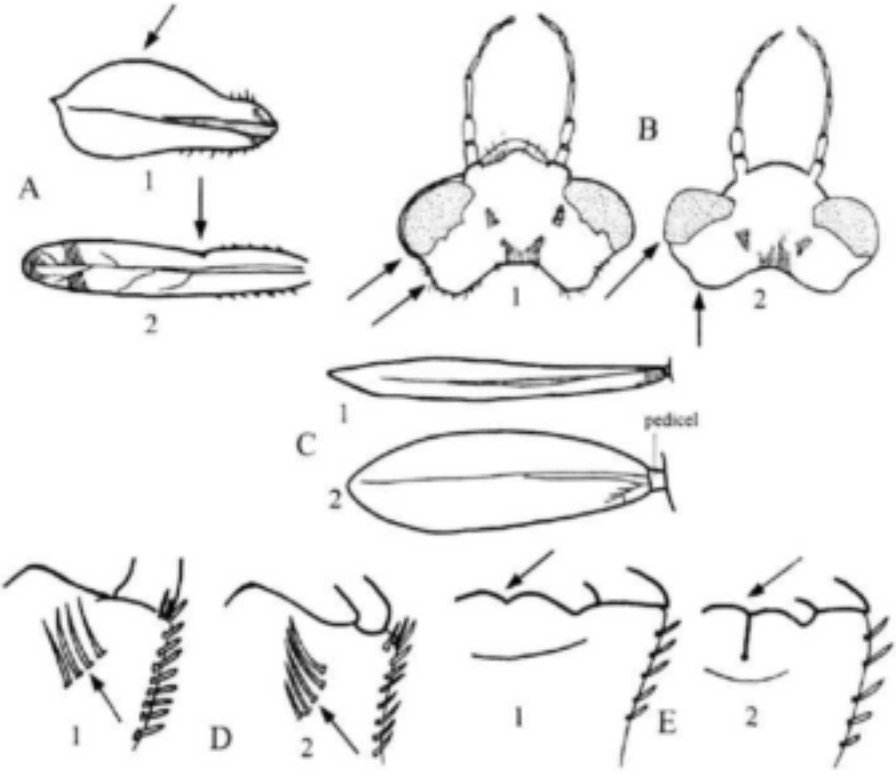

Fig. 3.10. Distinguishing features of zygopteran families and genera. **A**, lateral caudal appendage: A1, widening in the distal half (arrowed), in *Ceriagrion glabrum*; A2, with node (arrowed), in *Pseudagrion hageni*. **B**, head outlines: B1, with angled lateral and posterior margins (arrowed), in *Agriocnemis pinheyi*; B2, with more rounded lateral and posterior margins (arrowed), in *Pseudagrion spernatum*. **C**, caudal appendage: C1, long and tapering, in *Agriocnemis pinheyi*; C2, leaf-like, in *Enallagma glaucum*. **D**, prementum setal configuration: D1, 4 + 4 setae, in *Enallagma glaucum*; D2, 5 + 5 setae, in *Ischnura senegalensis*. **E**, margin of prementum: E1, indented (arrowed), in *Chlorocypha* sp. E2, incised (arrowed), in *Platycypha caligata*.

Chlorocyphidae

Two genera have been described from the region (see Appendix). Only the larva of a central African *Chlorocypha* species, *C. triafaria* (formerly *C. straeleni*), is known (Pinhey 1959). The larva of *Platycypha caligata* has been described by Barnard (1937) and Pinhey (1959).

CHLOROCYPHIDAE FINAL INSTAR LARVAE AND EXUVIAE: KEY TO SOUTHERN AFRICAN GENERA

1. Antenna with first segment three times the length of second segment; prementum not incised, only indented (Fig. 3.10E1); tarsal claws slender .... *Chlorocypha*
– Antenna with first segment two to two and a half times length of second segment; prementum with short cleft (Fig. 3.10. E2); tarsal claws short and robust .... *Platycypha*

KEY TO ANISOPTERAN FAMILIES OF SOUTHERN AFRICA (Figs 3.11–3.21)

1. Antenna of four segments (terminal one often minute) (Fig. 3.11A1); tarsi of fore and middle legs of only two segments; prementum short, broad, squarish and median lobe not incised .... **Gomphidae**
– Antenna of six to eight segments (Fig. 3.11A2); all tarsi with three segments; prementum flat and elongated or strongly concave; median lobe may or may not be incised 2

2. Prementum flat and elongated (Fig. 3.11B1), not square, with median lobe incised at apex; usually no premental setae, sometimes with palpal setae; abdomen elongated .... **Aeshnidae**
– Prementum strongly concave with broad labial palps forming a basket-like arrangement (Fig. 3.11B2); several premental and palpal setae; abdomen generally broad 3

3. Labial palps ending in deep crenations (i.e. dentations) (Fig. 3.11C1); palpal setae robust; legs usually very long (Fig. 3.17A–C), with hind femora longer than width of head; anal pyramid short (shorter than median length of S8) (Fig. 3.17A–C); cerci normally over half length of paraprocts .... **Corduliidae**
– Labial palps rarely with deep crenations, but in some species crenations more or less developed (Fig. 3.11C2); palpal setae slender; legs variable in length, usually shorter than in the Corduliidae (as in Figs 3.19 & 3.21); anal pyramid variable in length, but usually longer than median length of S8 in those with crenulated palps; cerci at most half length of paraprocts .... **Libellulidae**

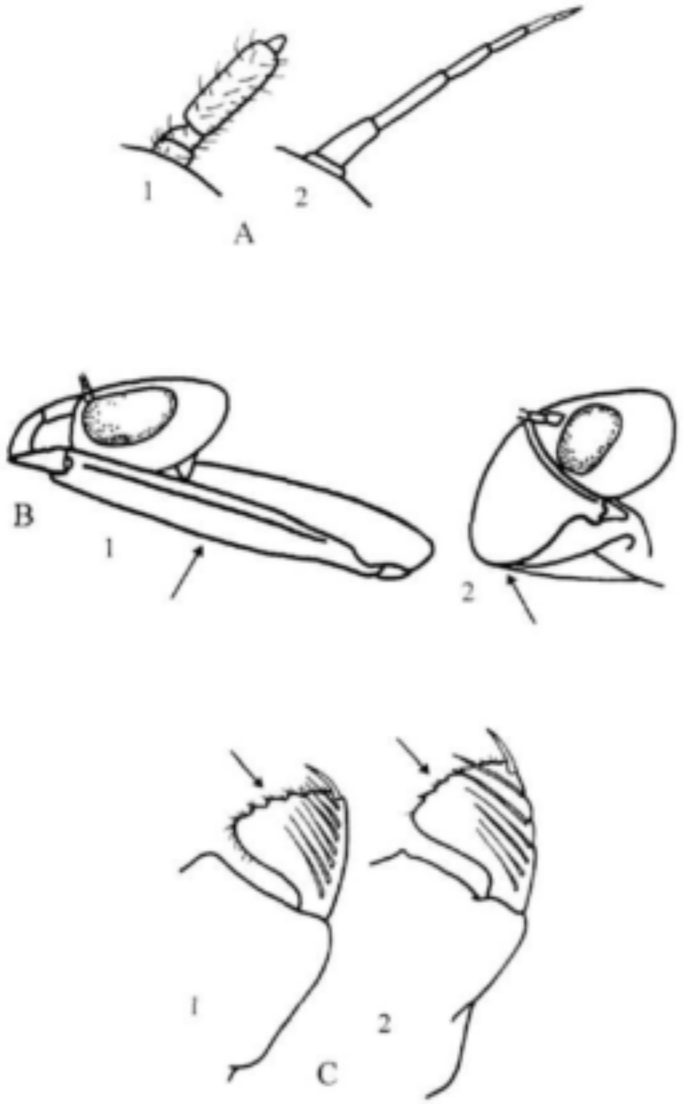

Fig. 3.11. Distinguishing features of anisopteran families. **A**, antenna: A1, with four segments, in Gomphidae; A2, with six to seven segments (in all families except Gomphidae). **B**, prementum shape (side view from left): B1, flat and elongated (arrowed), in Aeshnidae; B2, concave with broad labial palps forming a basket (arrowed), in Corduliidae & Libellulidae. **C**, labial palps, dorsal view: C1, ending in deep crenations (arrowed), in Corduliidae; C2, smooth or with only shallow and irregular indentations (arrowed), in most, but not all, Libellulidae (cf. Fig. 3.18A1 *Pantala*).

Gomphidae

(Fig. 3.12 and 3.13)

Fourteen genera have been described from the region (see Appendix). Full or partial descriptions of gomphid larvae have been given by Corbet (1956a, 1956c, 1957c), Pinhey (1959, 1961) and Di Domenico et al. (1994). The following preliminary key does not include *Diastatomma* and *Cinitigomphus* for which larvae have not yet been described.

GOMPHIDAE FINAL INSTAR LARVAE AND EXUVIAE: KEY TO SOUTHERN AFRICAN GENERA

1. Body, when viewed from above, extremely long and slender .... *Neurogomphus* (Fig. 3.13A)
– Body rounded or fusiform (Figs 3.12A1, 2 & 3.13B–H) 2

2. Abdomen rounded and moderately flattened dorso-ventrally (Fig. 3.12A1) and triangular in cross section; wing sheaths parallel (Fig. 3.12 C2) and reaching beyond the posterior margin of abdominal segment 5 3
– Abdomen fusiform (Fig. 3.12A2) or parallel-sided, moderately dorso-ventrally flattened (more cylindrical in exuviae) wing sheaths divergent (Fig. 3.12C1) or parallel (Fig. 3.12C2) and reaching, at most, the posterior margin of segment 5 4

3. Larva medium sized (total length = 27–31 mm); antenna with third segment considerably longer than combined length of the first segment and second segment (Fig. 3.12B1); abdomen with dorsal spines on segments 2–8 (2–5 spike-like, 6–7 blade-like, 8 poorly developed, a small protuberance just visible on segment 9 and lateral spines on segments 4–9 ..... *Ictinogomphus* (Fig. 3.13B)
– Larva small (total length =19–21 mm); antenna with third segment about equal to combined length of the first segment and second segment (Fig. 3.12B2); abdomen with dorsal spines on segments 6–9 .... *Gomphidia*

4. Abdomen parallel-sided; larva small (total length =17–19 mm); latero-posterior angles of head bluntly spined; antenna with third segment equal to combined length of first two segments .... *Microgomphus*
– Abdomen fusiform; larva medium to large (total length = 20–56 mm); latero-posterior angles of head rounded, without blunt spines; antenna with third segment equal to, or greater than, combined length of first two segments 5

5. Abdomen with tenth segment elongated and equal to or greater than combined lengths of segments 8 and 9 (Fig. 3.12D1, D2) 6
– Abdomen with tenth segment not elongated and less than combined length of segments 8 and 9 (Fig. 3.12E1, E2) 7

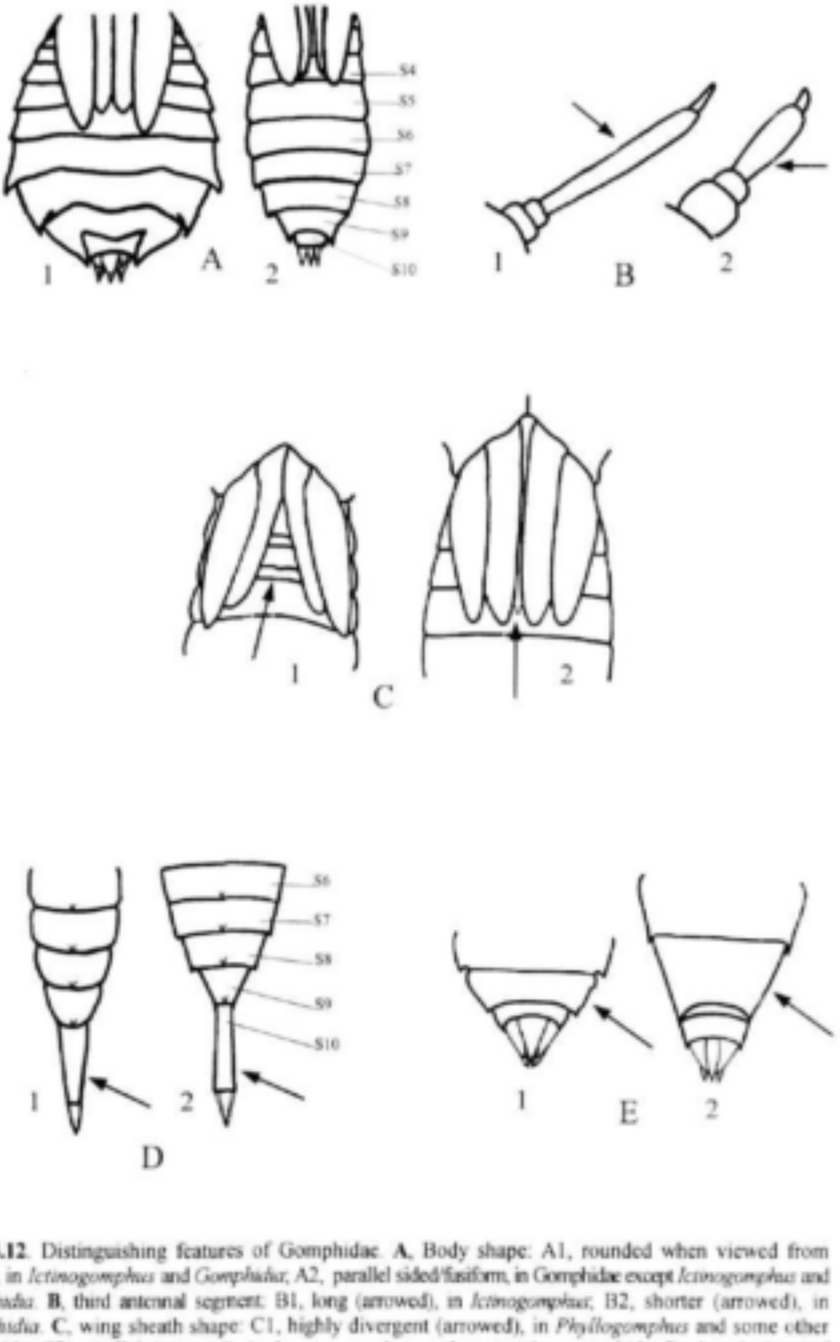

Fig. 3.12. Distinguishing features of Gomphidae. **A**, Body shape: A1, rounded when viewed from above, in *Ictinogomphus* and *Gomphidia*; A2, parallel sided/fusiform, in Gomphidae except *Ictinogomphus* and *Gomphidia*. **B**, third antennal segment: B1, long (arrowed), in *Ictinogomphus*; B2, shorter (arrowed), in *Gomphidia*. **C**, wing sheath shape: C1, highly divergent (arrowed), in *Phyllogomphus* and some other gomphids; C2, parallel (arrowed), in *Lestinogomphus*, and some other gomphids. **D**, dorsal views of 10th abdominal segment: D1, slightly convergent and about equal to combined length of segments 8 and 9 (arrowed), in *Phyllogomphus*; D2, slightly divergent and longer than the combined length of segments 8 and 9 (arrowed), in *Lestinogomphus*. **E**, dorsal view of 9th abdominal segment: E1, short and wide (arrowed), in *Onychogomphus*, and some other gomphids; E2, relatively long and narrow (arrowed), in *Notogomphus*.

6. Very large (total length greater than 48 mm); wing sheaths strongly divergent (Fig. 3.12C1); abdomen with tenth segment slightly convergent and equal to combined length of segments 8 and 9 (Fig. 3.12D1) .... *Phyllogomphus* (Fig. 3.13C)
– Small (total length less than 23 mm); wing sheaths parallel (Fig. 3.12C2); abdomen with tenth segment slightly divergent and greater than combined length of segments 8 and 9 (Fig. 3.12D2) .... *Lestinogomphus* (Fig. 3.13D)

7. Dorsal abdominal spines present (Fig. 3.13E); wing sheaths widely divergent (Fig. 3.13G) 8
– Dorsal abdominal spines absent (or at most, small protruberances) (Fig. 3.13H); wing sheaths parallel (Fig. 3.13H) (not divergent) or narrowly divergent 11

8. Dorsal abdominal spines only on segments 2 and 3 or 2–4 (at most, vestigial spines on segments 4–5 or segments 5–9) 9
– Abdominal segments 3–9 with small, sharp, pointed dorsal spines .... *Ceratogomphus* (Fig. 3.13E)

9. Antenna with fourth segment a strong curved seta, resembling a tarsal claw (Fig. 3.13F,G), and as long as second segment (Fig. 3.12B1) 10
– Antenna with fourth segment diminutive (much shorter than any other segment), and a small seta .... *Nepogomphoides*

10. Abdomen with dorsal spines on segments 2–4 , lateral spines on segments 7–9 long and distinct, larger than last (fourth) antennal segment .... *Crenigomphus* (Fig. 3.13F)
– Abdomen with dorsal spines on segments 2 and 3, lateral spines on segments 7 and 8 very small, shorter than last antennal segment .... *Paragomphus* (Fig. 3.13G)

11. Abdomen with ninth segment short and wide (Fig. 3.12E1) .... *Onychogomphus*
– Abdomen with ninth segment longer and narrower (Fig. 3.12E2) .... *Notogomphus* (Fig. 3.13H)

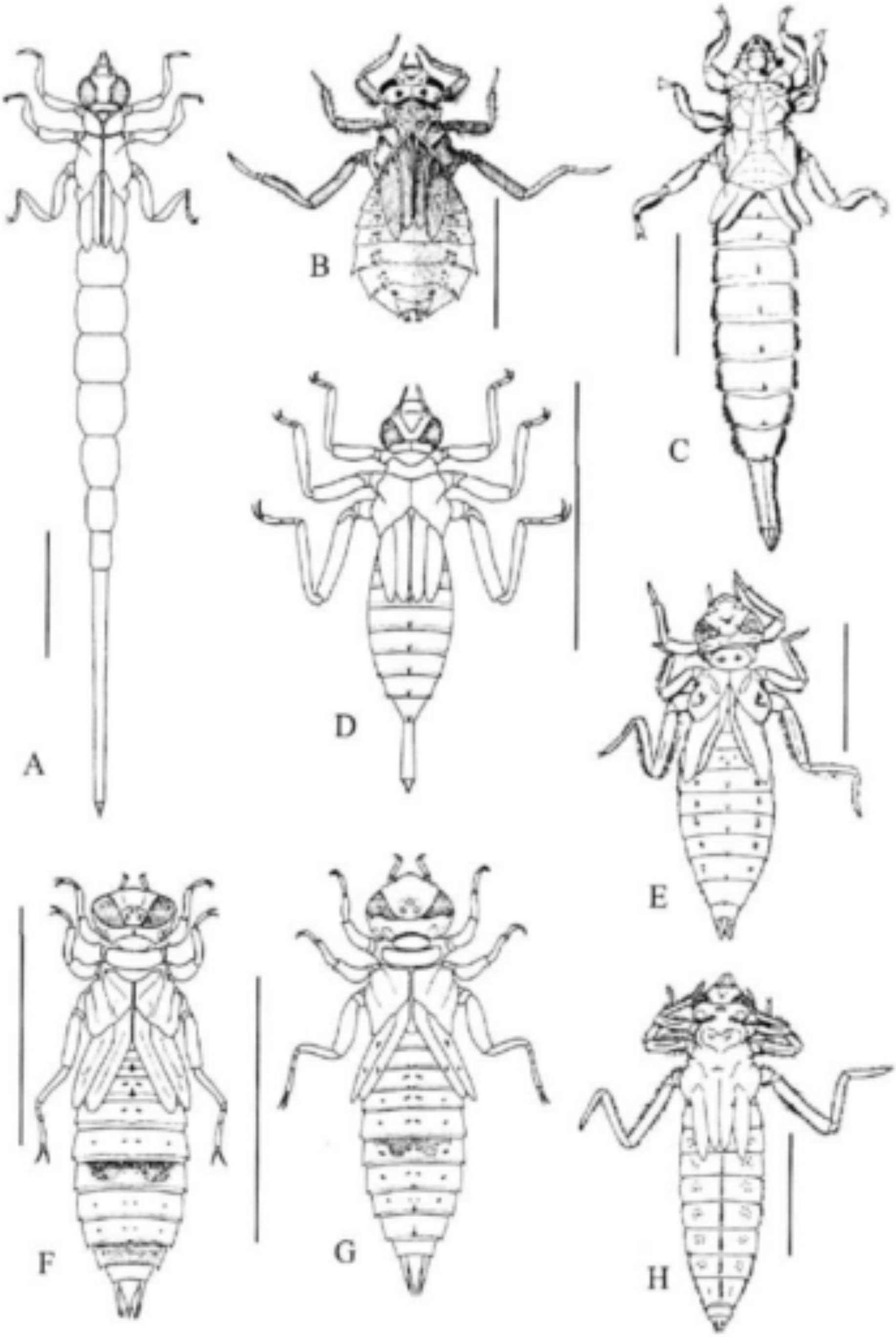

Fig. 3.13. Larvae of southern African Gomphidae (dorsal views): **A**, *Neurogomphus* sp; **B**, *Ictinogomphus ferox*; **C**, *Phyllogomphus brunneus*; **D**, *Lestinogomphus angustus*; **E**, *Ceratogomphus pictus*; **F**, *Crenigomphus renei*; **G**, *Paragomphus genei*; **H**, *Notogomphus praetorius*. (A after Corbet 1962; B after Corbet 1956a; C after Di Domenico et al. 1994; D after Corbet 1956c; E & H after Samways & Whiteley 1997; F & G after Corbet 1957c). Scale bar = 10 mm.

Aeshnidae

(Figs 3.14 & 3.15)

Six genera have been described from the region (see Appendix). Larvae have been described by Askew (1988), Chelmick (1999), de Marmels (1975), Gardner (1983), Pinhey (1959), Samways et al. (1993) and Samways & Whiteley (1997). The following preliminary key does not include *Heliaeschna,* for which the larva is unknown, while the features for *Anaciaeschna* are based on an Asian species (Lieftinck 1962).

AESHNIDAE FINAL INSTAR LARVAE AND EXUVIAE: PRELIMINARY KEY TO SOUTHERN AFRICAN GENERA

1\. Premental setae present; antenna with eight segments .... *Gynacantha*
– Premental setae absent; antenna with six or seven segments 2

2\. Eyes very large, markedly flattened dorsally and with posterior margins forming a transverse straight line; outline of head rounded (Fig 3.14A1) prementum extending to hind legs (Fig. 3.14B1); abdominal segments 7–9 with lateral spines .... *Anax* (Fig. 3.15A & B)
– Eyes smaller, not markedly flattened (hemispherical) and with posterior margins not forming a transverse straight line; outline of head somewhat rectangular, not rounded (Fig. 3.14A2); prementum not extending beyond middle legs (Fig. 3.14B2); abdominal segments 6–9 with lateral spines 3

3\. Wing sheaths reach abdominal segment 5 (Fig. 3.15C) .... *Anaciaeschna*
– Wing sheaths only reach abdominal segments 3 or 4 (Fig. 3.15D) ...... *Aeshna*

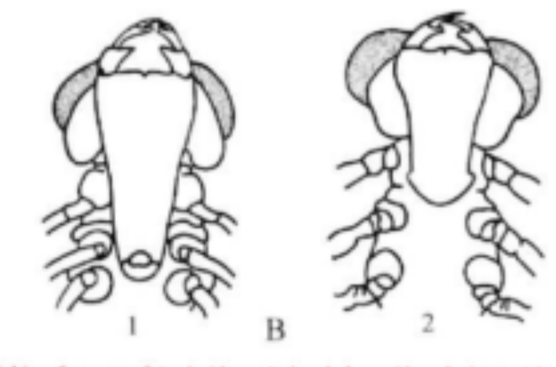

Fig. 3.14. Distinguishing features of Aeshnidae. **A**, head shape (dorsal view): A1, rounded, in *Anax*; A2, not rounded, more rectangular, in *Aeshna & Anaciaeschna*. **B**, prementum (ventral view), length: B1, reaches hindlegs, in *Anax*; B2, reaches middle legs, in *Aeshna*.

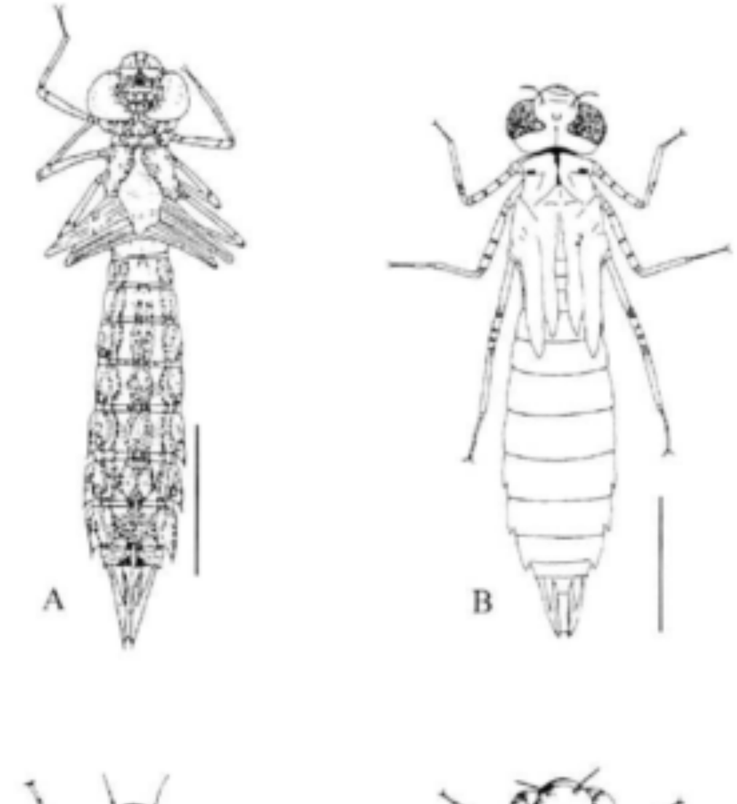

Fig. 3.15. Larvae of southern African Aeshnidae (dorsal views): **A**, *Anax ephippiger*; **B**, *Anax imperator*; **C**, *Anaciaeschna montivagans* (not a southern African species); **D**, *Aeshna minuscula*. (A after de Marmels 1975; B aftter Samways & Whiteley 1997; C after Lieftinck 1962; D after Samways et al. 1993). Scale bar = 10 mm

Corduliidae

(Figs 3.16 & 3.17)

Three genera have been recorded from the region (see Appendix). Larvae have been described by Barnard (1937), Corbet (1957b) and Pinhey (1959). The following preliminary key includes *Hemicordulia*, although this information is based on Lieftinck's (1962) description of a species not occurring in Africa.

CORDULIIDAE FINAL INSTAR LARVAE AND EXUVIAE: PRELIMINARY KEY TO SOUTHERN AFRICAN GENERA

1. Head with a distinctive frontal horn with one to two pairs of conical tubercles in post-ocular region (Fig. 3.16A1); eyes very prominent; abdomen flattened and broadly ovate in dorsal view (i.e. greatest width: length ratio less than 1:18) with medio-dorsal spines (on segments 4–9 in *P. bifasciata* (Fig 3.17B) but on all segments in *P. monoceros* and *P. picta*. (Fig. 3.17A) .... *Phyllomacromia* (Fig. 3.17)
– Head not as above; eyes prominent but small (Fig. 3.16A2); abdomen regularly ovate (i.e. width: length ratio more than 1:1.8) and without medio-dorsal spines 2

2. Lateral margin of head behind eyes angular (Fig. 3.16A2) .... *Syncordulia*
– Lateral margin of head behind eyes rounded (Fig. 3.17C) .... *Hemicordulia*

Fig. 3.16. Distinguishing features among the Corduliidae. **A**, head shape (dorsal views): A1, with frontal horn (arrowed) and post-ocular tubercles (arrowed), e.g. in *Phyllomacromia*); A2, (with no frontal horm nor post-ocular tubercles), e.g. in *Syncordulia*.

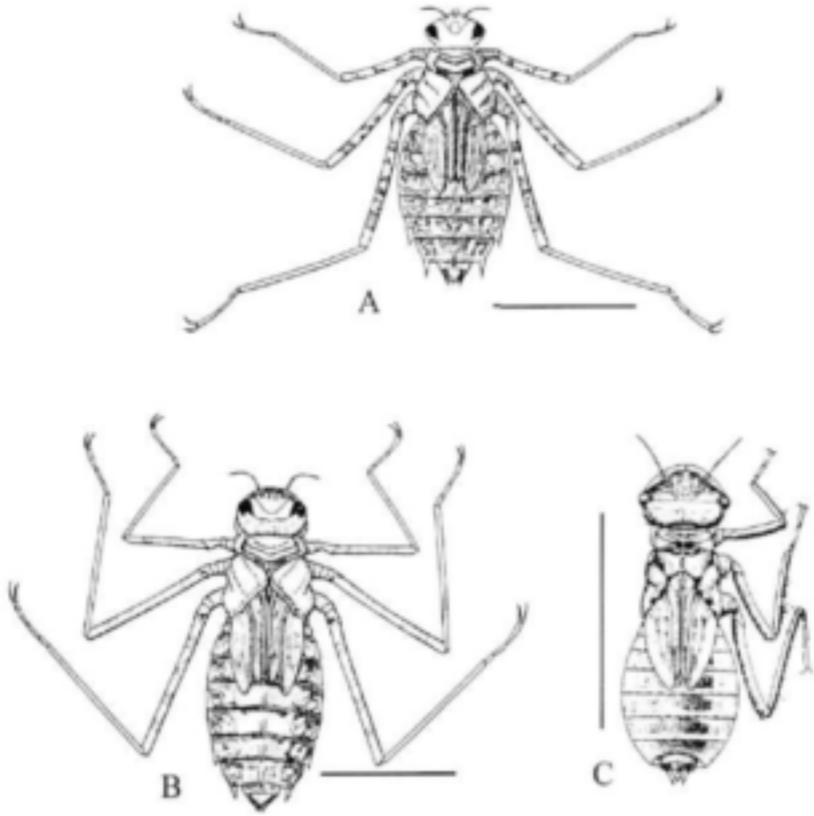

Fig. 3.17. Larvae of southern African Corduliidae (dorsal views): **A**, *Phyllomacromia picta*; **B**, *P. bifasciata*; **C**, *Hemicordulia olympica* (not a southern African species). (A & B after Corbet 1957b; C after Lieftinck 1962). Scale bar = 10 mm.

Libellulidae

(Figs 3.18–3.21)

Thirty-eight genera occur in the region (see Appendix). Larvae have been described by Barnard (1937), Cammaerts, 1975, Carchini & Di Domenico (1996), Carchini, Samways & Caldwell (1992), Carchini, Samways & Di Domenico (1992), Clausnitzer (1999), Corbet (1957a), Di Domenico et al. (2001), Hassan, 1977, Lieftinck (1962), Pinhey (1959, 1961), Samways et al. (1993), Samways et al. (1997), Samways et al. (1998) and Whiteley et al. (1999). It must be emphasized that the following key is very tentative and should only be used as a guideline, especially as the genera *Aethiothemis, Aethriamanta, Allorrhizucha, Eleuthemis, Hadrothemis, Lokia, Malgassophlebia, Monardithemis, Neodythemis, Nesciothemis, Porpacithemis, Porpax* and *Thermochoria* are not included as the larvae have not yet been described.

LIBELLULIDAE FINAL INSTAR LARVAE AND EXUVIAE: PRELIMINARY KEY TO SOUTHERN AFRICAN GENERA

1. Labial palps with distinct teeth or crenations on inner margins (Fig. 3.18A1) 2
– Labial palps without teeth or strong crenations or, at most, only weakly crenulated (Fig. 3.18A2) 5

2. Abdominal segments 8 and 9 with long backward-pointing, lateral spines (Fig. 3.18B); body length greater than or equal to 24 mm 3
– Abdominal segments 8 and 9 with very small or no lateral spines; body length less than 18 mm 4

3. Each labial palp with ten strong dentations on the inner margin (Fig. 3.18 A1); head as wide as thorax (Fig. 3.18C1); spines on lateral spines, either absent or short and not distinct .... *Pantala* (Fig. 3.21F)
– Each labial palp with only a moderately crenulated inner margin; head wider than thorax (Fig. 3.18C2); with distinct spines on lateral spines .... *Tramea* (Fig. 3.21H)

4. Small lateral spines present on abdominal segments 8–9 .... *Tetrathemis*
– No lateral spines on abdominal segments 8–9 .... *Notiothemis* (Fig. 3.19A)

5. Eyes small (Fig. 3.18 D1) 6
– Eyes large (Fig. 3.18 D 2) 11

6. Abdomen with very few setae, lateral spines on segments 8 and 9; femora of forelegs longer than distance between inner margins of eyes 7
– Abdomen densely covered with fine setae; no lateral spines on segments 8 and 9; femora of forelegs shorter than distance between inner margins of eyes .... *Orthetrum* (Fig. 3.19B)

7. Abdominal segment 3 with an acute dorsal spine; anal pyramid very prominent and protruding (Fig. 3.18 E1) .... *Tholymis* (Fig. 3.21E)
– Abdominal segment 3 without a dorsal spine (dorsal spines begin on segment 4); anal pyramid short and hardly extending beyond the tip of the spines on abdominal segment 9 (Fig. 3.18 E2) 8

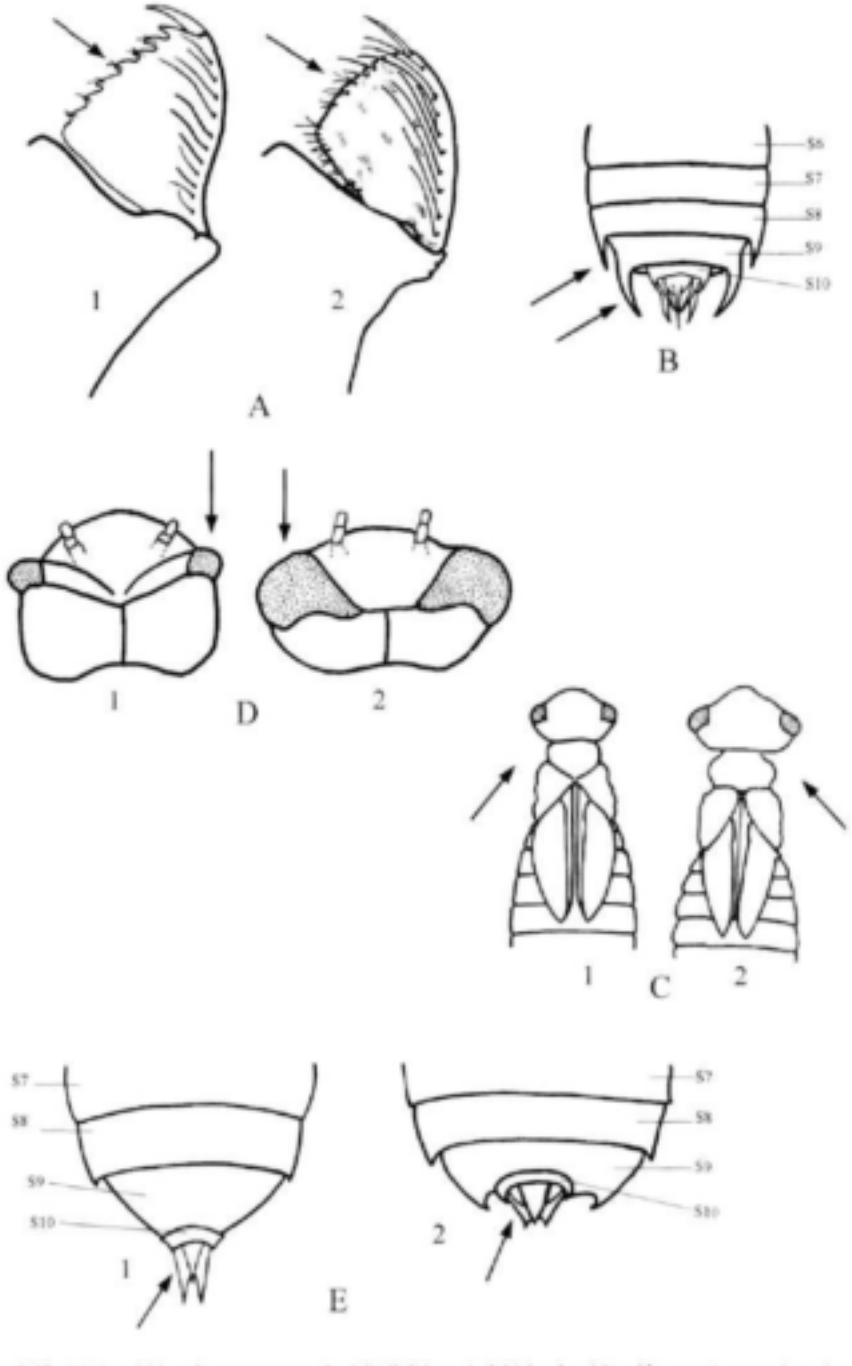

Fig. 3.18. Distinguishing features among the Libellulidae.: **A**, labial palp: A1, with crenations or dentations (arrowed), in *Pantala*; A2, with only weak crenations (arrowed), in *Hemistigma*. **B**, abdominal segments 8 and 9 with long, backward-pointing spines (arrowed), in *Pantala*. **C**, width of head: C1, about the same width as thorax (arrowed), in *Pantala*; C2, wider than thorax (arrowed), in *Tramea*. **D**, eye size: D1, with small eyes, in *Orthetrum*; D2, with large eyes, in *Trithemis*. **E**, anal pyramid: E1, long and prominent (arrowed), in *Tholymis*; E2, short, in *Rhyothemis*.

8. Labial palps with 5-7 & 5-7 setae (Fig. 3.20 A1); abdomen with lateral spines on segments 8 and 9 short (Fig. 3.18E2).................. *Rhyothemis* (Fig. 3.21C)

– Labial palps with 3-4 & 3-4 setae (Fig. 3.20A2); abdomen with lateral spines on segments 8 and 9 long and acute 9

9. Labial palps with 4 & 4 setae (Fig. 3.20A2); abdomen with tip of lateral spines on segment 9 not extending as far as tip of anal pyramid .... *Brachythemis leucosticta* (Fig. 3.19H)

– Labial palps with 3 & 3 setae; abdomen with tip of lateral spines on segment 9 at same level as tip of anal pyramid 10

10. Wing sheaths just extend to reach segment 7; abdomen with dorsal spine on segment 9 prominent, backward-pointing, extending over segment 10 .... *Brachythemis lacustris* (Fig. 3.19G)

– Wing sheaths extend only to segment 6; abdomen with dorsal spine on segment 9 small, the tip not reaching segment 10 .... *Parazyxomma* (Fig. 3.21D)

11. Abdomen with prominent dorsal spines 19

– Abdomen without dorsal spines 12

12. Prementum short, reaching only to bases of forelegs (see Aeshnidae, Fig. 3.14B2) .... *Bradinopyga*

– Prementum reaching bases of middle legs 13

13. Body length about 12 mm; cerci very long, almost as long as paraprocts (Fig. 3.20B); antenna short, six-segmented .... *Acisoma*

– Body length 13 mm or more; cerci long or short; antenna long, seven-segmented 14

14. Abdomen with lateral spines on segments 8 and 9 very short; cerci short, at most half the length of anal pyramid 15

– Abdomen with lateral spines on segments 8 and 9 long; cerci very long, almost as long as anal pyramid 16

15. Labial palps with 11–12 & 11–12 setae (Fig. 3.20C) .... *Philonomon*

– Labial palps with 9–10 & 9–10 setae .... *Diplacodes* (Fig. 3.19E)

16. Inner margin of labial palp smooth or with only vague indentations, not crenulated (Fig. 3.20D1) 17

– Inner margin of labial palp minutely crenulated with 12 indentations (Fig. 3.20D2) .... *Crocothemis* (Fig. 3.19F)

17. Abdomen without two dark, dorsal bands; prementum reaching to midway or beyond middle legs; 8–12 & 8–12 palpal setae; 9–13 + 9–13 premental setae... 18

– Length of abdomen with two, strong dark, dorsal bands; prementum just reaching middle legs; 12–14 & 12–14 palpal setae (Fig. 3.20D1); 14–16 + 14–16 premental setae.............................. Some species of *Sympetrum* (Fig. 3.19I) (but *S. fonscolombii* in southern Africa has small dorsal spines which are not easily visible: see couplet 23).

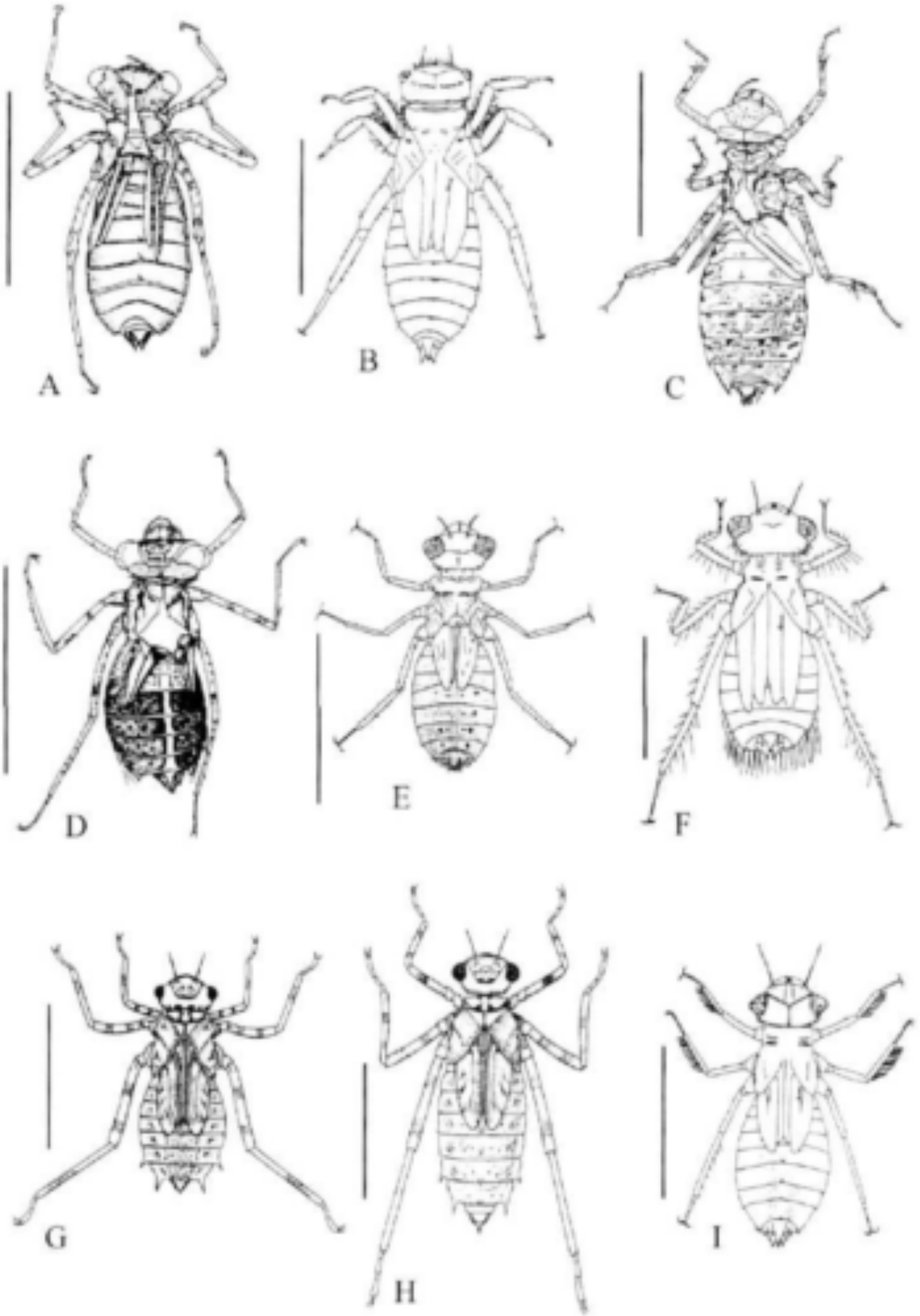

Fig. 3.19. Larvae of southern African Libellulidae (dorsal views): **A**, *Notiothemis jonesi*; **B**, *Orthetrum caffrum*; **C**, *Chalcostephia flavifrons*; **D**, *Hemistigma albipuncta*; **E**, *Diplacodes lefebvrii*; **F**, *Crocothemis erythraea* (with setae exaggerated to show patterning); **G**, *Brachythemis lacustris*; **H**, *Brachythemis leucosticta*; **I**, *Sympetrum fonscolombii*. (A after Samways et al. 1997; B, E, F & I after Samways & Whiteley 1997; C after Di Domenico et al. 2001; D after Whiteley et al. 1999; G & H after Corbet 1957a).

18. Prementum reaching to middle point of middle legs; 10 & 10 palpal setae; labial palps very spotty (Fig. 3.18A2) 12–13 + 12–13 premental setae ………… ………………………………………………………… *Hemistigma* (Fig. 3.19D)
– Prementum reaching beyond middle legs; 8–12 & 8–12 palpal setae; 9–12 + 9–12 premental setae ……………………………………………… *Palpopleura*

19. Antennae very short, less than the distance between their bases; prementum short and robust ……………………………………………………… 20
– Antennae long, more than the distance between their bases; prementum longer and less robust ……………………………………………………… 22

20. Body length about 17 mm; abdomen with lateral spines absent from segment 7 and short and inconspicuous on segments 8 and 9 (Fig. 3.20E1) abdomen triquetral with dorsal spines very large and tooth-like (Fig. 3.20F1); prementum reaching bases of middle legs; premental setae 3 + 3; palpal setae 9–9 & 10–10 …… ……………………………………………………………… *Atoconeura*
– Body length 21 mm or longer; lateral spines long and conspicuous on segments 8 and 9 (Fig. 3.20E2); abdomen ovate with dorsal spines moderate and pointing backwards (Fig. 3.20F2) ……………………………………………… 21

21. Lateral spines on segments 8–9; dorsal spines large …………………… *Zygonyx*
– Lateral spines on segments 7–9, and dorsal spines moderately sized ………….. …………………………………………………………………… *Olpogastra*

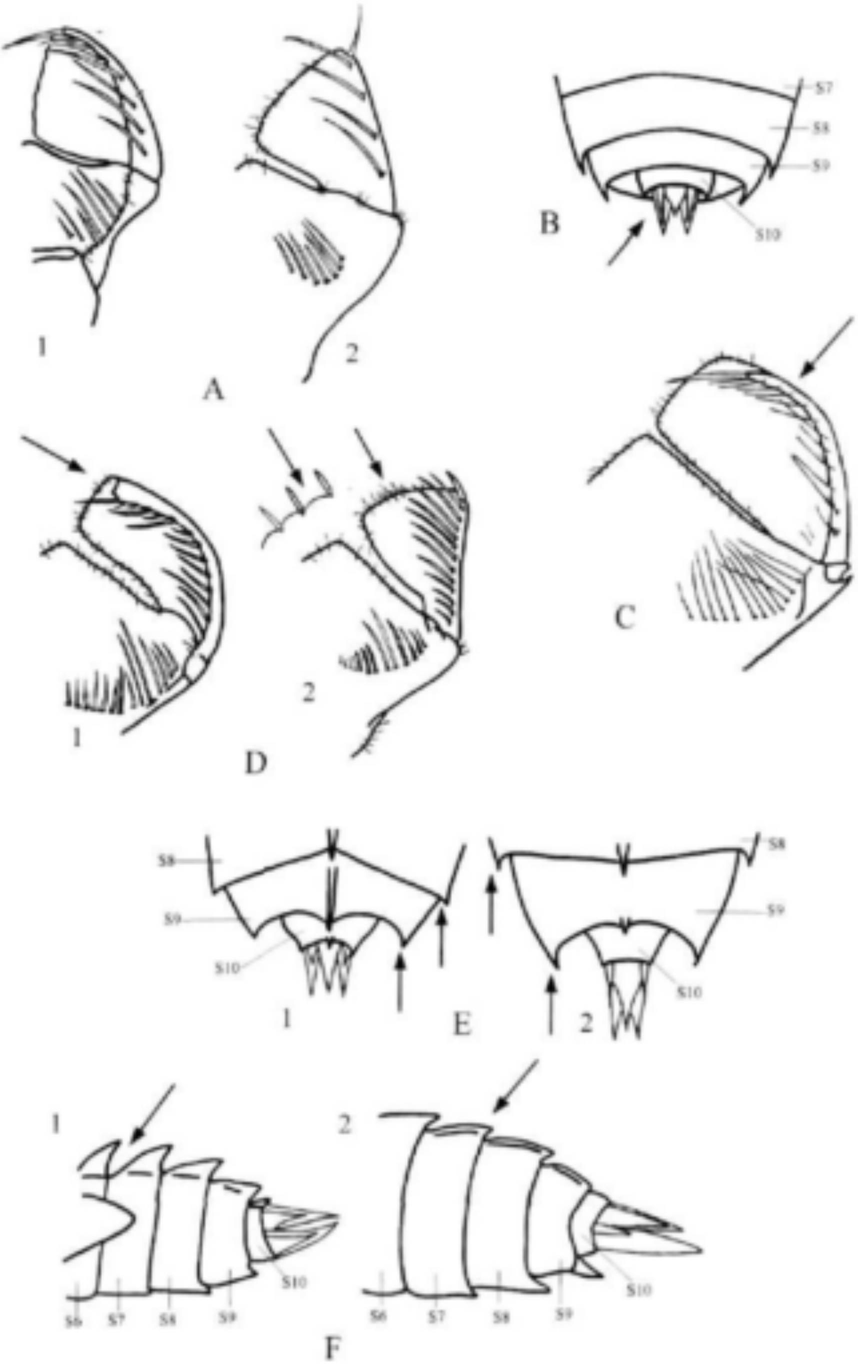

Fig. 3.20. Distinguishing features among the Libellulidae. **A**, labial palps: A1, of *Rhyothemis semihyalina*; A2, of *Brachythemis leucosticta*. **B**, tip of abdomen showing long cerci of *Acisoma panorpoides* (arrowed). **C**. labial palp of *Philonomon luminans* with 11–12 & 11–12 setae (arrowed). **D**, end of labial palps: D1, smooth (arrowed), in *Sympetrum fonscolombii*; D2, crenulated, in *Crocothemis erythraea* (arrowed). E, spines on abdominal segments 8 & 9: E1, short (arrowed), in *Atoconeura biordinata*; E2, long (arrowed), in *Zygonyx natalensis*. **F**, dorsal spines: F1, strong spines (arrowed), in *Atoconeura biodinata*; F2, smaller spines (arrowed), in *Zygonyx natalensis*.

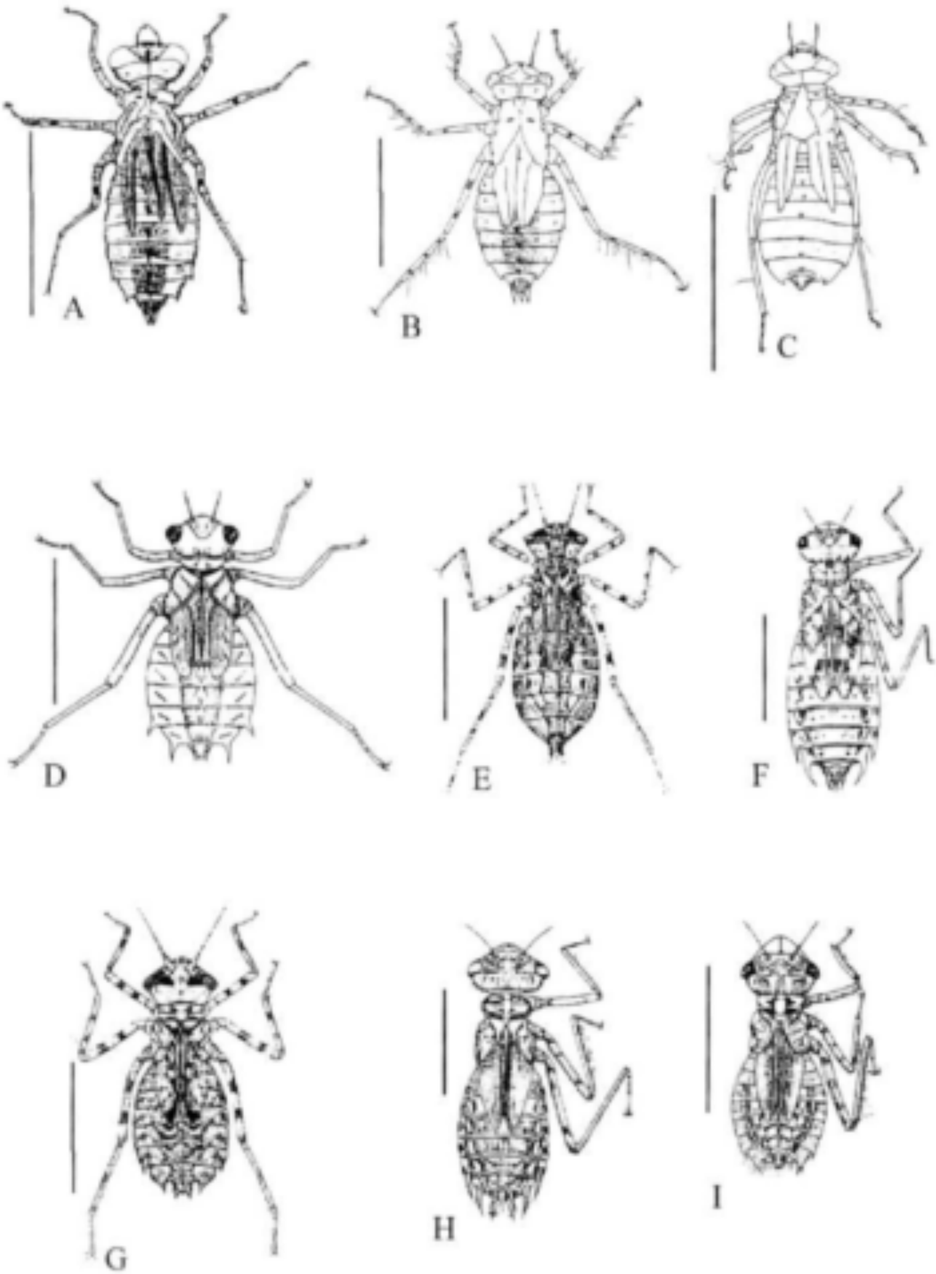

Fig. 3.21. Larvae of southern African Libellulidae (dorsal views): **A**, *Trithemis werneri*; **B**, *Trithemis dorsalis*; **C**, *Rhyothemis semihyalina*; **D**, *Parazyxomma flavicans*; **E**, *Tholymis tillarga*; **F**, *Pantala flavescens*; **G**, *Zyxomma petiolatum* (not a southern African species); **H**, *Tramea transmarina* (not a southern African species); **I**, *Macrodiplax cora*. (A after Samways et al. 1993; B after Samways & Whiteley 1997; C after Samways et al., 1998; D after Corbet 1957a; E–I after Lieftinck 1962).

22. Lateral spines on abdominal segment 9 very long and pointed, extending beyond the anal pyramid .... *Macrodiplax* (Fig. 3.21I)
– Lateral spines on abdominal segment 9 small to large but not extending beyond anal pyramid 23

23. Lateral spines on abdominal segments 8 and 9 small (and minute in comparison with the anal pyramid) 24
– Lateral spines at least on abdominal segment 9 large 25

24. Abdomen with two, dark, dorsal, longitudinal bands; fore and hind tibiae with tufts of setae .... *Sympetrum fonscolombii* (Fig. 3.19I)
– Abdomen variously mottled and speckled but without two, dark, dorsal bands; tibiae sprinkled with short and long setae .... *Trithemis* (Figs 3.21A & B)

25. Abdomen with lateral spines on segments 8 and 9 prominent, sharp and of similar lengths 26
– Abdomen with lateral spines short on segment 8 , and long on segment 9; long setae on legs and tip of abdomen.......... .... *Urothemis*

26. Anal pyramid slender, and longer than the middle region of abdominal segment 9; head and labial palps irregularly speckled .... *Chalcostephia* (Fig. 3.19C)
– Anal pyramid wider, and about as long as abdominal segment 9; head and labial palps not speckled .... *Zyxomma* (Fig. 3.21G)

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CHAPTER 3: APPENDIX

Odonata species and subspecies of southern Africa

(with summaries of geographical distributions)

Species	Distribution
ZYGOPTERA	
Synlestidae	
Chlorolestes apricans Wilmot, 1975	SA (EC)
Chlorolestes conspicuus Hagen in Selys, 1862	SA (WC)
Chlorolestes draconicus Balinsky, 1956	LES, SA (KZN)
Chlorolestes elegans Pinhey, 1950	MWI, MOZ, SA (LIM), ZIM
Chlorolestes fasciatus (Burmeister, 1839)	LES, SA (EC, FS, KZN, MPL, LIM, WC), SWZ
Chlorolestes tessellatus (Burmeister, 1839)	SA (EC, KZN,WC)
Chlorolestes umbratus Hagen in Selys, 1862	SA (WC)
Ecchlorolestes nylephtha (Barnard, 1937)	SA (WC)
Ecchlorolestes peringueyi (Ris, 1921)	SA (WC)
Lestidae	
Lestes amicus Martin, 1910	ANG, MWI, MOZ, ZAM, ZIM; also Tanzania
Lestes dissimulans Fraser, 1955	ANG, BOTS, MWI, MOZ, SA (KZN, LIM), ZAM, ZIM; north to Kenya and Senegal
Lestes ictericus Gerstaecker, 1869	MWI, MOZ, NAM, SA, (KZN), ZAM, ZIM; north to Kenya and Senegal
Lestes ochraceus Selys, 1862	MWI, ZAM, ZIM; north to Sudan and The Gambia
Lestes pallidus Rambur, 1842	ANG, BOTS, LES, MWI, MOZ, NAM, SA (FS, GT, KZN, LIM, NW), ZAM, ZIM; north to Somalia, Sudan and Senegal
Lestes pinheyi Fraser, 1955	ANG, BOTS, MWI, ZAM, ZIM; north to D. R. Congo and Nigeria
Lestes plagiatus (Burmeister, 1839)	ANG, BOTS, LES, MWI, MOZ, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Kenya, Uganda and Nigeria
Lestes tridens McLachlan, 1895	ANG, BOTS, MOZ, SA (KZN, MPL), ZAM, ZIM; north to Somalia and Nigeria
Lestes uncifer Karsch, 1899	BOTS, MWI, MOZ, NAM, SA (KZN, MPL), ZAM, ZIM; north to Somalia, Uganda and Nigeria
Lestes virgatus (Burmeister, 1839)	BOTS, MWI, MOZ, SA (EC, GT, KZN, MPL, LIM, NW, WC), ZAM, ZIM; north to Ethiopia, Uganda and Nigeria
Protoneuridae	
Prodasineura flavifacies Pinhey, 1981	ZAM
Chlorocnemis marshalli marshalli Ris, 1921	MWI, MOZ, ZAM, ZIM; north, as a colour variant, to Uganda and D. R. Congo
Chlorocnemis montana St. Quentin, 1942 *maccleeryi* Pinhey, 1969	MWI: the nominotypical subspecies occurs in Tanzania
Chlorocnemis nigripes Gambles, 1967	ANG; north to Uganda and Nigeria
Chlorocnemis wittei Fraser, 1955	MOZ, ZAM, ZIM; north, as a colour variant, to Uganda and D. R. Congo
Elattoneura frenulata (Hagen, in Selys, 1860)	ANG, SA (WC)
Ellattoneura glauca (Selys, 1860)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Kenya and Uganda
Ellattoneura tropicalis Pinhey, 1974	BOTS, MWI, MOZ, ZAM, ZIM; north to Uganda and D. R. Congo

Species	Distribution
Platycnemididae	
Allocnemis leucosticta Selys, 1863	SA (EC, KZN, MPL, LIM, WC)
Metacnemis angusta Selys, 1863	SA (WC)
Metacnemis valida (Hagen, in Selys, 1863)	SA (EC)
Mesocnemis singularis Karsch, 1891	ANG, BOTS, MWI, NAM, SA (KZN, MPL, NC), ZAM, ZIM; north to Uganda and Senegal
Oreocnemis phoenix Pinhey, 1971	MWI
Coenagrionidae	
Teinobasis malawiensis Pinhey, 1966	MWI
Ceriagrion bakeri Fraser, 1941	ANG, ZAM; north to Uganda and Nigeria
Ceriagrion bidentatum Fraser, 1941	ANG, BOTS, MWI, NAM, ZAM; north to D. R. Congo and Uganda
Ceriagrion glabrum (Burmeister, 1839)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, LIM, NW, WC), SWZ, ZAM, ZIM; north to Ethiopia and The Gambia
Ceriagrion katamborae Pinhey, 1961	BOTS, ZAM
Ceriagrion kordofanicum Ris, 1924	MWI, MOZ, ZAM
Ceriagrion mourae Pinhey, 1969	MOZ
Ceriagrion platystigma Fraser, 1941	ZAM; also D. R. Congo
Ceriagrion sakejii Pinhey, 1963	ZAM; also D. R. Congo
Ceriagrion sanguinostigma Fraser, 1955	ZAM; north to Uganda and Equatorial Guinea
Ceriagrion suave Ris, 1921	BOTS, MWI, MOZ, NAM, SA (MPL), ZAM, ZIM; north to Ethiopia and The Gambia
Ceriagrion whellani Longfield, 1952	BOTS, ZAM, ZIM; north to Kenya and Sierra Leone
Pseudagrion acaciae Förster, 1906	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, KZN, MPL), SWZ, ZAM, ZIM; north to Kenya and D. R. Congo
Pseudagrion angolense Selys, 1876	ANG
Pseudagrion assegaii Pinhey, 1950	BOTS, SA (GT, KZN, MPL), ZAM, ZIM
Pseudagrion basicornu Ris, 1936	ANG; north to Liberia
Pseudagrion bicoerulans Förster, 1906	MWI; also Kenya and Tanzania
Pseudagrion caffrum (Burmeister, 1839)	LES, SA (EC, KZN)
Pseudagrion citricola Barnard, 1937	SA (EC, FS, GT, KZN, MPL, LIM, NW)
Pseudagrion coeleste Longfield, 1947	ANG, BOTS, MWI, SA (MPL), ZAM, ZIM; north to Chad
Pseudagrion coeruleipunctum Pinhey, 1964	ANG, ZAM
Pseudagrion commoniae (Förster, 1902) *nigerrimum* Pinhey, 1950	BOTS, MOZ, SA (KZN, MPL, LIM), SWZ; north to Kenya, with the nominotypical subspecies in Ethiopia and Somalia
Pseudgrion deningi Pinhey, 1961	BOTS, ZAM; also D. R. Congo
Pseudagrion draconis Barnard, 1937	SA (EC, FS, WC, KZN)
Pseudagrion dundoense Longfield, 1959	ANG
Pseudagrion fisheri Pinhey, 1961	ANG, BOTS, ZAM
Pseudagrion furcigerum (Rambur, 1842)	SA (WC)
Pseudagrion gamblesi Pinhey, 1978	ANG, MWI, MOZ, SA (KZN, MPL), ZAM, ZIM; north to Kenya
Pseudagrion glaucescens Selys, 1876	ANG, BOTS, MWI, MOZ, ZAM, ZIM; north to Kenya and The Gambia
Pseudagrion greeni Pinhey, 1961	ZAM; also D. R. Congo
Pseudagrion hageni hageni Karsch, 1893	SA (EC, WC)

Species	Distribution
Coenagrionidae (cont.)	
Pseudagrion hageni tropicanum Pinhey, 1966	MWI, MOZ, SA (EC, GT, KZN, MPL, LIM, WC), SWZ, ZAM, ZIM; north to Kenya and Nigeria
Pseudagrion hamoni Fraser, 1955	MWI, MOZ, NAM, SA (KZN, MPL, LIM), ZAM, ZIM; north to Sudan, Morocco and Senegal
Pseudagrion helenae Balinsky, 1964	BOTS, MWI, ZAM
Pseudagrion inconspicuum Ris, 1931	ANG, MWI, ZAM
Pseudagrion inopinatum Balinsky, 1971	SA (MPL)
Pseudagrion kersteni (Gerstaecker, 1869)	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), ZAM, ZIM; north to Uganda and Cameroon
Pseudagrion kibalense (Longfield, 1959)	ANG, ZAM; also D. R. Congo and Uganda
Pseudagrion lindicum Grünberg, 1902	MOZ; north to Somalia
Pseudagrion makabusiense Pinhey, 1950	ANG, MOZ, SA (LIM), ZAM, ZIM; also D. R. Congo
Pseudagrion massaicum Sjöstedt, 1909	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), ZAM, ZIM; north to Eritrea and Ghana
Pseudagrion melanicterum Selys, 1876	ANG, ZAM; north to Uganda and Senegal
Pseudagrion newtoni Pinhey, 1962	SA (EC, KZN, WC)
Pseudagrion nubicum Selys, 1876	BOTS, MWI, NAM, ZAM, ZIM; north to Sudan, the Levant and The Gambia
Pseudagrion rufostigma Longfield, 1945	ANG, BOTS, ZAM, ZIM
Pseudagrion salisburyense Ris, 1921	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC) SWZ, ZAM, ZIM; north to Ethiopia
Pseudagrion sjoestedti Förster, 1906 *jacksoni* Pinhey, 1961	ANG, BOTS, ZAM; north to Uganda
Pseudagrion sjoestedti pseudosjoestedti Pinhey, 1964	MWI, MOZ, SA (MPL), ZIM; north, with other colour morphs, to The Gambia
Pseudagrion spernatum Selys, 1881 *natalense* Ris, 1921	MWI, MOZ, SA (EC, FS, GT, KZN, WC), SWZ, ZAM, ZIM; nominotypical and other colour morphs north to Ethiopia
Pseudagrion sublacteum sublacteum (Karsch, 1893)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, NC), ZAM, ZIM; north to Somalia, Morocco and The Gambia; also Comores
Pseudagrion sudanicum Le Roi, 1915 *rubroviride* Pinhey, 1955	BOTS, MWI, MOZ, NAM, SA (MPL), ZAM, ZIM; north to D. R. Congo
Pseudagrion symoensii Pinhey, 1967	ZAM
Pseudagrion umsingaziense Balinsky, 1963	SA (KZN, LIM)
Pseudagrion vaalense Chutter, 1962	LES, SA (FS, GT, MPL, NC, NW)
Pseudagrion vumbaense Balinsky, 1963	ZIM
Pseudagrion williamsi Pinhey, 1964	ANG, ZAM; also Nigeria
Aciagrion africanum Martin, 1908	MWI, MOZ, ZIM; north to Congo and Guinea Bissau
Aciagrion congoense (Sjöstedt, 1917)	MOZ, SA (KZN); also D. R. Congo and Uganda
Aciagrion gracile gracile (Sjöstedt, 1909)	MWI. Also D. R. Congo and Uganda
Aciagrion gracile attenuatum Fraser, 1928	MWI, MOZ, ZAM, ZIM; also The Gambia
Aciagrion heterosticta heterosticta Fraser, 1955	ZAM; also D. R. Congo
Aciagrion macrootithenae Pinhey, 1972	ANG, ZAM; also D. R. Congo
Aciagrion nodosum (Pinhey, 1964)	ZAM

Species	Distribution
Coenagrionidae (cont.)	
Aciagrion pinheyi Samways, 2001	SA (KZN)
Aciagrion rarum Longfield, 1947	ANG, ZAM
Aciagrion steeleae Kimmins, 1955	ANG, BOTS, ZAM; also D. R. Congo
Aciagrion zambiense Pinhey, 1972	ANG, ZAM
Enallagma angolicum Pinhey, 1966	ANG, BOTS, ZAM
Enallagma cuneistigma Pinhey, 1969	ZIM
Enallagma elongatum (Martin, 1907)	MWI, MOZ, SA (KZN, LIM), SWZ, ZAM, ZIM; north to D. R. Congo and Ethiopia
Enallagma glaucum (Burmeister, 1839)	ANG, BOTS. LES. MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, WC), SWZ, ZAM, ZIM; north to Ethiopia; also La Reunion
Enallagma nigridorsum Selys, 1876	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, GT, KZN, MPL, WC), ZAM, ZIM; north to Ethiopia and Cameroon
Enallagma polychromaticum Barnard, 1937	SA (WC)
Enallagma rotundipenne Ris, 1921	LES, SA (GT, KZN)
Enallagma sapphirinum Pinhey, 1950	SA (EC, FS, GT, KZN)
Enallagma sinuatum Ris, 1921	MWI, SA (KZN), ZAM, ZIM; north to D. R. Congo and Tanzania
Enallagma subfurcatum Selys, 1876	MWI, MOZ, SA (WC), ZAM, ZIM; north to Ethiopia and Nigeria
Enallagma subtile Ris, 1921	BOTS, MWI, MOZ, NAM, ZAM, ZIM
Enallagma vaginale vaginale Sjöstedt, 1917	ZAM; also D. R. Congo; the subspecies *E. v. longfieldae* occurs in Kenya, Tanzania and Uganda
Ischnura senegalensis (Rambur, 1842)	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM Throughout Africa, and in Asia to the Phillippines; also Madagascar, Mauritius, Seychelles and Canary Islands
Agriocnemis angolensis angolensis Longfield, 1947	ANG, NAM
Agriocnemis angolensis spatulae Pinhey, 1974	ANG, ZAM
Agriocnemis exilis Selys, 1872	ANG, BOTS, MWI, MOZ, NAM, SA (EC, KZN, MPL, LIM), SWZ, ZAM, ZIM; north to Ethiopia and Senegal; also Madagascar and Mauritius
Agriocnemis falcifera falcifera Pinhey, 1959	SA (EC, KZN)
Agriocnemis falcifera transvaalica Pinhey, 1974	SA (LIM)
Agriocnemis forcipata Le Roi, 1915	ANG, ZAM; north to Sudan and Gabon
Agriocnemis gratiosa Gerstaecker, 1891	BOTS, MWI, MOZ, NAM, SA (KZN), ZAM; also D. R. Congo and Tanzania
Agriocnemis pinheyi Balinsky, 1963	MOZ, SA (KZN, MPL, LIM), ZAM, ZIM
Agriocnemis ruberrima ruberrima Balinsky, 1961	SA (KZN)
Agriocnemis ruberrima albifrons Balinsky, 1963	BOTS
Agriocnemis victoria Fraser, 1928	ANG, BOTS, ZAM; north to Uganda and Senegal

Species	Distribution
Chlorocyphidae	
Chlorocypha consueta (Karsch, 1899)	ANG, MWI, MOZ, SA (KZN), ZAM, ZIM; also D. R. Congo and Tanzania
Chlorocypha croceus croceus Longfield, 1947	ANG (West Central)
Chlorocypha croceus bamptoni Pinhey, 1975	ANG (South West)
Chlorocypha frigida Pinhey, 1961	ZAM
Chlorocypha rubriventris Pinhey, 1975	ANG
Chlorocypha victoriae (Förster, 1914)	ANG; also Cameroon, D. R. Congo and Uganda
Chlorocypha wittei Fraser, 1955	ANG, ZAM; also D. R. Congo
Platycypha caligata caligata (Selys, 1853)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM, north to Somalia and Guinea Bissau, with different morphs in Angola and Malawi
Platycypha fitzsimonsi fitzsimonsi (Pinhey, 1950)	SA (EC, KZN, WC)
Platycypha fitzsimonsi inyangae Pinhey, 1958	ZIM
Platycypha lacustris chingolae Pinhey, 1962	ZAM; also D. R. Congo. The nominotypical subspecies occurs in D.R. Congo, Uganda and Kenya
Platycypha rufitibia (Pinhey, 1960) *lucalaensis* Pinhey, 1967	ANG; the nominotypical subspecies occurs in Gabon
Calopterygidae	
Phaon iridipennis (Burmeister, 1839)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, KZN, MPL, LIM), SWZ, ZAM, ZIM; north to Somalia and Senegal, with a colour morph in Madagascar
Umma declivium Förster, 1906	MWI, ZAM; also Tanzania
Umma distincta Longfield, 1933	ANG, ZAM; also D. R. Congo
Umma femina Longfield, 1947	ANG
ANISOPTERA	
Gomphidae	
Ictinogomphus dundoensis Pinhey, 1961	ANG
Ictinogomphus ferox (Rambur, 1842)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, LIM, NW), ZAM, ZIM; north to Kenya and Senegal
Ictinogomphus regisalberti (Schouteden, 1934)	ANG; also D. R. Congo
Diastatomma ruwenzorica Pinhey, 1961	ANG; also Uganda, D. R. Congo
Diastatomma selysi Schouteden, 1934	ZAM; north to Congo and Equatorial Guinea
Diastatomma soror Schouteden, 1934	ANG, ZAM; also D. R. Congo
Cinitigomphus dundoensis dundoensis Pinhey, 1961	ANG, BOTS, ZAM; also D. R. Congo
Gomphidia bredoi (Schouteden, 1934)	ANG; also Uganda
Gomphidia quarrei quarrei Schouteden, 1934	BOTS, MWI, SA (MPL), ZAM, ZIM
Gomphidia quarrei confinii Pinhey, 1974	MOZ
Microgomphus bivittatus Pinhey, 1961	ANG
Microgomphus mozambicensis Pinhey, 1959	MOZ, ZIM
Microgomphus nyassicus (Grünberg, 1902)	MWI, ZAM, ZIM; also D. R. Congo
Lestinogomphus angustus Martin, 1911	BOTS, MWI, MOZ, NAM, SA (GT, KZN, MPL), ZAM, ZIM; north to Kenya and Ivory Coast
Notogomphus dendrohyrax (Förster, 1906)	MWI, MOZ, ZIM; also Tanzania
Notogomphus praetorius (Selys, 1878)	ANG, MOZ, SA (EC, GT, KZN, MPL, LIM), ZAM, ZIM; also D. R. Congo

Species	Distribution
Gomphidae (cont.)	
Notogomphus zernyi (St Quentin, 1942)	MWI, ZIM; also Tanzania
Neurogomphus chapini (Klots, 1944)	MWI; also Kenya, D. R. Congo
Neurogomphus uelensis Schouteden, 1934	MOZ; also D. R. Congo
Neurogomphus vicinis Schouteden, 1934	BOTS; also D. R. Congo
Neurogomphus (three undescribed species)	ZAM, ZIM
Phyllogomphus brunneus Pinhey, 1976	BOTS, SA (MPL), ZAM, ZIM
Phyllogomphus dundomajoricus Fraser, 1957	ANG
Phyllogomphus dundominusculus Fraser, 1957	ANG
Phyllogomphus latifasciae Pinhey, 1961	ANG, MWI
Phyllogomphus orientalis Fraser, 1957	ANG; also Uganda
Phyllogomphus selysi Schouteden, 1933	ANG; also D. R. Congo
Crenigomphus cornutus Pinhey, 1956	BOTS, NAM, SA (MPL), ZAM, ZIM
Crenigomphus hartmanni (Förster, 1898)	ANG, MWI, MOZ, SA (EC, KZN, MPL, WC), ZAM, ZIM; also Kenya, Tanzania and D. R. Congo
Crenigomphus renei Fraser, 1936	ZAM; also Uganda, Tanzania and D. R. Congo
Ceratogomphus pictus Selys, 1854	BOTS, LES, MOZ, SA (EC, FS, GT, KZN, MPL, NC, NW, WC), ZIM; al;so D. R. Congo
Ceratogomphus triceraticus Balinsky, 1963	SA (WC)
Paragomphus acuminatus Fraser, 1949	ZIM; also D. R. Congo; (this species may be a form of *P. fritillarius* (Sely, 1892) (Pinhey 1984a)
Paragomphus alluaudi (Martin, 1915)	ANG; also Kenya and Tanzania
Paragomphus cataractae Pinhey, 1963	ZAM, ZIM
Paragomphus cognatus (Rambur, 1842)	ANG, MWI, MOZ, SA (EC, FS, GT, KZN,MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Ethiopia and Nigeria
Paragomphus dicksoni Pinhey, 1969	SA (WC)
Paragomphus elpidius (Ris, 1921)	BOTS, MWI, MOZ, NAM, SA (KZN, MPL, WC), SWZ, ZAM, ZIM; north to D. R. Congo and Kenya
Paragomphus genei (Selys, 1841)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, GT, KZN, MPL, LIM, WC), SWZ, ZAM, ZIM; north to southern Europe, Middle East and Asia Minor
Paragomphus longiventris Fraser, 1955	ZIM; also D. R. Congo; (confirmation as to whether this is a true species is needed)
Paragomphus machadoi Pinhey, 1961	ANG
Paragomphus magnus Fraser, 1952	MOZ, ZIM; also Kenya
Paragomphus nyassicus Kimmins, 1955	MWI, ZIM
Paragomphus sabicus Pinhey, 1950	BOTS, MOZ, NAM, ZAM, ZIM; (this species may be a form of *P. fritillarius* (Selys, 1892) (Pinhey 1981)
Paragomphus zambeziensis Pinhey, 1961	ZIM
Onychogomphus kitchingmani Pinhey, 1964	ZAM
Onychogomphus quirkii Pinhey, 1964	ZAM
Onychogomphus supinus supinus Selys, 1854	MWI, MOZ, SA (KZN, MPL, LIM), ZIM; the subspecies *O. s. nigrotibialis* occurs in East Africa
Nepogomphoides stuhlmanni (Karsch, 1899)	MWI; also Tanzania

Species	**Distribution**
Aeshnidae	
Aeshna ellioti Kirby, 1896 *usambarica* Förster, 1906	MWI, SA (MPL, LIM), ZIM; the nominotypical subspecies occurs north from D. R. Congo to Ethiopia
Aeshna minuscula McLachlan, 1896	NAM, SA (EC, FS, GT, KZN, MPL, WC)
Aeshna moori Pinhey, 1981	ZAM
Aeshna rileyi Calvert, 1892	ANG, MWI, MOZ, ZAM, ZIM; north to Ethiopia and Sudan
Aeshna subpupillata McLachlan, 1896	MOZ, SA (EC, GT, KZN, MPL, LIM, WC), SWZ, ZIM
Aeshna wittei Fraser, 1955	ZAM; also D. R. Congo
Anaciaeschna triangulifera McLachlan, 1896	ANG, MWI, MOZ, SA (KZN, GT, LIM, NW), ZAM; north to Ethiopia; also Madagascar
Anax bangweuluensis Kimmins, 1955	BOTS, ZAM
Anax chloromelas Ris, 1911	MWI, MOZ, ZAM; north to Uganda and Sierra Leone
Anax congoliath Fraser, 1953 *lisomboae* Pinhey, 1962	ZAM; the nominotypical subspecies occurs in Cameroon, Gabon and D. R. Congo
Anax ephippiger Burmeister, 1839	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, LIM, NW), ZIM; north to Europe, Indian Ocean islands and Asia; formerly *Hemianax ephippiger* (Gentilini & Peters, 1993)
Anax imperator Leach, 1815 *mauricianus* Rambur, 1842	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM, Afrotropical; the nominotypical subspecies occurs in North Africa, Azores, Europe and western Asia
Anax speratus Hagen, 1867	ANG, BOTS, MWI, MOZ, NAM, SA (EC, KZN, MPL, LIM, WC), SWZ, ZAM, ZIM; north to Ethiopia
Anax tristis Hagen, 1867	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, LIM), ZAM, ZIM; north to Sudan and The Gambia; also some Indian Ocean islands
Gynacantha bullata Karsch, 1891	MWI; also Kenya, Uganda, Tanzania and D. R. Congo
Gynacantha manderica Grünberg, 1902	MWI, MOZ, SA (EC, KZN), ZAM, ZIM; north to Somalia and Ivory Coast
Gynacantha ochraceipes (Pinhey, 1960)	MWI; also Tanzania and Central African Republic
Gynacantha sevastopuloi (Pinhey, 1961)	ZAM; also Tanzania, Uganda and D. R. Congo
Gynacantha sextans McLachlan, 1896	ANG, ZAM; also D. R. Congo and west to Ivory Coast
Gynacantha vesiculata Karsch, 1891	ANG, MWI, MOZ, ZAM; north to Kenya and Ghana
Gynacantha villosa Grünberg, 1902	BOTS, MWI, MOZ, SA (KZN), ZAM; north to Uganda and Nigeria
Gynacantha zuluensis Balinsky, 1961	MWI, MOZ, SA (KZN)
Heliaeschna cynthiae Fraser, 1939	ZAM; north to Uganda and Cameroon
Heliaeschna libyana (Fraser, 1928)	ANG; also Uganda
Heliaeschna trinervulata Fraser, 1955	MWI, ZAM; north to Uganda and Nigeria
Heliaeschna ugandica McLachlan, 1896	ANG; also Uganda and D. R. Congo
Corduliidae	
Phyllomacromia aequatorialis Martin, 1906	ANG; north to Ivory Coast
Phyllomacromia aureozona (Pinhey, 1966)	ZAM; also D. R. Congo and Uganda
Phyllomacromia bicornis (Förster, 1906)	ANG; also Somalia and D. R. Congo
Phyllomacromia bifasciata Martin, 1912	BOTS, MWI, MOZ, NAM, SA (KZN, MPL, WC), ZAM, ZIM; north to Sudan and The Gambia
Phyllomacromia bispina (Fraser, 1954)	ZAM; also D. R. Congo and Uganda
Phyllomacromia congolica (Fraser, 1955)	BOTS, ZAM; north to Uganda and Sierra Leone
Phyllomacromia dundomimaculus Fraser, 1957	ANG

Species	Distribution
Corduliidae (cont.)	
Phyllomacromia funicularia (Martin, 1906)	ANG; also Cameroon
Phyllomacromia kimminsi kimminsi (Fraser, 1954)	BOTS, ZAM; north to Uganda and Sierra Leone
Phyllomacromia melania (Selys, 1871)	ANG; north to Ivory Coast
Phyllomacromia monoceros (Förster, 1906)	MWI, MOZ, SA (MPL), ZAM, ZIM; north to Kenya
Phyllomacromia overlaeti (Schouteden, 1934)	ANG, ZAM; also D. R. Congo
Phyllomacromia paludosa (Pinhey, 1976)	BOTS, ZAM, ZIM
Phyllomacromia picta (Hagen in Selys, 1871)	BOTS, MWI, MOZ, SA (EC, FS, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Kenya and Chad
Phyllomacromia subtropicalis (Fraser, 1954)	ZIM; also D. R. Congo
Phyllomacromia unifasciata (Fraser, 1954)	ANG, ZAM; also D. R. Congo
Syncordulia gracilis (Burmeister, 1839)	SA (KZN, WC)
Syncordulia venator (Barnard, 1933)	SA (WC)
Hemicordulia asiatica Selys, 1878	MWI, SA (KZN); also Uganda and Asia
Libellulidae	
Tetrathemis polleni (Selys, 1869)	ANG, MWI, MOZ, SA (EC, KZN, MPL), ZIM; north to Somalia and Nigeria
Malgassophlebia bispina Fraser, 1958 *longistipes* Pinhey, 1964	ZAM; the nominotypical subspecies occurs in D. R. Congo
Allorrhizucha klingi Karsch, 1889	ANG, ZAM; north to Sierra Leone
Allorrhizucha preussi Karsch, 1891	ZAM; north to Uganda and Nigeria
Neodythemis fitzgeraldi Pinhey, 1961	ZAM
Monardithemis flava Longfield, 1947	ANG, ZAM
Notiothemis jonesi jonesi Ris, 1919	MWI, MOZ, SA (EC, KZN, MPL), ZIM; north to Kenya and D. R. Congo
Notiothemis robertsi Fraser, 1944	ZAM; north to Uganda and Nigeria
Hadrothemis camarensis (Kirby, 1889)	ANG, ZAM; north to Uganda and Ivory Coast
Hadrothemis defecta defecta (Karsch, 1891)	ANG, ZAM; north to Uganda (where the subspecies *pseudodefecta* occurs) and Sierra Leone
Hadrothemis scabrifrons Ris, 1910	MWI, MOZ, ZIM; north to Kenya and Cameroon
Hadrothemis versuta (Karsch, 1891)	ZAM; north to Congo and Ivory Coast
Orthetrum abbotti abbotti Calvert, 1892	ANG, MWI, MOZ, NAM, SA (EC, FS, KZN, MPL, LIM), SWZ, ZAM, ZIM; north to Kenya and Ivory Coast; the subspecies *malgassicum* occurs in Madagascar
Orthetrum angustiventre (Rambur, 1842)	ANG, ZAM; north to Uganda and Senegal
Orthetrum austeni (Kirby, 1900)	ANG, ZAM; north to Uganda and Sierra Leone
Orthetrum brachiale (Beauvois, 1817)	ANG, BOTS, MWI, MOZ, NAM, SA (GT, KZN, LIM, NW, WC), ZAM, ZIM; north to Kenya and the Gambia; also on some Indian Ocean islands
Orthetrum caffrum caffrum (Burmeister, 1839)	ANG, LES, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Ethiopia and The Gambia
Orthetrum chrysostigma chrysostigma (Burmeister, 1839)	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, GT, KZN, MPL, LIM, NW, WC), SWZ, ZAM, ZIM. With variations, north to the Arabian Peninsula, Morocco and The Gambia
Orthetrum guineense Ris, 1910	ANG, MOZ, NAM, SA (FS, GT, KZN, NC, LIM, NW), ZAM, ZIM; north to Uganda and Sierra Leone

Species	Distribution
Libellulidae (cont.)	
Orthetrum hintzi Schmidt, 1951	ANG, MWI, MOZ, SA (KZN, NC, LIM), SWZ, ZAM, ZIM; north to Uganda and Senegal
Orthetrum icteromelas Ris, 1910 *cinctifrons* Pinhey, 1970	ANG, BOTS, MWI, MOZ, SA (GT, KZN, MPL, LIM), ZAM, ZIM; north to Sudan and The Gambia
Orthetrum julia julia Kirby, 1900 *Orthetrum j. capicola* Kimmins, 1957 *Orthetrum j. falsum* Longfield, 1955	There is a considerable amount of variation in this species with one subspecies grading into another. MWI, MOZ, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to the Arabian Peninsula and The Gambia
Orthetrum machadoi Longfield, 1947	ANG, BOTS, MWI, MOZ, SA (GT, KZN, MPL, LIM), ZAM, ZIM; also D. R. Congo
Orthetrum macrostigma Longfield, 1945	ANG, ZAM; also Tanzania and D. R. Congo
Orthetrum microstigma Ris, 1911	ANG, ZAM; north to Kenya and Guinea Bissau
Orthetrum monardi Schmidt, 1951	ANG, ZAM; north to Uganda and The Gambia
Orthetrum robustum Balinsky, 1965	BOTS, SA (KZN), ZAM
Orthetrum rubens Barnard, 1937	SA (WC)
Orthetrum saegeri Pinhey, 1966	ZAM; also D. R. Congo and The Gambia
Orthetrum stemmale stemmale (Burmeister, 1839)	MWI, MOZ, NAM, ZAM, ZIM; north to Sudan and The Gambia; also Mauritius and La Réunion, with the subspecies *wrightii* in the Seychelles
Orthetrum trinacria Selys, 1841	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), ZAM, ZIM; north to Europe, Egypt, Morocco and The Gambia
Nesciothemis farinosa (Förster, 1898)	ANG, BOTS, MWI, MOZ, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), ZAM, ZIM; north to Egypt
Nesciothemis fitzgeraldi Pinhey in Longfield, 1955	ZAM
Aethiothemis bequaerti Ris, 1919	MWI, MOZ, ZAM; also D, R. Congo
Aethiothemis diamangae Longfield, 1959	ANG, MWI, ZAM; also D. R. Congo
Aethiothemis discrepans Lieftinck, 1969	ANG, BOTS, MWI, ZAM; also D. R. Congo
Aethiothemis solitaria Ris in Martin, 1908	ANG; also D. R. Congo
Palpopleura deceptor (Calvert, 1899)	BOTS, MWI, MOZ, SA (MPL, NC, LIM), SWZ, ZAM, ZIM; north to Ethiopia and The Gambia
Palpopleura jucunda jucunda Rambur, 1842	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, WC), SWZ, ZAM, ZIM; north to Kenya and Ivory Coast; the subspecies *radiata* occurs in Ethiopia and Sudan
Palpopleura lucia (Drury, 1773)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, GT, KZN, MPL, NC, LIM), SWZ, ZAM, ZIM; north to Kenya and The Gambia
Porpacithemis dubia Fraser, 1954	ZAM; also Congo, Gabon and D. R. Congo
Porpacithemis leakeyi (Pinhey, 1956)	ZAM
Chalcostephia flavifrons flavifrons Kirby, 1889	BOTS, MWI, MOZ, SA (KZN), ZAM, ZIM; north to Kenya and The Gambia; the form *spinifera* occurs in Madagascar
Thermochoria equivocata Kirby, 1889	MWI, MOZ, ZAM; north to Uganda and Sierra Leone
Hemistigma albipuncta (Rambur, 1842)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL), ZAM, ZIM; north to Kenya and The Gambia
Eleuthemis buettikoferi Ris, 1910	ANG, ZAM; north to Uganda and Sierra Leone
Eleuthemis quadrigutta Pinhey, 1974	ZIM
Porpax asperipes Karsch, 1896	ANG, ZAM; north to Sierra Leone
Porpax risi Pinhey, 1958	ANG, MOZ, ZAM, ZIM
Lokia ellioti Lieftinck, 1969	ZAM

Species	**Distribution**
Libellulidae (cont.)	
Acisoma panorpoides Rambur, 1842 *ascalaphoides* Rambur, 1842	ANG, BOTS, MWI, MOZ, NAM, SA (FS, KZN, MPL, LIM), ZAM, ZIM; north to Sudan; also Madagascar; the subspecies *inflatum* occurs in North Africa and the nominotypical subspecies in Asia
Acisoma trifidum Kirby, 1889	ANG, ZAM; north to Kenya and The Gambia
Diplacodes deminuta Lieftinck, 1969	MOZ, SA (KZN, LIM), ZAM, ZIM; (possibly also Kenya and Uganda)
Diplacodes lefebvrii (Rambur, 1842)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Europe and Asia; also Indian Ocean islands
Diplacodes okavangoensis Pinhey, 1976	BOTS, ZAM
Crocothemis brevistigma Pinhey, 1961	ZAM
Crocothemis divisa Karsch, 1898	ANG, BOTS, MWI, MOZ, SA (LIM), ZAM, ZIM; north to Sudan and Senegal; also Madagascar
Crocothemis erythraea (Brullé, 1832)	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Europe and Pakistan
Crocothemis sanguinolenta sanguinolenta (Burmeister, 1839)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), ZAM, ZIM; north to Somalia and Benin; also Madagascar; the subspecies *arabica* occurs in the Levant
Crocothemis saxicolor Ris, 1919	MWI, MOZ, ZAM, ZIM; also Liberia
Bradinopyga cornuta Ris, 1911	MWI, MOZ, NAM, SA, (KZN, MPL, LIM), ZAM, ZIM; north to Kenya
Brachythemis lacustris (Kirby, 1889)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, LIM, WC), ZAM, ZIM; north to Ethiopia and The Gambia
Brachythemis leucosticta (Burmeister, 1839)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, NC, LIM), SWZ, ZAM, ZIM; north to Europe and Asia Minor
Brachythemis wilsoni Pinhey, 1952	BOTS; north to Uganda and Nigeria
Sympterum fonscolombii (Selys, 1840)	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Europe and Mongolia; also many islands
Sympetrum navasi LaCroix, 1921	BOTS, MWI, NAM, ZAM, ZIM; north to Uganda and the Gambia
Philonomon luminans (Karsch, 1893)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, LIM), ZAM, ZIM; north to Somalia and The Gambia; also Assumption Island
Atoconeura biordinata biordinata Karsch, 1899	MWI, MOZ, ZAM, ZIM; north to Tanzania, D. R. Congo and Nigeria; with other subspecies in Kenya and Ethiopia
Trithemis aconita Lieftinck, 1969	MWI, MOZ, SA (KZN, MPL), ZAM, ZIM; north to Kenya and Ivory Coast
Trithemis aequalis aequalis Lieftinck, 1969	ZAM
Trithemis aequalis falconis Pinhey, 1970	BOTS
Trithemis annulata annulata (Beauvois, 1807)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, LIM, WC), ZAM; north to Europe and Asia Minor; also Madagascar and Mascarenes
Trithemis anomala Pinhey, 1956	ZAM

Species	Distribution
Libellulidae (cont.)	
Trithemis arteriosa arteriosa (Burmeister, 1839)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Somalia, Morocco and The Gambia
Trithemis bifida Pinhey, 1970	ZAM, ZIM; also Nigeria and Ivory Coast
Trithemis brydeni Pinhey, 1970	BOTS, ZAM
Trithemis dichroa Karsch, 1893	ANG, ZAM; north to Sudan and Sierra Leone
Trithemis donaldsoni donaldsoni (Calvert, 1899)	ANG, MOZ, SA (KZN, LIM, WC), ZIM; north to Somalia and Nigeria (?)
Trithemis dorsalis (Rambur, 1842)	ANG, MOZ, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; north to Kenya and D. R. Congo
Trithemis furva Karsch, 1899	ANG, LES, MWI, MOZ, SA, (EC, FS, KZN, MPL, NC, WC), SWZ, ZAM, ZIM; north to Ethiopia and Ivory Coast
Trithemis grouti Pinhey, 1961 *atra* Pinhey, 1961	ANG, ZAM; also Gabon and D. R. Congo; the nominotypical subspecies occurs from D. R. Congo to Nigeria, but there is some confusion between the two subspecies.
Trithemis hecate Ris, 1912	BOTS, MWI, MOZ, NAM, SA (KZN, MPL), ZAM, ZIM; north to Tanzania and The Gambia; also Madagascar, and Comores
Trithemis kirbyi Selys, 1891 *ardens* Gerstaecker, 1891	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, LIM, NW, WC), ZAM, ZIM; north to the Arabian Peninsula and The Gambia; the nominotypical subspecies occurs across Asia
Trithemis monardi monardi Ris, 1931	ANG, BOTS, NAM
Trithemis monardi insuffusa Pinhey, 1970	ANG, MWI, MOZ, ZAM, ZIM
Trithemis nuptialis Karsch, 1894	ANG, ZAM; north to Uganda and Sierra Leone
Trithemis pluvialis Förster, 1906	ANG, MWI, MOZ, SA (FS, KZN, MPL, LIM), ZAM, ZIM; north to Kenya and D. R. Congo
Trithemis pruinata Karsch, 1899	ZAM; north to Uganda and Guinea
Trithemis stictica (Burmeister, 1839)	ANG, BOTS, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, LIM, NW, WC), ZAM, ZIM; north to Ethiopia and Ivory Coast
Trithemis werneri Ris, 1912	ANG, MWI, MOZ, SA (LIM), ZIM; north to Sudan
Zygonyx atritibiae Pinhey, 1964	ZAM
Zygonyx eusebia (Ris, 1912)	ANG, ZAM; also D. R. Congo
Zygonyx flavicosta (Sjöstedt, 1899) *mwinilungae* Pinhey, 1961	ANG, ZAM; the nominotypical subspecies occurs from Uganda to Sierra Leone
Zygonyx natalensis (Martin, 1900)	ANG, BOTS, MWI, MOZ, SA (KZN, MPL, LIM, WC), ZAM, ZIM; north to Kenya and Guinea; the subspecies *elizabethae* occurs in Madagascar
Zygonyx regisalberti (Schouteden, 1934)	ANG; also D. R. Congo
Zygonyx speciosa (Karsch, 1891)	ANG; north from D. R. Congo to Nigeria
Zygonyx torridus (Kirby, 1899)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, LIM), SWZ, ZAM, ZIM; north to Europe and Asia; including Mauritius and La Réunion
Olpogastra fuelleborni Grünberg, 1902	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, WC), ZAM, ZIM; north to Sudan and Nigeria
Olpogastra lugubris (Karsch, 1895)	BOTS, MWI, MOZ, NAM, SA (LIM), ZAM, ZIM; north to Kenya and The Gambia

Species	Distribution
Libellulidae (cont.)	
Rhyothemis mariposa Ris, 1913	ANG, NAM, ZAM; also D. R. Congo
Rhyothemis notata (Fabricius, 1781)	ANG, BOTS, MWI, NAM, ZAM; north to Uganda and The Gambia
Rhyothemis semihyalina semihyalina (Desjardins, 1832)	ANG, BOTS, MWI, MOZ, SA (KZN, MPL, LIM), ZAM, ZIM; north to Algeria and The Gambia; also Madagascar, Mauritius, Seychelles and some other islands
Zyxomma atlanticum Selys, 1889	MOZ, SA (KZN); north to Uganda and Senegal
Parazyxomma flavicans (Martin, 1908)	BOTS, SA (KZN), ZAM, ZIM; north to Uganda and The Gambia
Tholymis tillarga (Fabricus, 1798)	BOTS, MWI, MOZ, NAM, SA (GT, KZN, LIM), ZAM, ZIM; Afrotropical, Asian and Australian
Pantala flavescens (Fabricius, 1798)	ANG, BOTS, LES, MWI, MOZ, NAM, SA (EC, FS, GT, KZN, MPL, NC, LIM, NW, WC), SWZ, ZAM, ZIM; globally pantropical
Tramea basilaris (Beauvois, 1817)	ANG, BOTS, MWI, MOZ, NAM, SA (GT, KZN, MPL, LIM), ZAM, ZIM; continental Africa, some islands and Asia
Tramea continentalis Selys, 1878	BOTS, MOZ, SA (KZN, WC), ZIM; coastal continental Africa north to Somalia and Senegal; also Assumption Island, Madagascar and Seychelles
Urothemis assignata (Selys, 1872)	ANG, BOTS, MWI, MOZ, SA (KZN, MPL, LIM), ZAM, ZIM; north to Somalia and Senegal
Urothemis edwardsii edwardsii (Selys, 1849)	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL, LIM), ZAM, ZIM; north to Sudan and The Gambia; the subspecies *hulae* occurs/used to occur in Israel
Urothemis luciana Balinsky, 1961	SA (KZN); also Somalia, Socotra, Mauritius, Asia and Australia
Aethriamanta rezia Kirby, 1889	ANG, BOTS, MWI, MOZ, NAM, SA (KZN, MPL), ZAM, ZIM; north to Kenya and The Gambia; also Madagascar.
Macrodiplax cora (Kaup in Brauer, 1867)	SA (KZN); also Somalia, Socotra, Mauritius, Asia and Australia

CHAPTER 4

PLECOPTERA

by

D.M. Stevens & M.D. Picker

The Plecoptera, or stoneflies, comprise a minor, primitive, aquatic order of the Neoptera (insects that are able to fold their wings), with about 2000 species worldwide, occurring on all continents except for Antarctica (Theischinger 1991). The name 'Plecoptera' means 'folded wings'.

Habitat

The nymphs of almost all species are aquatic, with most being found in cool, perennial streams. A few species are adapted to lakes, and others to temporary streams that dry up in summer (Stewart 1996). All the southern African stoneflies have aquatic nymphs which are restricted to streams or rivers. The nymphs may be found clinging to the submerged parts of large rocks, stones and the gravel on the stream bed, and to leaf packs and twigs. They may also be found in the hyporheos (Sánchez-Ortega & Alba-Tercedor 1990). Adults are found on the dry parts of partially submerged rocks, and within a short distance from the stream on rocks and riparian vegetation. On overcast or drizzly days the adults may be found on exposed surfaces, but on hot sunny days they take refuge in the cool damp microenvironment under stones and boulders (Picker 1985). Stonefly nymphs generally cannot tolerate thermal or organic pollution.

Reproduction and life history

The adults live for only a few days to a few weeks. Females are generally larger than males, and males of many species attract and court females by drumming the abdomen on the substrate where they will mate. This behaviour has not, however, been reported in stoneflies from the southern African region. During mating, the male climbs on top of the female and curls the tip of his abdomen underneath hers, enabling the female subgenital plate to interlock with the male epiproct (supra-anal lobe), and/or other copulatory structures. The terminalia vary greatly among the different families and genera. Mating may last several hours and sperm are transferred by one of a variety of structures such as the aedeagus, the paraprocts and the epiproct. Eggs are laid on the surface of the water, or below the surface, and become attached to the substrate by various anchoring methods (Stewart 1996). The life cycle is most commonly univoltine, but many species are semivoltine, with the life cycle lasting from two to as long as six years (Frutiger & Imhof 1997). Diapause is known to occur in both the embryonic and nymphal stages under extreme environmental conditions (Stewart 1996). Eggs take three to four weeks to hatch, followed by a variable number of nymphal instars. The final instar, easily recognisable by its black wing pads, crawls out the water onto a dry stone or vegetation to emerge from its exuvium as the adult stonefly. These exuviae (also called shucks) remain attached to the substrate for a few weeks after the adult has emerged. An adult stonefly may often be found in close proximity to its shuck. The life cycle is hemimetabolous. The exact life history of southern African plecopterans is unknown. The life cycle of the Notonemouridae is probably univoltine, but the number of instars is yet to be established.

Feeding

Feeding habits of the nymphs vary and include detritivory and herbivory (shredders, gatherers, scrapers), omnivory, and predation. Feeding habits may even change with the developmental stage of the nymph (Stewart 1996). Adults generally feed on algae, lichen and other plant material, although some do not feed (Gullan & Cranston 2000).

The nymphs of the Western Cape genus *Aphanicerca* (Notonemouridae) are shredders of leaf detritus, a major source of carbon in streams, with the microbial slime layer on decomposing leaf material thought to provide a source of nitrogen (Reynolds et al. 1997). Captive adult notonemourids will eat proteinaceous commercial fish flakes, so they probably do feed in the wild. The nymphs of another local stonefly genus, *Neoperla* (Perlidae), are voracious carnivores, preying on nymphal mayflies and simulids; adults of *Neoperla* probably do not feed (Picker 1985).

Economic importance

Stoneflies are useful indicators of water quality (Dallas & Day 1993), and their disappearance from a stream may indicate that thermal or chemical pollution has occurred. Stonefly nymphs, and adults that fall onto the water surface, are preyed on by larger carnivorous insect nymphs, frogs and fish, and form part of the food chain that supports economically important fish such as trout. Indeed, fly-fishermen tie flies that mimic adult stoneflies.

Southern African plecopterans

Of the 16 families of Plecoptera, only two occur in Africa: the Perlidae, found throughout Africa, and the Notonemouridae, restricted to southern Africa. The family Perlidae is represented by a species-complex (Picker 1980) of an unknown number of species, while the family Notonemouridae has been well collected and comprises 31 species in six genera. The group's centre of adaptive radiation is the Western Cape, accounting for more than half of the known species. Most of the southern African species are restricted to small areas. For example, two species, and one variety of a third species, all of different genera, are found only on Table Mountain. It is therefore likely that new notonemourid species may be found in remote mountain streams of southern Africa.

The nymphs of the Notonemouridae occur in cold, fast-flowing streams with stony substrates, and even in the moss-covered trickles on mountainsides, providing these are perennial or flow underground during the dry season. They may also be found in some streams that flow only in the rainy season, suggesting that these particular streams are perennial, but flow underground during the dry months. They are absent from stagnant, quiet, water bodies or slow-flowing deep rivers with sandy substrates.

The nymphs of the Perlidae have gills, and can better tolerate the lower oxygen concentrations of warmer water than the notonemourids. As well as occurring in fast-flowing mountain streams, perlids may also be found in rather warm, sluggish, turbid rivers (Picker 1985).

Collection and preservation

Nymphs can be obtained using any sampling method designed to catch invertebrates from rock surfaces and gravel of stony stream beds. For specific collection of nymphs, stones should be lifted from the margins of the stream. The nymphs will remain motionless for a short time and will then start to slowly wriggle across the surface of the stone. They can be handpicked carefully and transferred immediately into a vial of 70% alcohol.

Laboratory rearing to the adult stage may be necessary for identification to species level. In this case the nymphs should be transported to the laboratory in cold stream water, and transferred to an aerated tank, preferably kept in a cold constant-temperature environment. The tank should be provided with a rough substrate (for nymphs to grip onto) and partially submerged sticks or stones to allow the final instars to climb out the water.

A net covering over the tank will prevent the newly emerged adults from escaping. Commercial fish flakes are suitable food for the notonemourids, while perlid larvae require live insect larvae such as blackfly larvae.

In natural environments, the adults usually sit still on the rocks for long enough to facilitate capture. Once alerted to danger they will generally scurry along the surface before coming to rest in a safe microenvironment, usually under the rock or in a crack. If further pestered, they may leap into the air and fly weakly for a short distance. They can be caught by simply placing an alcohol- or water-wetted finger lightly on top of the insect, so that the wings stick to the finger, after which they are transferred to a container filled with 70% alcohol. To obtain living material, they can be captured by placing an open vial over the insect, which can be induced to enter the vial by sliding a thin piece of plastic or paper underneath, or by moving the vial around gently.

Conservation

Because of their dependence on pristine conditions, and their high levels of endemism, plecopterans can be regarded as vulnerable. The stocking of streams with trout combined with gradual degradation of freshwater ecosystems and the inadequacy of conservation measures has resulted in a decline in the conservation status of certain species, some of which are now vulnerable to extinction. Indeed, a number of species are known only from single stream localities. Preservation of the catchment in which these rare species occur is essential for their survival (Picker & Stevens 1999). In spite of considerable collecting effort, *Aphanicerca tereta* has not been found since its discovery in the 1920s (Barnard 1934), suggesting that it is either very localized or extinct. The Plecoptera do not have Red Data listing, but many species are endangered due to their very narrow distribution ranges, and the following are candidates for inclusion in future Red Data Books, where their status would be recorded as endangered: *Aphanicerca tereta, Aphanicerca uncinata, Aphanicerca gnua, Aphanicerca bovina, Aphanicerca capensis* varieties (to be described as species), *Aphanicercella nigra, Aphanicercella securata, Balinskycercella fontium*, and *Afronemoura stuckenbergi*.

GENERAL DESCRIPTION OF SOUTHERN AFRICAN PLECOPTERA

Although adult plecopterans are not aquatic, they are included in this guide because:

- Identification to species level using nymphs is impossible unless the adult genitalia are visible through the translucent cuticle of the final instar nymph. If mature nymphs are present in a benthic sample, knowledge of adult genitalia will enable accurate identification to species level. When black-wingpad nymphs are not present, however, specimens can usually be identified to generic level.

- Adults may inadvertently be included in a sample of aquatic invertebrates when washed off the underside of a partially submerged rock.
- At the end of an emergence season, a few adults may still be present in the absence of nymphs. These are easily obtained by sweeping the riparian vegetation or using emergence traps.

Stoneflies are morphologically a highly variable and divergent group, with different families showing major differences in the structure of the genitalia. The nymphs are streamlined, an adaptation to life in fast currents (Figs 4.2–4.4). The body is dorsoventrally flattened, and the legs positioned so that the body is kept flat against the substrate. The antennae are long and filiform; the compound eyes are large and three ocelli are present. The elongate body is clearly demarcated into three thoracic and 10 abdominal segments (Figs 4.2–4.4, 4.18A). Nymphs can swim weakly, but normally crawl sluggishly over the rock surface, and can be easily recognized by the pair of long, posterior, multi-segmented cerci. They can be confused with mayfly nymphs, but most ephemeropterans have three cerci, and swim and crawl vigorously. On the meso- and metathorax older stonefly instars show developing wing pads. They lie parallel to one another, with the fore pair more widely separated than the hind pair. The wing pads turn black in the final instar just prior to emergence of the adult. Gills may be present (Perlidae: Fig. 4.18A) or absent (Notonemouridae: Figs 4.2–4.4). The stonefly nymphs retain the same body shape throughout life.

The adults are small to medium sized, narrow-bodied insects, the length (excluding the wings) of notonemourids being about 4–9 mm, while that of perlids is about 20–25 mm. Notonemourids are brown to lead-grey in colour, while perlids are a yellowish-tan colour. Both have long, filiform antennae, large compound eyes and three ocelli. The notonemourids lose most of the nymphal cerci, retaining just one segment which hardly protrudes beyond the caudal extremity of the abdomen, and is not visible without a hand lens, whereas in the perlids the whole length of the cerci is retained in the adult. The two sub-equal pairs of wings are folded back over the elongate soft body, and in the notonemourids are furled closely around the abdomen. Brachyptery and aptery occur in a few species of notonemourid. The head is triangular, the head and thorax are dorsoventrally flattened, and the cylindrical abdomen is slightly narrower than the thorax. The abdomen comprises 10 segments, with vestiges of segments 11 and 12 modified to form the male external genitalia (Figs 4.7, 4.18B & C). The genitalia of the notonemourids are vastly different from those of the perlids (see later). Species are separated on features of the external genitalia, with the males being far more easily identified than the females. The large eggs of female perlids are also useful diagnostic features.

KEY TO THE SOUTHERN AFRICAN FAMILIES OF PLECOPTERA: ADULTS

1. Cerci short and single-jointed; first and third tarsal segments much longer than second segment; labial palps very short, not extending beyond the glossae (Fig. 4.1B) .... **Notonemouridae**

– Cerci long and multi-segmented; first and second tarsal segments equal in length, and much shorter than the third segment; labial palps very long, extending far beyond the glossae (Fig. 4.1A) .... **Perlidae**

KEY TO THE SOUTHERN AFRICAN FAMILIES OF PLECOPTERA: NYMPHS

1. Gills absent; no comb of long hairs on caudal margin of femora and tibiae (Figs 4.2–4.4) .... **Notonemouridae**

– Gills present; comb of long hairs on caudal margin of femora and tibiae (Fig. 4.18A) .... **Perlidae**

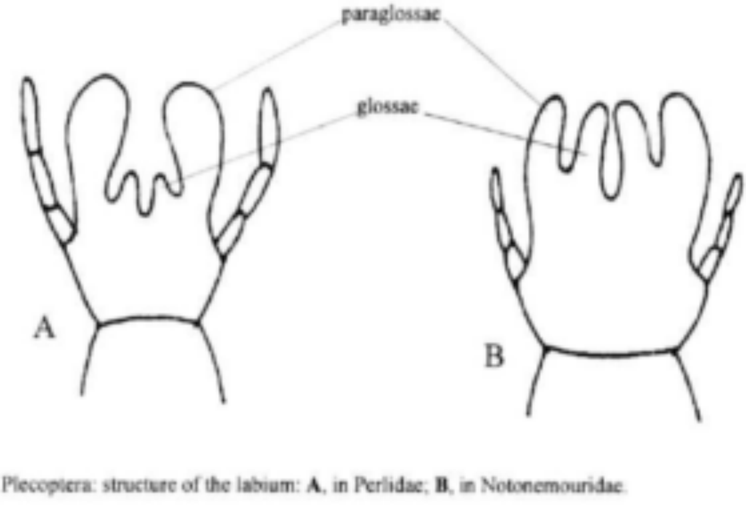

Fig. 4.1. Plecoptera: structure of the labium: **A**, in Perlidae; **B**, in Notonemouridae.

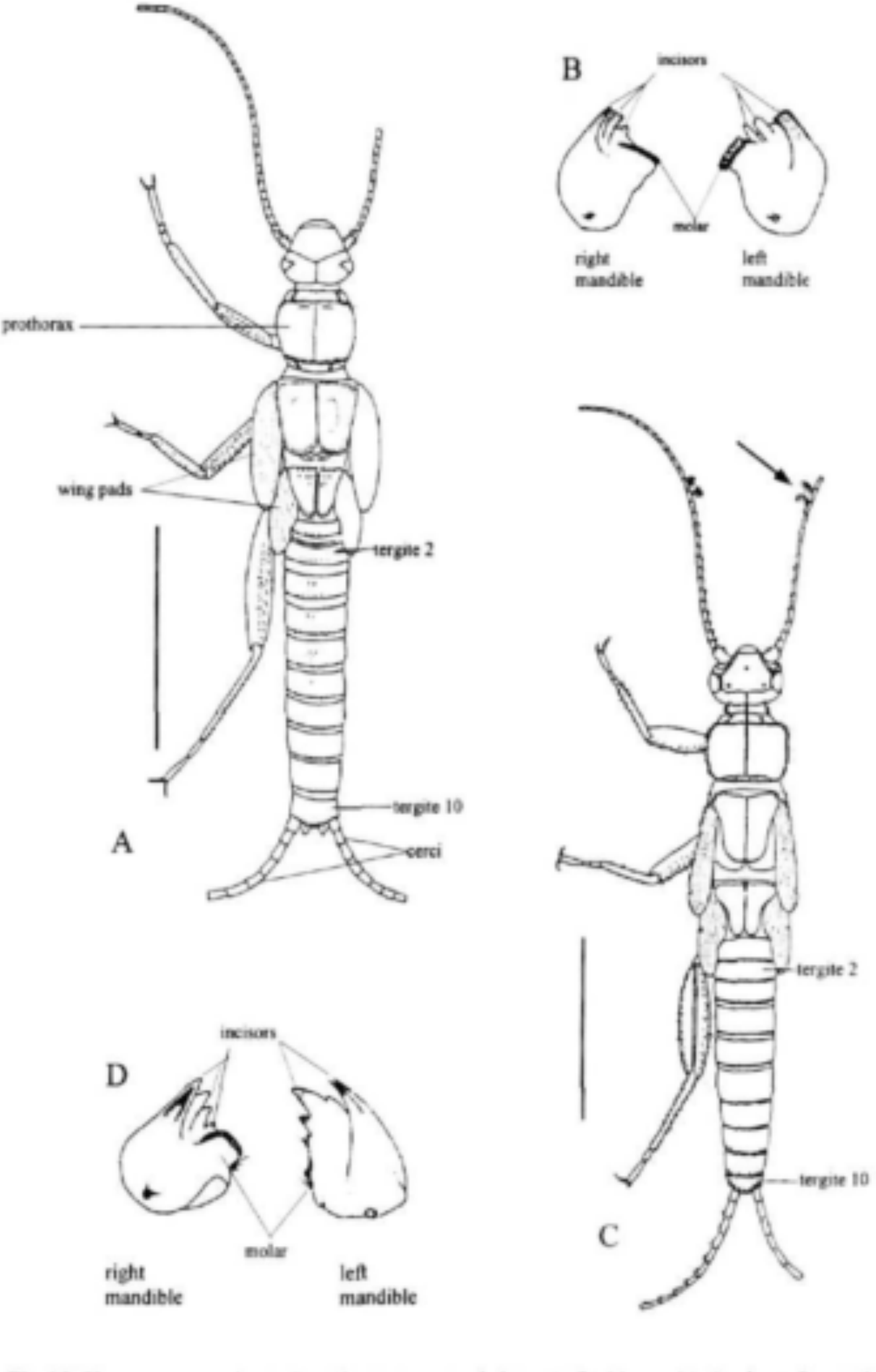

Fig 4.2. Plecopteran nymphs: **A–B**, *Aphanicercopsis tabularis*: **A**, final instar (black-wingpad) nymph with antennae and cerci truncated; **B**, detailed structure of the mandibles. **C–D**, *Afronemoura amatolae*: **C**, final instar (black-wingpad) nymph with antennae and cerci truncated (arrow indicates diagnostic medial tuft of antennal hairs); **D**, detailed structure of the mandibles. Scale bar = 2 mm. (After Picker & Stevens 1997).

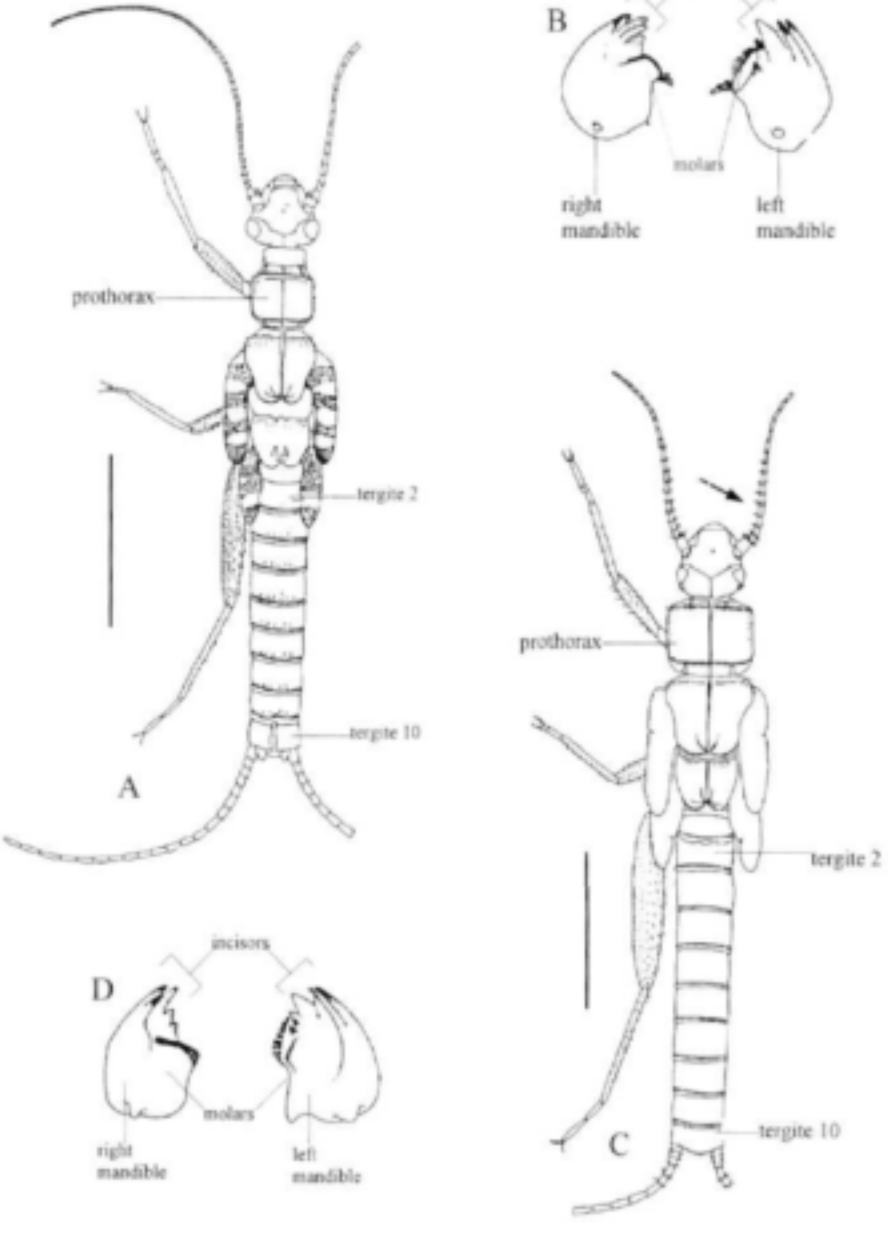

Fig. 4.3. Plecopteran nymphs: **A–B**, *Desmonemoura pulchellum*: **A**, final instar (black-wingpad) nymph, dorsal view with antennae and cerci truncated; **B**, detailed structure of the mandibles. **C–D**, *Aphanicerca capensis*: **C**, final instar (black-wingpad) nymph, dorsal view with antennae and cerci truncated (arrow indicates longer medial hairs on proximal region of antenna); **D**, detailed structure of the mandibles. Scale bar = 2 mm. (After Picker & Stevens 1997).

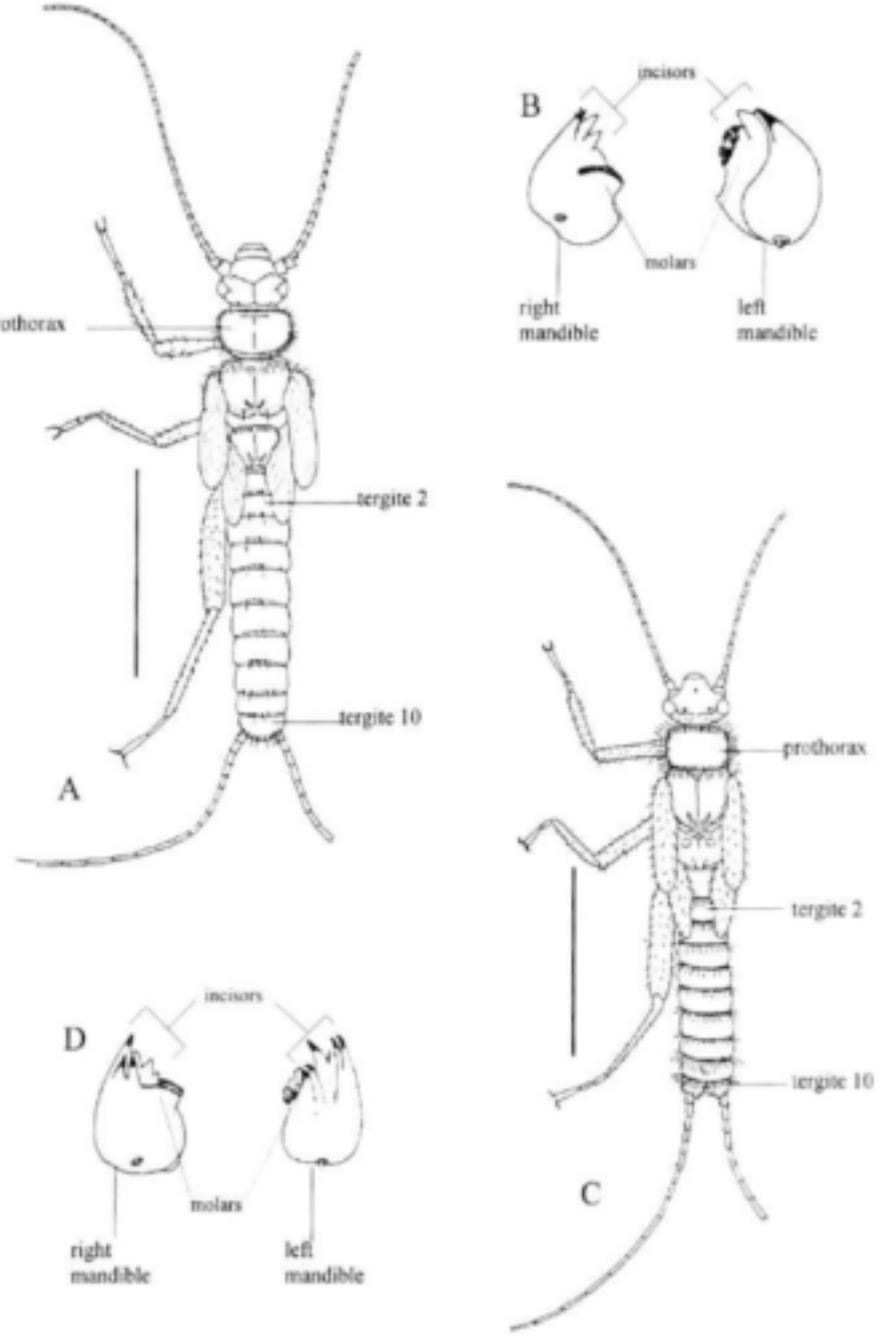

Fig. 4.4 Plecopteran nymphs: **A–B**, *Aphanicercella clavata*: **A**, final instar (black-wingpad) nymph, dorsal view with antennae and cerci truncated; **B**, detailed structure of the mandibles: **C–D**, *Balinskycercella tugelae*: **C**, final instar (black-wingpad) nymph, dorsal view with antennae and cerci truncated; **D**, detailed structure of the mandibles. Scale bar = 2 mm. (After Picker & Stevens 1997).

Family **Notonemouridae** Ricker 1950

The family Notonemouridae is endemic to the Southern Hemisphere, although these stoneflies are considered to be a derived subgroup of the northern suborder Arctoperlaria (Zwick 1973). Notonemourids have temperate affinities, being recorded from the mountains of the Western and Eastern Cape Provinces, the southern Cape, Lesotho and KwaZulu–Natal Drakensberg, the midlands of KwaZulu–Natal, and as far north as the Mpumalanga Drakensberg (Stevens & Picker 1995). They are a typical Gondwanan group, with relatives of the same family in the other southern continents.

Species from the southern African region were first described by Tillyard (1931), Barnard (1934) and Balinsky (1956 and 1967). Illies (1980) described a new genus, *Afronemoura*, and a revision of the family resulted in the description of another new genus, *Balinskycercella* (Stevens & Picker 1995). The resolution of the *Aphanicercella barnardi* species-complex added five new species (Stevens & Picker 1999). A further four new species were described by Picker & Stevens (1999). Descriptions of the nymphs of the most common species were provided by Picker & Stevens (1997).

Nymphs

The nymphs do not possess gills and are relatively small, reaching a maximum length of about 12 mm. All stonefly nymphs are covered in fine 'clothing hairs' (Hynes 1941) that are not taxonomically useful. It is the pattern and number of longer and thicker hairs, setae and bristles, that prove to be definitive characters in this family (Table 4.1; Figs 4.5 & 4.6). These characteristics are particularly important when situated on the posterior margins of abdominal segments, as well as on the antennae, wing pads, tergites and sternites.

Another taxonomically useful character is the extent of fusion of the abdominal tergites and sternites, the most anterior segments having the tergite and sternite separated by a pleurite, but more posteriorly fusing to form a ring (Picker & Stevens 1995) (Table 4.2). The fractional values in the key and Table 4.2 represent cases of incomplete fusion of sternite and tergite, where only the anterior half of a segment, when viewed laterally, has the tergite and sternite separated by a narrow membranous pleurite. Colour patterning is variable and, as such, is not widely used as a taxonomic character. The mandibular formula for each genus in the key to genera (nymphs) gives the number of incisors of the right:left mandible.

Table 4.1. Average number of major setae per nymphal abdominal segment (situated close to the posterior margin). Range in parentheses.

Dorsal abdominal setae

ASN	*A. tabularis* n = 5	*A. denticulata* n = 2	*A. outeniquae* n = 4	*B. tugelae* n = 1	*A. amatolae* n = 1	*D. pulchellum* n = 3	*A. capensis* n = 7	*A. bicornis* n = 1	*A. lyrata* n = 1	*A. clavata* n = 19	*A. bifurcata* n = 16	*A. cassida* n = 12	*A. scutata* n = 2
1	3.6 (1-6)	3.5 (3-4)	2.8 (1-4)	8	2	1.0 (0-3)	0	0	0	2.5 (2-5)	0	5.3 (2-8)	1.0 (0-2)
2	5.8 (5-7)	3.0	1.8 (0-4)	8	3	1.3 (0-4)	0	0	0	2.4 (2-4)	0	3.9 (2-6)	2.0
3	8.0 (6-10)	6.5 (6-7)	5.5 (4-8)	8	4	6.7 (3-12)	0	0	0	2.3 (2-4)	0	4.3 (2-7)	2.0
4	9.6 (8-12)	7.0 (6-8)	8.0 (6-10)	16	4	7.7 (5-12)	0	0	0	2.1 (1-4)	0	4.5 (2-6)	2.0
5	10.8 (10-12)	11.0 (8-14)	9.3 (5-12)	24	5	9.3 (4-16)	0	0	0	2.0 (1-3)	0	5.7 (4-8)	1.5 (1-2)
6	11.2 (10-12)	14.0 (12-16)	7.5 (6-10)	26	11	12.0 (4-20)	0	0	0	2.0	0	6.9 (5-10)	2.0
7	14.4 (8-26)	24.0 (22-26)	7.0 (4-8)	40	10	13.0 (3-20)	0	0	0	2.0 (1-3)	0	10.4 (8-18)	2.0
8	12.0 (8-16)	17.0 (8-26)	9.0 (6-12)	60	10	16.7 (12-22)	0.1 (0-1)	0	0	3.1 (2-6)	1.3 (0-2)	14.5 (12-18)	3.5 (3-4)
9	12.4 (10-14)	16.0 (8-24)	12.0 (8-14)	60	4	16.0 (10-22)	1.0 (0-2)	0	0	5.1 (4-9)	4.7 (3-8)	19.1 (14-22)	6.5 (6-7)
10	17.6 (8-50)	5.5 (3-8)	7.0 (4-8)	70	8	8.0 (6-10)	2.9 (0-8)	3	0	5.7 (3-9)	6.0 (4-8)	20.5 (16-24)	9.0 (6-12)

Ventral abdominal setae

ASN	*A. tabularis*	*A. denticulata*	*A. outeniquae*	*B. tugelae*	*A. amatolae*	*D. pulchellum*	*A. capensis*	*A. bicornis*	*A. lyrata*	*A. clavata*	*A. bifurcata*	*A. cassida*	*A. scutata*
1	0.8 (0-4)	0	0	0	6	0	0	0	0	0	0	0.1 (0-2)	0
2	3.2 (2-6)	0	0	12	4	0	0	0	0	2.0 (1-4)	0	1.5 (0-4)	2.0 (0-4)
3	4.8 (3-10)	4.0 (0-8)	0	10	4	0	0	0	0	1.9 (0-4)	0	3.1 (0-4)	3.0 (2-4)
4	6.8 (4-14)	8.0	0	8	4	0	0	0	0	1.9 (0-4)	0	3.1 (2-4)	2.0
5	9.2 (6-12)	10.0 (8-12)	0.5 (0-2)	8	2	3.3 (2-4)	0	0	0	1.8 (0-2)	0	3.9 (2-6)	3.0 (2-4)
6	11.2 (6-16)	15.0 (14-16)	2.0 (0-8)	20	4	4.0 (2-6)	0	0	0	1.9 (1-3)	0	4.3 (2-6)	3.0 (2-4)
7	18.0 (12-22)	23.0 (20-26)	4.0 (0-10)	20	4	2.7 (2-4)	0.3 (0-2)	0	0	1.9 (1-2)	0.1 (0-1)	6.5 (4-10)	2.0
8	34.8 (24-44)	26.0 (22-30)	12.5 (10-16)	30	6	6.0	0.9 (0-2)	0	0	2.2 (1-4)	2.0 (0-4)	9.5 (6-20)	2.5 (2-3)
9	44.0 (26-60)	24.0 (20-28)	16.5 (14-20)	40	6	12.0 (6-20)	3.7 (2-8)	4	2	3.8 (1-6)	6.3 (4-8)	16.3 (8-22)	6.0
10	5.2 (2-6)	3.0(2-4)	0	12	2	2.0	4.6 (0-10)	5	0	0.6 (0-4)	0	2.2 (2-4)	2.0

KEY: *Aphanicercopsis* species — *A. tabularis*, *A. denticulata*, *A. outeniquae*; *Aphanicerca* species — *A. capensis*, *A. bicornis*, *A. lyrata*; *Aphanicercella* species —*A. clavata*, *A. bifurcata*, *A. cassida*, *A. scutata*; *B. tugelae* = *Balinskycercella tugelae*; *D. pulchellum* = *Desmonemoura pulchellum*; ASN = Abdominal Segment Number

Table 4.2. Number of segments with pleurites (counted from segment 1)

Species	Mean number of pleurites
Aphanicerca bicornis	5.5 (n = 1)
Aphanicerca lyrata	5.0 (n = 1)
Aphanicerca capensis	5.0 (n = 7)
Desmonemoura pulchellum	5.0 (n = 3)
Afronemoura amatolae	5.0 (n = 1)
Aphanicercopsis denticulata	4.0 (n = 2)
Aphanicercopsis outeniquae	3.0 (n = 4)
Aphanicercopsis tabularis	3.5 (n = 5)
Aphanicercella clavata	6.0 (n = 19)
Aphanicercella scutata	6.5 (n = 1)
Aphanicercella bifurcata	6.0 (n = 14)
Aphanicercella cassida	6.0 (n = 11)
Balinskycercella tugelae	7.5 (n = 1)

In the south-western parts of the Western Cape nymphs are commonly found from February through to August, although nymphs of some species may still be found as late as December. In the more eastern parts of the country the nymphs occur later in the year, coinciding with the rainy season.

The adult genitalia are visible through the cuticle of the final instar nymphs. The insect should be pinned with fine pins under alcohol, and dissected from the dorsal side. The translucent cuticle covering the posterior abdominal segments is removed using fine forceps to expose the genitalia. The genitalia can then be examined under the stereo microscope for the purpose of further identification. Males are more easily identified than females.

The nymphs of three genera are easily recognized: the final instar of *Desmonemoura* shows obvious light and dark banding of the wing pads (Fig. 4.3A). A unique feature of *Afronemoura* is the thick, conspicuous tuft of hair on the antennae (Fig. 4.2C). In *Aphanicerca* nymphs, the hairs on the medial aspect of the proximal segments of the antennae are longer than the other antennal hairs (Fig. 4.3C). The remaining three genera are separable on more subtle characters given in the key.

Adult genitalia

Males can be distinguished from females by the presence of accessory reproductive structures located dorsally on the terminal segments of the male abdomen. In the Notonemouridae the epiproct or supra-anal lobe (Fig. 4.7) is found in all the genera, and is the main structure used in differentiating between males of many of the species of *Aphanicercella* (Figs 4.13–4.16), and also between the males of *Aphanicercopsis* (Figs 4.12E–H). It is located dorsally and terminally, and is a long, narrow or broad, median, sclerotized structure with its posterior end attached to the abdomen and is directed anteriorly. The paraprocts (Figs 4.7, 4.13–4.16) are paired structures arising ventrally and curving upwards over the posterior aspect of the insect. They form the intromittent organ for the passage of sperm (Barnard 1934), and are taxonomically useful in separating the members of the *Aphanicercella barnardi* species-complex (Figs 4.13–4.16) (Stevens & Picker 1999). The paraprocts comprise a number of sclerites in addition to the soft-tissue components. The **basal supporting processes of the paraprocts** (Figs 4.13–4.16) are structures originating on the transverse rods, lateral to the median arch. The **transverse rods** are transverse struts medially producing the basal supporting processes and primary supporting struts of the paraprocts. Thinner secondary supporting struts may also be present. The **arch processes** are extensions of the **median arch,** which lies in the midline between the two transverse rods. The **spinous process** is a slender process arising from the arch process in some species.

The paired dorsal lobes of tergite 9 are unique features of *Aphanicerca*, the variability in shape and size providing the main diagnostic characters of the different species (Figs 4.7A, 4.10A & C, 4.11A–E). They project posteriorly from the posterior margin of tergite 9, are large, cylindrical, and often bear spinules or denticles on the disto-medial aspect. Their function is unknown, but in *Aphanicerca capensis*, and probably also in the other species, they press rhythmically against the abdomen of the female during copulation.

Desmonemoura also has a modification of the posterior margin of tergite 9, in the form of paired, posteriorly-directed, elbow-shaped, flattened processes, terminating in a small spine (Figs 4.7F & 4.16E). Unique features of this genus are the very long, single-jointed cerci, and the equally long posteriorly-directed clasper of pleurite 10 (longer than the claspers of *Aphanicercella*), the lengths of which serve to separate the two species in the genus.

The median plate of tergite 10 lies ventral to the epiproct, between the two lateral plates of tergite 10, and in *Balinskycercella* bears an anterior hook (Figs 4.7E & 4.12A & C). *Afronemoura* can easily be recognized by one or two spines on the posterior margin of tergite 9 (Figs 4.7C, 4.9A & C).

The female genitalia are rather simple in comparison to those of the male. The genital opening is located at the caudal margin of sternite 7 in *Aphanicercella* and *Balinskycercella*, and sternite 8 in the other genera. The shape of the subgenital plate, which is the sternite overlying the genital opening, is taxonomically useful, as is the degree and pattern of sclerotization of the sternites (Figs 4.8, 4.9B & D, 4.10 B & D, 4.11F–I, 4.12B & D, 4.16F, 4.17).

KEY TO GENERA OF THE NOTONEMOURIDAE: NYMPHS

1\. Conspicuous tuft of coarse setae situated at one-third of the length of the antennae from the base, on closer examination comprising two groups of setae located approximately on segments 26 and 27; pleurites on abdominal segments 1–5; body appears smooth, but bearing fine short translucent setae (Fig. 4.5 I–J); mandibular formula 4:6 .... *Afronemoura* (Figs 4.2C & D)

– No tufts of setae on antennae 2

2\. Enlarged medial hairs extending from base to half the length of antennae; compound eyes very small; body virtually free of setae (Fig 4.5 A–B); pleurites on abdominal segments 1–5 or sometimes 1–5.5; mandibula formula 5:6 .... *Aphanicerca* (Figs 4.3C & D)

– No medial enlarged antennal hairs 3

3\. Body with numerous long setae (Fig. 4.6) 4

– Body appears smooth; setae short and inconspicuous where present (Figs 4.5G & H, K–P) 5

4\. Complete whorls of long setae on all abdominal segments (Fig. 4.6 I–J); incomplete mid-ventrally; pleurites on abdominal segments 1–7 or sometimes 1–7.5; wingpads evenly covered in long bristles; mandibular formula 6:6 .... *Balinskycercella* (Figs 4.4C & D)

– Incomplete whorls of setae on abdominal segments (Fig. 4.6 A–H); dorsal setae situated medially and not reaching lateral margins (exceptions have complete whorls restricted to segments 8–10); pleurites on abdominal segments 1–6 or sometimes 1–6.5; mandibular formula 4:5 .... *Aphanicercella* (Figs 4.4A & B)

5\. Abdominal segments 1–3 or 4 having pleurites; prothorax appearing circular, being of equal length and breadth with curved lateral margins; eyes very small; mandibular formula 4:4 .... *Aphanicercopsis* (Figs 4.2A & B; 4.5K–P)

– Abdominal segments 1–5 or 6 having pleurites; prothorax rectangular; wider than long; lateral margins straight; eyes round and very large; wingpads strikingly barred in more mature nymphs; occasionally with slightly enlarged medial hairs on first few antennal segments; mandibular formula 5:6 .... *Desmonemoura* (Figs 4.3A & B; 4.5G & H)

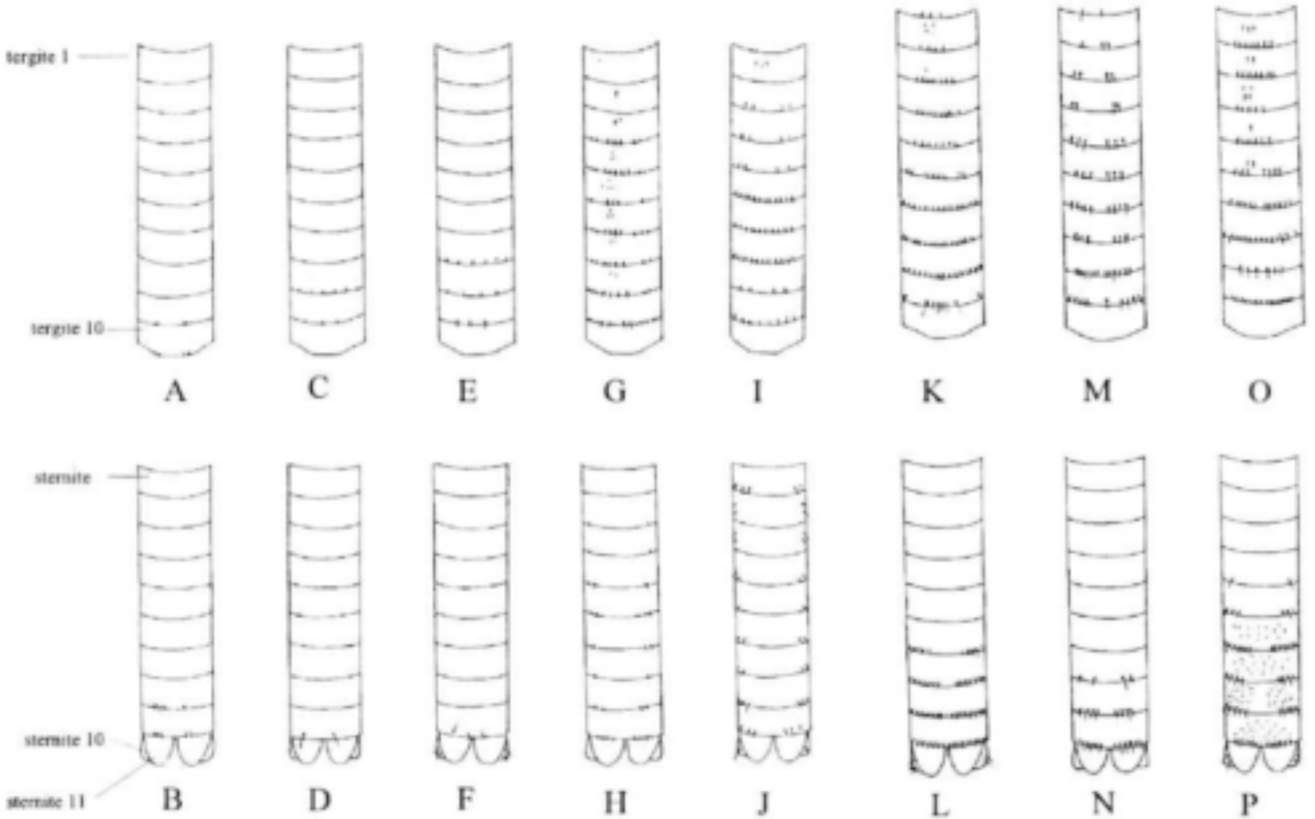

Fig. 4.5. Schematic nymphal abdominal setal patterns: **A–B**, *Aphanicerca bicornis*: **A**, dorsal view; **B**, ventral view. **C–D**, *Aphanicerca lyrata*: **C**, dorsal view; **D**, ventral view. **E–F**, *Aphanicerca capensis* (Table Mountain form): **E**, dorsal view; **F**, ventral view. **G–H**, *Desmonemoura pulchellum*: **G**, dorsal view; **H**, ventral view. **I–J**, *Afronemoura amatolae*: **I**, dorsal view; **J**, ventral view. **K–L**, *Aphanicercopsis denticulata*: **K**, dorsal view; **L**, ventral view. **M–N**, *Aphanicercopsis outeniquae*: **M**, dorsal view; **N**, ventral view. **O–P**, *Aphanicercopsis tabularis*: **O**, dorsal view; **P**, ventral view. (After Picker & Stevens 1997).

KEY TO GENERA OF THE NOTONEMOURIDAE: ADULT MALES

1. Wings strongly banded transversely; cerci and claspters of pleurite 10 much longer than the epiproct .... *Desmonemoura* (Figs 4.7F, 4.16E)
– Wings not banded transversely; cerci and processes of pleurite 10 (if present) short 2

2. Bifid dorsal process on tergite 9 .... *Aphanicerca* (Figs 4.7A, 4.10 A & C, 4.11A–E)
– No bifid dorsal process on tergite 9 3

3. One or two small median spines on posterior edge of tergite 9 .... *Afronemoura* (Figs 4.7C, 4.9A & C)
– No spines on posterior edge of tergite 9 4

4. Anterior apex of median plate of tergite 10 bent upward and produced into a recurved hook which may be bifid ...... *Balinskycercella* (Figs 4.7E, 4.12A & C)
– Anterior apex of median plate of tergite 10 not bent upward and not produced into a recurved hook 5

5. Distal margins of pleurite 10 elongated to form arm-like claspers; subgenital plate short and rounded .... *Aphanicercella* (Figs 4.7D, 4.13–4.16A–D)
– Distal margins of pleurite 10 not modified to form claspers, subgenital plate elongate .... *Aphanicercopsis* (Figs 4.7B, 4.12E–H)

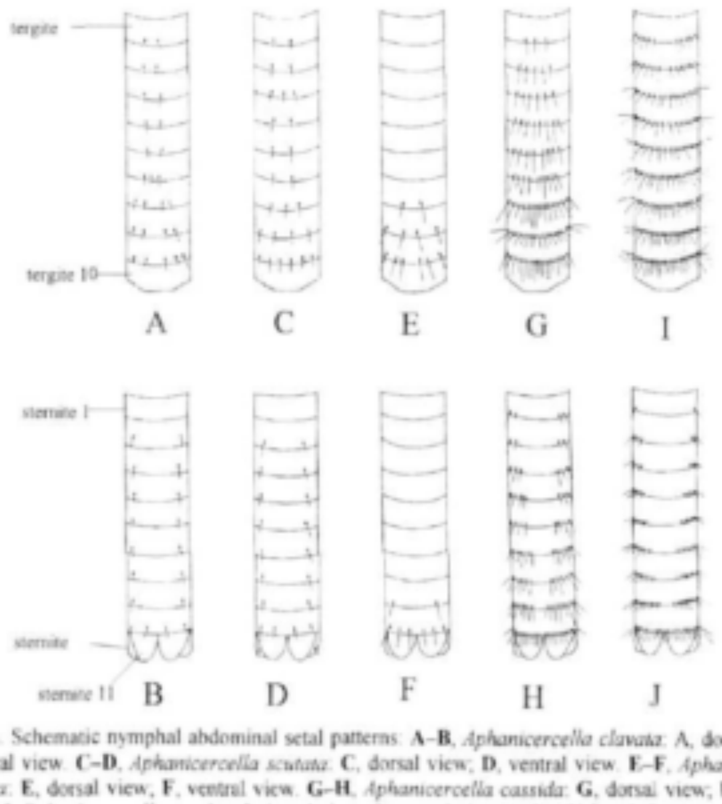

Fig. 4.6 Schematic nymphal abdominal setal patterns: **A–B**, *Aphanicercella clavata*: A, dorsal view; **B**, ventral view. **C–D**, *Aphanicercella scutata*: **C**, dorsal view; **D**, ventral view. **E–F**, *Aphanicercella bifurcata*: **E**, dorsal view; **F**, ventral view. **G–H**, *Aphanicercella cassida*: **G**, dorsal view; **H**, ventral view. **I–J**, *Balinskycercella tugelae*: **I**, dorsal view; **J**, ventral view. (After Picker & Stevens 1997).

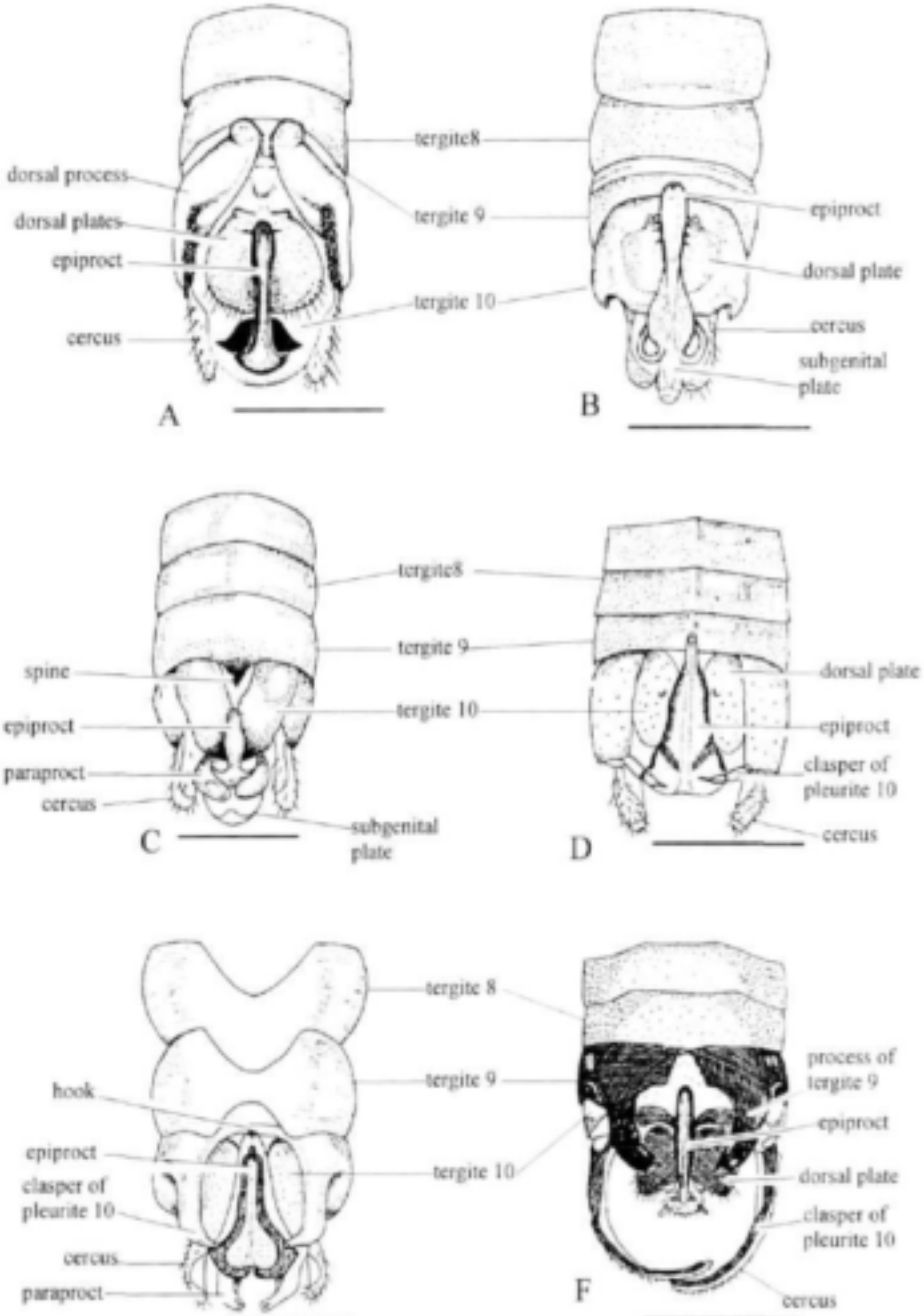

Fig. 4.7. External genitalia of male notonemourids representing the six genera (dorsal view): **A**, *Aphanicerca capensis* (Table Mountain form); **B**, *Aphanicercopsis tabularis*; **C**, *Afronemoura spinulata*; **D**, *Aphanicercella barnardi*; **E**, *Balinskycercella gudu*; **F**, *Desmonemoura pulchellum*. Scale bar = 0.5 mm. (After Stevens & Picker 1995).

KEY TO GENERA OF THE NOTONEMOURIDAE: ADULT FEMALES

1. Sternite 8 forms subgenital plate (Fig. 4.8A–C, F) 2
– Sternite 7 forms subgenital plate (Fig. 4.8D & E) 5

2. Wings strongly banded transversely; subgenital plate bilobate with a deep triangular incision posteriorly; sternite 7 bearing a transverse median bulge .... *Desmonemoura* (Figs 4.8F, 4.16F)
– Wings not banded transversely; no deep incision in subgenital plate; no structure on sternite 7 3

3. Large clear patch in middle of forewings; cerci short and cylindrical; subgenital plate short or elongate .... *Aphanicerca* (Figs 4.8A, 4.10B & D, 4.11F–I)
– No clear patch in middle of forewings; cerci very short and conical; subgenital plate elongated to form an ovipositor-like structure 4

4. Subgenital plate brown with distal tip slender and obscured by hairs .... *Afronemoura* (Figs 4.8C, 4.9B & D)
– Subgenital plate cream with distal tip robust and glabrous .... *Aphanicercopsis* (Fig. 4.8B)

5. Subgenital plate (sternite 8) often strongly developed and intensely sclerotized. When weakly developed and not intensely sclerotized, may have trilobate pattern of light sclerotization (*A. cassida*), or when sclerotization pattern absent, may be confused with *Balinskycercella*. The latter is however, larger, and geographically distant from the distribution of *Aphanicercella* .... *Aphanicercella* (Figs 4.8D, 4.17)
– Subgenital plate weakly developed and weakly sclerotized .... *Balinskycercella* (Figs 4.8E, 4.12B & D)

Afronemoura Illies 1980

Afronemoura species were originally placed in the genus *Aphanicercopsis* (Balinsky 1956, 1967). In 1980 the two known species, *Aphanicercopsis amatolae* and *A. spinulata* were moved to the new genus, *Afronemoura* (Illies 1980), and a third species, *A. stuckenbergi*, added in 1999 (Picker & Stevens 1999).

The nymphs are characterized by a tuft of setae about one-third of the way up from the base of the antennae (Fig. 4.2C). The adult males are characterized by the presence of one or two posteriorly-directed spines on the caudal margin of tergite 9 (Figs 4.7C, 4.9A & B). Of the three species, only the nymph of *A. amatolae* has been described (Figs 4.2C, 4.5I & J). The key to the adult males will enable accurate identification of mature nymphs of all three species at the black-wingpad stage.

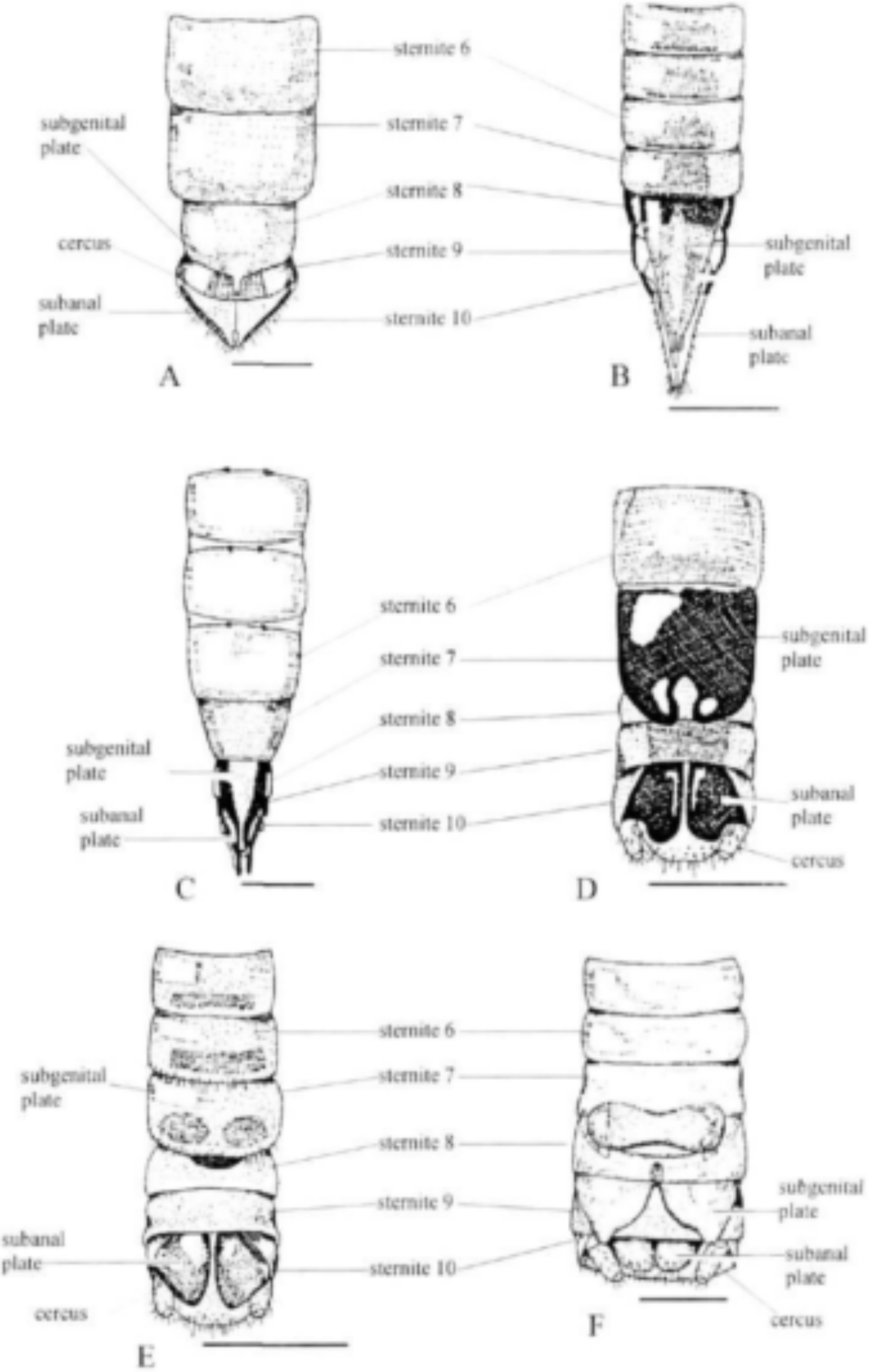

Fig. 4.8. External genitalia of female notonemourids representing the six genera (ventral view). **A**, *Aphanicerca capensis* (Table Mountain form); **B**, *Aphanicercopsis tabularis*; **C**, *Afronemoura amatolae*; **D**, *Aphanicercella clavata*; **E**, *Balinskycercella gudu*; **F**, *Desmonemoura pulchellum*. (After Stevens & Picker 1995).

KEY TO SPECIES OF *AFRONEMOURA:* ADULT MALES

1. One medial spine on posterior margin of tergite 9 ....*A. spinulata* (Fig. 4.7C)
– Two medial spines on posterior margin of tergite 9 2

2. Posterior margin of tergite 9 convex; two spines widely separated ....*A. amatolae* (Fig. 4.9C)
– Posterior margin of tergite 9 bilaterally concave; two spines close together and connected by a sclerotized band ....*A. stuckenbergi* (Fig. 4.9A)

Afronemoura amatolae (Balinsky 1956)

Characteristics of the nymph (Figs 4.2C, 4.5I & J; Tables 4.1 & 4. 2)

Individual nymphs of the species are large, the body length of the only measured mature male nymph being 6.8 mm. The diagnostic group of enlarged setae are situated approximately one-third of the way up the antennae, first evident as gradual enlargement of setae for seven segments, followed by dense tufts of enlarged setae on the next three to four segments. The body appears smooth, but bears enlarged stout spines on the posterior margins of tergites 8–10; pleurites are evident on the first five segments.

Characteristics of the adult genitalia (Figs 4.8C, 4.9)

The posterior margin of the male ninth tergite is posteriorly convex and bears two separated spines on either side of the midline. The apex of the female subgenital plate is bifid, with the two lobes separated from the main body of the plate by a definite neck region.

Records

This species has been found in disjunct areas, occurring in the Amatola Mountains (EC) in the south, and the Mpumalanga Drakensberg in the north. It has not been recorded from suitable mountainous habitat between these zones. It is sympatric with *A. spinulata* in the Amatola Mountains (EC) and in the Grahamstown district (EC).

Afronemoura spinulata (Balinsky 1956)

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Fig. 4.7C)

The posterior margin of the ninth tergite of the male forms two adjacent anterior concavities, with a single sclerotized spine on the apex of the median point between the two indentations. The apex of the female subgenital plate is bifid, with no neck between the main body of the plate and the base of the lobes.

Records

A. spinulata is a widespread species, occurring from Grahamstown, Hogsback and the Amatola Mountains (EC) in the south, to the KwaZulu–Natal midlands, apparently restricted to forest streams. The species has not been recorded from mountain streams of the nearby KwaZulu–Natal Drakensberg. Specimens from Ngome Forest (KwaZulu–Natal) are unusual in that the males have a particularly large spine on tergite 9 and females show a polymorphism for subgenital plate (ovipositor) length, which is either short or very long.

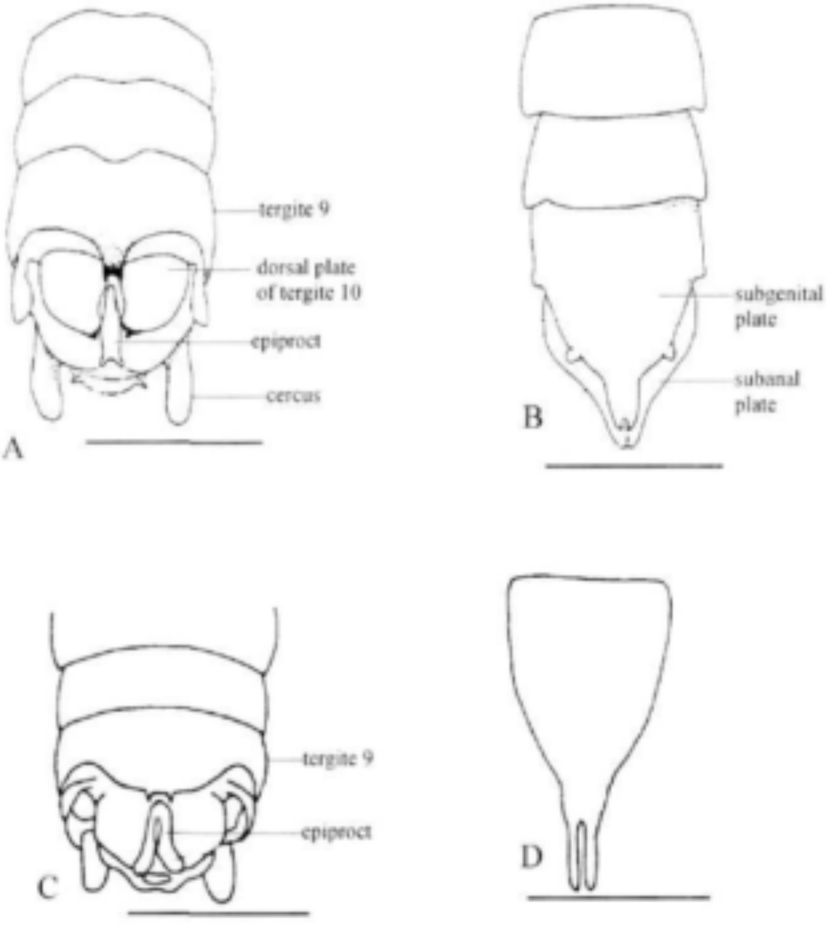

Fig. 4.9. External genitalia of two *Afronemoura* species: **A–B**, *A. stuckenbergi*: **A**, male (dorsal view); **B**, female (ventral view). **C–D**, *A. amatolae*: **C**, male (dorsal view); **D**, female, subgenital plate only (ventral view). (A–B from Picker & Stevens 1999; C–D after Balinsky 1956).

Afronemoura stuckenbergi Picker & Stevens 1999

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Fig. 4.9A & B)

The posterior margin of the ninth tergite of the male forms two adjacent anterior concavities, with two adjacent sclerotized spines on the apex of the median point, joined together by a sclerotized band. The female subgenital plate tapers to a parallel-sided terminal projection of which the distal half is bifid; about halfway along the length of the tapering part of the subgenital plate, the lateral margins bear a rounded projection not found in the other two species.

Records

Only collected from the type locality in Mariepskop (Mpumalanga).

Aphanicerca Tillyard 1931

There are eight species in this genus, of which two—*A. chanae* and *A. gnua*—were only recently described (Picker & Stevens 1999). The nymphs of any instar of this genus can be recognized by the longer hairs on the medial aspect of the proximal third of the antennae. The species can be identified in black-wingpad nymphs by examining the paired dorsal lobes of tergite 9 of the adult male genitalia (which vary in shape and size according to the species) and the epiproct. If the epiproct is not readily examinable, a correct identification can nevertheless be made on the appearance of the dorsal process by reference to Figs 4.7A, 4.10A & C and 4.11A–E. The females can usually be identified on the shape of the subgenital plate (Figs 4.8A, 4.10B & D, 4.11 F–I). The adults are readily distinguished in the field by the large clear patch on the forewings, which is visible in the live insect as a pale disc in the median plane on the folded wings.

KEY TO SPECIES OF *APHANICERCA:* ADULT MALES

1. Epiproct bears a denticulate convexity on ventral surface in lateral view 2
– No convexity on ventral surface of epiproct 6

2. Lobes of dorsal process of tergite 9 long, directed posteroventrally proximally and then gradually curving strongly upwards .... *A. gnua* (Fig. 4.10A)
– Lobes of dorsal process of tergite 9 not curving strongly upwards, but may be curved or bent medially or be subparallel 3

3. Distal third of lobes of dorsal process of tergite 9 curved strongly medially, and no ridge of spinules present ...... *A. lyrata* (Fig. 4.11C)
– Distal third of lobes of dorsal process of tergite 9 not curved strongly medially, although they may be elbow shaped, subparallel, or have a slight medial curve over entire length 4

4\. Lobes of dorsal process of tergite 9 bear a very conspicuous ridge of dorsal or medial spinules distally 5

– Lobes of dorsal process of tergite 9 slender and widely separated distal to the base, becoming subparallel or with a slight medial curve, with an inconspicuous row of minute dorsal spinules over almost the entire length .... *A. bicornis* (Fig. 4.11B)

5\. Lobes of dorsal process of tergite 9 bear a very dense and intensely sclerotized dorsomedial ridge of small spinules in the distal half, and may be twisted at the origin of that ridge .... *A. capensis* (Fig. 4.7A)

– Lobes of dorsal process of tergite 9 gently sigmoid with a medial ridge of large denticles originating slightly distal to the second curvature of the lobe .... *A. chanae* (Fig. 4.10C)

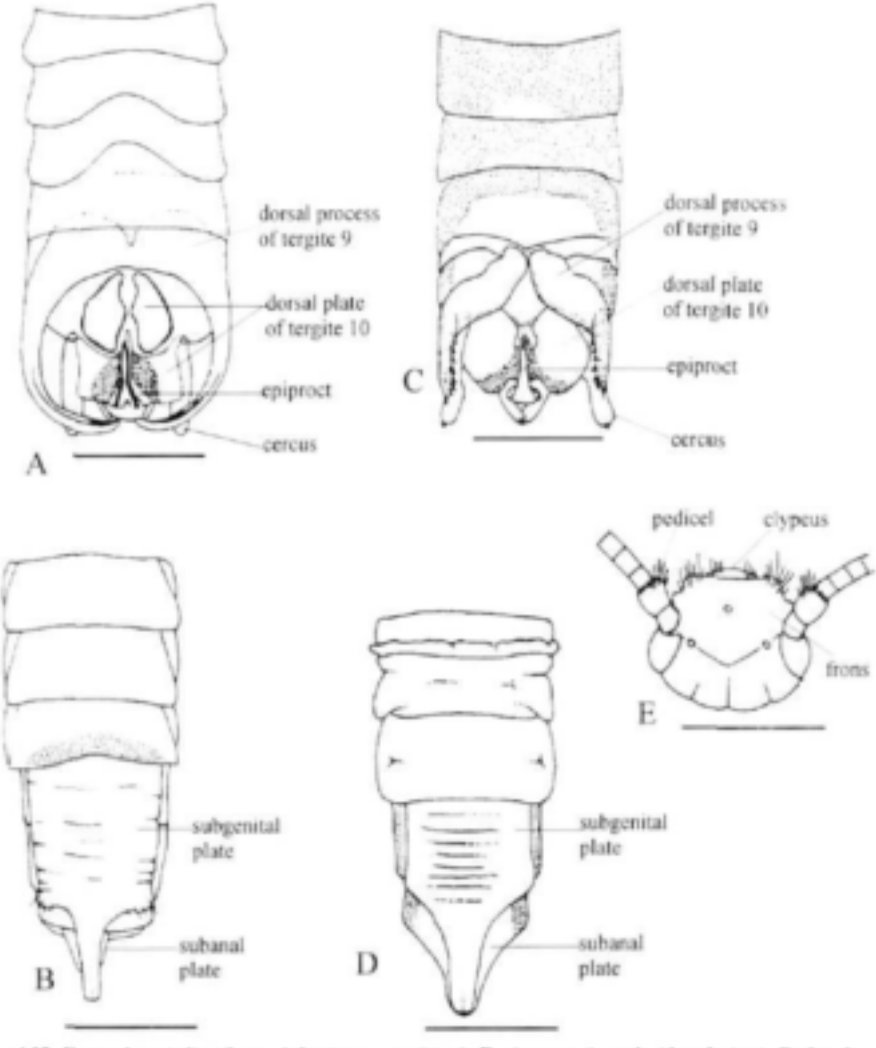

Fig. 4.10. External genitalia of two *Aphanicerca* species: **A–B**, *A. gnua*: **A**, male (dorsal view); **B**, female (ventral view). **C–D**, *A. chanae*: **C**, male (dorsal view); **D**, female (ventral view). **E**, *A. chanae* nymph, detail of characteristic setae on pedicel, frons and clypeus. (From Picker & Stevens 1999).

6. Lobes of dorsal process of tergite 9 apically truncate and recurved medially and dorsally .... *A. uncinata* (Fig. 4.11E)
– Lobes of dorsal process of tergite 9 apically acute and not recurved 7

7. Three to four sharp denticles on medial distal margin of lobes of dorsal process of tergite 9 .... *A. tereta* (Fig. 4.11D)
– No denticles on medial distal margin of lobes of dorsal process of tergite 9...... .... *A. bovina* (Fig. 4.11A)

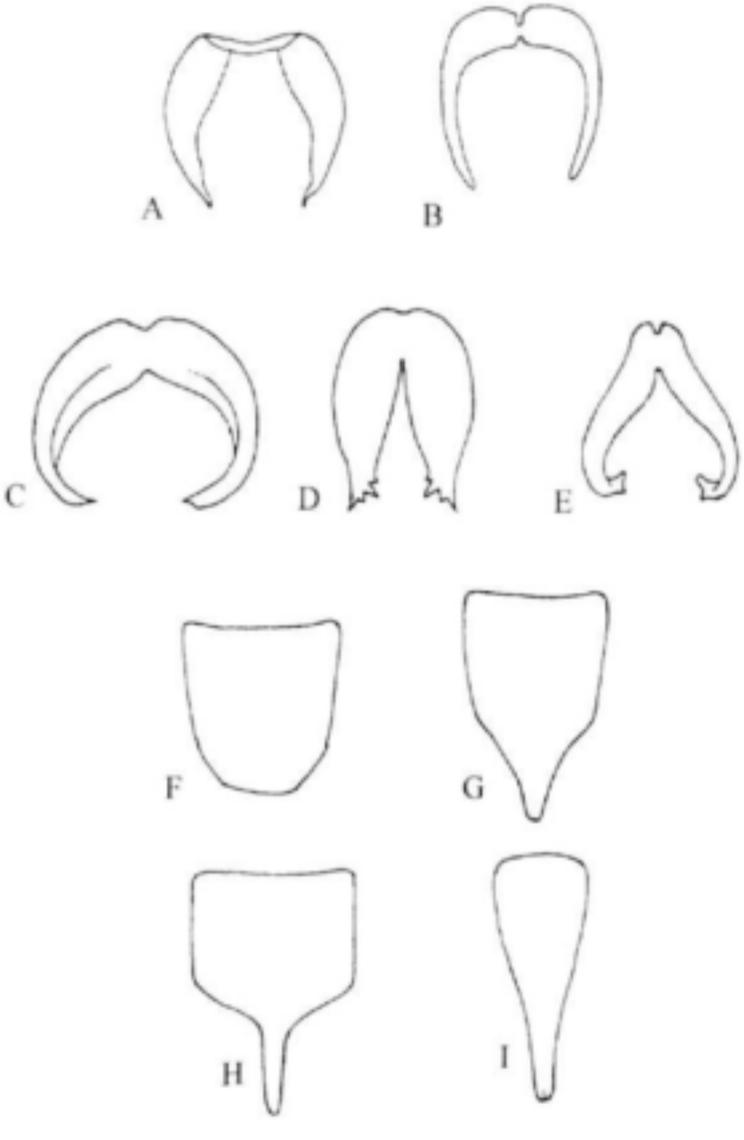

Fig. 4.11. Genital structures in five *Aphanicerca* species: **A–E**, dorsal processes of male tergite 9 (dorsal view): **A**, *A. bovina*; **B**, *A. bicornis*; **C**, *A. lyrata*; **D**, *A. tereta*; **E**, *A. uncinata*. **F–I**, female subgenital plates (ventral view): **F**, *A. bovina*; **G**, *A. bicornis*; **H**, *A. lyrata*; **I**, *A. uncinata*.
(D & E after Barnard 1934).

Aphanicerca capensis Tillyard 1931

Aphanicerca capensis, the Common Cape stonefly, is the most common southern African notonemourid, and only one of two species with a common name.

Characteristics of the nymph (Figs 4.3C & D, 4.5E & F; Tables 4.1 & 4. 2)

Nymphs of this species are large—male body length about 9.0–10.2 mm; female body length about 11.4–12.8 mm. The medial hairs of the proximal third of the antennae, including the pedicel, are far longer than the lateral hairs. The abdomen appears smooth with a fine comb of setae on the posterior margins of segments; pleurites are evident on the first five segments.

Characteristics of the adult genitalia (Figs 4.7A, 4.8A)

Males can be identified by the convexity on the ventral surface of the epiproct and by the shape of the dorsal process of tergite 9. The distal half of the dorsal process angles to the median line of the insect by differing degrees, depending on the geographical variety, and is adorned by a dense row of small spinules on the dorsomedial margin. The females can be identified by examination of the shape of the subgenital plate (sternite 8). The shape of the posterior margin varies, from a slight indentation, to a very long and slender process, again depending on the geographical variety or form of this species.

Records

A. capensis is a widespread species, occurring in the Western Cape from the Cederberg in the north, through Table Mountain and the mountains of the south-western parts of the Western Cape to the Tsitsikamma Mountains in the east, comprising at least 10 morphologically distinct forms that are the subject of current research, and probably all represent valid biological species.

Aphanicerca gnua Picker & Stevens 1999

Characteristics of the nymph

Nymphs unknown.

Characteristics of the adult genitalia (Fig. 4.10A & B)

The pronounced curvature and length of the dorsal process of tergite 9 distinguish the males of this species. The female may be identified by the shape of the subgenital plate. The anterior two-thirds of the female subgenital plate (sternite 8) is rectangular with slightly swollen posterior angles; the posterior margin runs transversely from the posterior angle for almost a quarter the width of the sternite before being produced into a subtriangular, apically bifid plate that extends beyond the apex of the subanal plates.

Records

Only recorded from Kleinboontjies River near Ceres (Witsenberg Mountains, Western Cape), where it is sympatric with one of the forms of *A. capensis*.

Aphanicerca lyrata Barnard 1934

Characteristics of the nymph (Figs 4.5C & D; Tables 4.1 & 4.2)

The almost complete lack of larger setae on the abdominal segments distinguish this species. However, due to potential confusion with *A. bicornis* and *A. capensis*, species identification can only be made with certainty by examining adult genitalia of final instar nymphs.

Characteristics of the adult genitalia (Figs 4.11C & H)

The distal third of the robust dorsal process of tergite 9 of the male curves strongly medially, and the epiproct bears a strong convexity on its ventral surface. The female subgenital plate is similar to that of *A. bicornis* in that in both, the proximal part is parallel-sided, and the distal lateral margins curve in gradually to meet acutely at the level of the apex of the subanal plates. In *A. lyrata*, the part proximal to the start of the concavity is wider than it is long, or the parts are about equal, while in *A. bicornis*, the proximal section is longer than it is wide.

Records

A. lyrata has only been recorded from Jonkershoek and Franschhoek in the south-western Western Cape.

Aphanicerca bicornis Barnard 1934

Characteristics of the nymph (Figs 4.5A & B; Tables 4.1 & 4.2)

The nymphs have almost no large abdominal setae, and may be confused with *A. capensis* and *A. lyrata* unless adult genitalia are present.

Characteristics of the adult genitalia (Fig. 4.11B & G)

The epiproct has a slight convexity where the denticles are situated, unlike *A. bovina* where there is no bulge and the row of denticles extends almost the whole length of the lobe. The lobes of the dorsal process of tergite 9 are slender and widely separated distal to the base, becoming almost parallel or curving slightly medially. The female can be separated from *A. lyrata* as outlined above.

Records

A. bicornis has been recorded from a restricted range in the central south-western parts of the Western Cape, known from the geographical limits of the Hex River Mountains in the north and the east, Jonkershoek in the west, and Hermanus in the south.

Aphanicerca chanae Picker & Stevens 1999

Characteristics of the nymph (Fig. 4.10E)

This species may be distinguished by the fringe of long setae on the anterodorsal margin of the pedicel, and the long setae on the lateral aspect of the frons. There are no stout setae on the tergites or sternites.

Characteristics of the adult genitalia (Figs 4.10C & D)

The lobes of the dorsal process of tergite 9 are gently sigmoid, with a medial ridge of large denticles originating slightly distal to the second curvature of the lobe. The female subgenital plate is very similar to that of *A. lyrata* (Fig. 4.11H), but the apex is bifid, while in that of *A. lyrata*, it is single.

Records

A. chanae is recorded from Heidelberg and Swellendam in the Langeberg Mountains of the Western Cape.

Aphanicerca uncinata Barnard 1934

This species has only been collected once since Barnard's description in 1934, and no specimens exist in the South African Museum in Cape Town.

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.11E & I)

The lobes of the dorsal process of tergite 9 are apically truncate and recurved medially and dorsally, the dorsal margins are raised and spinulose before the bend of the lobes, and setulose in the bend (Barnard 1934). The subgenital plate is elongate and lanceolate, tapering evenly to a subacute or narrowly rounded apex, which is shortly cleft (Barnard 1934).

Records

A. uncinata has only been recorded from the Hottentots Holland Mountains. In August 2000, specimens of both sexes were collected from Harold Porter Nature Reserve, Betty's Bay (WC).

Aphanicerca tereta Barnard 1934

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Fig. 4.11D)

The lobes of the dorsal process of tergite 9 are lanceolate with a distal band of posteriorly-directed spines, and three to four sharp denticles on the medial distal margin (Barnard 1934). The female is unknown.

Records

A. tereta is known only from the Riviersonderend Mountains in the south-western part of the Western Cape.

Remarks

This species has not been rediscovered since Barnard's description in 1934, and no specimens remain in the South African Museum in Cape Town.

Aphanicerca bovina Barnard 1934

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.11A & F)

The epiproct has no convexity where the denticles are located. The row of denticles extends for most of the length of the epiproct. In *A. bicornis*, which this species most closely resembles, there is a slight convexity in the epiproct, to which the denticles are restricted. In *A. bovina* the lobes of the dorsal process of tergite 9 are slightly curved to medial, with acute apices, and with spines and setae on the distal dorsal surface. The female subgenital plate is short and broad with a slightly convex posterior margin, and is connected to an ovipositor-like structure by a thin, median, dorsally-directed, sclerotized band.

Records

A. bovina has only been recorded from Jonkershoek and Franschhoek in the south-western part of the Western Cape.

Remarks

This is a rare species that has only been collected three times.

Balinskycercella Stevens & Picker 1995

The three species of this genus were discovered in 1956 by Balinsky (1956) who placed them in the genus *Aphanicercella*. They all share features that distinguish them from *Aphanicercella*, their closest relatives. Only the nymph of *B. tugelae* is known (Figs 4.4C & D, 4.6I & J), and is the most hirsute of all the southern African notonemourid nymphs examined to date. The nymph can be distinguished from another hirsute species, *Aphanicercella cassida* (Fig. 4.6G & H), by the thin membranous pleurite, separating tergite from sternite, from segments one through 7.5, while in *A. cassida*, pleurites extend as far caudally as the sixth segment (Table 4.2). The only species of *Aphanicercella* that is sympatric with *Balinskycercella* is *A. cassida*, and the adult males and females of these two taxa are readily distinguished (female *A. cassida* have a trilobate pattern of sclerotisation on the subgenital plate: Fig. 4.17G).

As the nymph of only one species is known, and because of the likely similarities expected between the species, positive species identification can only be done on examination of adult genitalia of the final instar nymphs. The males can be distinguished by examination of the median plate of tergite 10, the transverse rods of the paraprocts, and the epiproct. The adult females of the three species in this genus are very similar, and identification of final instar female nymphs is unlikely.

The genus has only been recorded from the headwaters in the Mont-aux-Sources district of the north-eastern escarpment of the Lesotho-Drakensberg Highlands, and Maluti Mountains of western Lesotho.

KEY TO SPECIES OF *BALINSKYCERCELLA* – ADULT MALES

1. Apical hook of median plate of tergite 10 bifid .... *B. fontium* (Fig. 4.12C)
– Apical hook of median plate of tergite 10 single 2

2. Transverse rods of paraprocts spatulate apically; epiproct has a distinct central waist, broadening towards apex .... *B. tugelae* (Fig. 4.12A)
– Transverse rods of paraprocts apically narrow and rounded; epiproct has no distinct waist, being almost parallel-sided .... *B. gudu* (Fig. 4.7E)

Balinskycercella tugelae (Balinsky) 1956

Characteristics of the nymph (Figs 4.4C & D, 4.6I & J; Tables 4.1 & 4.2)

Most parts of the body are covered in long setae. Male body length is about 6.5 mm. The dorsal surface of the wingpads bears numerous long setae. The abdomen bears conspicuous dorsal whorls of long setae (complete ventrally on segments 8–10); pleurites usually evident on the first eight segments.

Characteristics of the adult genitalia (Fig. 4.12A & B)

The hook of the median plate of the tenth tergite is easily visible anterior to the apex of the epiproct. In *B. tugelae* it is single, and the epiproct has a central waist-like narrowing. The female lacks a sclerotized plate at the genital opening, which distinguishes this species from *B. gudu* (Fig. 4.8E). It may not be possible to separate the females of *B. tugelae* and *B. fontium* (Fig. 4.12D).

Records

Only recorded from the headwaters in the Mont-aux-Sources district of the north-eastern escarpment of the Lesotho-Drakensberg Highlands, and Maluti Mountains of western Lesotho. It is often sympatric with *B. gudu.*

Balinskycercella gudu (Balinsky) 1956

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.7E, 4.8E)

In *B. gudu* the hook on the anterior apex of the median plate of tergite 10 is single, and the epiproct does not have a central waist-like narrowing. The female has a sclerotized plate at the genital opening, which distinguishes this species from *B. tugelae* (Fig. 4.12B) and *B. fontium*. (Fig. 4.12D).

Records

Only recorded from the headwaters in the Mont-aux-Sources district of the north-eastern escarpment of the Lesotho–Drakensberg Highlands, and Maluti Mountains of western Lesotho, where it is often sympatric with *B. tugelae*.

Balinskycercella fontium (Balinsky) 1956

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Fig. 4.12C & D)

This species is easily separated from the other two congeners by the bifid hook on the median plate of tergite 10. The female lacks the sclerotized plate at the genital opening seen in *B. gudu* (Fig. 4.8E), and cannot be separated from *B. tugelae* at the nymphal stage.

Records

Only recorded from the type locality of the Tugela River, Mont-aux-Sources in the KwaZulu–Natal Drakensberg.

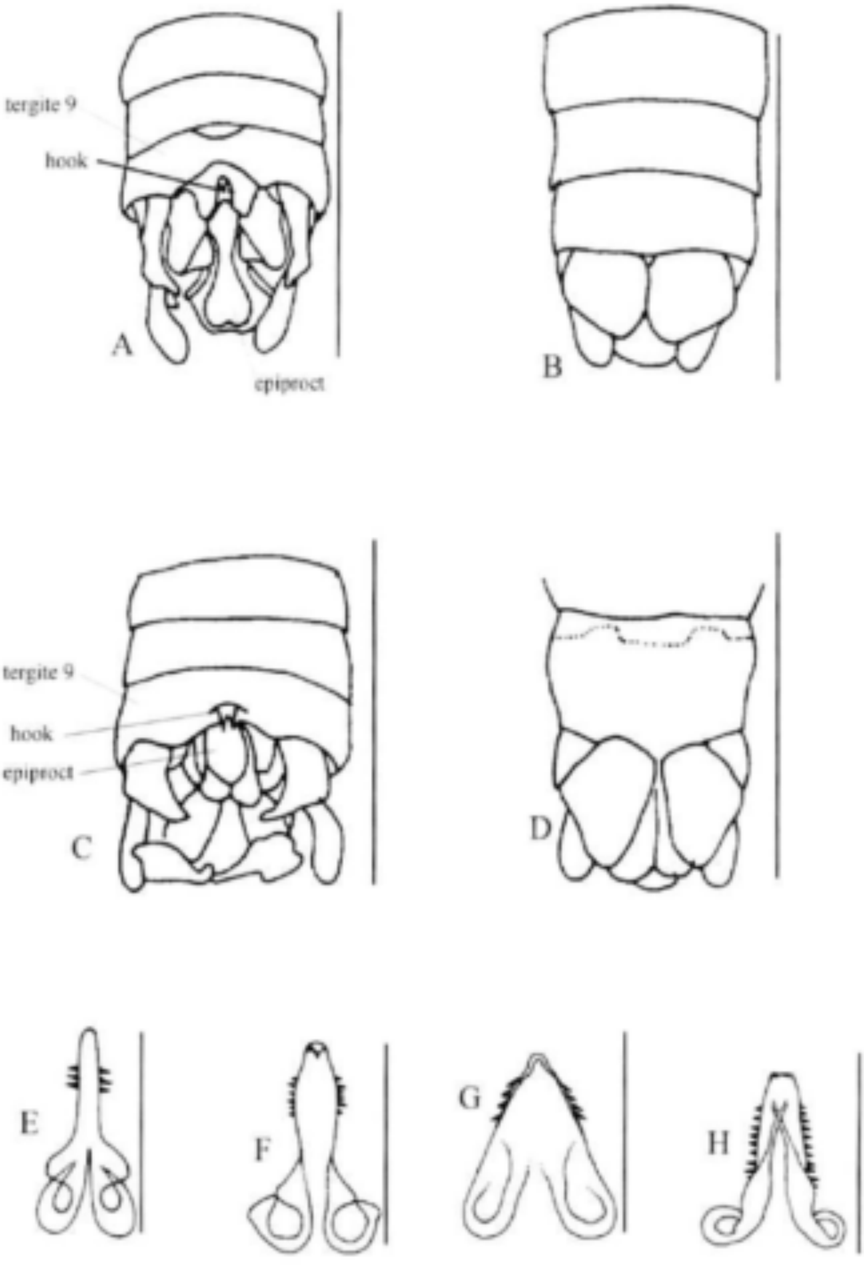

Fig. 4.12. **A–D**, external genitalia of two *Balinskycercella* species: **A–B**, *B. tugelae*: **A**, male (dorsal view); **B**, female (ventral view). **C–D**, *B. fontium*: **C**, male (dorsal view); **D**, female (ventral view). **E–H**, epiproct of male *Aphanicercopsis* species: **E**, *A. outeniquae*; **F**, *A. tabularis*; **G**, *A. hawaquae*; **H**, *A. denticulata*. Scale Bar: A–D = 1.0 mm; E–G = 0.3 mm.
(A–D after Balinsky 1956; others after Barnard 1934).

Aphanicercella Tillyard 1931

There are 11 species in this genus, of which six comprise the *Aphanicercella barnardi* species-complex (Stevens & Picker 1999). These are *A. clavata, A. bullata, A. flabellata, A. barnardi, A. securata* and *A. spatulata* (Figs 4.13–4.14). The five other species are separable from the *A. barnardi* species-complex on the appearance of the epiproct (Figs 4.15–4.16). All males of the *A. barnardi* species-complex have fairly similar epiprocts, but differ most obviously in the structure of the paraprocts (Fig. 4.13–4.14). Both the epiprocts and paraprocts are visible in mature nymphs. Females are not as readily distinguished from one another, unlike males (Fig. 4.17). The most diagnostic character is the shape and degree of sclerotization of the subgenital plate (Fig. 4.17). The only other useful characteristic is the extent and pattern of sclerotization on the sternites.

KEY TO SPECIES OF *APHANICERCELLA* – ADULT MALES

1. Epiproct apically incised 2
– Epiproct not apically incised 4

2. Medial margins of epiproct incision convex; width of incision equal to length of lateral margin of epiproct; clasper longer than, or equal in length to, dorsomedial margin of pleurite ....*A. nigra* (Fig. 4.16C & D)
– Medial margins of epiproct incision concave; width of incision about half or less than half the length of lateral margin of the epiproct; clasper shorter than dorsomedial margin of pleurite 3

3. Width of epiproct incision about half the length of lateral margin of epiproct; anterior margin of epiproct forms a heavily sclerotized broad band; lateral dorsal plates not fused anteriorly ....*A. quadrata* (Fig. 4.16A & B)
– Width of epiproct incision about one-quarter the length of lateral margin of epiproct; anterior margin of epiproct not heavily sclerotized; lateral dorsal plates fused anteriorly ....*A. bifurcata* (Fig. 4.15E & F)

4. Epiproct apically truncate with a subapical V-shaped sclerotized transverse strip; epiproct bears no minute apical ventral projection ....
....*A. scutata* (Fig. 4.15C & D)
– Epiproct apically acute, rounded, or sub-truncate without a subapical V–shaped sclerotized transverse strip; epiproct bears minute apical ventral projection 5

5. Median arch comprises only one process 6
– Median arch comprises more than one process 8

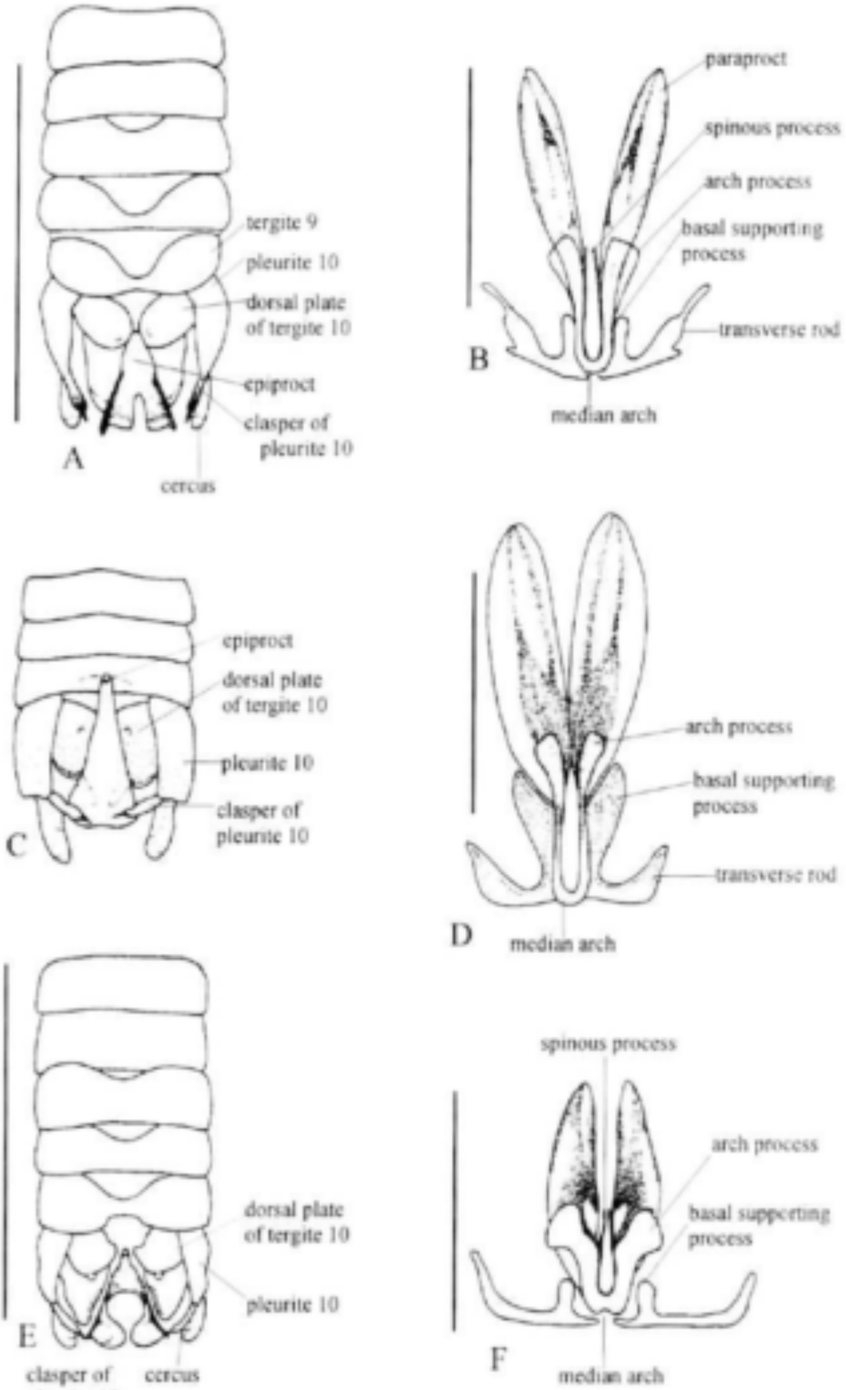

Fig. 4.13. Male *Aphanicercella* external genitalia (dorsal view) and paraprocts (ventral view). **A–B**, *A. quadrata*: **A**, external genitalia, dorsal view; **B**, paraproct, ventral view. **C–D**, *A. barnardi*: **C**, external genitalia, dorsal view; **D**, paraproct, ventral view. **E–F**, *A. securata*: **E**, external genitalia, dorsal view; **F**, paraproct, ventral view. (Scale Bar: A, C & E = 1.0 mm; B, D & F = 0.5 mm).

6. Basal supporting process of paraprocts free standing distal to its base, is elongate, and its apex bulges medially; clasper is equal in length to the dorsal margin of pleurite 10 .... *A. clavata* (Figs 4.14A & B)
– Basal supporting process of paraprocts firmly adherent to base of primary supporting strut of paraproct, short, and apically rounded without bulging; clasper is half to three-quarters the length of the dorsal margin of pleurite 7
7. Epiproct triangular with rounded apex; apical point of clasper originates eccentrically; median extension of median dorsal plate of tergite 10 elongate; arch process narrow but stout basally and abruptly changes angle and narrows into an acuminate extension distally; transverse rod bi-apically rounded, but internal sclerotized strut terminates acutely ....*A. bullata* (Figs 4.14C & D)
– Epiproct with lateral margin becoming convex and then concave distally, terminating acutely; clasper apical point originates centrally; median extension of median dorsal plate of tergite 10 short; arch process short, thin, and spinous; transverse rod bi-apically very broadly rounded ....*A. cassida* (Figs 4.15A & B)
8. Basal supporting process of paraprocts present 9
– Basal supporting process of paraprocts absent or vestigial ....
.... *A. flabellata* (Figs 4.14E & F)

9. Basal supporting process of paraprocts very large, fused to base of arch process, and free standing distally; clasper apical point originates anteriorly.........
.... *A. barnardi* (Figs 4.13C & D)
– Basal supporting process of paraprocts small, not fused to arch process, and not free standing distally; clasper apical point originates centrally 10

10. Spinous part of arch process caudally directed; transverse rod bi-apically acute; primary and medial secondary supporting struts of paraprocts joined by a transverse sclerotized band ....*A. securata* (Figs 4.13E & F)
– Spinous part of arch process dorsally directed; transverse rod bi-apically rounded, but internal sclerotized strut terminates acutely; primary and medial secondary supporting struts of paraprocts joined by an oblique sclerotized band...
.... *A. spatulato* (Figs 4.13A & B)

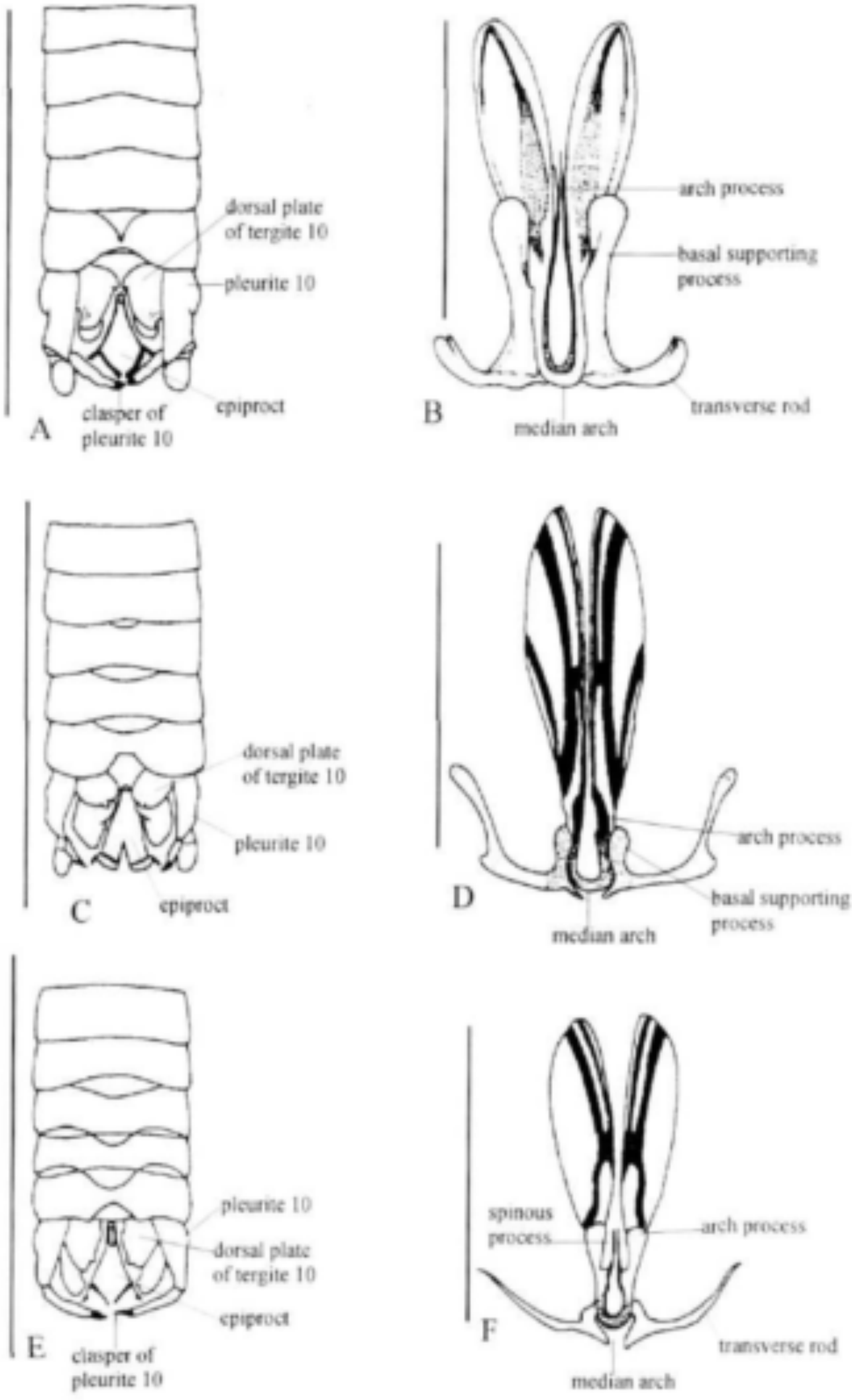

Fig. 4.14. Male *Aphanicercella* external genitalia (dorsal view) and paraprocts (ventral view). **A–B**, *A. clavata*: **A**, external genitalia, dorsal view; **B**, paraproct, ventral view. **C–D**, *A. bullata*: **C**, external genitalia, dorsal view; **D**, paraproct, ventral view. **E–F**, *A. flabellata*: **E**, external genitalia, dorsal view; **F**, paraproct, ventral view. (Scale Bar: A, C & E = 1.0 mm; B, D & F = 0.5 mm).
(After Stevens & Picker 1999)

Aphanicercella clavata Stevens & Picker 1999

Characteristics of the nymph (Figs 4.4A & B, 4.6A & B; Tables 4.1 & 4.2)

The nymphs of this species are small; male body length about 4.5 mm; female body length about 5.0–5.8 mm. The abdomen is brown with a pair of median long stout setae on the posterior margin of the tergites, frequently with additional stout setae between them; there is a similar arrangement of paired setae ventrally, but with setae more widely spaced; setae are more numerous on segments 9 and 10, forming a complete whorl on segment 9; pleurites are evident on the first six segments.

Characteristics of the adult genitalia (Figs 4.8D, 4.14A & B, 4.17D)

Epiproct triangular, with a well-rounded, bead-like, cream-coloured apex, becoming bilaterally concave towards the apex. The basal supporting process of the paraprocts has a characteristic medially-expanded apex. The median arch terminates in an elongate and very slender spinous arch process. The female subgenital plate has a diagnostic shape: it is very robust and intensely sclerotized, having a narrow, incised notch on the posterior margin, to form a thick, bi-lobate plate.

Records

A. clavata (along with *Aphanicercopsis tabularis*) is endemic to the Cape Peninsula (WC).

Aphanicercella bullata Stevens & Picker 1999

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.14C & D, 4.17E)

The epiproct is triangular, with the rounded apex bearing a minute, acute ventral projection. The basal supporting process of the paraprocts is short, rounded terminally, forming part of, and overlying, the thickened base of the primary supporting strut of the paraprocts. The median arch bears a thick and apically rounded arch process with a thin, acuminate terminal extension. The female does not have any diagnostic characters. The subgenital plate has a slightly convex posterior margin, and has almost complete sclerotization. Sternites 3 to 6 have an unbroken bar of pigment of variable size on the posterior margin. Sternite 9 is pigmented except for a small, median, clear, rectangular patch on the anterior margin.

Records

Aphanicercella bullata has the most eastern distribution range within the *A. barnardi* species-complex. This species is found in the Langeberg, Grootswartberg, Outeniqua and Elandsberg ranges of the Western Cape.

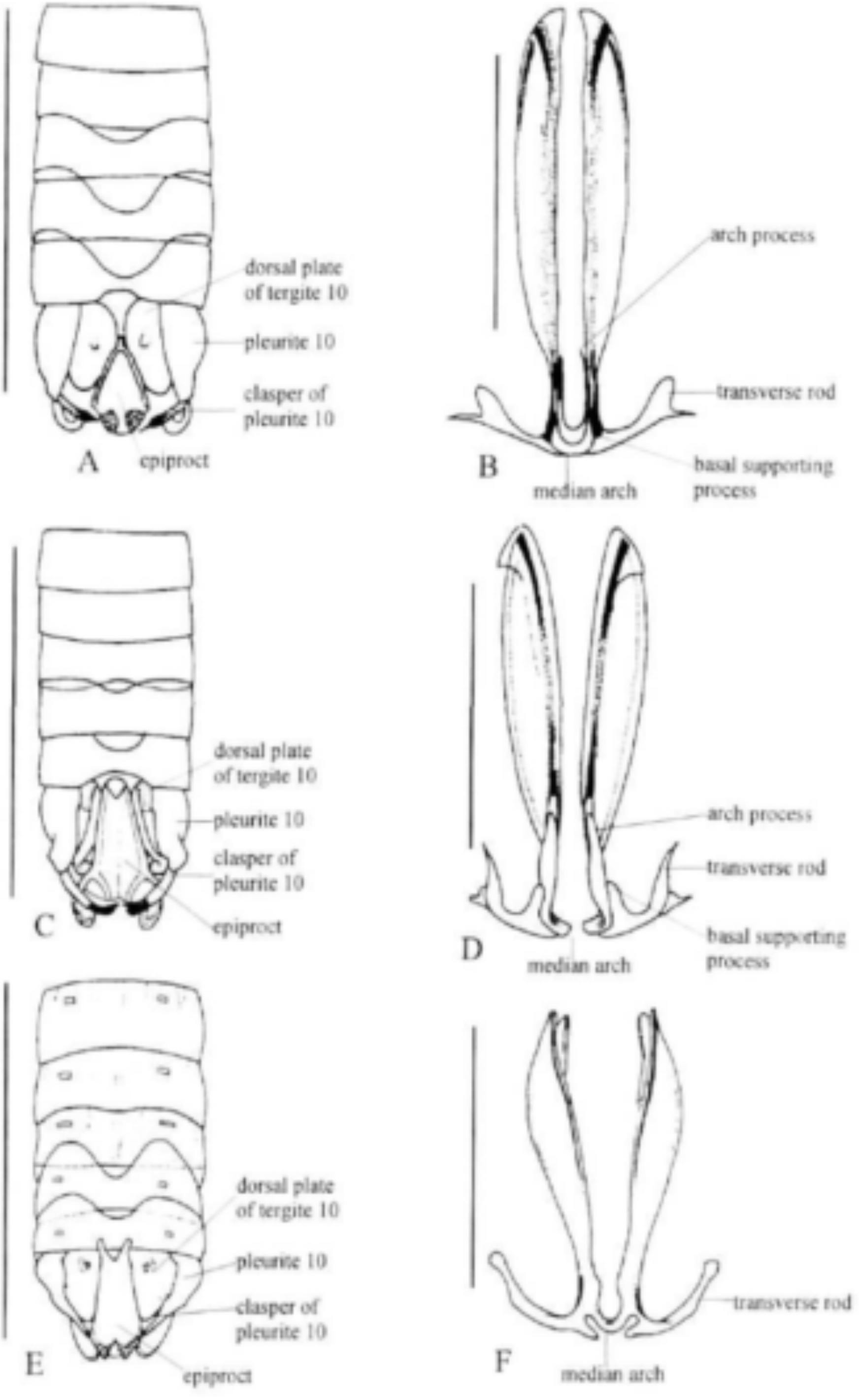

Fig. 4.15. Male *Aphanicercella* external genitalia (dorsal view) and paraprocts (ventral view). **A–B**, *A. cassida*: **A**, external genitalia, dorsal view; **B**, paraproct, ventral view. **C–D**, *A. scutata*: **C**, external genitalia, dorsal view; **D**, paraproct, ventral view. **E–F**, *A. bifurcata*: **E**, external genitalia, dorsal view; **F**, paraproct, ventral view. (Scale Bar: A, C & E = 1.0 mm; B, D & F = 0.5 mm).
(After Stevens & Picker 1999)

Aphanicercella flabellata Stevens & Picker 1999

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.14E & F, 4.17F)

The epiproct is triangular, bearing a dorsal median ridge distally, terminating in a rounded apex, which bears a minute, acute, ventral projection. The basal supporting process of the paraprocts is absent or vestigial. The median arch bears an apically-rounded arch process, and a slightly longer medial spinous process. The female may be mistaken for other species. The subgenital plate has a concave posterior margin, and is lightly, uniformly and extensively sclerotized. Sternites 3 to 6 have an unbroken bar of pigment on the posterior margin. Sternite 8 is unpigmented, and sternite 9 is pigmented except for a median unpigmented triangle on the anterior margin.

Records

A. flabellata has a central south-western distribution within the Western Cape, from the southern Witsenberg south of Ceres in the north, to Jonkershoek in the south and west, with Wolwekloof (east of Wolseley) the most eastern extent of its known range. This species was recorded once, possibly erroneously, from Clovelly in the Cape Peninsula (WC), but has not been found there again.

Aphanicercella barnardi (Tillyard) 1931

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.7D, 4.13C & D, 4.17B)

The epiproct is triangular with the rounded apex bearing a minute ventral projection. The basal supporting process of the paraprocts is broad and long, but slightly shorter than the arch process to which it is proximally fused. The median arch is produced into a spatulate arch process and a short and thin medial, caudally-directed spinous process. The female subgenital plate is entire, typically having a transverse posterior margin. Sclerotization is not uniform, producing a diagnostic pattern: the lateral margins are dark-brown with an indented paler transverse band on the distal half. Sternites 3 to 6 and 8 have an unbroken or broken bar of pigment on the posterior margin. Sternite 8 has pigmented lateral margins. Sternite 9 is entirely pigmented except for a median unpigmented rectangle on the anterior margin.

Records

A. barnardi is recorded from the following localities in the Western Cape: Worcester, the Skurweberge and Pakhuispas in the Cederberg.

Aphanicercella securata Stevens & Picker 1999

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.13E & F, 4.17C)

The epiproct is triangular, with the rounded apex bearing a minute ventral projection; the medial strut gradually broadens distally. The basal supporting process of the paraprocts is parallel-sided, apically-rounded, and about one-third the length of the arch processes. The median arch bears a large arch process that is rounded and laterally-expanded apically, with a shorter, thin, medial, caudally-directed spine; the arch process extends almost as far as the convergence of the primary and medial secondary supporting struts of the paraprocts. The female subgenital plate has a slightly concave posterior margin; the sclerotization is uniform and extensive, except for narrow anterior and posterior unpigmented bands. Sternites 3 to 6 have an unbroken bar of pigment on the posterior margins. Sternite 8 is unpigmented, and sternite 9 completely pigmented.

Records

A. securata has only been found at the farm *High Noon* near Villiersdorp in the Western Cape.

Aphanicercella spatulata Stevens & Picker 1999

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.13A & B, 4.17A)

The epiproct is triangular, with straight or slightly convex lateral margins. The apex is bluntly rounded or subtruncate, with a minute ventral acute projection. The basal supporting process of the paraprocts is short and rounded terminally, forming the thickened base of the primary supporting strut of the paraprocts. The median arch bears a large spatulate arch process and a small and very thin dorsally-directed spinous process. The subgenital plate of the female has a slightly concave posterior margin, and the sclerotization is uniform and extensive. Sternites 3 to 5 have an unbroken bar of pigment on the posterior margins. Sternite 6 has a dome-shaped pigmented band posteriorly. Sternite 8 is unpigmented, and sternite 9 entirely pigmented except for a median unpigmented rectangle on the irregular anterior margin.

Records

A. spatulata occurs in a narrow north-south strip including Bain's Kloof, the Grootdrakenstein Mountains, and the southern Hottentots Holland Mountains (WC).

Aphanicercella bifurcata Barnard 1934

Characteristics of the nymph (Fig. 4.6E & F; Tables 4.1 & 4.2)

The nymph has very few larger setae compared to the other three known nymphs of the genus. Because the nymphs of only four species are known, identification should be made on the basis of adult genitalia of the mature nymph.

Characteristics of the adult genitalia (Figs 4.15E & F, 4.17I)

The epiproct is apically incised, and the anterior margin of the incision is entirely concave. The length and width of the incision are less than one-quarter the length of the lateral margin of the epiproct. The basal supporting processes are apparently absent, although the lateral margin of the paraproct has a weak basal thickening, probably representing fusion of the two structures. The median arch bears a slender arch process that is fused to the medial surface of the paraproct. The female subgenital plate is entire, with a dome-shaped patch of pigmentation on the posterior margin, and pigmented lateral margins. Sternites 1 to 6 and 8 are unpigmented, and sternite 9 entirely pigmented.

Records

A. bifurcata is common in the Outeniqua, Langeberg and Riviersonderend Mountains (WC), with its geographic range extending from the Grootwinterhoek Mountains (WC) in the north and west to near Riviersonderend (WC) in the south, and Humansdorp (EC) in the east.

Aphanicercella quadrata Barnard 1934

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.16A & B, 4.17J)

The apex of the epiproct is heavily incised. Its anterior margin is entirely concave and heavily sclerotized as a broad band. The length and width of the incision are about one-third and about half the length of the lateral margin of the epiproct respectively. The basal supporting process is absent, although the lateral margin of the paraproct has a heavily sclerotized basal thickening, probably representing fusion. The median arch is produced into a spinous arch process, extending distally as far as the origin of the medial secondary supporting strut of the paraproct. The female subgenital plate is entire, and the sclerotization bell-shaped. Sternites 3 to 5 have an unbroken bar of pigment on the posterior margins. Sternite 6 is almost completely pigmented with a dome-shaped pattern. Sternite 8 has pigmented lateral margins. Sternite 9 is entirely pigmented except for a median unpigmented rectangle on the anterior margin.

Records

A. quadrata is endemic to the Cederberg (WC).

Aphanicercella nigra Barnard 1934

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Figs 4.16C & D, 4.17K)

The apex of the epiproct is heavily incised. The medial margins of the two arms are convex. The width of the incision is equal to the length of the lateral margin of the epiproct. The basal supporting process of the paraprocts is absent, although the lateral margin of the paraproct has a sclerotized basal thickening, probably representing fusion. The median arch bears a slender arch process which is fused to the medial surface of the paraproct. The female subgenital plate is sclerotized on its margins alone, with a slightly concave posterior margin. Sternites 3 to 6 have a broken or unbroken bar of pigment on the posterior margins. Sternite 8 has pigmented lateral margins, and sternite 9 is entirely pigmented.

Records

A. nigra has an unusually disjunct distribution, with records from the Cederberg, Franschhoek Pass, Grootwinterhoek Mountains near Uitenhage, and Humansdorp.

Aphanicercella scutata Barnard 1934

Characteristics of the nymph (Figs 4.6C & D; Tables 4.1 & 4.2)

The nymph has a similar setation pattern to *A. clavata*, and is more setose than *A. bifurcata*, and less setose than *A. cassida*. Because the nymphs of only four species are known, identification to species level should be made on the basis of adult genitalia of the mature nymph.

Characteristics of the adult genitalia (Figs 4.15C & D, 4.17H)

The epiproct is subtriangular with a truncate, lightly sclerotized apex. The sclerotized lateral margins end subterminally and are connected by a very thin V-shaped sclerotized strip. The basal supporting process forms a short lateral thickening of the base of the paraprocts. The median arch is produced into an apically acute arch process and a shorter, much thinner medial spine. The female subgenital plate is diagnostic, being very robust and having a broad and deep concave incision on the posterior margin. The sclerotization is intense and uniform. Sternites 3 to 6 have a broken or unbroken bar of pigment on the posterior margins. Sternite 8 is unpigmented, and sternite 9 is entirely pigmented.

Records

A. scutata is found from the Gydo Pass (Skurweberge, WC) in the north and east to Betty's Bay (WC) in the south and west, occurring commonly in the Bain's Kloof, Franschhoek, and Stellenbosch areas (WC).

Aphanicercella cassida Barnard 1934

Characteristics of the nymph (Figs 4.6G & H; Tables 4.1 & 4.2)

The nymph is more setose than the other known nymphs of the genus, and where sympatric with *Balinskycercella*, nymphs of the two species may be confused. Because the nymphs of only four species of *Aphanicercella* are known, identification to species level should be made on the basis of adult genitalia of the mature nymph.

Characteristics of the adult genitalia (Figs 4.15A & B, 4.17G)

The lateral margins of the epiproct are straight for two-thirds of their length, and then curve in medially, becoming convex and then concave distally, terminating in a small sharp point that bears a minute acute ventral projection. The lateral margin distal to the medial strut of the epiproct is obscured in normal dorsal view. The basal supporting process of the paraprocts forms the heavily sclerotized and thickened base of the primary supporting strut of the paraprocts. The arch process is short, thin, pale and spinous. The female subgenital plate has a deeply concave posterior margin, with sclerotization forming a trilobate pattern. Sternites 3 to 6 and 8 are unpigmented. Sternite 9 is completely pigmented.

Records

A. cassida has the widest range of any species within the family. It has been recorded from Magoebaskloof (Northern Province) to Wilderness in the south of the Western Cape, and from Seweweekspoort north of Riversdale (WC) in the west to Sabie (Mpumalanga Drakensberg) in the east. Populations occur sporadically whenever suitable habitat exists (mountain or forest streams).

Aphanicercopsis Barnard 1934

There are four species, all described by Barnard (1934). The compound eyes of the nymphs are relatively small (Fig. 4.2A), and they have a fewer number of pleurites than the other genera (Table 4.2). In the specimens examined so far, the nymphal pronotum does not extend beyond the limits of the prothorax, unlike the condition in the other genera. The nymph of *A. hawaquae* is still unknown. The nymphs cannot be distinguished from each other with certainty, except by examining the adult male genitalia of mature specimens. The females cannot be identified to species.

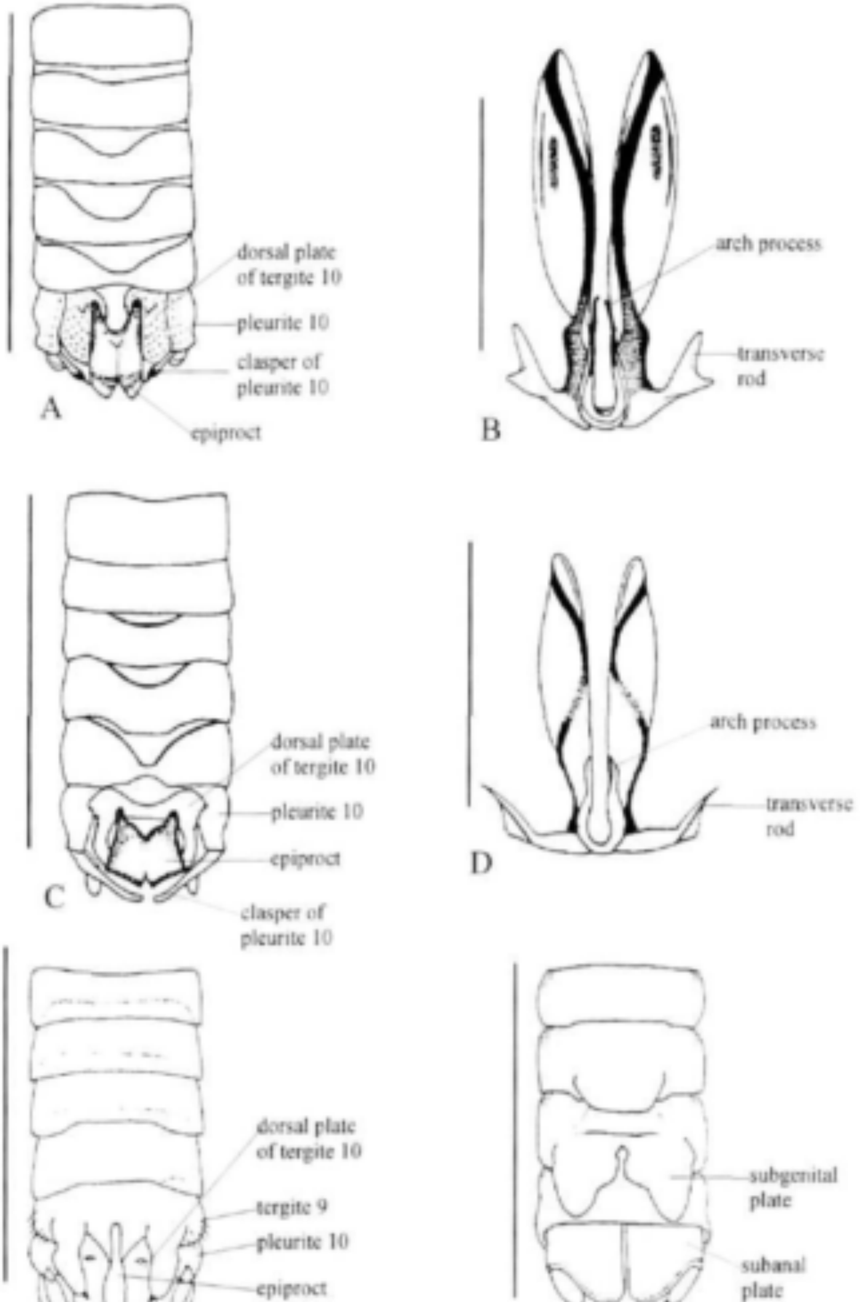

Fig. 4.16. External genitalia of *Aphanicercella* spp. and *Desmonemoura brevis*. **A–B**, *A. quadrata*: **A**, external genitalia, dorsal view; **B**, paraproct, ventral view. **C–D**, *A. nigra*: **C**, external genitalia, dorsal view; **D**, paraproct, ventral view. **E–F**, *Desmonemoura brevis*: **E**, external genitalia of male, dorsal view; **F**, external genitalia of female, ventral view (Scale Bar: A,C, E & F = 1.0 mm, B & D = 0.5 mm). (A–D after Stevens & Picker 1999; E & F after Picker & Stevens 1999).

This genus resembles *Aphanicercella* in the field, and is best distinguished from the latter under the stereo microscope. The shape of the male epiproct (Figs 4.7B, 4.12E–H) and the elongated subgenital plate of the male distinguish this genus from *Aphanicercella*. The female subgenital plate is highly elongated to form an ovipositor-like structure (although the function has not been demonstrated) (Fig. 4.8B). Aptery has been recorded in *A. denticulata* from the Palmiet River near Kleinmond (WC) (Barnard 1934), and *A. hawaquae* from Franschhoek Pass and Jonkershoek (WC).

KEY TO SPECIES OF *APHANICERCOPSIS* – ADULT MALES

1. Epiproct with lateral basal expansions (Figs 4.12E & F)....................................2
– Epiproct without lateral basal expansions (Figs 4.12G & H) 3

2. Lateral sclerotized struts of epiproct separated except apically; posterior angle of median dorsal plate of tergite 10 wide and rounded ....*A. tabularis* (Figs 4. 7B, 4.12F)
– Lateral sclerotized struts of epiproct meet at an acute angle just proximal to the lateral basal expansion; posterior angle of median dorsal plate of tergite 10 acute and narrow .... *A. outeniquae* (Fig. 4.12E)

3. Epiproct broad basally and narrowing abruptly distally, narrow subapical distal third denticulate .... *A. hawaquae* (Fig. 4.12G)
– Epiproct linguiform, lateral margins denticulate over middle third ....*A. denticulata* (Fig. 4.12H)

Aphanicercopsis tabularis Barnard 1934

Characteristics of the nymph (Figs 4.2A & B, 4.5O & P; Tables 4.1 & 4.2)

Individuals in this species are small to medium in size: male body length about 5.6 mm; female body length about 6.7–6.8 mm. The compound eyes are black and very small. The median third of the posterior margin of abdominal tergites bears a row of short stout bristles. A small group of bristles are situated medially on most segments. In most species sternites bear well-developed setae (especially on segments 8–10), often with conspicuous hair sockets on sternite 10; pleurites are evident on the first three to four segments.

Characteristics of the adult genitalia (Figs 4.7B, 4.8B, 4.12F)

The epiproct has a symmetrical, laterally-expanded, flange-like base, and an unsclerotized longitudinal central strip. The paraprocts are long with acute apices.

Records

This species is a Cape Peninsula (WC) endemic, where it is widespread.

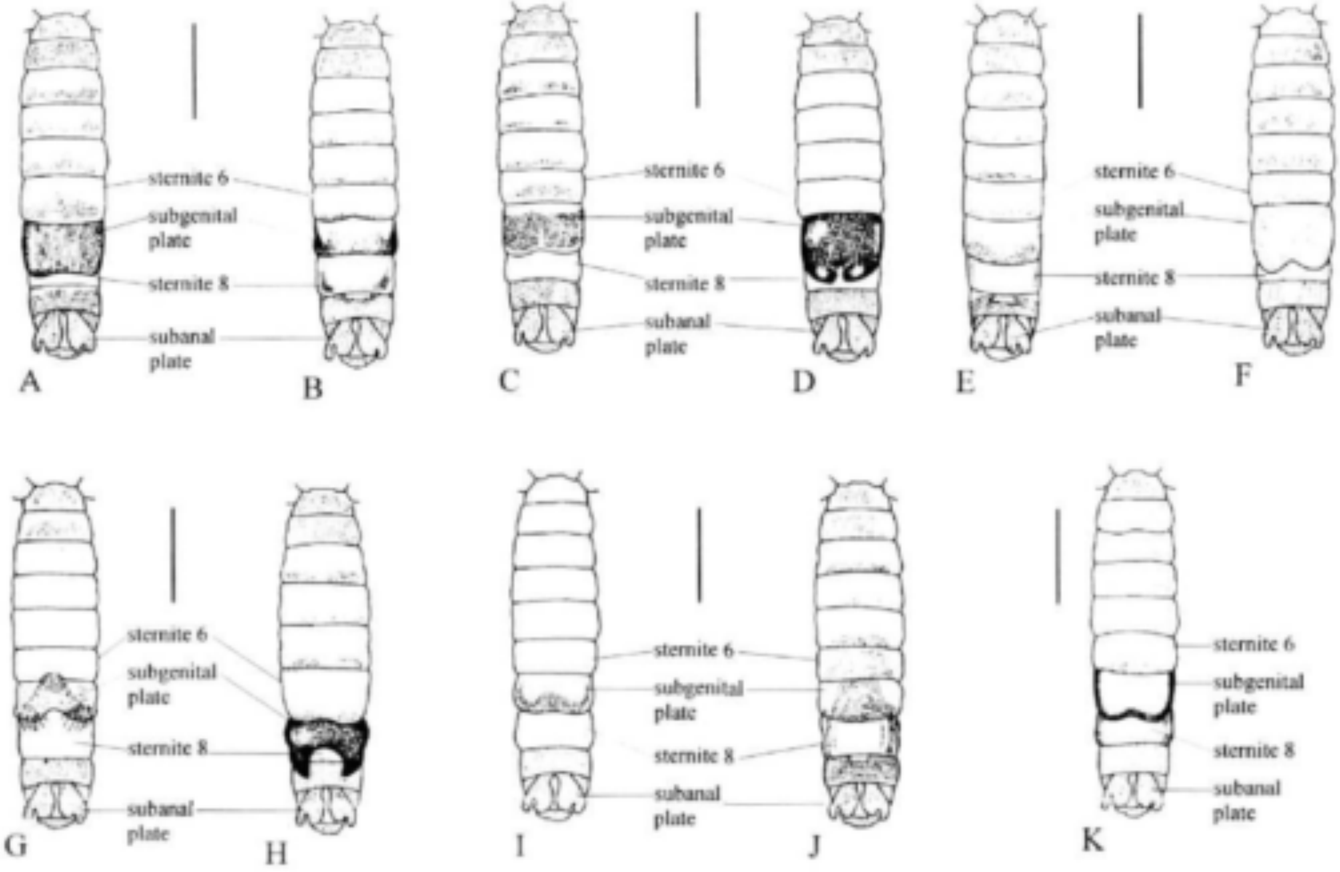

Fig. 4.17. Female *Aphanicercella* external genitalia, ventral view: **A**, *A. spatulata*; **B**, *A. barnardi*; **C**, *A. securata*; **D**, *A. clavata*; **E**, *A. bullata*, **F**, *A. flabellata*; **G**, *A. cassida*; **H**, *A. scutata*; **I**, *A. bifurcata*; **J**, *A. quadrata*; **K**, *A. nigra*. (Scale Bar = 1.0 mm). (After Stevens & Picker 1999).

Aphanicercopsis outeniquae Barnard 1934

Characteristics of the nymph (Figs 4.5M & N; Tables 4.1 & 4.2)

There are minor differences between the species of *Aphanicercopsis*. In comparison with the other three species in this genus, *A. outeniquae* appears to be less setose on sternites 4 and 10, and pleurites are only present on abdominal segments 1–3.

Characteristics of the adult genitalia (Fig. 4.12E)

The epiproct has a symmetrical, laterally-expanded, flange-like base, but no unsclerotized longitudinal central strip. The paraprocts are short and have truncated apices.

Records

A. outeniquae is recorded in the Western Cape from the Outeniqua and Tsitsikamma Mountains in the east, and also from Garcia's Pass (Riversdale) and Grootvadersbosch (Langeberg).

Aphanicercopsis hawaquae Barnard 1934

Characteristics of the nymph

Nymph unknown.

Characteristics of the adult genitalia (Fig. 4.12G)

The epiproct is broad basally, and narrows distally, forming a short, denticulate neck, that leads to a narrow, rounded apex.

Records

A. hawaquae occurs from Piketberg (WC) in the north to Swartberg east of Caledon (WC) in the south, with the western boundary being Piketberg, and the eastern being the Grootswartberg Mountains (WC). This species is sympatric with *A. denticulata* in the Swartberg area east of Caledon, Bain's Kloof, Franschhoek Pass and the Wellington Mountains (WC).

Aphanicercopsis denticulata Barnard 1934

Characteristics of the nymph (Figs 4.5K–L; Tables 4.1 & 4.2)

This species is very similar to the other species in this genus, but appears to differ in the number of pleurites, which are present on abdominal segments 1–4.

Characteristics of the adult genitalia (Fig. 4.12H)

The epiproct is narrow and linguiform. There are no lateral basal expansions, and the paraprocts are long and lanceolate.

Records

The known geographic range of *A. denticulata* in the Western Cape is bound by the Grootwinterhoek Mountains (Tulbagh) in the north, the Palmiet River in the south and west, and Swartberg east of Caledon in the east.

Desmonemoura Tillyard 1931

The only species to have a common name besides *A. capensis*, the Common Cape Stonefly, is *Desmonemoura pulchellum*, the Porcupine Stonefly. It owes its name to the strong banding pattern of the wings, a feature of the genus. This banding pattern is visible in the mature nymphal wingpads (Fig. 4.3A). The other recently-described species, *D. brevis* (Picker & Stevens 1999), is similar to *D. pulchellum* in also having a summer emergence pattern.

The adult males (Figs 4.7F, 4.16E) are characterized by paired posterior processes of the ninth tergite, long, (one-segmented) cerci and an equally long glabrous clasper of the tenth pleurite. The two species differ in the degree of elongation of the cerci and pleural claspers, as the name *D. brevis* suggests. The tergal processes differ from those of *Aphanicerca* in being flattened and arising laterally as opposed to the cylindrical processes which arise in the median plane in *Aphanicerca*. The adult females (Figs 4.8F, 4.16F) are readily distinguished from the other genera by the deep triangular incision in the subgenital plate (bilobate), and the transverse median bulge on the posterior aspect of the seventh sternite. No brachyptery or aptery has been recorded.

KEY TO SPECIES OF *DESMONEMOURA*: ADULT MALES

1. Cerci and claspers of pleurite 10 very long, extending about twice the distance from their bases to the epiproct .... *D. pulchellum* (Fig. 4.7F)

– Cerci and claspers of pleurite 10 extend almost equal to the distance from their bases to the epiproct .... *D. brevis* (Fig. 4.16E)

Desmonemoura pulchellum Tillyard 1931

Characteristics of the nymph (Fig. 4.3A & B; Tables 4.1 & 4.2)

The nymphs are medium to large—male about 6.3 mm and female about 5.5 mm long. The compound eyes are large and prominent. The wingpads are conspicuously banded in cream and dark-brown in older nymphs. The abdomen appears smooth, but bears a few stout setae on the posterior margins of segments, with a few scattered median spines on some segments. Pleurites are evident on the first five abdominal segments.

Characteristics of the adult genitalia (Figs 4.7F, 4.8F)

The cerci and claspers of pleurite 10 of the male are very long, extending about twice the distance from their respective bases to the epiproct. Sternite 7 bears a transverse lobe with swollen lateral extremities.

Records

D. pulchellum is most common in the south-western part of the Western Cape, but is also known from the Tsitsikamma Mountains at the border of the Western and Eastern Cape Provinces.

Desmonemoura brevis Picker & Stevens 1999

Characteristics of the nymph

The nymph is similar to that of the previous species, but can be separated by the adult genitalia in mature nymphs.

Characteristics of the adult genitalia (Fig. 4.16E & F)

In *D. brevis* males, the cerci and the claspers of the tenth pleurite are about half the length of those of *D. pulchellum*. In *D. pulchellum* females, the lobe on sternite 7 is much larger and is more swollen laterally than that of *D. brevis*.

Records

D. brevis has only been recorded from the Groot Swartberg and Outeniqua Mountains of the south-eastern part of the Western Cape.

Family **Perlidae** McLachlan 1870

The family Perlidae falls within the northern-origin suborder Arctoperlaria (Zwick 1973). A widespread and speciose family, in southern Africa it consists of just one genus. Hynes, in numerous publications (for example, Hynes 1952), synonymized all previously-described species of African *Neoperla* to one 'very variable' species, *Neoperla spio*. Subsequently it has been shown that there are in fact many *Neoperla* species (Picker 1980). Thus the original descriptions (Barnard 1934, Zwick 1973) are valid. Barnard (1934) had redescribed *N. transvaalensis* (Fig. 4.18C) and described a new species, *N. kunenensis* (Fig. 4.18B), from the region, but the group is in need of revision (Picker 1980). Differences between the nymphs of various species have not yet been established. Perlids have a tropical distribution and are found in the northern parts of the southern African region extending as far south as KwaZulu–Natal. The nymphs and adults may be found throughout the year, although they are most common during spring and summer. A single record near Prince Albert (WC) may represent the most southerly extension of the family.

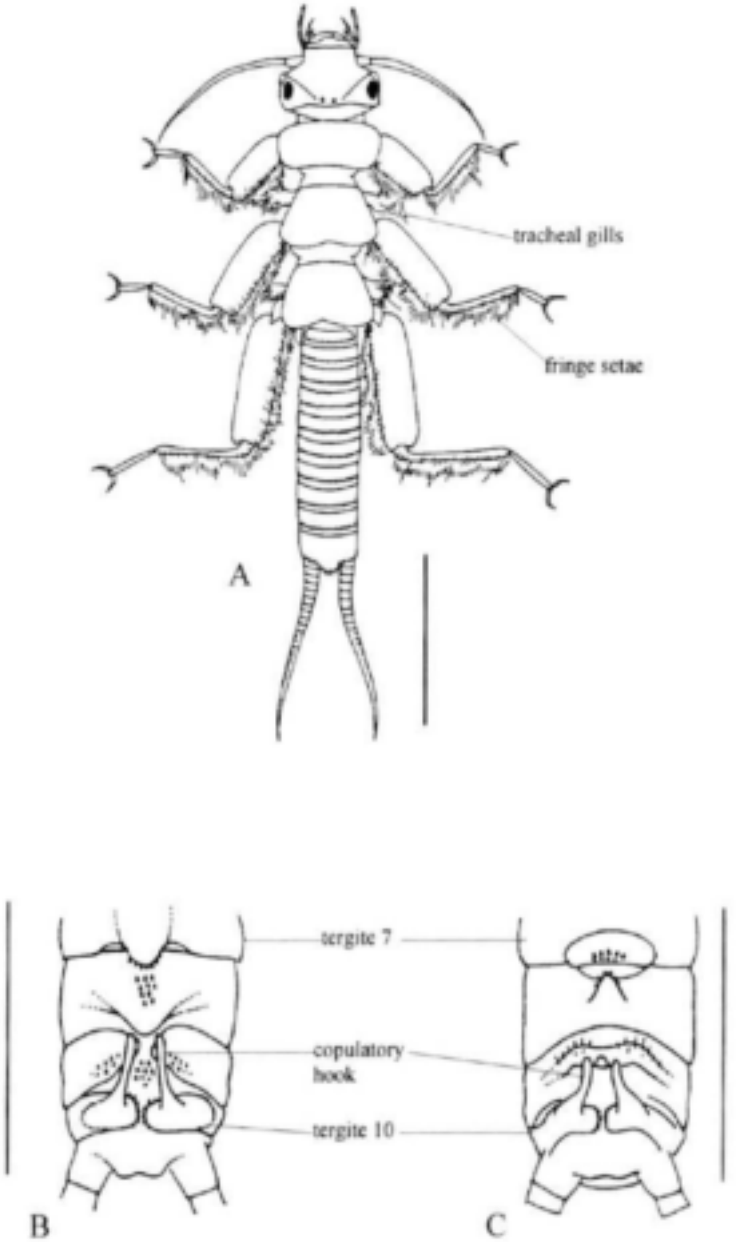

Fig. 4.18. A, *Neoperla* nymph, dorsal view. **B–C**, *Neoperla* spp. adult male external genitalia (dorsal view): **B**, *N. kunenensis*; **C**, *N. transvaalensis*. (Scale Bar = 5.0 mm). (Adults after Barnard 1934).

Nymphs (Fig. 4.18A)

The nymphs range in size from minute first instars to the large final instar nymphs of about 15 to 18 mm body length (excluding cerci). They have three pairs of double-branched tracheal gills positioned laterally between the prothorax and mesothorax, mesothorax and metathorax, and metathorax and abdomen. Another three pairs are positioned laterally on the pro-, meso- and metathorax dorsal to the attachment of the coxae, and additional pairs occur at the posterior end of the abdomen. The filiform antennae are devoid of setae or hairs, except for minute hairs only visible at high magnification. The posterior end of the abdomen bears a pair of long filiform, multi-segmented, spinous cerci. The caudal margin of the femora and tibiae bear a row of long fine setae. The legs bear short thick spines on the lateral surfaces. Besides clothing hairs on the abdomen, there are short thick bristles on the caudal margin of the tergites, and on the lateral parts of the caudal margin of the sternites. The lacinia of the maxillae is long, robust, and sharp, its function being to assist the mandibles in devouring live prey.

Adults (Fig. 4.18B & C)

Adult *Neoperla* measure about 15 mm in length, (excluding cerci and wings), and about 20 mm including the cerci, which, unlike the situation in the notonemourids, are retained as long multi-segmented structures easily visible with the naked eye. The main copulatory structures in the male are the copulatory hooks on segment 10, that resemble two side-by-side clenched fists in a thumbs up position, and the spiny membranous aedeagus, that is not visible externally.

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GLOSSARY OF TERMS

abdomen	of insects, the third and most posterior tagma or division of the body (the first being the head and the second the thorax); with no appendages except sometimes a pair of terminal cerci (q.v.)
acuminate	narrowing to a sharp point
aedeagus	in insects, the male intromittent organ
Afrotropical Region	region of Africa south of the Sahara Desert (see Fig. 2.1, p. 17)
anal pyramid	in Odonata, the terminal part of the abdomen of nymphal anisopterans (dragonflies) formed by the pointed paraprocts
antenna	(pl. antennae): either of the pair of jointed first appendages on the head of an insect
anterior	the front end
anteromedial	a part at the front in the middle
apex	tip
appendage	in insects, any of the paired, articulated structures attached to each segment (or somite)
aptery	of adult insects, wingless
asymmetrical gills	in Ephemeroptera, gills in which the upper or lower margins are not equal, or the development of tracheae is unequal in the two halves of the gill
basal	at the base of, or near the point of, attachment
benthic	pertaining to, or living on, the bottom
biacuminate	ended in a double point
brachyptery	of adult insects, having shorter-than-normal wings
carapace	a shield-like cuticular extension covering part of the body
carina	a crest ridge
caudal	pertaining to the cauda or the anal end of the insect body
cerci	(sing. *cercus*): a pair of appendages arising from abdominal segment 11
chamfered	with a sloping edge
chitin	the tough, brownish material that forms the major portion of the exoskeletons of most arthropods
claspers	forcep-like structures associated with the male reproductive parts at the posterior end of the abdomen in some insects
claw	a hollow, sharp organ at the end of the insect leg, distal to the tarsus (q.v.)
cleft	split
concave	curving inwards
concavity	the quality of being concave (q.v.)

conical	shaped like a cone
convergent	coming together
coxa	the first (proximal) of the articles of an insect leg
cranial	referring to the head
crenation	fine notches, usually forming a border
dentate	finely toothed
denticles	small teeth
diapause	a period of suspended development or growth, accompanied by greatly decreased metabolism and usually controlled by environmental conditions
distal	the part of a structure furthest from the midline or from its point of attachment (cf. *proximal*)
divergent	separate, going in different directions
dorsal	referring to the upper surface (the 'back') of an organism
dorsoventrally flattened	flattened as if from above
eccentric	off-centre
elongate	drawn out, lengthened
emarginate	notched: as if with a section cut out from the margin
endemic	referring to organisms found only in a particular area
edentate	without teeth
endophytic	within a plant
entire	of margins, complete, not notched or slit
epiproct	in some insect orders, a dorsal relic of segment 11
Euparal	a resin-based substance used for mounting specimens on to glass slides prior to microscopic examination
excentric	not in the centre
exoskeleton	(= cuticle, integument): of insects, the external chitinous covering, often hardened by tanning
falcate	sickle shaped, convexly curved
femur	(pl. femora): the thigh: usually the stoutest segment of the insect leg, articulated to the body through trochanter (q.v.) and coxa (q.v.) and bearing the tibia (q.v.) at its distal end
fibril	fine, fibrous structure
fibrilliform	of the shape of a fibril or fibrils (q.v.)
filamentous	thread-like
filiform	thread-like, consisting of numerous small segments
filter feeder	(= filterer): an animal that feeds by filtering minute particles out of water
filterer	see *filter feeder* (q.v.)
frons	the sclerite forming the forehead region of an insect
fusiform	streamlined, tapering at least at one end

galea	the outer lobe or gnathobase (q.v.) on the maxilla (q.v.) (cf. *galea-lacinia*)
galea-lacinia	in insects, the outer (galea) and inner (lacinia) lobes or 'gnathobases' (q.v.) on the maxilla (q.v.)
gatherer	an invertebrate that feeds by collecting particulate matter
gill	a special, variously formed, respiratory organ in the aquatic immature stages of many insects
glossa	(pl. = glossae): the paired inner lobe of the labium
gnathobase	a lobe or projecting portion of one of the basal segments of an appendage, situated near the mouth, used in the process of feeding; in the insect maxilla there are normally two gnathobases, an inner and an outer
Gondwanan	pertaining to the ancient southern continental land mass that included Antarctica, South America, Africa, India and Australasia

head	the first tagma or division of an insect body (the second is the thorax and the third the abdomen)
hemimetabolous	of insects, those with incomplete metamorphosis—that is, developing from egg to nymph to adult without an intervening pupal stage
holometabolous	of insects, those with complete metamorphosis—that is, developing from larva to pupa to adult
herbivore	an animal that feeds on plant material
Holarctic	of the northern Nearctic and Palearctic regions
hypognathous	having the head vertical and the mouth directed ventrally
hypopharynx	in insects, a sensory structure on the upper surface of the labium (q.v.) that serves as an organ of taste
hyporheos	the area within the stream bed

imago	the adult stage of an insect
in tandem	one behind the other
incised	cut into
incisor	the cutting edge of the mandible (q.v.)
indented	dented
instar	in arthropods, a stage of development between moults
interstitial	referring to the spaces between sediment particles

labial	belonging, or referring to the labium (q.v.)
labial palp	sensory appendage of the insect labium (q.v.)
labium	in insects the posteriormost mouthpart, consisting of the fused second maxillae and lower lip
labrum	in insects, the anteriormost mouthpart, the 'upper lip', which covers the base of the mandibles (q.v.)
lacinia	a blade; the inner lobe of the gnathobase (q.v.) of the maxilla (cf. *galea-lacinia*)

lacustrine	pertaining to, or living in, lakes or ponds
lamella	(pl. lamellae): a thin plate or leaf-like process
lamellate	leaf-like
lanceolate	sword-shaped
larva	in a life cycle, an immature stage that looks and behaves differently from the adult
lateral	pertaining to the side or flank of an animal
lentic	still: of environments where the water is not flowing
lingua	in Ephemeroptera, the outer lobes of hypopharynx, on either side of the superlingua (q.v.)
linguiform	tongue-shaped
lotic	flowing: of environments where the water is running
mandibles	(sing. mandible): in insects, the first pair of mouthparts: hardened jaws used for crushing, biting or otherwise breaking down food
mandibular	(adj.): pertaining to the mandibles (q.v.)
mantle cavity	in molluscs, that part of the skin that covers the organs enclosed within the visceral hump
maxilla	(pl. maxillae): the second pair of jaws in a mandibulate insect
maxillary	(adj.): pertaining to the maxillae (q.v.)
mentum	the distal sclerite of the insect labium bearing the movable parts
medial	at or towards the midline of the body
mesothorax	the second of the three segments that make up the thorax of an insect
metathorax	the third of the three segments that make up the thorax of an insect
microtrichia	minute, hairlike setae
molar	(=mola): the ridged or roughened grinding surface of the mandibles (q.v.)
Nearctic	of North America roughly north of the Tropic of Cancer
nymph	an immature insect of any taxon with a hemimetabolous life cycle
obtuse	of an angle, wider than 90°
ocellus	a simple eye; in insects, a single eye, consisting of a single lens, located between the compound eyes and the antennae
ocular	referring to the eyes
oligochaetes	earthworms and their kin
omnivore	an animal that feeds on both animal and plant matter
operculate	forming a lid: in mayflies, the large flat anteriormost pair of gills that act as a cover for the more posterior pairs
ovate	oval in shape
oviposition	in insects, laying and placing of eggs

palette-shaped	like a painter's palette
Palearctic	of northern Africa and Eurasia outside of the tropics
palp	an articulated branch, usually of a mouthpart
pantropical	of all major tropical areas of the world
papilliform	of the shape of a nipple, tubercle or papilla
paraglossa	(pl. = paraglossae): one of the paired lobes on the lateral margins of the labium
paraproct	structure modified from segment 11 often used in copulation
parthenogenesis	asexual reproduction in which an egg develops without being fertilized
pectinate	comb-like; applied to structures with even processes like the teeth of a comb
pedicel	a stalk
periphyton	the community of plants, animals and associated detritus adhering to and forming a surface coating on stones, plants and other objects under water
plastron	see *carapace*
pleurite	membranous region between dorsal tergite and ventral sternite
posterior	at or towards the tail end of the body
prementum	the region of the labium (q.v.) distal to the mentum (q.v.)
produced	extended
prognathous	having the head horizontal with the jaws directed forward
prostheca	a mandibular sclerite (q.v.) set with hair
prothorax	the first of the three segments that make up the thorax of an insect
proximal	towards the point of attachment (cf. *distal*)
psammophilous	sand-dwelling
saccoid	sac-like
scape	the first antennal segment
sclerite	any single hardened or sclerotized plate forming the body wall of an arthropod
scraper	an invertebrate that feeds by scraping algal and microbial films off the substratum
semioperculate	in mayflies, refers to gills that partially cover other (more posterior) gills
semivoltine	a life cycle that takes longer than one year to complete
seta	a chitinous hair or bristle
setulose	covered in fine hairs
shredder	an invertebrate that feeds by chewing up dead plant material
sigmoid	s-shaped
spatulate	shaped like a spatula, short and blunt
spine	a tough, pointed seta (q.v.)
sternite	a ventral sclerite (q.v.)
sternum	the ventral part of a segment

subanal plate	one of the last pair of sclerites on the ventral side of the insect abdomen
subimago	that stage in ephemerids just after emergence from the pupa and before the final moult
superlingua	the inner structure of the hypopharynx (q.v.)
suture	a seam indicating the division between sclerites
tarsus	(pl. tarsi): the last of the five segments or elements that make up the leg of an insect; may itself be divided to form up to five tarsal joints
teneral	the condition of the imago shortly after emergence, when it is not entirely hardened or fully of the mature colour
tergite	a dorsal sclerite (q.v.)
thorax	the middle of the three tagmata (sections) that make up the body, the first being the head and the third the abdomen; in insects, consisting of three segments: the prothorax, the mesothorax and the metathorax
tibia	(p. tibiae): the fourth of the five segments or elements that make up the leg of an insect
trachea	(pl. tracheae): any of the tubes delivering air into the body of an insect (and extending into the gills of many aquatic forms)
tracheal gills	in anisopteran (Odonata) nymphs, lamelliform strcutures in the rectum, supplied with tracheae and tracheoles (q.v.) and serving as respiratory organs
tracheated	supplied with tracheae (q.v.)
tracheation	the arrangement or system of distribution of tracheae (q.v.)
tracheole	a very small, slender trachea (q.v.); one of the finer branches of the tracheae
triquetal	triangular in cross section, with three flat sides
trochanter	a sclerite of the insect leg between the coxa and femur (q.v.)
trophic	related to food and feeding
tubercle	a small rounded protuberance
univoltine	of life cycles, those completed within one year
ventral	referring to the underside of the body
villopore	a small, circular to oblong patch of minute, fine, simple setae located proximally on the ventral margin of the femora
wing sheath	the exoskeleton covering the developing wings of nymphal and pupal insects
wingbud	the wing developing within the wing sheath (q.v.)
wingpad	in insect nymphs, external buds that will ultimately form the wings

GLOSSARY OF PLACE NAMES

NEW PROVINCIAL NAMES IN SOUTH AFRICA TOGETHER WITH ABBREVIATIONS USED IN THE TEXT

Eastern Cape (EC)	formerly the eastern part of the Cape Province.
Free State (FS)	formerly the Orange Free State.
Gauteng (GT)	formerly the Pretoria/Witwatersrand/Vereeniging complex: part of the Transvaal.
KwaZulu–Natal (KZN)	formerly Natal, which included Zululand.
Mpumalanga (MPL)	formerly the 'eastern Transvaal'.
Northern Cape (NC)	formerly the north-western part of the Cape Province.
Limpopo (LIM)	formerly the 'northern Transvaal' (prior to 1994) and 'Northern Province' (from 1994–2002).
North West (NW)	formerly the 'western Transvaal'.
Western Cape (WC)	formerly the 'western Cape'.

ABBREVIATIONS OF OTHER COUNTRIES IN SOUTHERN AFRICA

BOTS	Botswana
LES	Lesotho
MWI	Malawi
MOZ	Mozambique
NAM	Namibia
SWZ	Swaziland
ZAM	Zambia
ZIM	Zimbabwe

REGIONAL NAMES

Bushmanland	(= Boesmanland): The north-eastern parts of Namibia, the south-western parts of Botswana and the drier northern areas of the Northern Cape.
Cape	One of the four former provinces of South Africa now named as follows: the north-western part is now the Northern Cape; the south-western part is now the Western Cape ; the eastern part, together with the former Ciskei and Transkei (qv), is now the Eastern Cape.
Caprivi	The north-eastern 'panhandle' of Namibia.
Damaraland	The west-central region of Namibia.
Delgoa Bay	(= Baia de Maputo): large bay on east coast of Mozambique, site of Maputo Harbour
Drakensberg Mountains	The mountain range stretching from the northern regions of the Eastern Cape through the highlands of KwaZulu–Natal, Lesotho and the eastern Free State to Mpumalanga.
Greater Namaqualand	The south-eastern part of Namibia (also see 'Namaqualand').
Griqualand East	Border region between the Transkei (qv) and KwaZulu–Natal.
Griqualand West	Arid region from Bloemfontein (Free State) westwards into the North West Province.
Highveld	High-altitude inland plateau characterized by grassland vegetation. Predominantly in Gauteng and the Free State.
Kalahari	The desert region of the northern North West Province, southern Botswana and south-eastern Namibia.
Karoo	Arid central region of southern Africa characterized by low scrub vegetation and very little grass cover: predominantly in the southern Northern Cape, the western parts of the Eastern Cape, the former Transkei (qv) and the northern border of the Western Cape.
Kaokoveld	(=Kaokoland): the arid north-western coastal regions of Namibia.
Kruger National Park	Large nature reserve in the north-eastern region of Mpumalanga on the Mozambique border.
Makatini Flats	Pongola River floodplain, north-east of Jozini, Maputaland (q.v.)

Maputaland	Coastal plain in the north eastern region of KwaZulu–Natal and southern Mozambique, bounded by the Lebombo Mountains in the west and the Indian Ocean in the east.
Namaland	The coastal areas of the central Namib (qv) in Namibia.
Namaqualand	Arid region along the western parts of the Northern Cape and continuing into Namibia, where it is known as Greater Namaqualand (qv).
Namib Desert	The coastal desert of south-western Africa, extending roughly from the Orange River to Benguela in Angola.
Natal	One of the four former provinces of South Africa, which previously included the region variously known as Zululand and KwaZulu, now re-named KwaZulu–Natal.
Northern Province	One of the nine provinces of South Africa, now called 'Limpopo'.
Orange Free State	One of the four former provinces of South Africa, now known as the Free State.
Owamboland	(=Ovamboland): Northern region of Namibia.
Southern Cape	The southern coastal strip from Cape Agulhas in the west to Cape St Francis in the east.
Transkei	The region colloquially known as the Transkei is now part of the Eastern Cape Province, stretching from the Kei River to Port Edward on the KwaZulu–Natal border.
Transvaal	One of the four former provinces of South Africa: the northern part is now the Limpopo Province; the eastern part is now Mpumalanga; the southern part is now Gauteng and the western region is now part of the North West Province.
Zululand	in KwaZulu–Natal, the eastern coastal belt and adjacent interior from the Tugela River to the Mozambique border .

INDEX OF SCIENTIFIC AND COMMON NAMES