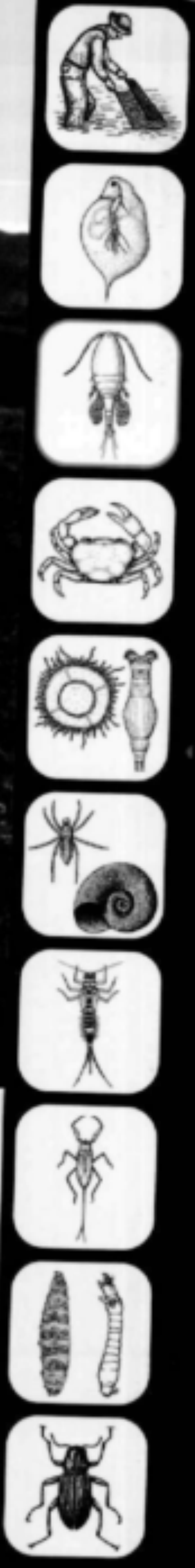
Guides to the

Freshwater Invertebrates of Southern Africa



Volume 3: Crustacea II

Ostracoda, Copepoda and Branchiura

Editors: JA Day, IJ de Moor, BA Stewart & AE Louw

TT 148/01

Water Research Commission

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Prepared for the Water Research Commission

by

Editors: JA Day, IJ de Moor, BA Stewart
& AE Louw

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Cover photograph by FC de Moor: temporary pan on the farm *Glen Avis* in the southern Drakensberg (Eastern Cape).

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').

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PREFACE

This identification guide is one of a series of ten volumes 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It is a truism that identification guides are perpetually out of date, particularly in terms of nomenclature, due to advances in systematics.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 periodically revised, 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 which 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 families of invertebrates. Subsequent volumes contain keys to different invertebrate groups, most often logically clustered together. However, in some instances, the need for cost-effectiveness has resulted in the creation of some rather uncomfortable 'bedfellows', such as the arachnids and molluscs that are combined in Volume 6.

It should be noted that references have been limited to key publications that will assist the reader in finding valuable sources of information. They are, therefore, referred to as 'Useful References' and may include some publications not cited in the text.

The volumes in this 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 chapters on Crustacea. 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, and Irene de Moor was contracted to take on the job of 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 volume, have contributed time and expertise towards the drafting of the keys. The original authors were not 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 South African Museum and the Water Research Commission 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 are also acknowledged for their assistance in the production of this book: Ferdy de Moor, Fred Gess, Sarah Gess, Helen James and Carlos Lugo-Ortiz of the Albany Museum for providing constant advice on editorial and technical details relating to the systematics of freshwater invertebrates; Nikki Köhly for her excellent drawings of invertebrates and Nancy Bonsor for assisting with tracing and other graphics; Bronwyn Tweedie, Debbie Brody and John Keulder of the Graphics Services Unit, Rhodes University, for drawing the maps and producing bromides, and Drini van Rensburg and Yuven Gounden of the WRC for their 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, however, 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, so the emphasis has naturally fallen on this region.

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

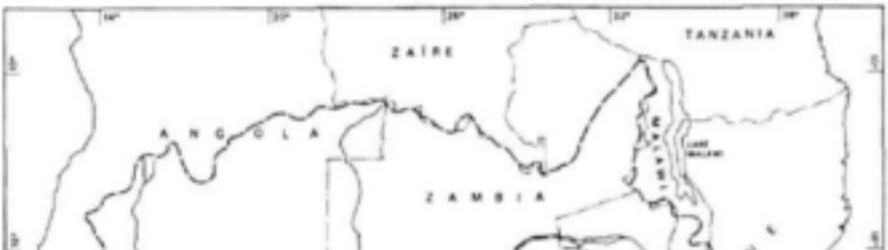

Fig. 1. Southern Africa: the region covered by this series of invertebrate guides.

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 which often arises in association with regional names, a 'Glossary of place-names' has been compiled (see page 169), 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

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INTRODUCTION

THE OSTRACOD, COPEPOD AND BRANCHIURAN CRUSTACEANS

by

J.A. Day

This volume deals with three classes of crustaceans that seem, at first glance, to be unprepossessing; indeed, the individuals in all three of these groups are so small as to be easily overlooked. Yet they are fascinating and include some of the most ecologically important of all animals. Although copepods are very small — most are less than 1 mm — they are the major grazers of open waters, converting phytoplankton to animal protein. They occur in untold millions and rough estimates suggest that the standing stock of copepods in the oceans is of the order of billions of tons. Although far smaller numbers occur in inland waters, they are still crucially important in the food webs of lakes and wetlands.

While most copepods live as part of the plankton in open waters, most ostracods are benthic, scurrying around on the bottom, or on the surfaces of plants, where they feed on detritus or periphyton. Although the biomass of ostracods in natural waters is generally vastly less than that of the copepods, the ostracods — at least in southern African inland waters — are taxonomically more diverse. And because their calcified shells fossilize easily, their remains are particularly useful for tracking environmental changes in lakes and wetlands over hundreds or thousands of years.

In contrast to the copepods and ostracods, the branchiurans form a small taxon of just a few species of fish parasites. It seems that in most cases they have little effect on their hosts, although dense infestations by some species have been known to result in fish kills.

THE SYSTEMATIC POSITION OF OSTRACODA, COPEPODA AND BRANCHIURA

It is sometimes difficult to remember that higher taxa are nothing but human constructs, useful to us in our attempts to classify and to make sense of the diversity of species on this Earth, but of no biological reality. This is particularly obvious when dealing with the higher taxa in the Arthropods in general, and the Crustacea in particular. Crustacean systematists regularly argue about details of the taxonomic relationships between crustaceans and other groups, as well as the relationships between one crustacean group and another. Indeed, they do not even agree on whether the Crustacea should be included in the Phylum Arthropoda, or whether the taxon should itself be elevated to the level of phylum: the Phylum Crustacea. As a compromise, we have decided in these volumes to treat the Arthropoda as a single phylum and the major components (the crustaceans, chelicerates and insects) as subphyla.

At least as many arguments abound regarding the relationships between one major crustacean taxon and another. It is generally agreed that the primitive phyllopodous crustaceans all belong in a single group, the Class Branchipoda, which is the subject of Volume 2 in the present series (Day et al. 1999). The Class Malacostraca also forms a fairly homogenous group of 'higher crustaceans', which includes familiar forms like the crabs and prawns as well as krill and other more obscure, shrimp-like animals. Of the remaining classes, the Remipedia and Cephalocarida are small groups of obscure animals (none of which occur in fresh waters), the Ostracoda, Copepoda and Cirripedia are widespread and speciose, and the Branchiura is a small class of fish parasites, many of which occur in fresh waters. Since the cirripedes (barnacles and their kin) are entirely marine, they need concern us no further. Of the three groups treated in the present volume, the copepods and branchiurans are closely related to each other (indeed, until relatively recently the branchiurans were considered to be a group of parasitic copepods), while the ostracods seem to come from a rather different stock. Despite appearances, though, various respected crustacean biologists (e.g. Dahl 1956; Siewing 1960) have suggested that the ostracods and copepods should be placed, together with the Cirripedia, in a single class: the Class Maxillopoda. The Maxillopoda as a taxon is not commonly accepted, though, not least because its members are much more variable in fundamental morphology than are the members of the other classes of crustaceans. For a discussion on the systematics and phylogeny of the crustaceans, see Hessler (1982) and Schram (1986).

COLLECTION, PRESERVATION AND REARING OF SMALL FREE-LIVING CRUSTACEANS

Ostracods are found mostly on the bottoms of lakes and wetlands, although a few wetland species seem to spend at least part of their life-cycles in mid-water as components of the plankton. In contrast, most copepods are planktonic, although some are benthic or even interstitial, living between sand grains on sandy or muddy substrata. With few exceptions, neither ostracods nor copepods occur in running waters. Small crustaceans like ostracods and many copepods are easily collected using a small, long-handled net with a mesh of no more than 0.1 mm (see Chapters 1 & 2 for further notes on recommended mesh sizes). Since different species live in different parts of a lake or wetland, a representative collection of the species living in a particular system requires netting close to the bottom, in the water column, and in and around submerged vegetation and other substrata. Planktonic copepods can be collected in this way, but larger samples are best obtained using a regular plankton net. Details of collecting equipment can be found in Davies & Day (1998), in Volume 1 of the present series, and in the relevant chapters in this volume.

Samples should be fixed in 4% neutralised formaldehyde (one part of concentrated formalin to nine parts of water, neutralised with a few broken sticks of blackboard chalk, or approximately 50–100 ml powdered chalk or bicarbonate of soda, per litre of fixative). After 24–48 hours, the formalin solution should be replaced with a solution of 70–80% ethyl alcohol or 1% phenoxytol (the non-toxic ethylene glycol monophenyl ether).

Specimens need to be examined in detail if they are to be identified to genus or species. In most cases this requires a dissecting microscope of at least 40-times magnification. Magnifications (using a compound microscope) of between 100 and 400 times may, however, be required to obtain sufficient detail for the examination of certain appendages. In these cases specimens must be mounted in water or glycerine (alcohol tends to evaporate very rapidly) on a microscope slide under a coverslip. More specific details on the preservation and examination of individual taxa are provided in the following chapters.

Specimens of many species can be reared from dried mud. Simple aquaria can be set up in small (1–5 litre) plastic or glass containers with distilled water. Place about 400–900 ml of dried mud from the bottom of a temporary pool into a container so that the substratum is about 10–20 mm deep, and cover with distilled or de-ionised water to a depth of 50–100 mm. Keep the aquarium lit during the daytime so that algae (the best food for many small crustaceans) can grow from spores in the mud. Such systems are usually entirely self-sustaining and can be dried and wet again and again, producing a new generation of invertebrates, algae and bacteria each time they are wet.

For more detailed descriptions of specialized collection, dissection and preservation techniques, the reader is referred to the relevant chapters in this volume.

Collection and preservation of branchiurans

Being parasites, branchiurans are normally collected only from their hosts. Details are provided in Chapter 3.

CRUSTACEAN STRUCTURE: SOMITES AND APPENDAGES

While the internal body structure of crustaceans does not, in general, vary much from one class to another, the number of somites ('segments'), and the number and type of appendages, certainly do. Indeed, the adaptive modification of appendages has probably been the key feature in the adaptive radiation of the Crustacea as a whole. In many of the taxa, these adaptations have been accompanied by changes, usually slight, in the number of somites that make up the body. Since these modifications are sometimes interpreted differently by taxonomists working on the different taxa of crustaceans, the terminology can be very confusing. This topic is covered in detail in Volume 1 of this series (Day & de Moor, In Prep. a), but for convenience is also discussed briefly below.

The crustacean body

The bodies of crustaceans and other arthropods are divided into a number of serially-repeated units called *somites* or, commonly but less correctly, *segments*. The number of somites is usually fixed within a particular taxon. The body of any 'higher' crustacean, for instance, is composed of nineteen somites arranged in three regions or *tagmata*: the head tagma, or *cephalon*, consists of five somites, the thorax of eight and the abdomen of six. Posteriorly, the anus usually opens ventrally on the last true abdominal somite. A flap is often present posterior to this last somite and is termed the telson.

Crustacean appendages

The terminology of crustacean appendages can be confusing, especially since taxonomists of different taxa sometimes use different words for homologous structures, and also because homologous structures may have very different appearances and functions in the different taxa. Even the word 'appendage' is sometimes used interchangeably with the words 'leg' and 'limb'. In essence, the appendages of the head are two pairs of antennae, of which the first is usually sensory and the second is used for locomotion, copulation or sensation; a pair of mandibles, used for chewing or piercing; and two pairs of maxillae, used for 'tasting' and handling food. The thoracic appendages or *thoracopods* are primitively used for locomotion although the anteriormost pairs may be modified as food-handling structures, in which case they are called *maxillipeds*. In some taxa the locomotory thoracopods are also known as *pereiopods* (variously spelled also as peraeopods or pereopods). Abdominal appendages, which are absent from the groups covered in this volume, are usually called *pleopods* unless they occur on the very last segment, in which case they are known as *uropods*. In some taxa, including the ones covered in this volume, the last somite does not bear a pair of truly segmental appendages, but is instead furnished with a pair of unsegmented hooks or rods known variously as *caudal furcae* or *caudal rami*.

Table 1 summarizes the terminology relating to somites, tagmata and appendages of the non-marine ostracods, the freeliving copepods, and the branchiurans as used in this volume. Note that in ostracods the entire body appears to consist of only about seven rather indefinite somites. Although the head and thoracic regions are given different names, no clear tagmosis (division into regions) is evident. Tagmosis in copepods does not correspond with the anatomical divisions of head, thorax and abdomen. Instead, the head and the first one or two thoracic somites fuse to form the *cephalosome*, the remaining four or five thoracic somites form a region known as the *metasome* and the last four or five somites are collectively called the *urosome*. In branchiurans the head also consists of five somites, while the rest of the body is reduced to four thoracic somites and an abdomen that consists of no more than a pair of unsegmented flaps.

The reader is referred to other chapters in this volume as well as the Glossary for further details.

HOW TO RECOGNIZE AN OSTRACOD

Ostracods are small crustaceans encased in bivalve shells. All those that live in fresh waters are less than 10 mm long and most are no more than 1–2 mm in length. At first glance they may be confused with small bivalved molluscs but of course the body of a mollusc is soft and muscular, while a crustacean has a hard, segmented body and jointed appendages. Two other groups of crustaceans have bivalved carapaces: the conchostracans and the cladocerans, both of which can co-occur with ostracods. Conchostracans are easily distinguished because they possess many pairs of flattened, leaf-like legs and a distinctly segmented body. While the valves of ostracods are usually brittle, calcified and opaque, those of cladocerans are soft and transparent.

KEY TO FRESHWATER ORGANISMS WITH BIVALVED SHELLS

1. Shell brittle, calcified and opaque; body of animal soft, muscular and not segmented, with no exoskeleton or jointed appendages .... **bivalve molluscs** (see Vol. 6— Day & de Moor In Prep.b)

– Shell variable; body of animal covered by a thin chitinous exoskeleton and bearing jointed appendages 2

2. Trunk of animal (i.e. the part behind the head) divided into at least ten, but usually more than 20, segments; limbs numerous, flattened and setose on the edges .... **conchostracan branchiopods** (see Vol. 2— Day et al. 1999)

– Body not clearly segmented; no more than six pairs of limbs behind the mouthparts 3

3. Head entirely enclosed within the valves; valves brittle and opaque, so animal not usually visible within; no limbs flattened or phyllopodous .... **ostracods** (see Chapter 1, p. 9–77)

– Head not enclosed within the valves; valves soft, usually transparent so animal visible within; all thoracic limbs flattened and phyllopodous .... **cladocerans** (see Vol. 2 — Day et al. 1999).

HOW TO RECOGNIZE A COPEPOD

Copepods are extremely small individuals — only a few taxa reach a length of even 5 mm and most are less than 2 mm. Typically they look like minute prawns or shrimps, with a segmented body, two pairs of antennae (one pair usually very large) anteriorly, a number of pairs of thoracic limbs, and no abdominal limbs other than the single pair that makes up the caudal furca. Because of their very small size one is unlikely to confuse

Table 1. Terminology of some morphological features of the non-marine ostracods, copepods and branchiurans.

Tagma	Somite no.	Ostracoda	Copepoda	Branchiura
Head	1	Antennula (=A1)	antennule (=antenna 1, A1)	antennule (reduced)
	2	Antenna (=A2)	antenna (=antenna 2, A2)	antenna (reduced)
	3	Mandible (=Md)	mandible (=Md)	mandible (modified)
	4	Maxillula (= Mx1)	maxillule (=maxilla 1, Mx1)	maxillule (= suction disc)
	5	—	maxilla (=maxilla 2, Mx2)	maxilla
Thorax	1	first thoracopod (= T1)	maxilliped (=Mxp)	leg 1
	2	second thoracopod (= T2)	pedigerous somite 1 (= pediger 1, Pdg 1, P1)	leg 2
	3	third thoracopod (=T3)	pedigerous somite 2 (= pediger 2, Pdg 2, P2)	leg 3
	4	—	pedigerous somite 3 (= pediger 3, Pdg 3, P3)	leg 4
	5	—	pedigerous somite 4 (= pediger 4, Pdg 4, P4)	
	6	—	pedigerous somite 5 (= pediger 5, Pdg 5, P5)	
	7	—		
Abdomen		much reduced, no obvious somites; body may end in a pair of caudal furcae	urosome of 2–5 somites; body ends in a pair of caudal rami	reduced to a pair of non-segmented flaps; body may end in a pair of tiny furcal (=caudal) rami

copepods with any other crustaceans from inland waters, particularly planktonic forms.

HOW TO RECOGNIZE A BRANCHIURAN

Branchiurans are difficult to mistake for anything else. They are bizarre-looking, flattened crustaceans that, except after they have laid eggs and are about to die, are found only as ectoparasites of fish. The most characteristic feature in most branchiurans is the maxillules, which are hugely expanded to form a pair of ventral suckers (see Fig 3.1 — p 127).

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CHAPTER 1

OSTRACODA

by

K. Martens

Ostracods form an important part of the zoobenthos in African inland waters but are often neglected in ecological surveys. This aversion to research on ostracods is at least partly due to the fact that identification requires complete dissection, for which some skill and experience, and good microscopes, are necessary. Nevertheless, ostracods are not necessarily more difficult than, for example, chydorids or harpacticoids, and it is hoped that the present chapter will illustrate this.

About 45 papers on southern African ostracods have been published, reporting on more than 150 nominal species. The most important work is the large monograph by Sars (1924a), in which about 40 new species and ten new genera were described and another 30 species redescribed. Mainly because of this work, the fauna of the Western Cape Province has the best known ostracod fauna in the African region. McKenzie (1971) compiled taxonomic and faunistic data on southern African ostracods. Martens' (1984b) checklist of non-marine ostracods of the entire African continent incorporated these data and added some of the older literature. Three important papers summarize the ostracod biodiversity in Namibia: Curtis 1991, Curtis et al. 1998 and Day 1990. McKenzie (1977) published a key to the South African ostracod genera. Subsequent taxonomic changes and additional generic records have, however, rendered it obsolete, and the present key differs from that of McKenzie in many respects.

Ecology and feeding

Ostracods can be found in a variety of aquatic or humid environments and are also tolerant of harsh environmental conditions. They occur in both marine and non-marine environments and are known from nearly all types of aquatic habitats: littoral (marginal vegetation), lake benthos, streams and interstitial waters, fresh to highly saline waters (in salinities of up to three times seawater) and in temporary environments. Ostracods of the families Cyprididae, Ilyocyprididae and Notodromadidae (see below) mostly have natatory setae on the Antennae and can swim. Others lack these setae and are entirely benthic. Some species are also known from semi-terrestrial (mosses) and terrestrial (leaf-litter in forests) habitats.

Most species are relatively unselective scavengers. Some of the larger forms are known to be occasional predators on copepods, whereas other species graze on diatoms on littoral macrophytes. As scavengers and detritus-feeders, ostracods form an important part of aquatic ecosystems. Few organisms, on the other hand, are known to feed on ostracods, although stomach content analysis of some East African fishes has revealed large numbers of ostracods, and some taxa were originally described from fish guts.

Reproduction

The ontogeny of ostracods follows the same pattern in all non-marine groups. There are eight larval instars, the ninth instar being the adult. The first two to three instars generally do not feed but digest the egg yolk that they carry with them. Only from the 4th stage onwards do larvae start to feed actively. During postembryonic development, appendages are progressively acquired and chaetotaxy (number of segments, setae and claws) is gradually completed. Smith & Martens (2000) provide a full description of the post-embryonic ontogeny of a non-marine ostracod, *Eucypris virens* (Cyprididae). There are no further moults after the animal reaches the adult stage (i.e. growth is determinate) and animals mature after the final moult.

At least three fundamentally different reproductive strategies are distinguished within non-marine ostracod groups: full sexuality (in some Candonidae and Cytheroidea), mixed reproduction (Cyprididae, Candonidae and Limnocytheridae) and ancient asexuality (Darwinulidae). These reproductive modes have a large impact on genetic, morphological and ecological diversities (extant diversities, as well as the dynamic aspects) and, as a result, species with different reproductive modes have different competitive abilities with regard to colonization of habitats, habitat predictability, habitat stability and ecological specialization (Martens 1998b). The Cyprididae are clearly the most successful ostracod group in Africa, no less than 80% of all African non-marine ostracod species being cypridids (Martens 1998a).

At least part of their success is related to their mixed mode of reproduction. Unlike groups with cyclic parthenogenesis (e.g. the cladoceran *Daphnia*), cypridid ostracods with mixed reproduction have two types of females, sexual and asexual. Most of these species also have *geographic parthenogenesis*, which means that asexual females occur in the entire distribution range of the species, while sexual populations occur in a restricted area only. In Europe, for example, the presence of sexual populations is limited to the Mediterranean (Horne & Martens 1999). In South Africa, sexual populations of otherwise parthenogenetic species have been found in high-altitude pools in the Drakensberg (e.g. *Sarscypridopsis trigonella* — pers. obs.).

The Darwinulidae are unique from an evolutionary point of view in that they have persisted without sexual reproduction for at least 100 million, maybe even 200 million, years. This violates ruling evolutionary theory on the prevalence of sexuality in the living world (see Martens 1998b for an overview). Darwinulidae make up only a few percent of the total specific diversity of non-marine ostracods in the world (Rossetti & Martens 1998), but they are relatively more speciose in the southern hemisphere than in the northern hemisphere.

Most Cytheroidea and all Cypridoidea can produce drought-resistant eggs, which can survive for many decades. While crustaceans generally require a sexual cycle before they are able to produce drought-resistant eggs (e.g. ephippia in Cladocera), even fully asexual ostracod females can do so. Cyprididae can furthermore produce both drought-resistant and subitaneous eggs in the same clutch. Darwinulidae do not produce such desiccation-resistant stages, but they can survive unfavourable conditions for many weeks (up to months) in a state of *torpidity*.

Eggs are laid either directly on the substrate or on plants. Females of some species (in the Timiriaseviinae and in the Darwinulidae, see below) have brood cavities in their carapaces, in which eggs and juveniles up to the third or fourth stage are nursed.

Zoogeography

To date, about 500 ostracod species in about 80 genera have been described from the African continent (Martens 1984b) and about 150 of these occur in southern Africa, representing more than 50 genera. The affinities between faunas from the Cape provinces and East Africa (*Globocypris*, *Ramotha*, and others) are not unexpected and match the pattern observed in other groups. There are also clear zoogeographical affinities with the Indian subcontinent, where representatives of otherwise exclusively Ethiopian genera (such as *Pseudocypris*, *Sclerocypris* and *Paracypretta*) occur. Both observations merely confirm established patterns, which have well-documented historical causality in continental drift (Martens & Coomans 1990).

The presumed faunal relationships between the Cape provinces and West Palaearctic faunas are far more limited than was previously suspected, and are largely the result of homeomorphies. The presumed European species of the African genus *Cypricercus* are now lodged in separate genera in the Cypricercinae (McKenzie 1982, Martens 1994), while the North American *Cypriconcha* and the South African *Megalocypris* are clearly distinguished groups, which do not even belong to the same subfamily (Martens 1986).

The most striking faunal elements of this region are, of course, the endemics of the western and eastern Cape. There are only a few endemic genera (i.e. *Homocypris*, *Liocypris*), but a significant number of the extant genera have species endemic to the Cape provinces. Another belt of high endemism comprizes the northern and central parts of Namibia and Botswana and the southern part of Zimbabwe. Generic endemicity in the temporary waters of that area (e.g. *Afrocypris, Ovambocypris, Apatelecypris, Eundacypris*, and *Amphibolocypris*) is comparable to levels found in the East African ancient Lake Tanganyika (Martens, 1998a). Surprisingly, few cosmopolitan species occur (e.g. *Heterocypris incongruens*, *Sarscypridopsis aculeata*), and considerable speciation has occurred in temporary water groups (*Heterocypris*, *Sclerocypris*).

COLLECTION, PRESERVATION AND EXAMINATION OF OSTRACODS

A large variety of techniques can be used to collect, kill, preserve, dissect and store ostracods. Space does not allow an exhaustive review here, so only a few selected examples are provided. This implies that other techniques and chemicals can be used with equal success. Proper research on ostracods does, however, demand a number of specific precautions, not always necessary for other aquatic invertebrate groups, and it is, therefore, advisable to read the following section carefully.

Collection

Most ostracods have a benthic or periphytic mode of life and are best collected by moving a handnet amongst littoral vegetation or by scraping the bottom of lakes and ponds. A double-frame net is especially suitable for collecting ostracods. This has an outer rectangular frame (of about 150 x 250 mm) with a handle attached to it at a 45° angle. Mesh (with pore size of about 150 µm) is attached to a slightly smaller inner frame by means of pieces of wire and this prevents wear and tear on the attachment of the mesh.

In deeper lakes, the benthos must be sampled with a box-corer, a grab or a corer. It is also advisable to check decaying branches and logs in pools, as some species tend to cling to such substrata. Surface mud can be collected from dried up vleis and dams and, since most groups have desiccation-resistant eggs, they can be raised from the mud by simply adding distilled water in the laboratory. As not all eggs hatch immediately, it is advisable to dry the same mud and then re-wet it a couple of times. Terrestrial ostracods (e.g. *Mesocypris*) can be extracted by either washing mosses over a net or with a Tullgren or Berlese apparatus.

Fixation

In the field, animals are best killed and fixed in a 4% formaldehyde solution. (Add the necessary volume of concentrated formalin — liquid or powder — to the sample). However, when collecting ostracods, it is vital that the formalin is neutralized, for example, by adding sodium-bicarbonate crystals (baking soda) or blackboard chalk. If ostracods are kept in acidic formalin for a number of days, the valves will rapidly decalcify and identification then becomes extremely difficult.

Preservation

Even with perfectly neutral formalin, it is still advisable to transfer specimens within a week to 70–80 % ethanol. This medium is not only more comfortable to work with when ostracods are picked out under a stereo-microscope, but its dehydrating effect also facilitates dissection.

Dissection and storage

Proper identification and description of specimens invariably demands a complete dissection of the soft parts. The dissection, which is not easy and requires a steady hand, is performed with two needles, using either the smallest type of steel insect-needles (size 000) fitted in convenient handles, or pieces of tungsten wire. The dissection requires two major steps: (1) opening the valves and separating valves and soft body and (2) dissecting the soft parts. The first step is performed in 96 % ethanol in an embryo dish. It is sometimes necessary to crush one valve, when the carapace is globular and tightly closed. If only a few specimens are available it is advisable to note the external features prior to dissection (e.g. width–length ratio, overlap of valves, shape of ovarium, colours, etc.). Once the valves and soft parts have been separated, the valves are dried in air and are stored in micro-palaeontological (cavity) slides. Soft parts are transferred to glycerine on a slide or slides, where the second part of the dissection takes place. Here frustration will be the price paid for experience, but it is good to consider the following suggestions:

* Divide the body into an anterior and a posterior part (between the fourth and the fifth appendages).
* Leave the Antennula and Antenna attached to the body until the very last stage, as they will facilitate the orientation of the pieces.
* The fifth appendage in most taxa, and the furcae in the Cypridopsinae, are hard to find and several specimens may have to be dissected before examination is possible.
* When dealing with large specimens (of 3 mm or more), divide the appendages over at least two slides.

The dissected appendages are then covered with a cover-slip and the preparation is sealed, either with glyceel or normal nail polish. Another medium used to store soft parts is polyvinyl-lactophenol. This chemical dries (polymerizes) and does not normally require sealing.

GENERAL MORPHOLOGY AND TERMINOLOGY

Symbols and abbreviations

A1 = Antennula; A2 = Antenna; cms = central muscle scars; H = height of valves; L = length of valves; LV = left valve; Md = Mandible; Mx1 = Maxillula; RV = right valve; T1 = first thoracopod; T2 = second thoracopod; T3 = third thoracopod; Fu = Furca (caudal ramus); ls = lateral shield of hemipenis; ms = medial shield of hemipenis, db = dorsal branch of furcal attachment; vb = ventral branch branch of furcal attachment; W = width of carapace. 'Height to length ratio' refers to the height and length of a valve. 'Width to length' refers to the ratio of width to length of a valve.

<u>Special setae</u>: d_1 and d_2 are on the first and second segment respectively of the second thoracopod in Cypridoidea and of special interest in the Cyprididinae (Fig. 1.14B–E); for the identification of the genera in the Darwinulidae, special setae w, x and y on the mandibular palp are of importance (Fig. 1.16G–I). In the figures, arrows above the illustrations of entire valves point anteriorly.

General comments

Ostracods are small- to medium-sized bivalved crustaceans. Due to a partial reduction of the thorax and an almost complete reduction of the abdomen, the body is completely enveloped by the carapace, which consists of two lateral valves. Only those aspects of the morphology of the valves and soft parts that are used in the accompanying keys will be dealt with here. More complete accounts of ostracod morphology can be found in van Morkhoven (1962) and Hartmann (1966, 1975).

Valves

Ostracod valves consist of an *outer* and an *inner* lamella. Along the valve margins, where these two lamellae are fused, a number of structures occur (Fig. 1.1), most of which are of extreme importance with regard to taxonomy and identification. The margin of the peripheral *calcified part of the inner lamella* is called the *inner margin*. The space between the outer lamella and the calcified part of the inner lamella is called the *vestibulum*, and *radial* or *marginal septa* (connecting inner and outer lamellae in the vestibulum) can occur here. Part of the outer and inner lamellae can be fused (*fused zone*) and *marginal pore canals* mostly cut through this area. The inner margin of the fused zone is the *line of concrescence*. It is important to make a distinction between the radial septa in the vestibulum (not always present) and the marginal pore canals (nearly always present in Cytheroidea and Cypridoidea) in the fused zone. On the calcified part of the inner lamella, a ridge-like *inner list* can occur. When valves are examined in internal view with transmitted light, the valve margin, the inner margin, the line of concrescence, the inner list and the selvage are distinguishable.

In the generic key presented here, it is vital to distinguish between inner lists and selvages and this is not always straightforward. The selvage is the original valve margin that has been inwardly displaced. This means that part of the outer lamella follows the selvage to the inside of the valve (where one would normally expect inner lamella) and a new apparent valve margin is created. The selvage thus remains associated with the primary fused zone, with marginal pore canals on which setae occur (on the selvage). The inner list, on the other hand, never bears a row of hairs. A new (secondary) fused zone with pore canals and hairs will be formed near the new actual valve margin. A second feature by which a selvage and an inner list can be distinguished is that a selvage continues uninterrupted into the dorsal hinge, whereas an inner list normally ends at some distance from the hinge.

Selvages and inner lists form part of the closing mechanism of the valves, the selvage of the right valve fitting between the selvage and inner list of the left valve when the valves are closed. Dorsally the hinge in one valve consists of an anterior and a posterior cardinal tooth with a cardinal groove between them. The teeth fit into anterior and posterior cardinal sockets in the other valve, which have between them an intercardinal bar that fits into the cardinal groove of the first valve.

The valves are closed by powerful *adductor muscles*. The attachment sites of these muscles (both central and dorsal) give typically arranged *muscle scars* (Fig. 1.1A). The shape and number of the *central muscle scars*, situated near the centre of each valve, are of special taxonomic importance. The entire outer lamella has normal *pores* bearing setae on the external surface. All sorts of carapace ornamentation (spines, thorns, tubercles, ridges, pits, nodes etc.) can occur, the most impressive being the alae, which are hollow, ventro-lateral, wing-like expansions that occur in a few species.

Appendages

There is no consensus among ostracod workers with regard to the terminology of the appendages. Generally, non-marine ostracods are considered to have a pair of each of the following appendages (Fig.1.2A): Antennula, Antenna, Mandible, Maxillula, first, second and third thoracopods; a paired furca is mostly also present. The general morphology of the different appendages is relatively uniform, although significant differences occur between the families and superfamilies, especially in the appearance of the fifth appendage. This limb is considered to be cephalic in origin by some, and in that case it would be a Maxilla. Other scientists hold that it is a first thoracopod. Smith & Martens (2000) offer convincing ontogenetic evidence for the latter case and in the present chapter the fifth appendage is considered to be a first thoracopod in all three lineages, even if its appearance is very different.

Cypridoidea: In females, this fifth appendage consists of an undivided *protopodite*, a respiratory plate (*exopodite*), and a one- to three-segmented palp (*endopodite*) (Fig.1.2B). In males of this superfamily, the palps are sometimes asymmetrical and prehensile (Fig. 1.2C) and are used during copulation. The sixth pair of appendages (second thoracopods) consists of genuine walking legs and the seventh pair (third thoracopods) are cleaning limbs, with or without a distal pincer-shaped organ.

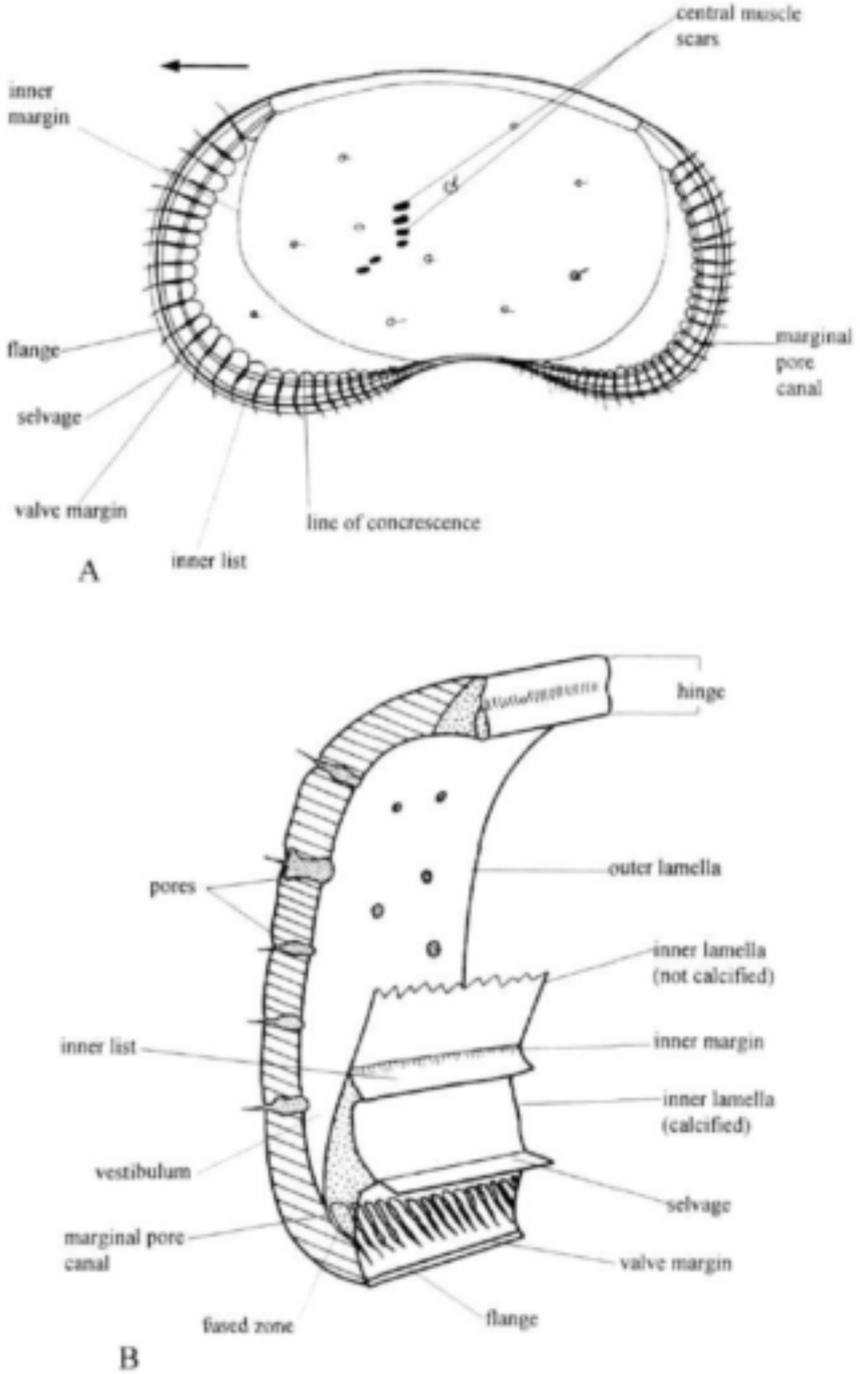


Fig. 1.1. Ostracoda: A, internal view of a hypothetical right valve; B, anterior stereo-section of a hypothetical valve, showing marginal structures. (Redrawn after Hartmann 1966).
→ points towards the anterior of the animal.

Darwinuloidea: the fifth pair of appendages forms a pair of maxillipeds, while the sixth and seventh pairs are true walking limbs.

Cytheroidea: the fifth pair of appendages forms a pair of genuine walking limbs so that there are three pairs of walking limbs (Fig 1.3A).

The *Antennula* is the first head appendage; in the Cypridoidea it has mostly long natatory setae.

The *Antenna* is used for crawling and manipulating food and in the males also for copulation. All of the Cypridoidea, except for the Candoninae, also have natatory setae and this limb is also used for swimming.

The *Mandible* consists of a heavily sclerotized coxa, with powerful teeth, and a mandibular palp, usually with complex chaetotaxy (arrangement of setae). Unfortunately, many diagnostic features are on this appendage.

The *Maxillula*, which is the fourth and last head appendage, consists of a large respiratory plate, a basal plate carrying a palp, and three endites. Apart from the respiratory plate, it is a small appendage which is easily lost or overlooked during dissection.

Of the three *thoracopods*, the appearance of the first is discussed above. The second thoracopod is invariably a walking limb. The third thoracopod is either a walking or a cleaning limb or, in some cytherid males, may function in courtship display, in which case it can be asymmetrically produced.

The body ends in a small tubular extension, the *postabdomen*, flanked by a pair of furcae. The furcae have a very different appearance in the different taxa and there is some discussion as to the homology of these structures. According to Meisch (2000), for instance, they are modified uropods. Most cypridids have a pair of powerful furcae (caudal rami) used for crawling but reduced to flagella in the Cypridopsinae and, independently, in a few other lineages. The furcal attachment, a chitinous structure attached to the body, has some diagnostic features, such as a triangular proximal structure in the Herpetocypridinae (Fig. 1.12B,C) and a distal Triebel's loop in the Cypricercinae (Fig. 1.12D,E). In both the Cytheroidea and the Darwinuloidea, the furca is either reduced to a flagellum or absent.

The chaetotaxy of all these limbs consists of various segments (which may be fused or not), claws (strong, moveable structure), setae (long and flexible, but without hinging attachment) and setules (fine structures either in rows on setae or in groups on segments).

Reproductive organs are paired. Males usually have four paired testicular tubes, that are spiralled in the carapace. The Cyprididae have the longest spermatozoa in the animal kingdom and a specimen of 1 mm can have

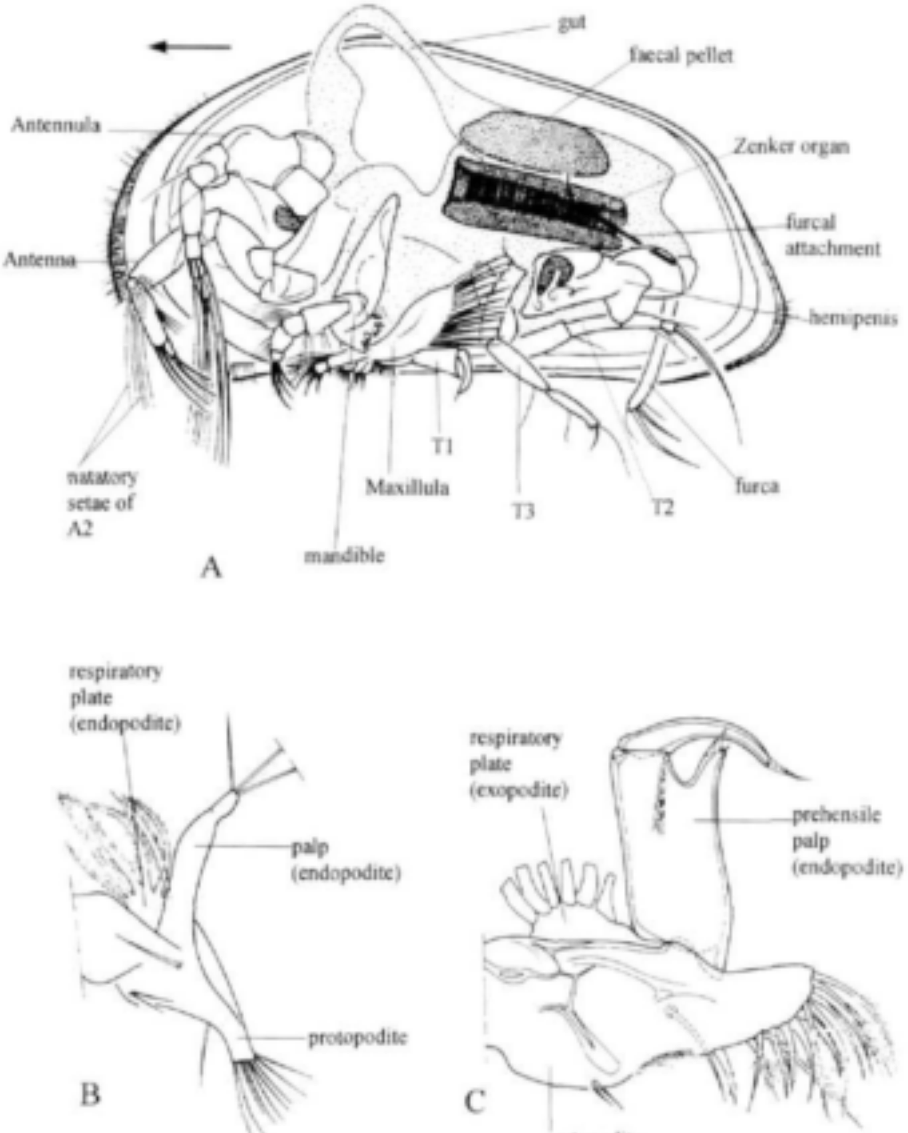


Fig. 1.2. *Sclerocypris exserta,* showing general characteristic features of ostracods: A, male, left lateral view, with left valve removed and only left appendages shown; B, T1 of female, C, left T1 of male showing prehensile palp. (After Martens 1986).
KEY: T1 = first thoracopod; T2 = second thoracopod, T3 = third thoracopod.
⟶ points towards the anterior of the animal.

spermatozoa of 10 mm and more in length. To handle these excessively long spermatozoa during insemination, the ductus ejaculatorius is modified to form a muscular *Zenker organ* (Fig. 1.2A). There are two *hemipenes* and the morphology of these structures is highly diagnostic. The *peniferum* is a chitinous, transparent sheath enveloping the internal structures and mostly forming two distal lobes: the *medial* (ms) and the *lateral* (ls) *shields*. In this superfamily especially, the shape of these shields is used to identify species. In the Cytheroidea, the hemipenes have a built-in pump, rather than an exterior Zenker organ. The copulatory complex, consisting of the actual *intromittent organ* and various structures of the *clasping organ*, is situated on the outside of the peniferum, instead of being enveloped by it. The clasping organ generally consists of an upper and a lower ramus, each of which can be absent, or reduced or differentiated into various other structures (e.g. lateral and hook-like processes in *Limnocythere*), which are highly diagnostic. In the Darwinuloidea, no males are known.

Females generally have fewer diagnostic features in their reproductive systems: the only characters used here are the shape of the *genital lobes* (expansions of the abdomen situated at the postero-ventral part of the body) and of the lateral, paired *ovaria* (mostly visible in lateral view, through the transparent carapace). The *genital corner* consists of the genital lobes and the genital operculum, which covers the genital aperture.

SOUTHERN AFRICAN OSTRACODS

There are three orders of ostracods with extant representatives: the Myodocopida, the Platycopida and the Podocopida. Only the Podocopida has non-marine representatives, in the form of three superfamilies: the Cytheroidea, the Cypridoidea and the Darwinuloidea, none of which is endemic to southern Africa.

A total of about 150 species and subspecies are reported from southern Africa thus far. They represent about 50 genera, which are discussed in the following key. A further four genera are included because they may have representatives in the subtropical parts of southern Africa. However, this is only a part of the total taxonomic diversity that can be expected in southern Africa. Dozens of new species at present await description and various habitats, such as rivers and their adjacent interstitial domains, remain largely unexplored with regard to their ostracod faunas. The ostracod fauna of Lake Sibaya (KwaZulu–Natal) is unique, with largely marine affinities, and most taxa remain undescribed to date. The inclusion of these taxa could, therefore, not be justified, not even in open nomenclature, and most of the Lake Sibaya ostracods cannot be identified with the present key.

The key given below is valid for adult ostracods only. None of the eight juvenile stages can be identified with certainty. Furthermore, it is not always easy to distinguish between juveniles and adults. Sometimes juveniles are even erroneously described as new species in different genera (e.g. juveniles of *Sclerocypris* have been described in *Eucypris*), or even as new genera (e.g. *Gesa*, a juvenile of *Chrissia*). Early larval stages can be recognized as such by their smaller size, more weakly calcified valves, and a reduced number of incompletely developed appendages (e.g. the first instar has only the Antennula and Antenna, and a rudiment of the Mandible). Adult, mature animals can be distinguished from large larvae primarily by the condition of the reproductive system. Adult females are mostly ovigerous (with eggs in the uteri), whereas mature males have fully developed copulatory appendages and Zenker organs in the Cypridoidea. Late instars have all appendages, but they lack part of the chaetotaxy (setae and claws on the different segments). If present, natatory setae on the Antennae give a good indication of which larval stage one is dealing with. For example, in the Cyprididae the Antennae of adults have six large and one small setae while in the last larval instar they have five large and one small setae.

Full scientific names of species, including references to first descriptions, are not given in the keys to genera, but are listed, together with general distribution records, in the full checklist of species (Table 1.1) on page 69.

KEY TO THE GENERA OF OSTRACODS IN SOUTHERN AFRICAN INLAND WATERS

1. Valves elongate or subquadrate (Fig. 1.3B); surface smooth; central muscle scars arranged in a rosette (arrowed in Fig. 1.3C) (Superfamily **Darwinulidae**) 51

– Valves elongate, subquadrate, rounded or globular; surface smooth or with ornamentation; muscle scars not in a rosette 2

2. Last three pairs of appendages, excluding furca, are subequal similar walking limbs (Fig. 1.3A); four central muscle scars in a vertical row (arrowed in Fig. 1 .3G) (Superfamily **Cytheroidea**) 3

– Last three pairs of appendages (excluding furca), with different shapes and functions (Fig. 1.2A); central muscle scars with a different pattern (Fig. 1.3I,J) (Superfamily **Cypridoidea**) 7

3 Fused zone in anterior valve margins with numerous pore canals (about 40 along frontal edge); males with walking limbs asymmetrical on left and right sides .... *Cyprideis*

– Fused zone in anterior valve margin with fewer pore canals (about 20 along frontal edge); males with left and right walking limbs symmetrical (Limnocytheridae) 4

4. Strong sexual dimorphism in width of valves, with males relatively slender and females posteriorly very broad (brood cavity); ventral side flattened, often set with ridges (Fig. 1.3E, F); no lateral spines; hemipenis as in Fig. 1.3N .... *Gomphocythere*

– No such sexual dimophism; ventral side not flattened; lateral spines sometimes present; hemipenis of a different type (Fig. 1.3K–M) 5

5. Hemipenis with copulatory process forming a large spiral (arrowed in Fig. 1.3M, but not seen like this when flattened on a slide); third walking limb of male with a reduced basal segment (Fig. 1.3D) (Eastern Cape) .... *Leucocythere*

– Hemipenis with copulatory process not forming a spiral; third walking limb normally developed in both sexes (Fig. 1.3A) 6

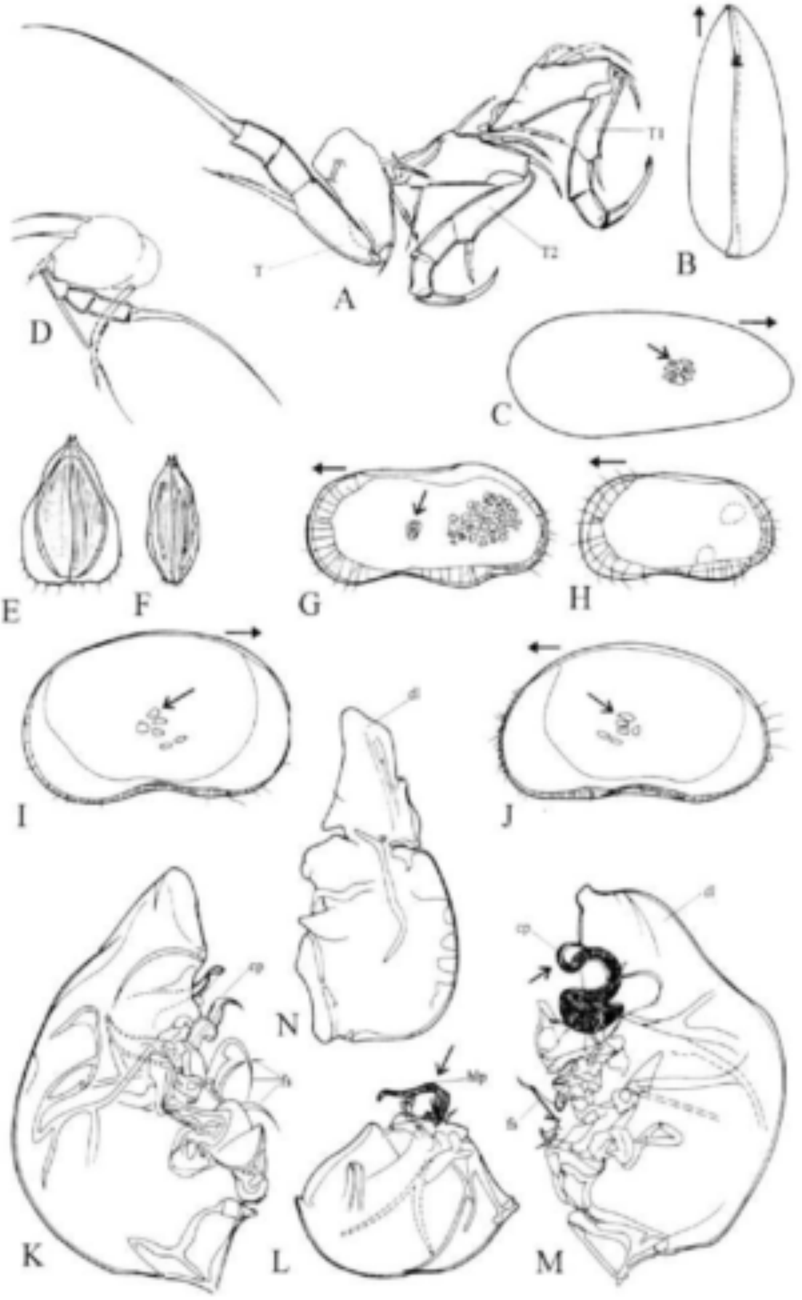


Fig. 1.3. Ostracoda. A, *Limnocythere* sp, last three appendages (walking limbs).
B–C, *Darwinula stevensoni* carapace: B, dorsal view; C, right lateral view. D. *Leucocythere helenae*, third walking limb. E–F, *Gomphocythere expansa*: E, female carapace, ventral view; F, male carapace, ventral view. G–H, *Limnocythere* sp: G, male right valve, internal view; H, female right valve, internal view. I–J, *Kapcypridopsis barnardi*: I, female left valve, internal view; J, male right valve, internal view. K, *Ovambocythere milani*, hemipenis. L, *Limnocythere tudoranceai*, hemipenis.
M, *Leucocythere helenae*, hemipenis. N, *Gomphocythere expansa*, hemipenis outline.
(A, G, H, L redrawn after Martens 1990a; D, M after Martens 1991d; K after Martens 1989; E, F after Sars 1924a; I, J after McKenzie 1977).
KEY: cp = copulatory process; dl = distal lobe; fs = furcal setae; hlp = hook-like process.
⟶ points towards the anterior of the animal; ⟶ indicates distinctive features.

6. Hemipenis (arrowed in Fig. 1.3L) with a large hook-like process; copulatory process straight, with complex apex; all furcal setae straight and small; male substantially longer than female (Fig. 1.3G,H) ....*Limnocythere*
– Hemipenis (Fig. 1.3K) without hook-like process, copulatory process with one twist; one furcal seta hook-like; male in lateral view less high, but not longer than, female (N. Namibia) .... *Ovambocythere*
– Hemipenis (Fig. 1.4C,J) without hook-like process; all furcal setae straight; copulatory process sickle-shaped; almost no sexual dimorphism in valve shape (Fig. 1.4D,E,G,H) ....*Korannacythere*
7. Maxillula with third masticatory process carrying four to six stout, serrated claws (arrowed in Fig. 1.6A); eye-cups contiguous but not fused (arrowed in Fig. 1.6C–D) 8
– Maxillula with third masticatory process carrying only two smooth claws (arrowed in Fig. 1.6B) and many setae; eye-cups fused 9

8. Valves without spines, but set with prominent pits (Fig. 1.6D); frontal inner lamella with 'lunules' (Fig. 1.6E,F; arrowed in Fig. 1.6F); furca reduced to flagella (Fig. 1.6G) .... *Oncocypris*
– Valves set with spines (Fig. 1.6C); frontal inner lamella without 'lunules'; furca with a stout ramus with two claws and at least one large proximal seta.............
....*Centrocypris*

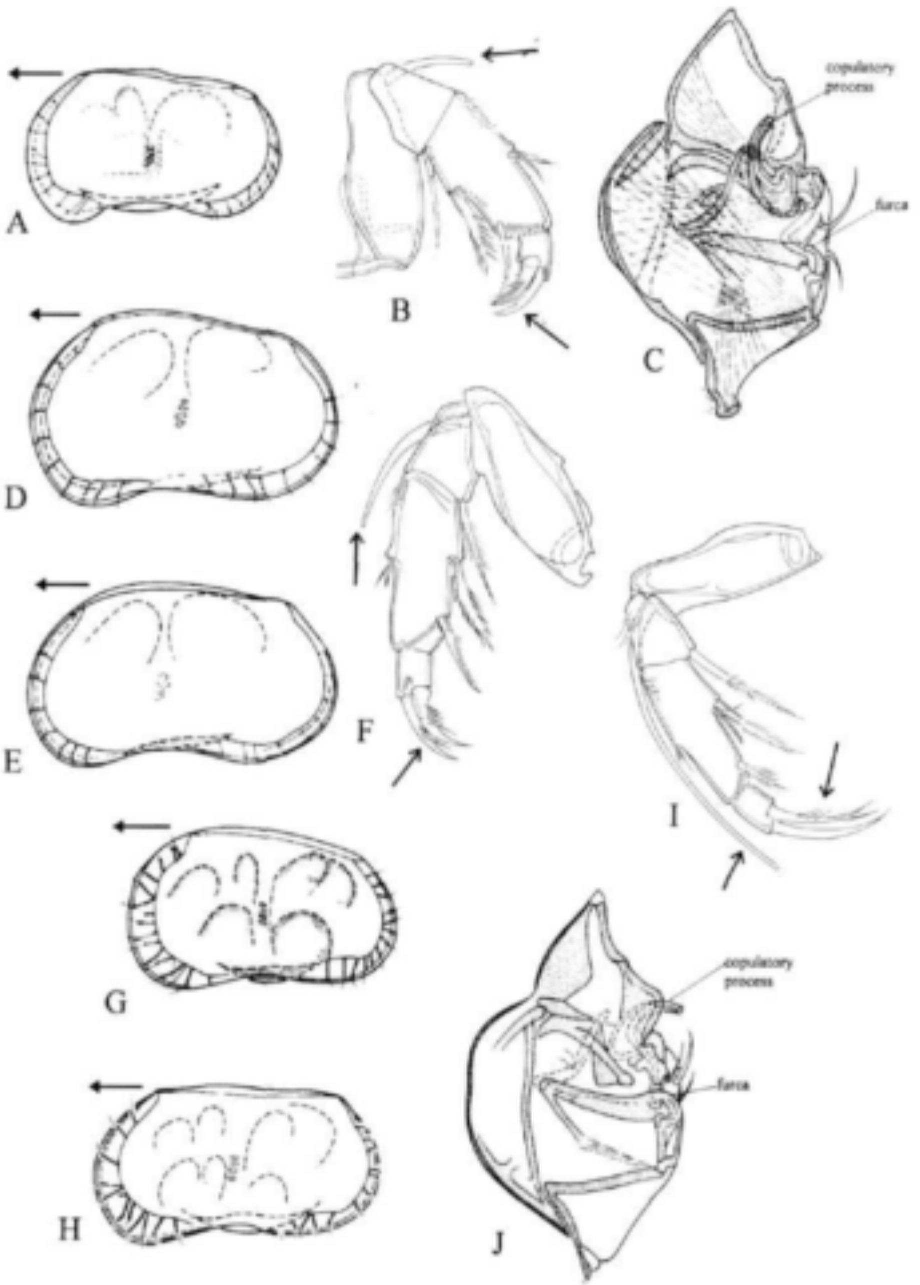


Fig. 1.4. A–C, *Korannacythere devriesi*: A, female right valve, internal view; B, male Antenna, showing short exopodite; C, hemipenis. D–F, *K. ugiensis*: D, female right valve, internal view; E, male right valve, internal view; F, male Antenna, showing exopodite of intermediate length. G–J, *K. hamerae*: G, female right valve, internal view; H, male right valve, internal view; I, male Antenna, showing exopodite of normal length; J, hemipenis.
(All redrawn after Martens 1996).
⟶ points towards the anterior of the animal; ⟶ indicates distinctive features.

9. Furca in females reduced to flagella, usually with a basal seta (Fig. 1.8A,B); furca completely absent in males; Antenna with natatory setae; valves smooth, pitted or striped, never with pronounced longitudinal ridges 10

– Furca, in both males and females, with an elongated ramus and one elongated terminal claw (Fig. 1.5C); Antenna without natatory setae (Fig. 1.5B); valves set externally with about ten pronounced longitudinal ridges (Fig. 1.5A); subterranean .... *Namibcypris*

– Furca with rami and at least two terminal claws, in most cases also with one to two setae (Fig. 1.6H); Antenna with natatory setae sometimes short, but always present; valves usually smooth, sometimes pitted or set with spines or alae 15

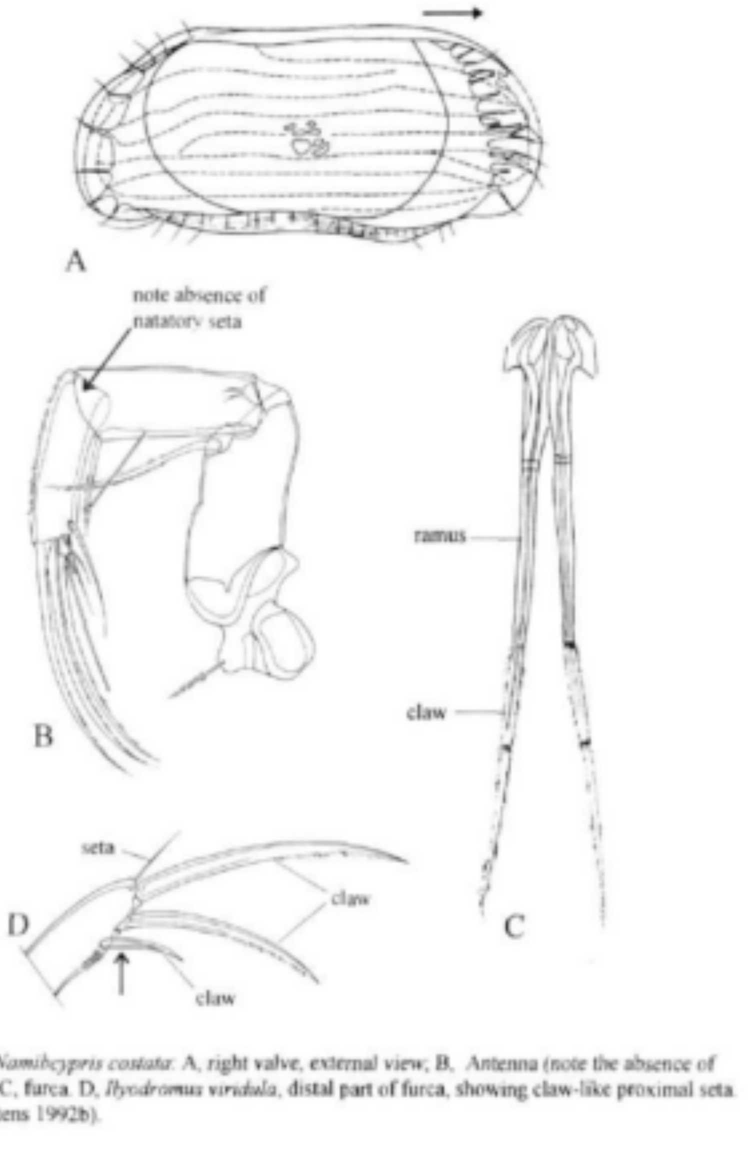


Fig. 1.5. A–C, *Namibcypris costata*: A, right valve, external view; B, Antenna (note the absence of natatory setae); C, furca. D, *Ilyodromus viridula*, distal part of furca, showing claw-like proximal seta. (A–C after Martens 1992b).

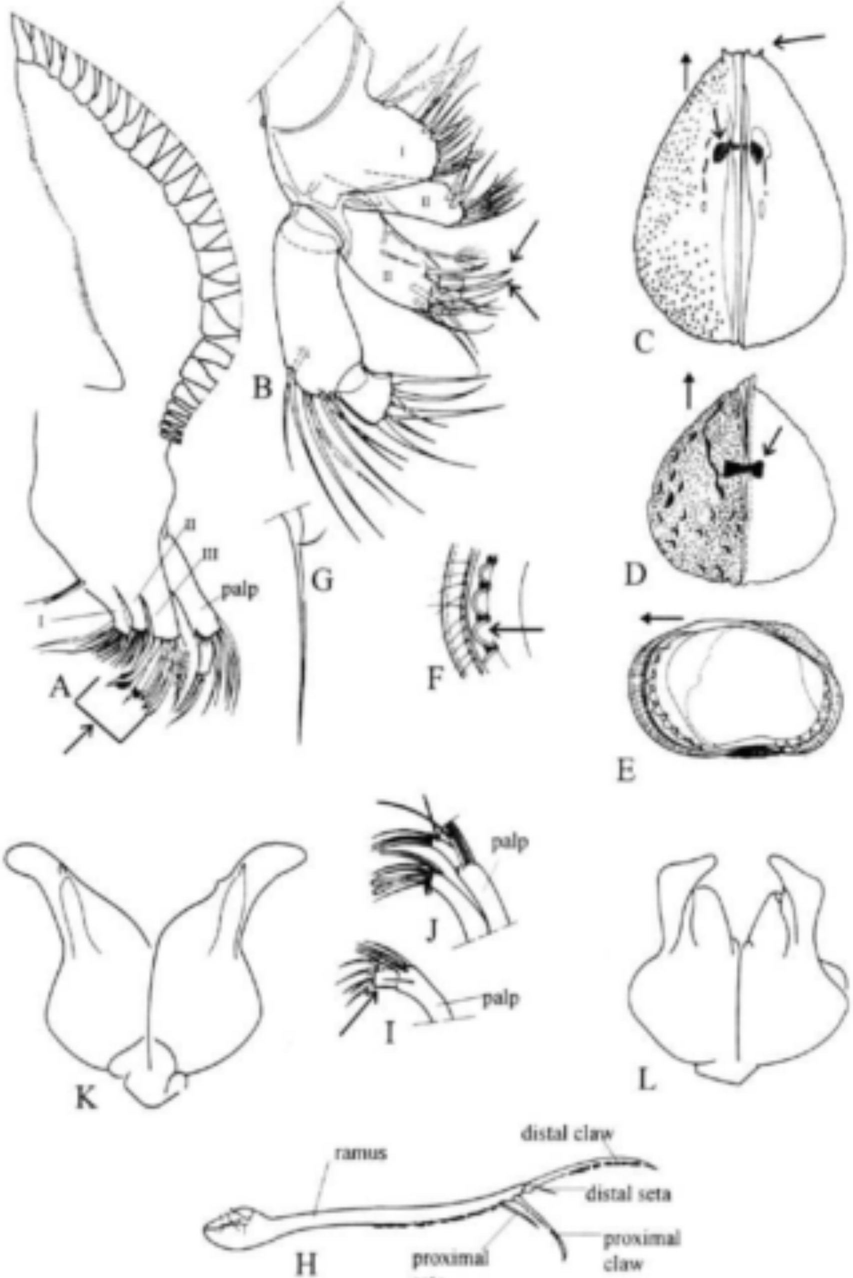


Fig. 1.6. A, *Oncocypris* sp, Maxillula. B, *Sclerocypris* sp., Maxillula. C, *Centrocypris* sp. carapace, dorsal view. D–G, *Oncocypris* sp.: D, carapace, dorsal view; E, right valve, internal view; F, detail of anterior margin; G, whip-like furca. H, *Sclerocypris* sp., 'normal' furca with two claws, two setae and a sclerified ramus. I, *Potamocypris* (*Cyprilla*) sp., Maxillulary palp. J, *Cypridopsis* sp., Maxillulary palp. K, *Plesiocypridopsis* sp., outline of hemipenes. L, *Sarscypridopsis* sp., outline of hemipenes. (B, H after Martens 1986).

——→ points towards the anterior of the animal; ——→ indicates distinctive features.

10\. Maxillula with terminal segment of palp distally widened (Fig. 1.6I) .... *Potamocypris*

– Maxillula with terminal palp segment cylindrical (Fig. 1.6J) *11*

11\. In dorsal view, left valve overlapping right valve anteriorly (Antennae attach and usually protrude from carapace anteriorly) (Fig. 1.7H, I, K) 12

– In dorsal view, right valve overlapping left valve anteriorly (Fig. 1.7B,D,F) 13

12 Surface of valves set with tubercules or spines (Fig. 1.7G–J) ....*Zonocypris*

– Surface of valves smooth, at most set with shallow pits (Fig. 1.7K, L).. *Cypridopsis*

13 Valves with rounded dorsal margin, subreniform in lateral view (Fig. 1.3J); natatory setae on Antenna short, not reaching tip of penultimate segment ....*Kapcypridopsis*

– Valves mostly subtriangular, nearly always with a blunt angle dorsally (Fig. 1.7 A,C,E); natatory setae on Antenna mostly well developed, reaching to or beyond tips of claws 14

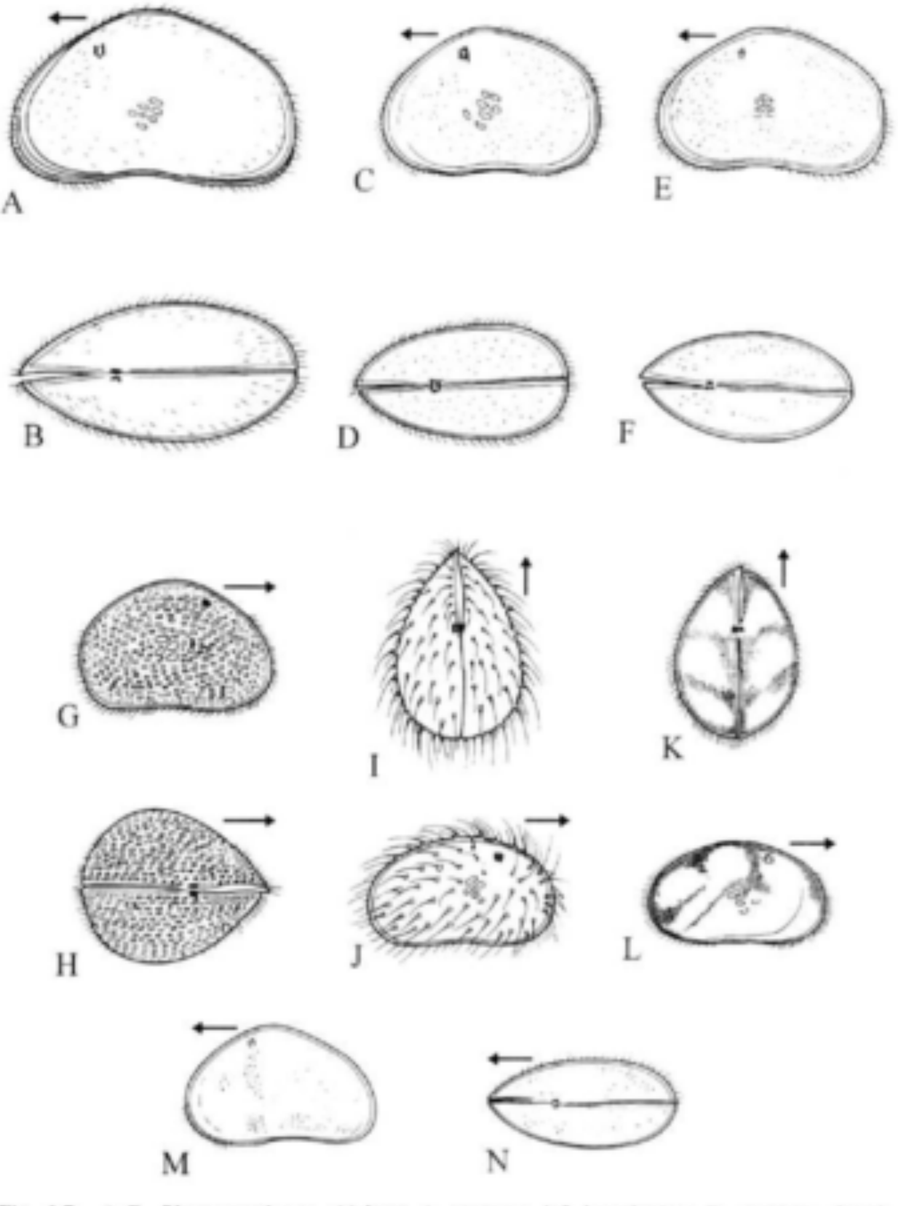


Fig. 1.7. A–B, *Plesiocypridopsis aldabrae*: A, carapace, left lateral view; B, carapace, dorsal view. C–D, *Sarscypridopsis gregaria*: C, carapace, left lateral view; D, carapace, dorsal view.
E–F, *Sarscypridopsis clavata*: E, carapace, left lateral view; F, carapace, dorsal view.
G–H, *Zonocypris cordata*: G, carapace, right lateral view; H, carapace, dorsal view.
I–J, *Zonocypris tuberosa*: I, carapace, dorsal view; J, carapace, right lateral view.
K–L, *Cypridopsis africana*: K, carapace, dorsal view; L, carapace, right lateral view.
M–N, *Sarscypridopsis ochracea*: M, carapace, left lateral view; N, carapace, dorsal view.
(All redrawn after Sars 1924*a*, 1924*b*).

→ points towards the anterior of the animal.

14. In undissected males, hemipenes with tips of lateral shield (the protruding lobes) curved upwards (but diverging when hemipenes, detached from rest of soft parts, but attached to each other, are flattened between slide and coverslip: Fig. 1.6K); surface of valves smooth, set only with hairs; basis of furca in females long with nearly parallel sides (Fig. 1.8A) .... *Plesiocypridopsis*

– In undissected males, hemipenes with tips of lateral shields curved downward (but converging when flattened: Fig. 1.6L);some species with valves set with spines (long or short), others striated or set only with hairs; basis of furca in females short, tapering (Fig. 1.8B) .... *Sarscypridopsis*

15. Third thoracopod with fourth (distal) segment (arrowed in Fig. 1.8C) clearly separated from third, bearing three setae 16

– Third thoracopod a cleaning limb, with fourth segment minute or fused with third segment, bearing one long seta, one flexible claw and a pincer-hook (arrowed in Fig. 1.8D, detailed in Fig. 1.8E) 19

16. Valves subrectangular, with surface heavily pitted and set with ridges, vertically plugged with deep folds (sulci) (Fig.1.8F, G); palps of fifth limb in females two- to three-segmented (arrowed in Fig. 1.8H) ....*Ilyocypris*

– Valves not as above; palps of fifth limb in females never fully divided into segments (Fig. 1.2B) 17

17. Natatory setae absent from Antennae; valves elongate and laterally compressed (Fig. 1.8I), about 1 mm long; furca without proximal seta (arrowed in Fig. 1.8J) .... *Candonopsis*

– Natatory setae on Antennae well developed (Fig. 1.8K); valves not elongate, small (<1 mm); furca with two setae and two claws (Fig. 1.6H) 18

18. Both valve margins without tubercles, right valve overlapping left valve anteriorly .... *'Cyclocypris'*

– Margin of right valve with tubercles (check at high magnification), left valve overlapping right valve anteriorly .... *Physocypria*

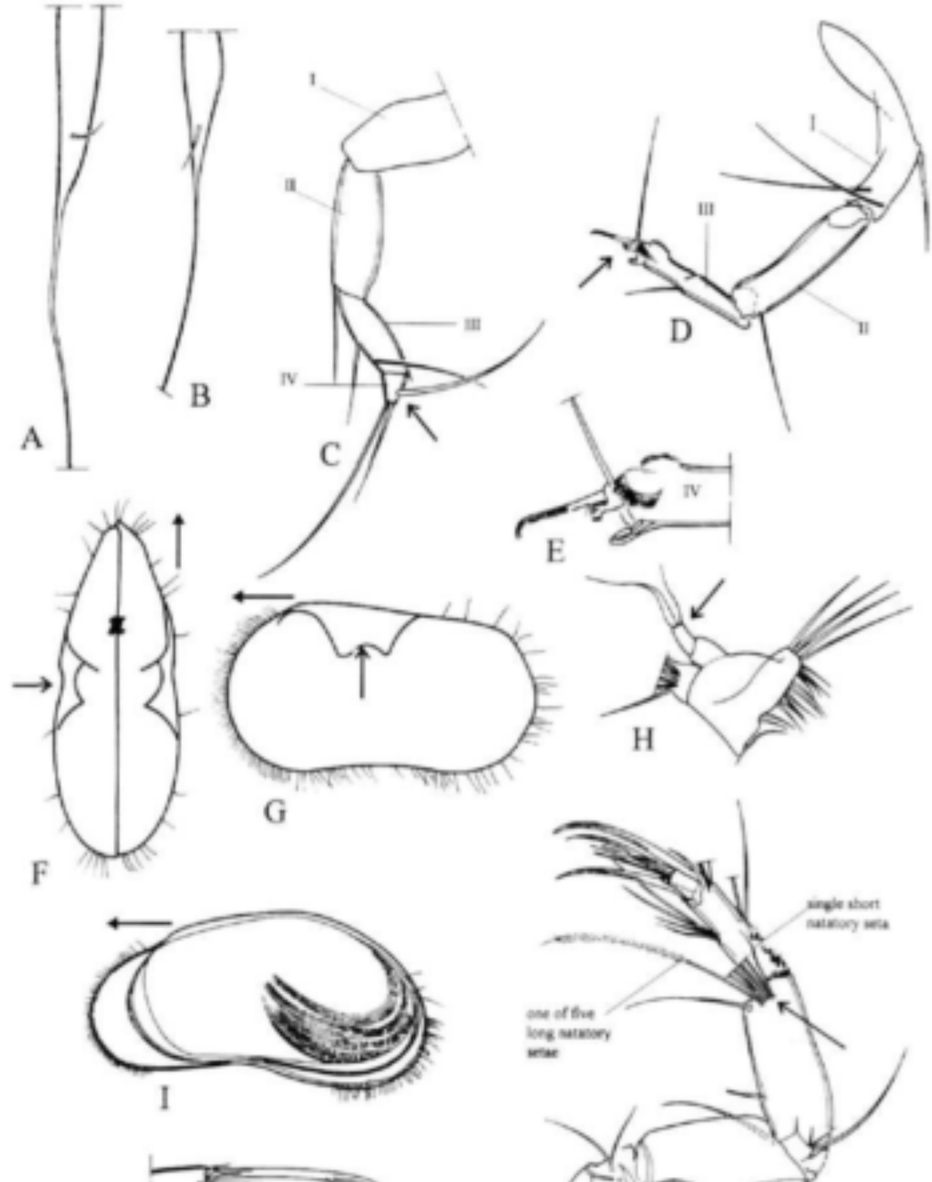


Fig. 1.8. A, *Plesiocypridopsis* sp., furca. B, *Sarscypridopsis* sp., furca. C, *Ilyocypris* sp., third thoracopod, showing separate fourth segment. D–E, *Sclerocypris* sp.: D, third thoracopod, showing pincer shaped distal part; E, detail of pincer. F–H, *Ilyocypris* sp.: F, carapace in dorsal view, showing lateral sulci. G, carapace in left lateral view; H, Maxillule of female, showing divided palp.
I–J, *Candonopsis* sp.: I, male carapace in left lateral view. J, distal part of furca, showing absence of proximal seta. K. *Sclerocypris* sp., Antenna. (D, E, K redrawn after Martens 1986; I, J after Martens 1984).
→ points towards the anterior of the animal; ⟶ indicates distinctive features.

19. Antennula with five flagellated claws (arrowed in Fig. 1.9A); all species longer than 2 mm (mostly larger, up to 8 mm) 20
– Antennula without flagellated claws; carapace mostly (but not always) less than 2 mm in length 24

20. Anterior selvage in both valves distinctly inwardly displaced (Fig. 1.9B–D) 21
– Anterior selvage not distinctly inwardly displaced in either valve (Fig. 1.9E, F) 23

21. Anterior selvage in right valve displaced over more than three-quarters of the distance between valve margin and inner margin (Fig. 1.9B,D); natatory setae on Antennae reaching tips of claws (Fig. 1.8K) 22
– Anterior selvage in right valve displaced over less than one-third of the distance between valve margin and inner margin (Fig. 1.9C); natatory setae on Antennae not reaching tip of penultimate segment (arrowed in Fig. 1.9G) .... *Megalocypris*

22. Posterior part of ovaria turned in ventral direction (Fig. 1.9D) .... *Hypselecypris**
– Posterior part of ovaria turned in dorsal direction .... *Sclerocypris*

23. Dorsal margin nearly straight; right valve with a conspicuous inner list (Fig. 1.9E) .... *Apatelecypris*
– Dorsal margin rounded, high; right valve without prominent inner list (Fig. 1.9F) .... *Eundacypris*

24. One or both valves with marginal septa (Fig. 1.9 H–J) 25
– No marginal septum in either valve 28

25. Marginal septa in both valves 26
– Marginal septum in right valve only 27

26. Valves globular, short and high (Fig. 1.9 H, I); furcae slender, symmetrical .... *Cypretta*
– Valves elongated, laterally flattened (Fig. 1.9J); left and right furcae strongly asymmetrical, especially in the armature of rami and claws (Fig. 1.10A,B) .... *Stenocypris*

* Not yet recorded in southern Africa

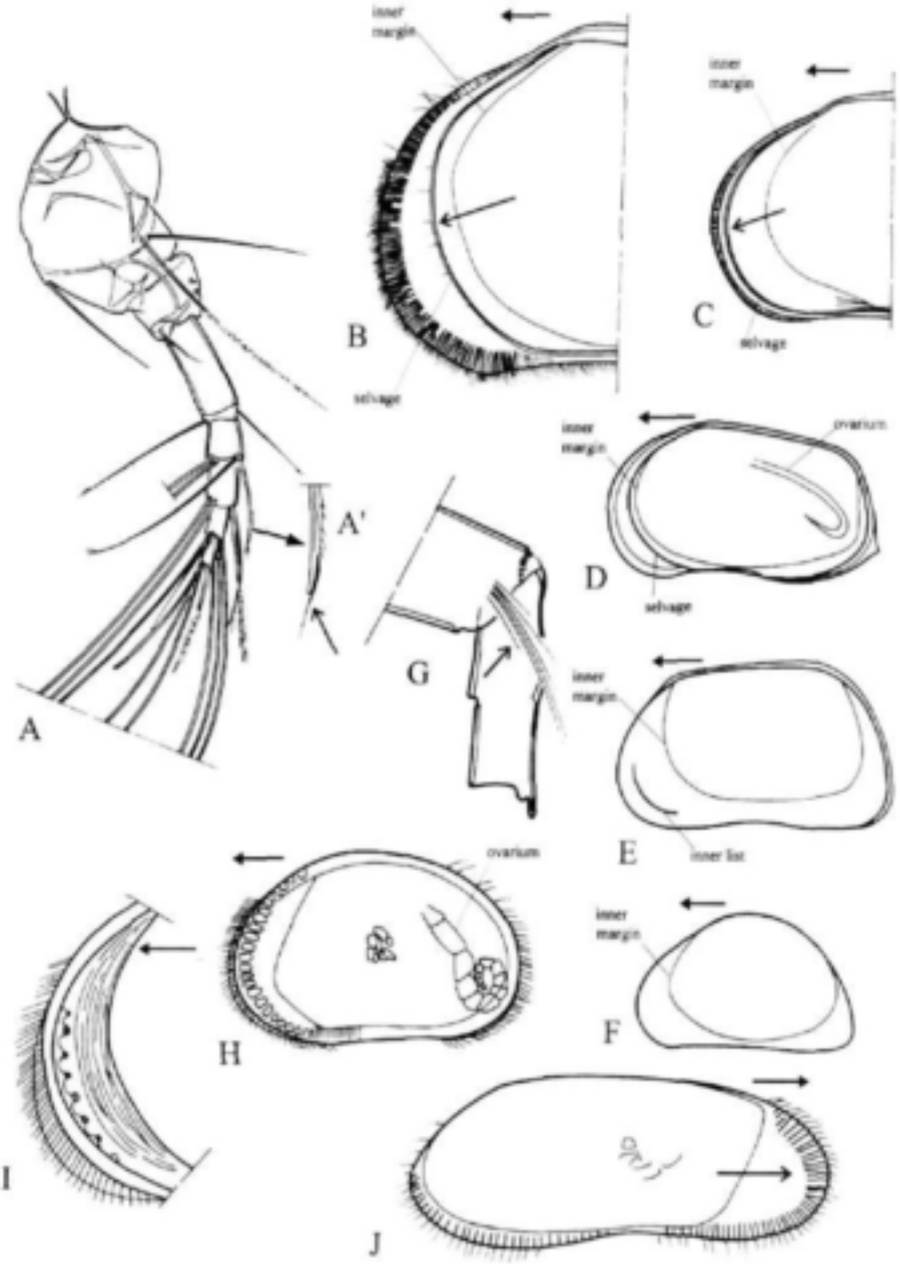


Fig. 1.9. A, *Sclerocypris* sp., Antennula, showing flagellated claws (detailed in A'). B, *Sclerocypris sarai*, structure of anterior margin of right valve (internal view). C, *Megalocypris* sp., structure of anterior margin of right valve (internal view) D, *Hypselecypris wittei*, internal view of right valve. E, *Apatelecypris schultzei*, internal view of right valve. F, *Eundacypris superba*, internal view of right valve. G, *Megalocypris* sp., Antenna, showing short natatory setae. H–I, *Cypretta* sp.: H, right valve internal view, showing marginal septa; I, detail of anterior margin. J, *Stenocypris major*, carapace in right lateral view, showing marginal septa. (A, A', B, C, G redrawn after Martens 1986).
→ points towards the anterior of the animal; ⟶ indicates distinctive features.

27. Surface of valves striated .... *Paracypretta*
– Surface of valves smooth .... *Bradycypris*

28. Left and right furcae asymmetrical, with three claws (proximal bristle changed into a claw-like spine (arrowed in Figs. *1.10 C–D*) and a distal seta 29
– Left and right furcae symmetrical or asymmetrical, with proximal bristle either missing a seta, never claw-like (Figs 1.6H) 30

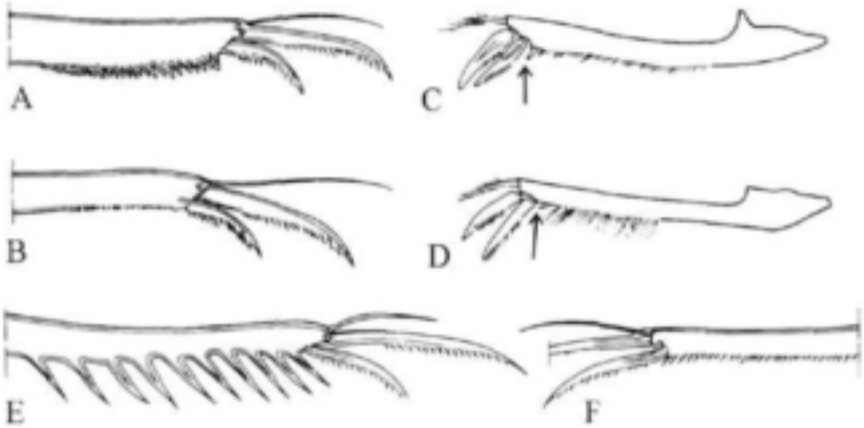


Fig. 1.10. A–B, *Stenocypris major*: A, distal part of left furca; B, distal part of right furca. C–D, *Mesocypris terrestris* (with arrows indicating claw-like proximal seta): C, distal part of right furca; D, distal part of left furca.. E–F, *Parastenocypris junodi*: E, distal part of left furca; F, distal part of right furca. (A, B after Martens 1984; C, D after Harding 1953).

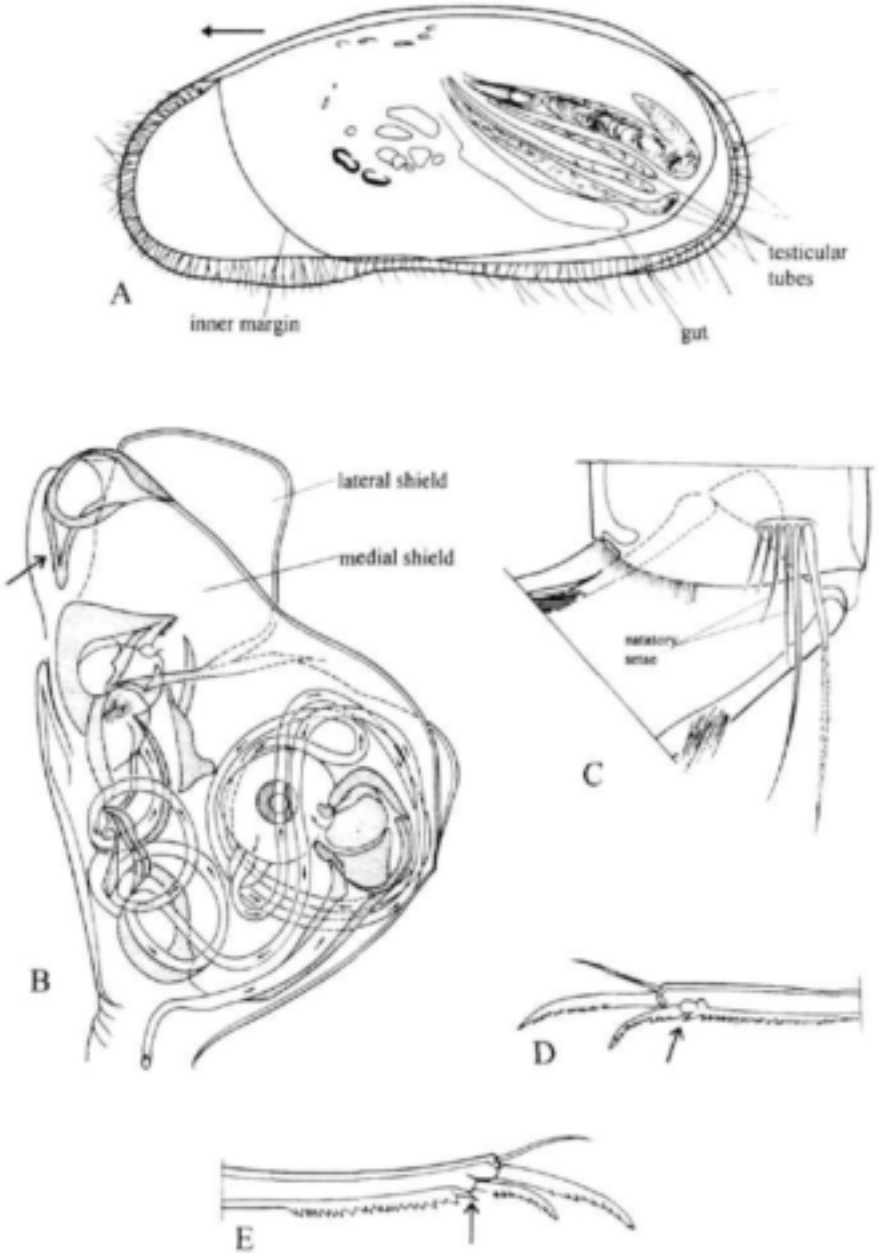


Fig. 1.11. A–E, *Humphcypris greenwoodi*, male: A, right valve, internal view; B, hemipenis; C, part of antenna, showing short natatory setae; D–E, furcae showing claw-like proximal setae: D, right furca, distal part; E, left furca, distal part.

(All redrawn after Martens 1997).

⟶ points towards the anterior of the animal; ⟶ indicates distinctive features.

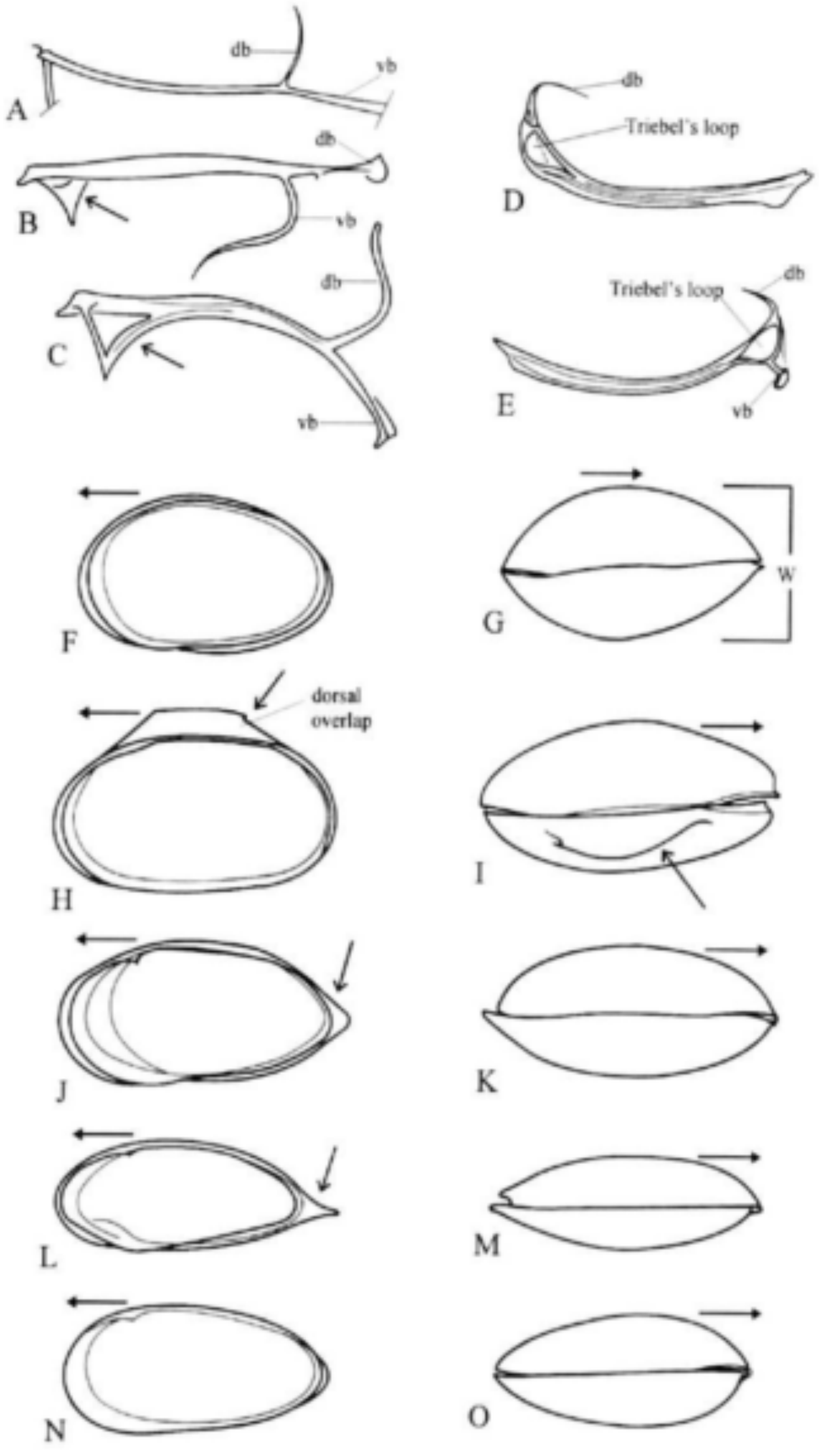
29. Small and rounded, valves densely set with long setae; eyes absent; terrestrial .... *Mesocypris*
– Longer and elongated, not hairy; eyes present; aquatic 35

30. Furcal attachment distally with loculi (Triebel's loop: Fig. 1.12D, E) 31
– Furcal attachment distally without such loculi (Fig. 1.12A–C) 33

31. Furcal attachment without ventral branch (Fig. 1.12D); valves laterally flattened .... *Tanycypris*
– Furcal attachment with dorsal and ventral branch (Fig. 1.12E); width of valves at least one-third of length 32
32. Carapace semi-globular (Fig. 1.12F, G) or with a dorsal outgrowth on right valve (arrowed in Fig. 1.12H, I) .... *Strandesia*
– Carapace elongated, with caudal process (Fig. 1.13J–M, arrowed in Fig. 1.12 J, L) or without caudal process (Fig. 1.12N, O) .... *Cypricercus*

33. Left and right furcae symmetrical 34
– Left and right furcae asymmetrical, especially in the armature of rami and claws (Fig. 1.10A,B,E,F) 36

Fig. 1.12. A, *Sclerocypris* sp., furcal attachment (note: no Triebel's loop or basal triangle). B, *Parastenocypris hodgsoni*, furcal attachment, (note: weakly developed basal triangle and no Triebel's loop). C, *Herpetocypris* sp., furcal attachment, (note: strong basal triangle and no Triebel's loop). D, *Tanycypris* sp., furcal attachment, showing Triebel's loop (note: no ventral branch). E, *Cypricercus* sp., furcal attachment, showing Triebel's loop. F–G, *Strandesia vavrai*: F, female right valve internal view; G, carapace in dorsal view. H–I, *Strandesia mercatorum*: H, female right valve, internal view; I, carapace in dorsal view. J–K, *Cypricercus episphaena*: J, female right valve, internal view; K, carapace in dorsal view. L–M, *Cypricercus* sp. nov.: L, male right valve, internal view; M, carapace in dorsal view. N–O, *C. cuneatus*: N, male right valve, internal view; O, carapace in dorsal view. (A redrawn after Martens 1986; F–O redrawn from unpublished SEM micrographs.)
KEY: db = dorsal branch; vb = ventral branch; w = width of carapace.
→ points towards the anterior of the animal; → indicates distinctive features.


A
db
vb
B
db
vb
C
db
vb
D
db
Triebel's loop
E
Triebel's loop
db
vb
F
G
W
H
dorsal overlap
I
J
K
L
M
N
O

34. Marginal pore canals branched (Fig. 1.13B); some species with valves pointed anteriorly or posteriorly ....*Parastenocypris**
– Marginal pore canals simple and straight (Fig. 1.13C); valves always rounded anteriorly and posteriorly ....*Chrissia*

35. Natatory setae on Antenna short, not reaching halfway down the penultimate segment (Fig. 1.11C) .... *Humphcypris*
– Natatory setae on Antenna long, mostly reaching about halfway to the end of the claws (Fig. 1.7K) .... *Ilyodromus*

36. Furcal attachment proximally with a sclerotized triangle (arrowed in Fig. 1.12B, C); valves, when seen with transmitted light, with dots in between the normal pore canals; valves always elongated 37
– Furcal attachment without a clearly delimited proximal triangle (Fig. 1.12A); *no such dots on valves; valve shapes may vary* 38
37. Left valve posteriorly pointed (Fig. 1.13A); furca without proximal seta (Fig. 1.10B) ....*Acocypris*
– Left valve posteriorly rounded; furca with two claws and two setae (Fig. 1.6H) ....*Herpetocypris*

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* NOTE ADDED IN PROOF: Martens (2001— *Crustaceana* **74**(3): 295–308) has recently placed *Parastenocypris* into the synonymy of *Chrissia*.

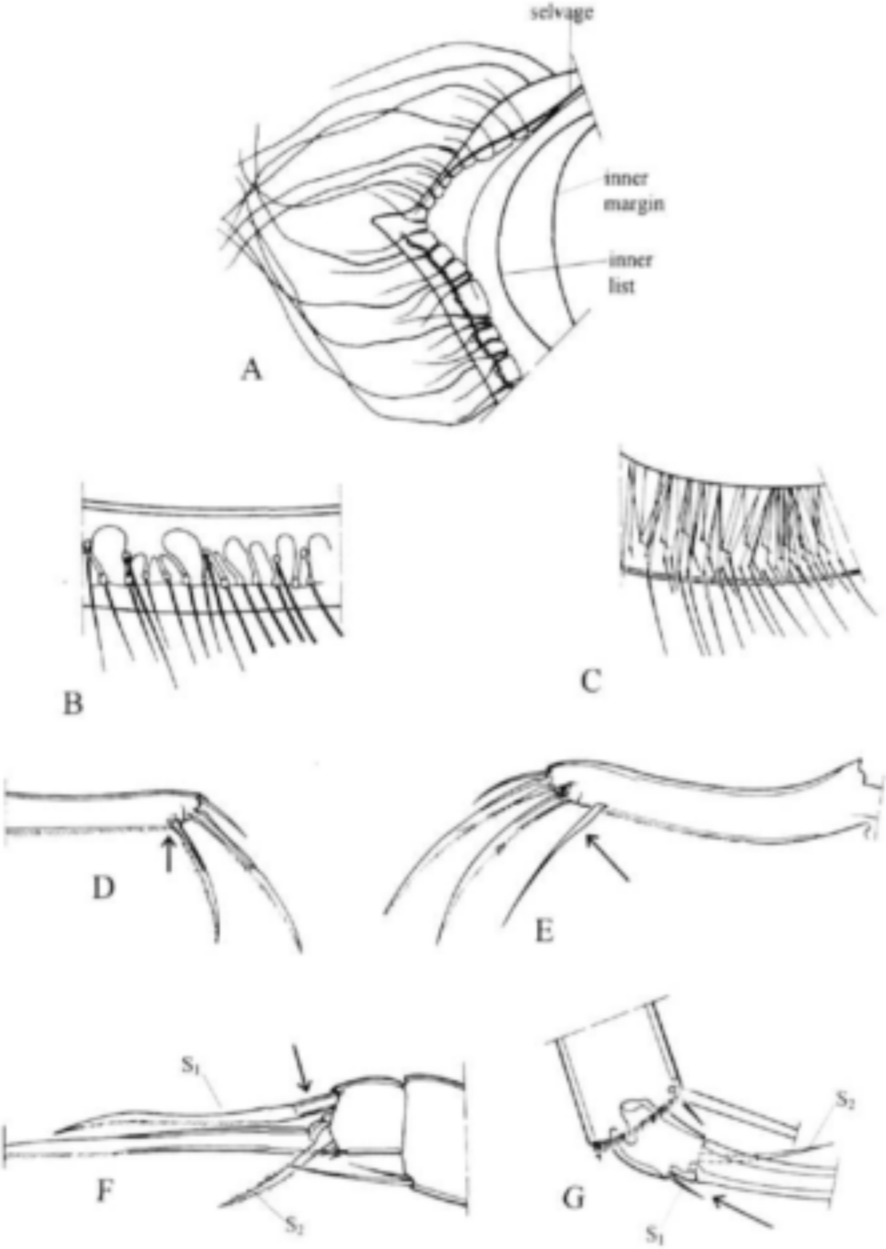

Fig. 1.13. A, *Acocypris capillata*, left valve, internal view, detail of caudal margin. B, *Parastenocypris* sp., ventral margin of left valve, showing branching pore canals. C, *Chrissia* sp., ventral margin of left valve, showing simple and straight pore canals. D, *Amphibolocypris* sp., furca, showing absence of proximal seta. E, *Isocypris* sp., furca, showing long proximal seta. F, *Amphibolocypris* sp., distal part of second thoracopod, showing long claw-like seta S_2. G, *Isocypris* sp., distal part of second thoracopod, showing short seta S_1.
(B after Hartmann 1964; C after Hartmann 1957)

38. Posterior inner margin running on valve margin, with no part of the caudal inner lamella calcified (Fig. 1.17B);valves thin and semi-oval. (Note: '*Isocypris*' *nivea* (Fig. 1.17A) has a solid uncalcified caudal inner lamella that could be mistaken for a calcified inner lamella, and which will then show an inner margin) 39
– Posterior inner margin clearly distinct from valve margin (see Fig. 1.8D–F)... 40

39. Second thoracopod with subterminal seta S_1 (arrowed in Fig. 1.13F) on terminal segment developed into a second claw, always longer than one-half of the terminal claw; furca without proximal seta (Fig. 1.13D) .... *Amphibolocypris*
– Second thoracopod with subterminal seta S_1 short, about one-tenth of length of terminal claw (arrowed in Fig. 1.13G); furca with two claws and two setae (Fig. 1.13E) .... *Isocypris*

40. Third segment of third thoracopod with two lateral setae (arrowed in Fig. 1.14A) .... *Candonocypris*
– Third thoracopod with only one lateral seta on third segment (two arrows in Fig. 1.7D) 41

41. Segment III of second thoracopod undivided (Fig. 1.14D,E) 42
– Segment III of second thoracopod divided (Fig. 1.14B,C) 43

42. Anterior selvage largely inwardly displaced in both valves; lateral spines and ala sometimes present, but no ventral ala; seta d_1 on second thoracopod about three times as long as seta d_2 (Fig. 1.14E) .... *Cypris*
– Frontal selvage in both valves submarginal; all but one species with ventral ala (Fig. 1.14F,G); seta d_2 missing from second thoracopod (Fig. 1.14D)....... .... *Pseudocypris*

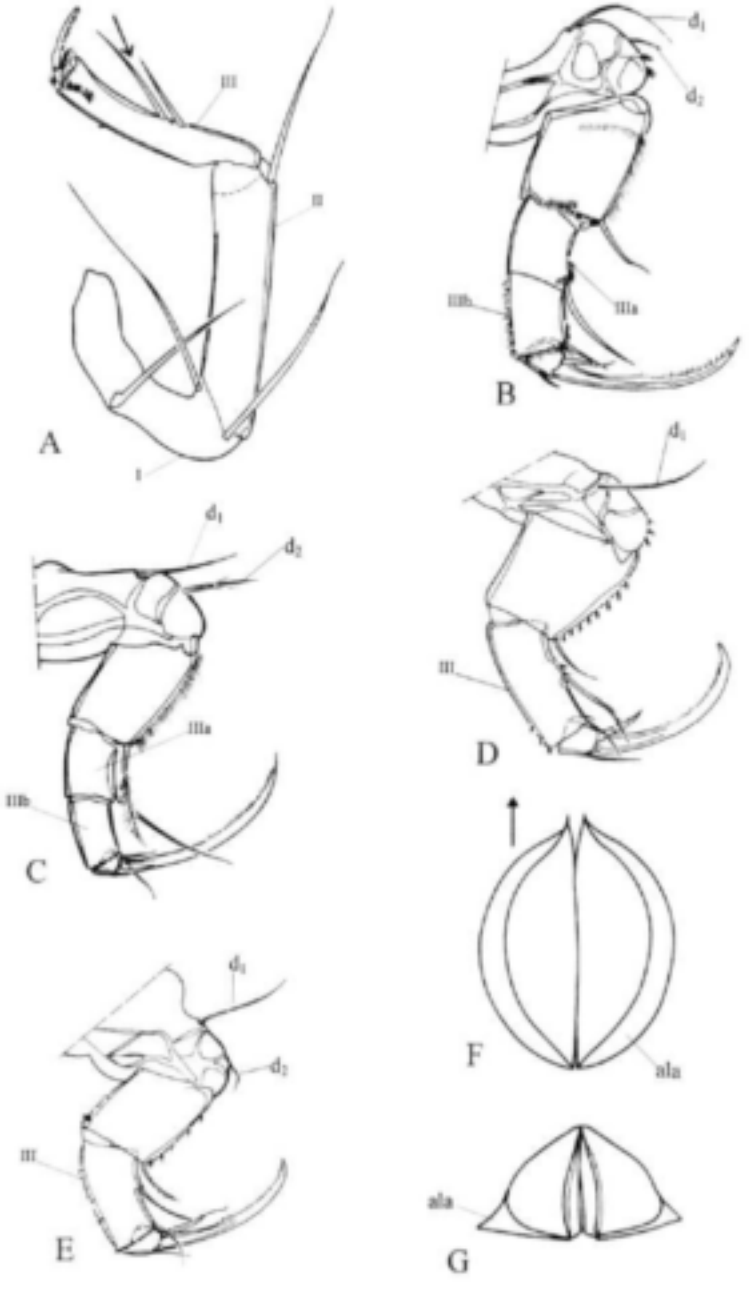

Fig. 1.14. A, *Candonocypris novaezelandiae*, third thoracopod showing two setae on segment III.
B, *Ramotha* sp., second thoracopod, showing setae d_1 and d_2 and divided segment III.
C, *Globocypris trisetosa*, second thoracopod, showing setae d_1 and d_2 and divided segment III.
D, *Pseudocypris* sp., second thoracopod, showing setae d_1 and d_2 and undivided segment III.
E, *Cypris* sp., second thoracopod, showing setae d_1 and d_2 and undivided segment III.
F, *Pseudocypris acuta*, carapace in dorsal view. G. *Pseudocypris acuta*, carapace in frontal view.
(B redrawn after Martens 1991*a*; C–E after Martens 1990*b*); F, G after Sars 1924*a*).
——→ points towards the anterior of the animal; ——→ indicates distinctive features.

43. At least one valve with anterior selvage largely inwardly displaced (Fig. 1.15B,C) 44
– No inwardly displaced anterior selvage on either valve (Fig. 1.15A) 46

44. Anterior selvage inwardly displaced on right valve only (Fig. 1.15B,C,E); left valve with a large frontal inner list (Fig. 1.15F; seta d_1 on second thoracopod about three times as long as seta d_2 (Fig. 1.14B) .... *Ramotha*
– Anterior selvage on both valves inwardly displaced; setae d_1 and d_2 on second thoracopod sub-equal in length (Fig. 1.14C) 45

45. Valves globular (i.e. width of animal about two-thirds of length); length about 1.5 mm .... *Globocypris*
– Valves elongate (i.e. width of animal about one-half of length); length about 5 mm ....*Afrocypris*
46. One of the valves with marginal denticulations (Fig. 1.15A') 47
– Neither valve with marginal denticulations 49

47. Right valve denticulate along anterior and posterior margins (Fig. 1.15A, A'); left valve overlapping right valve anteriorly when seen in dorsal view 48
– Left valve denticulate along anterior and posterior margin; right valve overlapping left valve anteriorly .... *Hemicypris*

48. Right valve with dorsal outgrowth (arrowed in Fig 1.15A) .... *Cyprinotus*
– No such dorsal protuberance ....*Heterocypris*

49. Valves large (5 mm or more in length), laterally compressed (Fig. 1.15G)...... ....*Liocypris*
– Valves at most 3 mm in length, not laterally compressed 50
50. First thoracopod with a 'c' seta (as in Fig. 1.15D); in dorsal view anterior end with wart-like tubercles ....*Eucypris* s.s.*
– First thoracopod without a 'c' seta (as in Fig. 1.2B); no wart-like tubercles...... .... *Homocypris*

* not yet recorded in southern Africa.

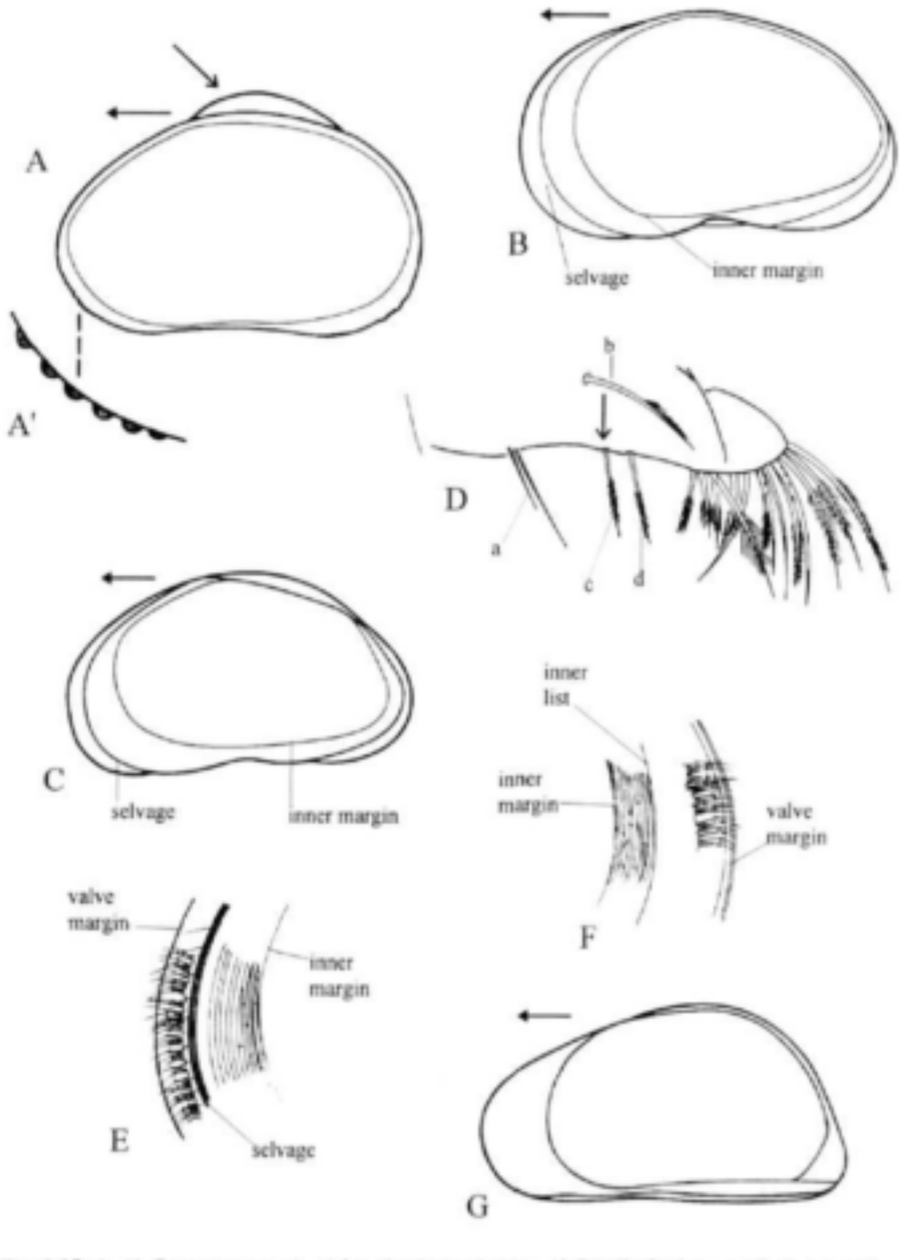

Fig. 1.15. A–A', *Cyprinotus* sp.: A, right valve internal view; A', Detail of valve margin. B, *Ramotha purcelli*, right valve internal view. C, *Ramotha producta*, right valve internal view. D, *Eucypris* s.s. sp. , first thoracopod (T1), showing position of seta 'c'. E–F, *Ramotha* sp.: E, schematic representation of anterior margin of right valve, showing position of selvage; F, schematic representation of anterior margin of left valve showing absence of selvage and presence of large inner list. G. *Liocypris grandis*, right valve internal view. (E, F after Lindroth 1957).
⟶ points towards the anterior of the animal; ⟶indicates distinctive features.

51. Right valve without postero-ventral keel, left valve with or without internal teeth (Fig. 1.16E); second segment of Antennula with three ventral setae (Fig. 1.16C); exopodite of Antenna with two setae and a spine (Fig. 1.16D) 52
– Right valve with postero-ventral keel (Fig. 1.16F); left valve with antero-ventral internal tooth (Fig. 1.16E); second segment of Antennula with two ventral setae (Fig. 1.16A); exopodite of Antenna with one seta and a spine (Fig. 1.16B) .... *Vestalenula*

52. Left valve with or without internal teeth; last segment of mandibular palp with fewer than five claws (three or four), penultimate segment with seta 'y' short or absent (*Fig. 1.16H, I*) 53
– Left valve with internal teeth (Fig. 1.16E); last segment of mandibular palp with five claws, penultimate segment with seta 'y' long .... *Penthesilenula*

53. Left valve without internal teeth; right valve overlapping left valve, length >0.65 mm; penultimate segment of mandibular palp with seta 'z' long, seta 'y' short; setae 'a' and 'b' present (Fig. 1.16G) .... *Darwinula*
– Left valve with internal teeth (Fig. 1.16E); right valve overlapping left valve, *or visa versa*, length < *0.65 mm*; penultimate segment of mandibular palp with seta 'z' short, seta 'y' absent, seta 'a' absent (Fig. 1.16H) .... *Alicenula*

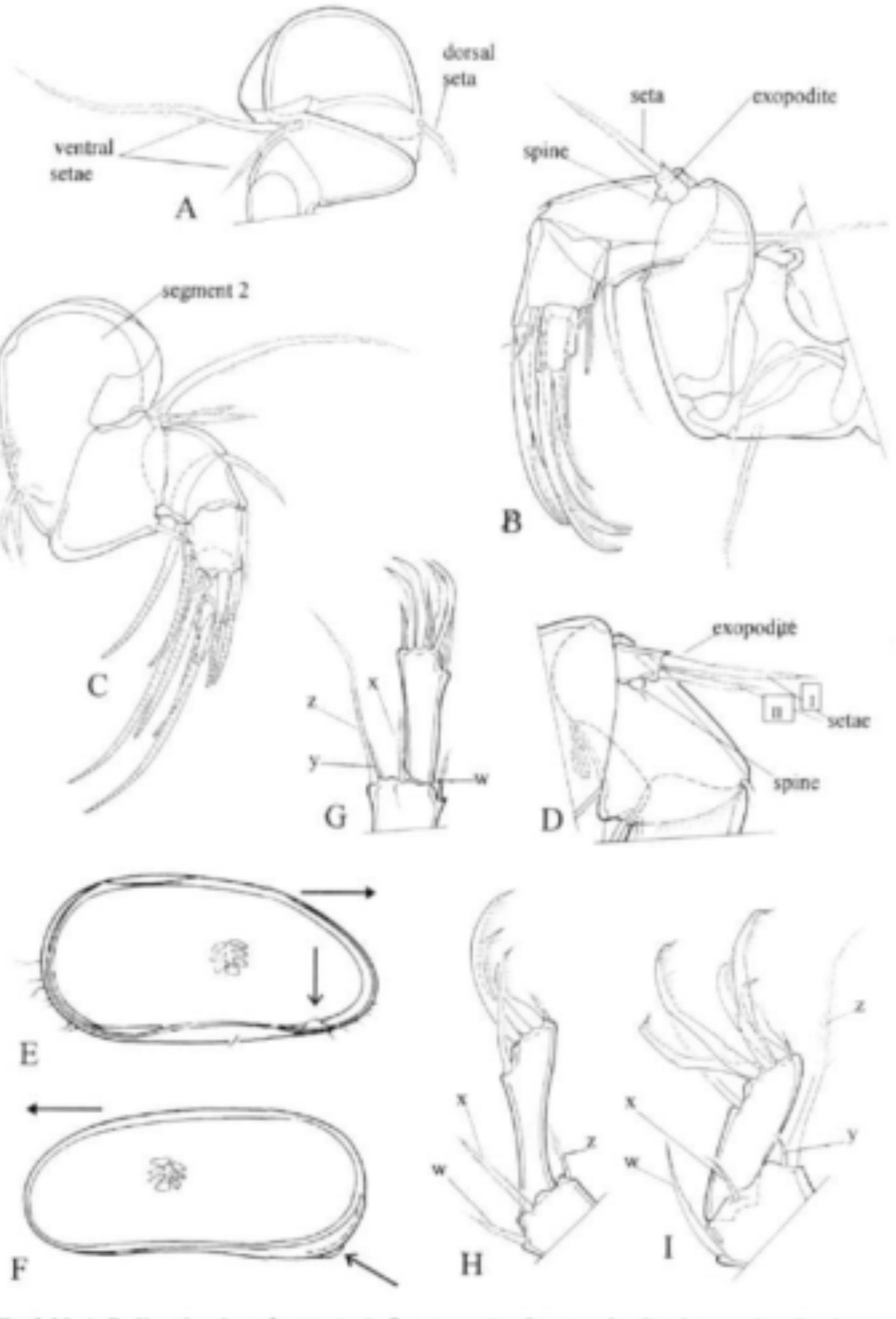

Fig. 1.16. A–B, *Vestalenula molopoensis*: A, first segments of Antennula, showing one dorsal and two ventral setae; B, Antenna, showing exopodite with one seta and one spine. C–D, *Alicenula inversa*: C, Antennula, showing two dorsal , and three ventral setae on first segment; D, detail of Antenna, showing exopodite with two seta and one spine. E–F, *Vestalenula* sp.: E, left valve, internal view, showing antero-ventral internal tooth; F, right valve, internal view, showing postero-ventral external keel. G, *Darwinula stevensoni*, distal part of Mandibular palp. H, *Alicenula inversa*, distal part of Mandibular palp. I. *V. molopoensis*, distal part of Mandibular palp.
(All redrawn after Rossetti & Martens 1998). KEY: w, x, y, z indicate special setae.
→ points to the anterior of the animal; → indicates distinctive features.

ADDITIONAL NOTES ON SELECTED OSTRACOD TAXA

The state of knowledge of South African non-marine ostracods is very unevenly distributed over the different taxonomic groups. Some groups have been revised at the specific level and are more extensively elaborated on below. Others, like most Cypridopsinae, are still in a state of taxonomic confusion, with considerable uncertainty about the validity of certain species and a general absence of good diagnostic characters. The present section gives specific keys and some taxonomic notes on groups that have been revised in recent years; a complete list of all recorded species in the region follows in Table 1.1.

Superfamily **DARWINULOIDEA** (Brady & Norman, 1889)

Family **Darwinulidae** Brady & Norman, 1889

(revised by Rossetti & Martens 1998)

This is the only extant family within the superfamily. Four of the five known genera have representatives in the region. Individuals of all species are small, less than 1 mm in length, and generally occur in low densities in permanent habitats.

Alicenula Rossetti & Martens, 1998

Type species: Darwinula serricaudata Klie, 1935

Figs 1.16C, D, H

Characteristic features

Valves elongated (*c.* 0.6 mm long), with antero-ventral and posterior internal teeth in the LV and without ventral keel on the RV. RV overlapping LV or LV overlapping RV. Dorsal margin evenly sloping. First segment of A1 with two dorsal setae, second segment with one dorso-apical seta and three ventral setae. A2 with two long setae and a spine on exopodite; first endopodal segment with two ventro-apical setae. Seta '*y*' on penultimate segment of Md-palp absent. Adults with postabdomen mostly large and spinous.

Southern African species.

The only known representative of this genus in southern Africa to date is *Alicenula inversa*, originally described from dolomitic springs, lakes and rivers in the North West Province. This species has a RV/LV overlap and is relatively small, about 0.5 mm long. The presence of the type species, *A. serricaudata*, with a LV/RV overlap, in the northern part of the region is to be expected.

Darwinula Brady & Robertson, 1885

Type species: Darwinula stevensoni (Brady & Robertson, 1870)
Figs 1.3B, C, 1.18G

Characteristic features

Valves in lateral view, generally oblong and elongate, cigar-shaped (about 0.7 mm long), without internal teeth in the LV and without ventral keel on the RV. RV overlapping LV. First segment of A1 with two dorsal setae, second segment with one dorsal and three ventral setae; fourth segment of endopodite with two dorsal setae. A2 with two long setae and a spine on exopodite; first endopodal segment with two ventro-apical setae. Seta *y* much shorter than seta *z* on penultimate Md-palp segment. Penultimate segment of T1 palp with two setae. Postabdomen present. Furca absent in adults, present in juveniles.

Southern African species

The genus is monospecific. *Darwinula stevensoni* occurs in southern Africa in the benthos of lakes and in the sediment of rivers. The species is not rare, but generally occurs in low densities.

Penthesilenula Rossetti & Martens, 1998

Type species: Darwinula incae Delachaux, 1928.

Characteristic features

Small (length *c.* 0.4 mm) to relatively large (length = 0.8 mm) darwinulids, sub-rectangular in lateral view, with dorsal margin straight over at least part of its length, anterior margin narrowly rounded, caudal margin nearly straight. LV generally overlapping RV on all sides except dorsal side. LV with two rounded internal teeth (antero-ventral and postero-ventral). RV without postero-ventral keel. First segment of A1 with two dorsal setae, second segment with three ventral setae and one dorsal seta. A2 exopodite with two long setae and a spine, first endopodal segment with two ventro-apical setae. Setae *y* and *z* on penultimate segment of Md-palp both long, subequal.

Southern African species

Penthesilenula brasiliensis is the only southern African representative of this genus and has been recorded as isolated specimens from streams in the Drakensberg.

Vestalenula. Rossetti & Martens, 1998

Type species: Darwinula boteai Danielopol, 1970.

Figs 1.18A, B, E, F, I

Characteristic features

Small darwinulids (length mostly 0.6 mm or less), with valves elongate or short and subquadrate. RV with a short, postero-ventral, external keel. LV with short (rounded) internal antero-ventral tooth, no caudal or caudo-ventral internal teeth. LV overlapping RV. Dorsal margin straight over part of its length. First segment of A1 with one dorsal seta, second segment with two ventral setae; fourth segment without ventro-apical seta. A2 with one long setae and a spine on exopodite. Seta *y* on penultimate Md-palp segment short; last segment with five apical claws. Adults mostly with furca, postabdomen smooth or absent.

Southern African species

This is the most speciose darwinulid genus, with species living either interstitially or associated with hyporheic habitats. There are at least three species in southern Africa. *Vestalenula molopoensis* occurs in dolomitic springs, lakes and rivers in the North West Province; *V. flexuosa* is known from springs in northern Namibia and thus far, an undescribed species occurs in or near Lake Sibaya (northern KwaZulu-Natal). *Vestalenula flexuosa* differs from all other species in the genus by its pronounced asymmetry between anterior and posterior sides in dorsal and ventral views. The species can further be distinguished from *V. molopoensis* by the longer and more sloping dorsal margin, by the form and position of the keel on the RV (which is more pronounced in the latter species) and by the fact that *V. molopoensis* generally has a slightly different pattern and fewer (7–8) central muscle scars.

SUPERFAMILY **Cytheroidea** Baird, 1850

Family **Limnocytheridae** Klie, 1938

Subfamily **Limnocytherinae** Klie, 1938

(revised by Danielopol et al. 1990, Martens 1990a, 1991b)

This is the most common sub-family of the Cytheroidea in non-marine habitats. Four genera have representatives in southern Africa. In none of these do females have brood pouches.

Korannacythere Martens, 1996

Type species: Korannacythere devriesi Martens, 1996

Figs 1.4 A–J

Characteristic features

Individuals small (length ≤0.5mm), with anterior cardinal teeth in the hinge of the RV absent, posterior cardinal teeth in RV minute or absent, hinge bar in LV smooth; almost no sexual dimorphism in valve shape and structure. Marginal pore canals few, about ten along anterior margin, short and straight, not branched; fused zone narrow. A2 with three curved apical claws, two proximal ones spinuous, in both sexes; exopodite shorter in males than in females (length of this exopodite in both sexes is species specific). Hemipenis simple, with both upper ramus and lower ramus of clasping organ absent; furca with a short base and three setae, copulatory process simple, sickle-shaped.

Southern African species

The genus is endemic to the Drakensberg region of southern Africa. Three species have thus far been described: *Korannacythere devriesi* occurs in the western part of the Drakensberg (Free State), *K. ugiensis* was described from the southern part (Eastern Cape and southern part of Kwa-Zulu–Natal) and *K. hamerae* is common in the East, namely in KwaZulu–Natal. All species can easily be distinguished by the shape of the valves, the length of the A2 exopodite in the males, and the shape of the copulatory process on the hemipenis. All species occur in very similar habitats, namely temporary rockpools at altitudes between 1900 and 2400 m.a.s.l. The morphological radiation in this genus was discussed from an evolutionary point of view in Martens (2000).

Limnocythere Brady, 1868

Type species: Cythere inopinata Baird, 1843

Figs 1.3A, G, H, L, M

Characteristic features

Males more elongated and mostly longer than females. In dorsal view carapace with anterior side sometimes building a rostrum, posterior side always with LV overlapping RV. Hinge with anterior cardinal tooth on RV of variable size and shape. Hemipenis with three furcal setae, a lower ramus consisting of a lateral process and a prominent, hook-like process, with upper ramus either reduced to an elongated tentacle or completely absent. A1 and T3 without special features.

Southern African species

This genus has shown a considerable radiation in the East African Rift Valley lakes, the exact extent of which still remains unknown (Martens 1990a). Four species have been reported from southern Africa. They can be identified on the shape of the valves and, where males are known, on the morphology of the hemipenis. *Limnocythere inopinata* only occurs in parthenogenetic populations in the region and is almost certainly an introduced (Holarctic) species. *Limnocythere tudoranceai* is most likely of East African origin, while *L. aethiopica* is an endemic of the Lake Chrissie area (Mpumalanga). Both *L. tudoranceai* and *L. aethiopica* occur in sexual populations. *Limnocythere stationis* belongs to a group of asexual species in the genus. It is known from an artificial impoundment in KwaZulu–Natal and could also be a European introduction.

Leucocythere Kaufmann, 1892

Type species: L. mirabilis Kaufmann, 1892

Fig. 1.3D

Characteristic features

Carapace with sexual dimorphism in size and shape: females with a paedomorphic shape and of smaller size than the male. Hinge with anterior cardinal tooth on RV considerably smaller than posterior one; intercardinal bar crenulated, with ridges more pronounced at both extremities than in the centre. Seta on first endopodial segment of A2 shorter in males than in females. Third walking limb in males of aberrant shape: first endopodial segment with a hyper-elongated and swollen seta and with distal claw long, slender and strongly curved. Male copulatory appendage with reduced clasping organs, consisting of two short, poorly sclerified rami, upper ramus with a lamellar shape; copulatory process shaped as a spiral, distal part of apex tubular.

Southern African species

The only species thus far reported from the region, *L. helenae*, is known from one locality only in the Eastern Cape, namely a temporary system of streams and pools near Grahamstown (Martens 1991b).

Ovambocythere Martens, 1989

Type species: O. milani Martens, 1989

Fig. 1.3K

Characteristic features

Male valves about as long as female valves, those of females, however, being significantly higher and somewhat wider in dorsal view; dorsal margin in females curved, caudally sloping. Valve surface in both sexes pitted, except for two dorsal lobes and a ridge running along the anterior and the ventral margins of both valves. Hinge with bar of RV weakly crenulated; posterior and anterior teeth prominent, the anterior tooth being the largest. A1 in both sexes with terminal segment long and straight, T3 in males of the *Limnocythere*– rather than the *Leucocythere*-type. Hemipenis large, with furca consisting of two setae and a hook-like structure; lower ramus a three-dimensional plate, upper ramus a long process.

Southern African species

The genus is monospecific, and the type species is known from its type locality only. Specimens were raised in the lab from dried mud collected from a completely desiccated pan in Ovamboland, northern Namibia.

Subfamily **Timiriaseviinae** Mandelstam, 1960

Only one of the seven extant genera of the subfamily occurs in this region.

Gomphocythere Sars, 1924

Type species: Limnicythere (sic) *obtusata* Sars, 1910.

Fig. 1.3E, N

Characteristic features

Females with a brood pouch, causing considerable sexual dimorphism in the width of the carapace. Valves with inverse hinge (with teeth on LV, and sockets on RV), with posterior cardinal tooth on LV larger than anterior one. Ventral surface in some species set with ridges. A1 with penultimate segment set with six claw-like setae and weakly, or not at all, divided. T3 the largest walking limb. Posterior part of female abdomen with one furca, bearing two furcal setae and three hirsute furcal lobes. Hemipenis with large, articulating distal lobe, without a lateral seta.

Southern African species

Cytheridella (sic) *obtusata*, identified by Müller (1914), is actually *G. capensis*, of which *G. expansa* is a synonym (see Martens 1993). This species is generally typical of slightly saline conditions (Martens et al. 1996).

KEY TO SPECIES OF *GOMPHOCYTHERE* FROM SOUTHERN AFRICA

1. Female with caudal part in dorsal view nearly subquadrate (Fig. 1.3E); hemipenis with lobe 'l' tapering, distally pointed (Fig. 1.3N) .... *G. capensis*
– Female with caudal part in dorsal view more rounded; hemipenis with lobe 'l' subquadrate .... *G. obtusata*

SUPERFAMILY **Cypridoidea** Baird, 1845

Family **Cyprididae** Baird, 1845

More than 80% of the specific diversity of non-marine ostracods in Africa belongs in this family, which comprises about 20 subfamilies, half of which have representatives in the region. Only a few groups have been revised and can be elaborated upon below.

Subfamily **Cypridinae** Baird, 1845

(revised by Martens 1990b, 1991a)

Cypris O.F. Müller, 1776

Type species: Cypris pubera O.F. Müller, 1776

Fig. 1.14E

Characteristic features

Both valves with anterior selvage largely inwardly displaced; structure of selvage in RV simple, antero-ventral valve margin in this valve lip-like, produced. LV with an additional anterior inner list. LV furthermore overlapping RV caudally and ventrally; T2 with penultimate segment undivided and seta d_1 about two to three times as long as d_2.

Southern African species

Both *C. decaryi* (in Namibia) and *C. latissima* (in KwaZulu–Natal) occur in the northern part of the region. The circumtropical *C. subglobosa* may also occur there.

KEY TO THE SPECIES OF *CYPRIS* FROM SOUTHERN AFRICA

1. Valve surface conspicuously sculptured and pitted, but without lateral alae; length about 1.5 mm .... *C. subglobosa*
– Valve surface set with shallower pits or smooth 2

2. Width-to-length ratio greater than 4/5; lateral alae present and running over more than half the total length, possibly with lateral spines; length about 2 mm .... *C. latissima*
– Width-to-length ratio less than 3/4; surface smooth, no lateral ala; length about 1.5 mm .... *C. decaryi*

Pseudocypris Daday, 1908

Type species: P. bouvieri Daday, 1908

Figs1.14D, F, G

Characteristic features

Both valves with anterior selvage submarginal; valve margins often serrate; at least LV anteriorly with a large inner list. Most species with exterior lateral ala. T2 with penultimate segment fused; seta d_2 completely missing. Inner spermiductus (sperm duct) of hemipenis generally with more (six to eight) '8'–shaped loops than in *Cypris*.

Southern African species

Species of this genus are typical of temporary pools. Each seems restricted to a certain part of the region (Table 1.1). *Pseudocypris gibbera* is one of the most common species in Namibia and Botswana.

KEY TO THE SPECIES OF *PSEUDOCYPRIS* FROM SOUTHERN AFRICA

1. Valves set with long spines; length about 3.3 mm .... *P. spinosa*
– No long spines on valves 2

2. Ala prominent (width of ala in the middle in dorsal view about one-third of the width of one valve: Fig. 1.14F) 3
– Ala narrower or absent 5

3. Ala prominent and evenly rounded along most of the circumference 4
– Ala only prominent in the centre, concavely curved towards posterior and anterior extremities; length of valves about 2.9 mm .... *P. expansa*

4. Valves elongated in lateral view, height-to-length ratio less than 1/2; length about 3 mm .... *P. acuta*
– Height-to-length ratio greater than 3/5; length about 3 mm .... *P. circularis*

5. Traces of ala present in the centre in dorsal view; length about 2.6 mm .... *P. triquetra*
– Ala absent; length 2.02–2.2 mm .... *P. gibbera*

Ramotha Martens, 1991

Type species: Eucypris hirta Sars, 1924.

Figs 1.14B, 1.15B, C, E, F

Characteristic features

Mostly globular and large (2–3 mm). RV with frontal and caudal selvage inwardly displaced over a large distance, but with anterior valve margin not ventrally lip-like. LV without inwardly displaced selvage, but with a large inner list situated in the centre of a wide anterior calcified inner lamella and on the posterior inner margin; ventrally with a conspicuous outer list (on the outer surface of the valve). Caudal valve margin of the RV crenulated. T2 with penultimate segment divided and with seta d_1 two to three times as long as seta d_2.

Southern African species.

Most of the southern African representatives of this genus are restricted to the Cape provinces; *R. curtisae* occurs in Namibia and Zimbabwe, while *R. producta* is found both in the Cape and in high-altitude pools in the Drakensberg. As for the previous genus, species of *Ramotha* are typical of temporary pools.

KEY TO THE SPECIES OF *RAMOTHA* FROM SOUTHERN AFRICA

1. Length of female more than 2.5 mm (female 2.7– 2.8 mm, male about 2.2 mm .... *R. trichota*

– Length of female less than 2.5 mm 2

2. Ventral margin (including selvage in right valve and inner list in left valve) conspicuously produced ventrally in the first third, especially in the female; carapace extremely hairy, in dorsal view with anterior edge asymmetrically produced to the right; length about 1.4–1.8 mm .... *R. hirta*

– Ventral margin not conspicuously produced, carapace not very hairy 3

3. Width-to-length ratio greater than or equal to 2/3; front in dorsal view conspicuously pointed, resembling a beak 4

– Width-to-length ratio less than or equal to 1/2; front in dorsal view less produced 5

4. Valves in lateral view with a nearly evenly rounded dorsal margin, a nearly straight ventral margin and with anterior and posterior margins nearly evenly rounded; length 1.8–2.0 mm .... *R. corpulenta*

– Valves in lateral view more elongated, with curved ventral margin and with anterior margin more broadly rounded than posterior one; length 1.7–1.8 mm .... *R. capensis*

5. Valves sub-triangular 6
– Vales not sub-triangular, more elongated 7

6. Carapace in dorsal view with concavely produced beak; length 1.5–1.8 mm .... *R. trigona*
– Carapace in dorsal view anteriorly and posteriorly convexly rounded; length 1.4–1.7 mm .... *R. curtisae*

7. Anterior margins of isolated valves broadly rounded, passing into the dorsal margin almost without an angle (Fig. 1.15B); length 2.0–2.2 mm .... *R. purcelli*
– Anterior margin of isolated valves less broadly rounded, more pointed, and with an angle between anterior and dorsal margin (Fig. 1.15C); length 2.1–2.4 mm .... *R. producta*

Globocypris Klie, 1939

Type species: G. trisetosa Klie, 1939

Fig. 1.14C

Characteristic features

Globular, with a largely inwardly displaced anterior selvage in both valves; RV furthermore with this selvage sunk into the interior of the valve and with an inwardly displaced posterior selvage. LV with a large anterior inner list and with a lip-like antero-ventral margin to the valve margin; T2 with penultimate segment divided, setae d_1 and d_2 subequal.

Southern African species

The only species, *G. trisetosa*, is locally very abundant in temporary pools in East and Southern Africa, including the Eastern Cape Province. Male unknown. Length *c.* 1.3–1.4 mm.

Subfamily **Megalocypridinae** Rome, 1965

(revised by Martens, 1986, 1988)

This subfamily is almost entirely endemic to Africa, the only exceptions being one or two species of *Sclerocypris* from India (described as *Barathcypris*, a synonym of *Sclerocypris*). Individuals of most species in this subfamily are very large; in fact the largest living non-marine ostracod, *Megalocypris princeps*, belongs here and is a Western Cape endemic.

Sclerocypris Sars, 1924

Type species: Sclerocypris clavularis Sars, 1924

Figs 1.6B, H; 1.8D, E, K; 1.9A, B; 1.12A; 1.17C-H; 1.18; 1.19

Characteristic features

Valves large (2–5 mm), frontal selvage in both valves strongly inwardly displaced, generally over *c.* 3/4 of the distance between the valve margin and the inner margin. Ventral selvage in RV running close to or nearly on the valve margin. External surfaces of both valves pitted, more densely towards the anterior and posterior edges. Ovaria coiled caudally towards the dorsal side. T1 with 'd'-seta on protopodite short and with a broad base; prehensile palps either symmetrical or strongly asymmetrical, right palp generally being the larger. T2 with seta d_1 shorter than d_2. Dorsal and ventral branches of furcal attachment simple. Hemipenis with lateral shield always consisting of one lobe only, larger than the medial shield.

Southern African species

Eleven species and two subspecies have been described from southern Africa, four from South Africa and the others from Namibia. Species in this genus are most common in temporary vleis, where they can be found crawling on the pond bottom or clinging to logs. A key to the species is given below. New species will certainly be discovered in the region. It is, therefore, advisable to check illustrations and (re-) descriptions in Martens' papers. Some species cannot be identified from females only.

KEY TO SPECIES OF *SCLEROCYPRIS* FROM SOUTHERN AFRICA

1. Posterior part of left valve in females without inwardly displaced selvage......2

– Posterior part of left valve in females with selvage, at least partially, inwardly displaced (Fig. 1.17C–E) 3

2. Hemipenis with lateral shield subrectangular and with ventral lobe of medial shield pointed (Fig. 1.19G); length 2.7–3.2 mm ...... *S. dedeckkeri*

– Hemipenis with lateral shield and ventral lobe of medial shield dorsally rounded (Fig. 1.19F); length 3.7–3.9 mm ...... *S. sarsi*

3 Posterior part of female left valve as in Fig. 1.17E 4

– Posterior part of female left valve as in Fig. 1.17D 6

– Posterior part of female left valve as in Fig. 1.17C 7

4. Medial shield of hemipenis with triangular ventral lobe (arrowed in Fig. 1.18B); length 2.4–3.5 mm ...... *S. exserta*-group (Fig. 1.2)

– Medial shield of hemipenis without triangular ventral lobe 5

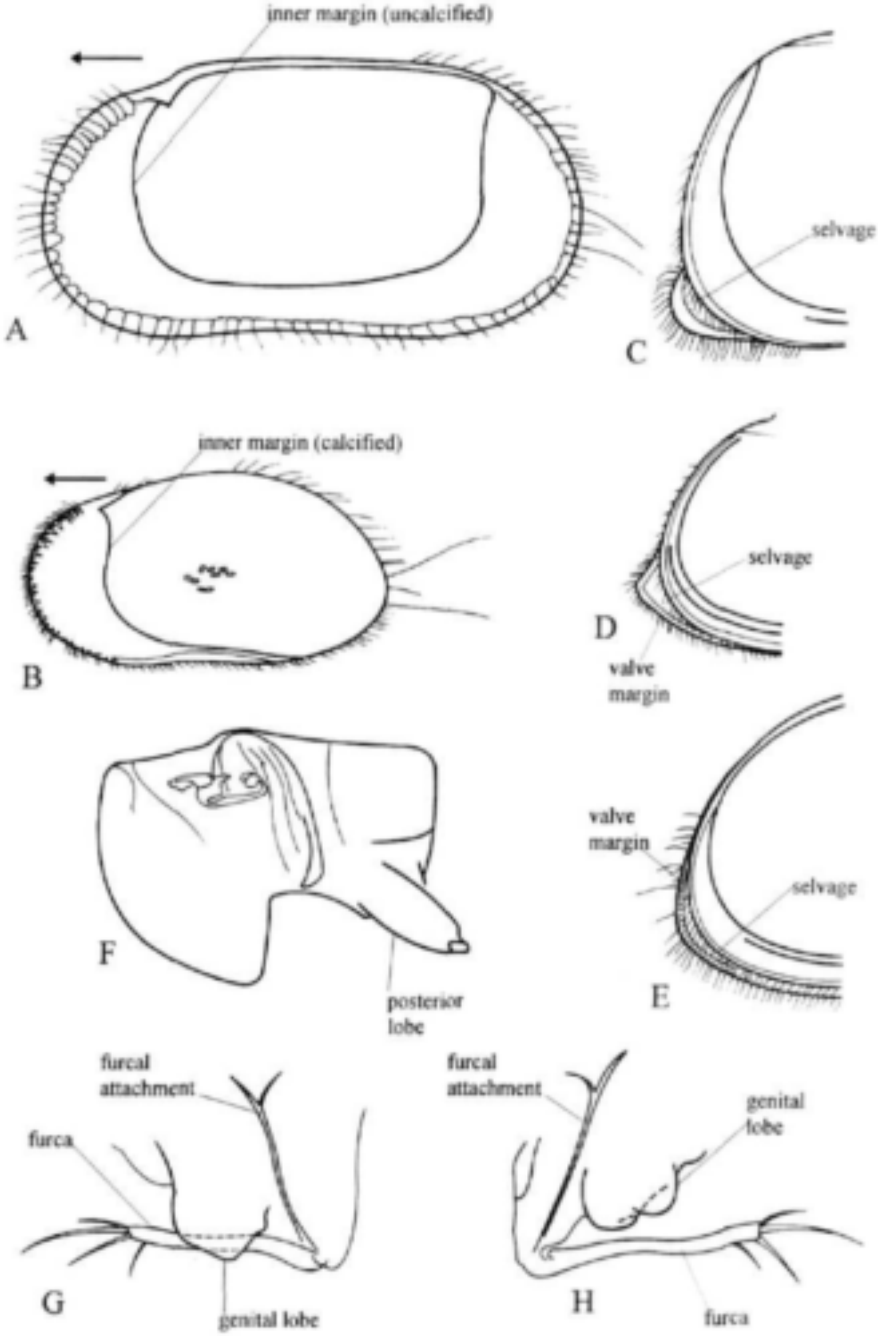

Fig. 1.17. A, *'Isocypris' nivea*, female right valve internal view. B, *'Isocypris' priomena*, female right valve internal view. C, *Sclerocypris tuberculata*, left valve internal view, caudal margin. D, *S. dumonti*, left valve internal view, caudal margin. E, *S. exserta*, left valve internal view, caudal margin. F, *S. tuberculata*, genital corner of female. G, *S. zelaznyi zelaznyi*, genital corner of female. H, *S. zelaznyi etoshensis*, genital corner of female.
(F after Klie 1933; G, H after Martens 1988).

5. Hemipenis with dorsal lobe of medial shield a pointed hook (arrowed in Fig. 1.18A), lateral shield subtriangular; length 3.2–3.4 mm .... *S. demoori*
– Hemipenis with dorsal lobe prominent (Fig. 1.18E), but without pointed hook; lateral shield subquadrate; length 2.7–2.9 mm .... *S. clavularis*

6. Dorsal margin straight, although sloping; lateral shield of hemipenis with sides nearly parallel (Fig. 1.19A); height-to-length ratio 1/2; length 2.5–3.0 mm .... *S. dumonti*
– Dorsal margin rounded; height-to-length ratio greater than 3/5; lateral shield of hemipenis suboval, rounded along the entire circumference (Fig. 1.19B); length 3.1–4.1 mm .... *S. major*

7. Hemipenis large, with lateral shield subtriangular and medial shield nearly straight (Fig. 1.19H); length 3.9–4.2 mm .... *S. dayae*
– Length about 3 mm; other features different (lateral shield not subtriangular and medial shield not straight) 8

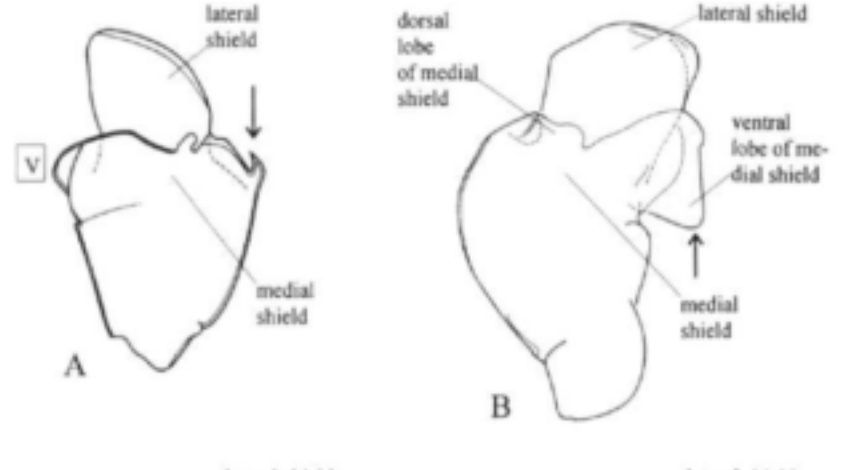

Fig. 1.18. Outlines of hemipenis: A, *Sclerocypris demoori*; B, *S. exserta*; C, *S. tuberculata*; D, *S. coomansi*; E, *S. clavularis*. (B after Martens 1986). KEY: V = ventral

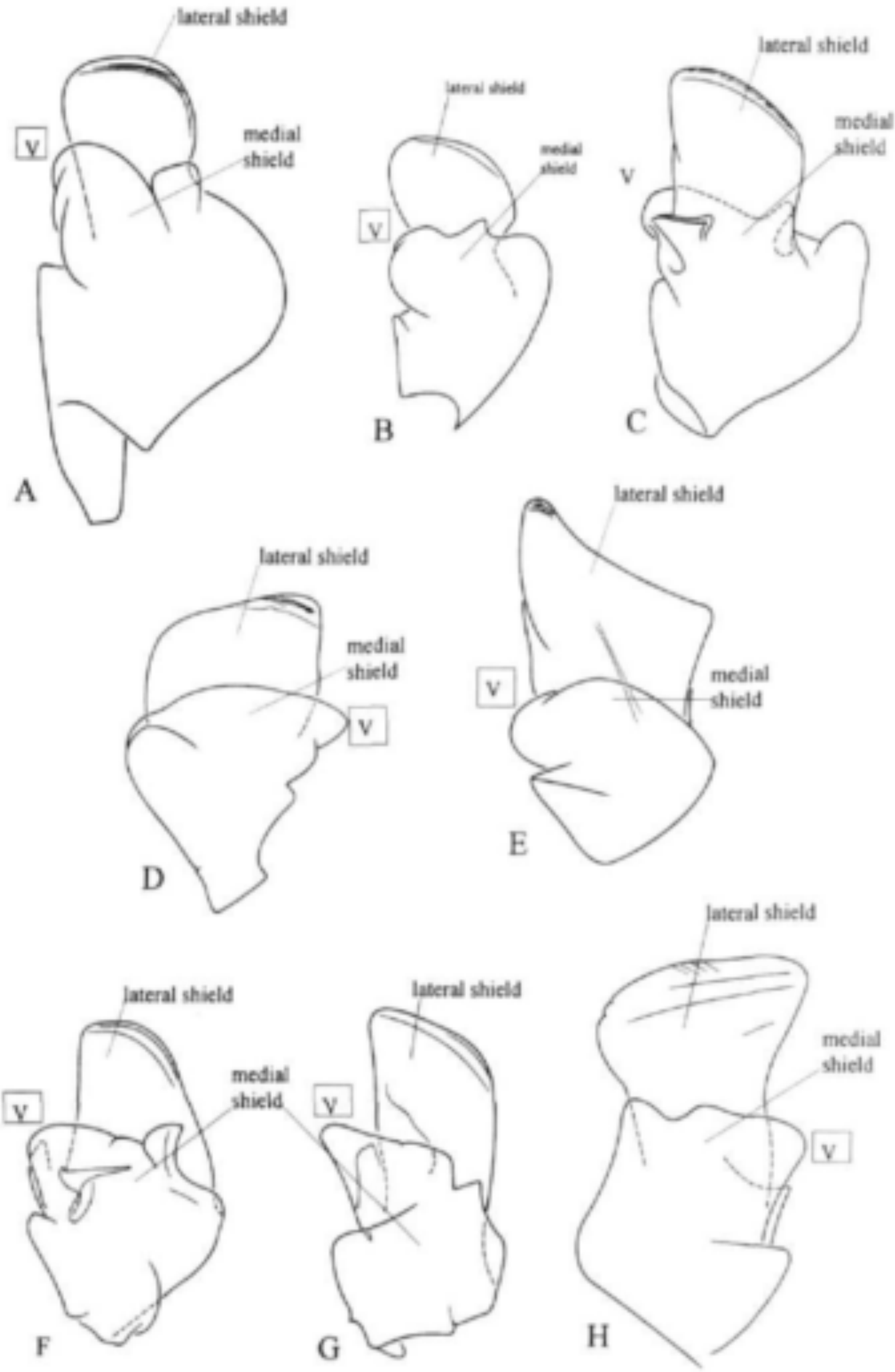

Fig. 1.19. Outlines of hemipenis: A, *Sclerocypris dumontii*; B. *S. major*; C, *S. zelaznyi zelaznyi*; D, *Megalocypris hispida*; E, *M. durbani*; F, *Sclerocypris sarsi*; G, *S. dedeckkeri*; H. *S. dayae*. KEY: V = ventral

8. Surface of valves always tuberculated; genital corners in females with two distinct lobes, posterior lobe elongated (length about 2.5 x width) (Fig. 1.17F); hemipenis large, with subquadrate lateral shield and prominent and pointed dorsal lobe (Fig. 1.18C); length 3.0 mm .... *S. tuberculata*
– No tubercles; genital corner in females without elongated lobes (Fig. 1.17G, H); hemipenis (when male known) as in Fig. 1.5C (*S. zelaznyi*) 9

9. Female with genital lobe undivided (Fig. 1.17G), female right alve with posterior selvage inwardly displaced over the entire length; length 2.9–3.0 mm .... *S. zelaznyi zelaznyi*
– Female with genital corner consisting of two sub-equal lobes (Fig. 1.17H); female right valve with posterior selvage inwardly displaced in ventral part only; males unknown; length 2.5–3.2 mm .... *S. zelaznyi etoshensis*

Remarks

To distinguish between *S. exserta exserta*, *S. exserta makarikarensis* and *S. coomansi,* compare illustrations in Martens (1988).

Hypselecypris Rome, 1965

Type species: H. wittei Rome, 1965

Fig. 1.9D

Characteristic features

Most closely related to *Sclerocypris*, from which it differs by the ovaria, which are caudally upturned (turned downwards in *Sclerocypris*).

Remarks

Monotypic genus. The only species, *H. wittei* has been found once in Central Africa. Occurrence south of the Zambezi River is, however, not impossible. Length 3.0–3.2 mm.

Megalocypris Sars, 1898

Type species: Megalocypris princeps Sars, 1898

Figs 1.9C, G

Characteristic features

Valves large (5–8 mm), frontal selvage in RV inwardly displaced over less than half the distance between the valve margin and the inner margin. Fused zone narrow, pore-canals short, anterior canals branched near base only, posterior canals simple. Caudally, ovaria curved dorsally. Caudal inner margin in both valves evenly curved. Natatory setae on A2 not reaching tip of penultimate segment. Prehensile mandibular palps slightly asymmetrical. Seta d_1 on T2 about twice as long as d_2. Hemipenis with lateral shield large and distally dilated. Dorsal and ventral branches of furcal attachment without supplementary branches.

Southern African species

There are three known species including *M. princeps*, which is the largest living non-marine ostracod in the world. All three species are typical of temporary vleis, *M. hispida* and *M. princeps* being most common in the Western Cape; *M. durbani* occurs mostly in the Eastern Cape. Rome (1965) cited a juvenile specimen of *Megalocypris* from Namibia, but this is almost certainly erroneous. However, *M. durbani* has been reported with certainty from high altitude pools in the Drakensberg (Martens et al. 1999). The genus is, therefore, not endemic to the Cape.

KEY TO THE SPECIES OF *MEGALOCYPRIS* FROM SOUTHERN AFRICA

1. Length 6–8 mm .... *M. princeps*
– Length less than 5 mm. 2

2. Hemipenis as in Figure 1.19E; terminal segments of both prehensile mandibular palps narrowing; length about 4.7 mm .... *M. durbani*
– Hemipenis as in Figure 1.19D; terminal segments of right prehensile mandibular palp dilating; length 3.5–4.3 mm .... *M. hispida*

Apatelecypris Rome, 1965

Type species: *Herpetocypris schultzei* Daday, 1913

Fig. 1.9E

Characteristic features

Valves about 3 mm long; selvage in both valves inwardly displaced in a few places, but over very short distances only. Frontal inner lamella of both valves with prominent inner lists. Pore canals numerous and branched, ventro-caudal margin of both valves with a row of small teeth. Md-palp with setae s_1 and s_2 only slightly asymmetrical. Medial shield of hemipenis consisting of two parallel lobes. Furcal attachment with distal part of dorsal and ventral branches with additional branches.

Southern African species

A monotypic genus. The only species, *A. schultzei*, is endemic to Namibia, where it is the most common giant ostracod. Close to ubiquitous, the species tolerates high salinities, high temperatures and both stagnant and running water. It is, however, most common in (semi-) permanent rivulets. Length 1.4–2.9 mm. The relatively wide size range is not uncommon in this subfamily.

Eundacypris Martens, 1986

Type species: Sclerocypris superba Sars, 1924

Fig. 1.9F

Characteristic features

Valves large (*c.* 4 mm), selvage not inwardly displaced and absent along most of the valve margin, fused zone narrow, pore canals simple. Caudally, ovaria turn dorsally. Central muscle scars somewhat aberrant relative to the general megalocypridinid pattern, with several scars fused to each other. Prehensile mandibular palps asymmetrical, right palp the larger. Hemipenis relatively small, with internal parts weakly sclerotized. Dorsal and ventral branches of furcal attachment with minute, supplementary branches.

Southern African species

A monotypic genus represented by *E. superba*, known from ephemeral pools in Ovamboland (Namibia). Nothing else is known about its ecology. It appears to be a rare species. Length 4.0–4.1 mm.

Subfamily **Cypricercinae** McKenzie, 1971

On a worldwide scale, this subfamily harbours a lot of taxonomic confusion. The southern African genera and species are, however, relatively straightforward to identify.

Cypricercus Sars, 1895

Type species: Cypricercus cuneatus Sars, 1895

Figs 1.12E, J-O

Characteristic features

Carapace elongated, not flattened, usually with a caudal process on one of the valves; Triebel's loop and both ventral and dorsal branches in furcal attachment.

Southern African species

Only a few species occur in southern Africa, mostly in temporary waterbodies. *Cypricercus inermis*, previously erroneously placed in *Tanycypris*, is a synonym of *C. cuneatus*, since differences in the type material of the two species are minimal. Sars (1924a) cited a length of about 1.6 mm for *C. cuneatus* although type specimens of this species, and of *C. inermis*, do not exceed 1 mm in length. *Cypricercus* sp. nov. will be described elsewhere (Martens et al. In Prep.).

KEY TO THE SPECIES OF *CYPRICERCUS* FROM SOUTHERN AFRICA

1. Valves without caudal process (Fig. 1.12N, O) 3
– Caudal process present in at least one of the valves (Fig. 1.12J–M) 2

2. Caudal process in right valve only; length 1.5–1.6 mm ....*C. episphaena*
– Long caudal process on both valves; length greater than or equal to 2 mm ....*Cypricercus* sp. nov.

3. Carapace with dark-green dorsal patches; length 1.6–1.7 mm ..... *C. maculatus*
– No such coloration; length about 1 mm ....*C. cuneatus*

Strandesia Stuhlmann, 1888

Type species: *Cypris (Strandesia) mercatorum* Vavra, 1895

Figs 1.12F–I

Characteristic features

Individuals of most species globular, with or without dorsal outgrowth on RV. Triebel's loop and both ventral and dorsal branches present in furcal attachment.

Southern African species

This is a large and complex genus in need of revision, although only a few, easily identifiable species have thus far been found in southern Africa. Of these, only *S. mercatorum* and *S. elatior* belong in *Strandesia s.s.*

KEY TO THE SPECIES OF *STRANDESIA* FROM SOUTHERN AFRICA

1. Natatory setae on Antennae short, not reaching half way down penultimate segment ....*S. sudanica*
– Natatory setae on Antennae long, reaching tips of penultimate claws 2

2. Valves globular, without dorsal protuberance (Fig. 1.12F, G) 3
– Valves globular or laterally compressed, but with right valve showing a clear dorsal overlap 4

3. Length 1.4–1.5 mm (Namibia) ....*S. vavrai*
– Length about 1 mm ....*S. vinciguerrae*
4. Valves laterally compressed, dorsal protuberance as in Fig. 1.12H–I; length about 2 mm ....*S. mercatorum*
– Valves subglobular, dorsal outgrowth of right valve an evenly curved lobe (see Fig. 1.15A); length about 1 mm ....*S. elatior*

Tanycypris Triebel, 1959

Type species: *Cypris madagascarensis* G.W. Muller, 1898

Characteristic features

Very thin and transparent valves, narrow in dorsal view and with rounded anterior and posterior margins in lateral view; valves with wide frontal and caudal inner lamellae. Furcae long, generally conspicuously protruding on the caudal side; furcal attachment with the Triebel's loop but without ventral branch.

Southern African species

Two species are recorded from the northern part of southern Africa. *T. obtusa* (length about 1.3 mm) from the Lake Chrissie area, Mpumalanga, is relatively narrow caudally in lateral view. *Tanycypris* sp. from Namibia was identified by Rome (1965) as *T. clavigera,* but this identification has been questioned by Broodbakker (1984).

Remarks

Cypris inermis from KwaZulu–Natal and the Free State belongs in the genus *Cypricercus*, not in *Tanycypris* (see above).

Subfamily **Bradycypridinae** Hartmann & Puri, 1974

Both this subfamily and the Cyprettinae Hartmann, 1963, are characterized by globular carapaces with marginal septa and slender furcae. In the Cyprettinae both valves have anterior marginal septa while in the Bradycypridinae only RV have such septa.

Bradycypris Sars, 1924

Type species: Bradycypris intumescens (Brady, 1907)

Characteristic features

Individuals are rounded, with the marginal septa in the right valve; both valves smooth; furcae slender.

Southern African species

Bradycypris intumescens (length 1.3–1.5 mm) is found in different parts of South Africa (see Table 1.1); *B. radiata* is a junior synonym of this species, the main difference between the two being a somewhat wider flange on the left valve of *B. intumescens*.

Paracypretta Sars, 1924

Type species: *Paracypretta ampullacea* Sars, 1924

Characteristic features

Rounded individuals with marginal septa in the right valve; both valves striated. Furcae slender.

Southern African species

Only *P. aratra* is reported from KwaZulu–Natal; all other species are known only from the Cape provinces. *Paracypretta rubra* Sars, 1924, is a junior synonym of *P. syngramma minor* which, as an independent species, is named *P. minor*.

KEY TO THE SPECIES OF *PARACYPRETTA* FROM SOUTHERN AFRICA

1. Width about 0.7 of length; length about 1 mm .... *P. aratra*
– Width at least 0.75 times the length 2

2. Width nearly equal to length; length about 1 mm .... *P. ampullacea*
– Width 0.75–0.85 times the length 3

3. Surface of valves armed with stout spines; length about 1.1 mm .... *P. acanthifera*
– No stout spines, at most long hairs 4

4. Valves densely set with long hairs; colour of living animals brown to reddish; length 0.95 mm .... *P. minor*
– Valves scarcely covered with hairs; colour of living animals green; length 1.0–1.1 mm .... *P. syngramma*

Subfamily **Cypridopsinae** Bronstein, 1947

This, the most speciose subfamily of non-marine Ostracoda, is especially common in Africa. Cypridopsinae are invariably small animals (0.7 mm long or less) and the incidence of asexual reproduction is very high. Species are morphologically very variable, as they are comprised of morphologically distinct clonal groups. More often than not males are absent from the sampled populations, which excludes male reproductive characters from the description of new species. There is thus significant taxonomic confusion in this group and *Potamocypris* is the only genus of the Cypridopsinae for which a key to the species can be offered.

The subfamily is sometimes considered to be a family, with the reduced, flagellum-like furca as the main synapomorphic feature. However, several other groups (e.g. in the Candonidae and Notodromadidae) have also developed this structure. The flagellum-like furca of the Cypridopsinae can thus at most be a characteristic feature at the subfamily level within the Cyprididae.

Potamocypris Brady, 1870

syn.: *Proteocypris* Brady, 1907
syn.: *Cyprilla* Sars, 1924
Type species: Cypridopsis fulva Brady, 1868
Figs 1.6 A–J, 1.20

Remarks

The genus *Cyprilla* has previously been distinguished from *Potamocypris* s.s. by the large flanges on the left valve. However, Gauthier (1939) argued that as the width of these structures can vary considerably (even in one species), there is no good reason to maintain *Cyprilla* as a valid genus

Characteristic features

Potamocypris is distinguished from all other Cypridopsinae by the spatulate form of the second segment of the Maxillular palp (in all other cypridopsines, this segment is cylindrical). All species in southern Africa have a wide anterior flange on RV.

Southern African species

The following key to the species is provisional and specimens should always be compared to the figures in Sars (1924a). *Potamocypris mastigophora* is widespread in the whole of Africa. The other species display more restricted ranges and most are known from the Cape Provinces only, although *P. humilis* has also been recorded from Finland and Ethiopia. For a redescription of the latter two species, see Meisch (1985). *Potamocypris paludum* is a new name for *P. arcuata* (Sars, 1924) nec. Sars (1903).

KEY TO THE SPECIES OF *POTAMOCYPRIS* FROM SOUTHERN AFRICA

1 Right valve with wide dorsal overlap of left valve 2
– Dorsal overlap minute or lacking; length about 0.6 mm......... *P. humilis* (Fig. 1.20 G–H)

2\. Height half times the length or slightly less; length about 0.6 mm .... *P. mastigophora* (Fig. 1.20 A–B)
– Height greater than 0.6 times the length 3

3\. Natatory setae of Antennae short, not reaching half way down length of claws; flange relatively narrow; length about 0.5 mm ..... *P. paludum* (Fig. 1.20 E–F)
– Natatory setae longer, reaching up to or beyond claws; flange narrow or wide 4

4. Carapace arched, subtriangular, narrowing dorsally to a blunt angle; surface set with large pits; flange narrow; length 0.5 mm .....*P. gibbula* (Fig. 1.20 I–J)
– Carapace oval, quadrangular, dorsal margin nearly straight; surface densely set with knobs; flange relatively wide; length 0.6 mm ....*P. deflexa* (Fig. 1.20 C–D)

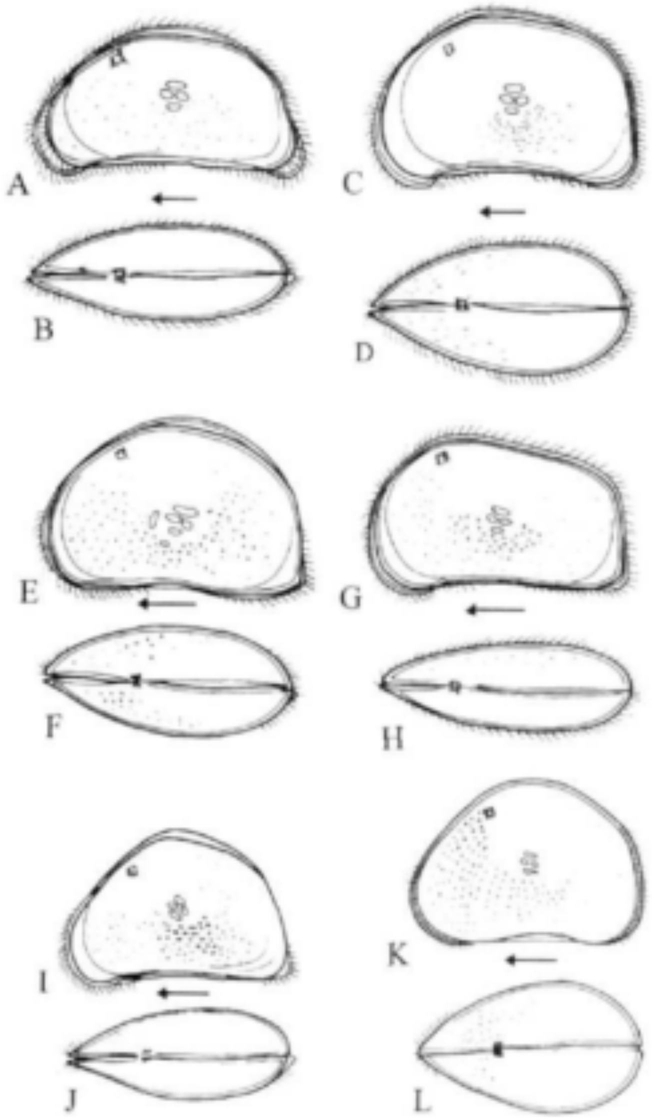

Fig. 1.20. A–B. *Potamocypris mastigophora*: A, carapace, left lateral view; B, carapace, dorsal view. C–D, *P. deflexa*: C, carapace, left lateral view; D, carapace, dorsal view. E–F, *P. paludum*: E, carapace, left lateral view; F, carapace, dorsal view. G–H, *P. humilis*: G, carapace, left lateral view; H, carapace, dorsal view. I–J, *P. gibbula*: I, carapace, left lateral view; J, carapace, dorsal view. K–L, *Sarscypridopsis tonsa*: K, carapace, left lateral view; L, carapace, dorsal view. (All redrawn after Sars, 924 *a*, 1924*b*). KEY ⟶ points towards the anterior of the animal

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CHECKLIST OF OSTRACOD SPECIES IN SOUTHERN AFRICA

Genera and species	Specific distribution in southern Africa	References for species
DARWINULOIDEA		
Alicenula Rossetti & Martens, 1998		
A. inversa (Martens & Rossetti, 1997)	NW Province	Martens & Rossetti 1997
Darwinula (Brady & Robertson, 1885)		
D. stevensoni (Brady & Robertson, 1870)	Lake Sibaya, NW Province, KwaZulu-Natal	Rossetti & Martens 1996, Martens et al. 1999
Penthesilenula Rossetti & Martens, 1998		
P. brasiliensis (Pinto & Kotzian, **19xx)??**	Drakensberg, KwaZulu-Natal	Martens et al. 1999
Vestalenula Rossetti & Martens, 1998		
V. molopoensis (Martens & Rossetti, 1997)	NW Province	Martens & Rossetti 1997
V. flexuosa Martens & Rossetti, 1996	Ovamboland (Namibia)	Rossetti & Martens 1999
V. sp. C	Lake Sibaya (KwaZulu-Natal)	Rossetti & Martens 1999
CYTHEROIDEA		
Korannacythere Martens, 1996		
K. devriesi Martens, 1996	Free State	Martens 1996
K. hamerae Martens, 1996	KwaZulu-Natal	Martens 1996
K. ugiensis Martens, 1996	Eastern Cape, KwaZulu-Natal	Martens 1996, Martens et al. 1999
Limnocythere Brady, 1868		
L. aethiopica Klie, 1934	Lake Chrissie (Mpumalanga)	Klie 1934
L. stationis Vavra, 1891	KwaZulu-Natal	Martens et al. 1999
L. tudoranceai Martens, 1990	Ovamboland (Namibia)	Martens 1990
L. inopinata (Baird, 1843)	Western Cape	Martens et al. 1996
Leucocythere Kaufmann, 1892		
L. helenae Martens, 1991	Eastern Cape	Martens 1991
Ovambocythere Martens, 1989		
O. milani Martens 1989	Ovamboland (Namibia)	Martens 1989
Gomphocythere		
G. capensis G. W. Müller, 1914 (syn. *G. expansa* Sars, 1924)	South Africa, widespread	Martens et al. 1996
G. obtusata Sars, 1910	South Africa, widespread	Martens et al. 1996, In Prep.
CYPRIDOIDEA		
Ilyocypris Brady & Norman, 1889		
I. australiensis Sars 1889	Western Cape	Sars 1924a
I. gibba (Ramdohr 1808)	KwaZulu-Natal, Eastern Cape	Martens et al. 1999, In Prep.
Oncocypris G.W. Muller 1898		
O. mulleri (Daday, 1910)	KwaZulu-Natal, Eastern Cape	Martens et al. 1999, In Prep.
O. voeltzkowi (G.W. Müller 1898	KwaZulu-Natal, former Transvaal, Eastern Cape and Namibia	Martens et al. 1999
Centrocypris Vavra, 1895		
C. cfr. *margaritifera* G.W. Müller, 1898	Namibia	Martens unpubl.
Candonopsis Vavra, 1891		
C. africana Klie, 1944		Martens et al. 1999
C. nama Daday, 1913	Namibia	Daday 1913
Namibcypris Martens, 1992		
N. costata Martens, 1992	Zesfontein, Namibia	Martens 1992
Physocypria Vavra, 1898		
P. capensis (Sars, 1896) (syn. *P. armata* (G.W. Muller 1898)	southern Africa,	Sars 1924a, G.W. Müller 1898, Martens et al. 1996, In Prep.
P. castanea (Brady, 1904)	KwaZulu-Natal	Brady 1904
Cypris O.F. Muller, 1776		
C. subglobosa Sowerby, 1840	circumtropical, not yet found in SA,	Martens 1990b
C. latissima G.W. Muller, 1989	KwaZulu-Natal	Martens 1990b, Martens et al. 1999
C. decaryi Gautier, 1933	E. Caprivi & Bushmanland, Namibia	Martens 1990b
Pseudocypris Daday, 1908		
P. spinosa (Methuen, 1910)	Lake Chrissie area (Mpumalanga)	Martens 1990b
P. expansa Sars, 1924	Northern Cape and former Transvaal	Martens 1990b
P. acuta (G. W. Müller, 1914) (syn. *P. testudo* Sars, 1924)	Eastern and Western Cape	Martens 1990b
P. circularis Sars, 1924	Namibia	Martens 1990b
P. triquetra Sars, 1924	Northern Cape	Martens 1990b
P. gibbera Sars, 1924	Namibia, Botswana	Martens 1990b

Checklist (cont.)

Genera and species	Specific distribution in southern Africa	References for species
Ramotha Martens, 1991		
R. trichota (G. W. Müller, 1908)	Western Cape	Martens 1992
R. hirta (Sars, 1924)	Western Cape	Martens 1992
R. corpulenta (Sars, 1895)	Western Cape	Martens 1992
R. capensis (G. W. Müller, 1908)	Western Cape	Martens 1992
R. trigona (Sars, 1895)	Western Cape	Martens 1992
R. curtisae Martens, 1991	Namibia and Zimbabwe	Martens 1992
R. purcelli (Sars, 1924)	Western Cape	Martens 1992
R. producta (Sars, 1924)	Eastern Cape, KwaZulu–Natal	Martens 1992, Martens et al. 1999
Globocypris Klie, 1939		
G. trisetosa Klie, 1939	Eastern Cape, KwaZulu–Natal	Martens 1990b, Martens et al. 1999
Afrocypris Sars, 1924		
A. barnardi Sars, 1924	Ovamboland, Namibia	Sars 1924b
Sclerocypris Sars, 1924		
S. dedeckkeri Martens, 1988	northern Namibia	Martens 1988
S. sarsi Martens, 1987	Namibia, South Africa (not Cape Provinces)	Sars 1924a, Martens 1987
S. exserta exserta Sars, 1924	Namibia	Sars 1924b
S. exserta makarikarensis Martens, 1988	Botswana	Martens 1988
S. coomansi Martens, 1986	Namibia	Martens 1986
S. demoori Martens, 1991	Eastern Cape	Martens 1991
S. clavularis Sars, 1924	Free State	Sars 1924a
S. dumonti Martens, 1988	Ovamboland (Namibia)	Martens 1988
S. major Sars, 1924	Ovamboland (Namibia)	Sars 1924b
S. dayae Martens, 1988	Northern Namibia	Martens 1988
S. tuberculata Methuen, 1910	Lake Chrissie (Mpumalanga)	Methuen 1910, Martens 1991a
S. zelaznyi zelaznyi Martens, 1988	Namibia	Martens 1988
S. zelaznyi etoshensis Martens, 1988	Etosha National Park (Namibia)	Martens 1988
Hypselecypris Rome, 1965		
H. wittei Rome, 1965,	Central Africa, not yet found in southern Africa	Rome 1965, Martens 1986
Megalocypris Sars, 1898		
M. princeps Sars, 1898	Western Cape	Sars 1898, Martens 1986
M. durbani (Baird, 1859)	Eastern & Western Cape, KwaZulu–Natal	Martens 1986, Martens et al. 1999, In Prep.
M. hispida Sars, 1924	Western Cape	Sars 1924a, Martens 1986
Apatelecypris Rome, 1965		
A. schultzei (Daday, 1913) (syn.: *A. brevis* (Sars, 1924))	endemic to Namibia	Daday 1913, Sars 1924a, Martens 1986
Eundacypris Martens, 1986		
E. superba (Sars 1924)	Ovamboland (Namibia)	Sars 1924b, Martens 1986
Cyprinotus Brady, 1886		
C. sp.	Northern Namibia	Martens, unpublished
Heterocypris Claus, 1893		
H. aurea (Sars, 1895)	Western Cape, KwaZulu–Natal, Namibia	Sars 1924a, Martens et al. 1999
H. calva (Rome, 1965)	Eastern and Western Cape, KwaZulu–Natal	Rome 1965, Martens et al. 1999, In Prep.
H. capensis (G. W. Müller, 1908)	Eastern & Western Cape	Martens et al. In Prep.
H. giesbrechti (G.W. Müller, 1898)	KwaZulu–Natal	Martens et al. 1999
H. gunningi (Methuen, 1910)	Lake Chrissie (Mpumalanga)	Methuen 1910
H. incongruens (Ramdohr, 1808)	Eastern & Western Cape, KwaZulu–Natal	Sars 1924a, Martens et al. 1999
H. oblonga (Sars, 1924)	Namibia, KwaZulu–Natal	Sars 1924b, Martens et al. 1999
H. ovularis (Sars, 1924)	Ovamboland and Kalahari, Namibia, KwaZulu–Natal	Sars 1924b, Martens et al. 1999
Hemicypris Sars, 1903		
H. inversa (Daday, 1913)	Kalahari, Botswana	Daday 1913, Martens 1984
H. reticulata (Klie, 1930)	KwaZulu–Natal	Martens et al. 1999
Homocypris Sars, 1924		
H. conoidea Sars, 1924 (syn.: *H. longirostrata* Rome, 1965)	Eastern & Western Cape	Sars 1924a
Cypricercus Sars, 1895		
C. cuneatus Sars, 1895 (syn. *C. inermis* (Brady, 1904)	Western Cape, KwaZulu–Natal, Freestate	Sars 1895, 1924a, Brady 1904, Martens et al. 1999
C. episphaena (G. W. Müller, 1908)	Western Cape, KwaZulu–Natal	G.W. Müller 1908, Martens et al. 1999
C. maculatus (G. W. Müller, 1908)	Western Cape	G.W. Müller 1908
C. sp. nov.	Eastern Cape	Martens unpubl.

Checklist (cont.)

Genera and species	Specific distribution in southern Africa	References for species
Strandesia Stuhlmann, 1888		
S. elatior Vavra, 1897	Northern Namibia	Martens unpubl.
S. mercatorum Vavra, 1895	Not yet found in southern Africa	Vavra 1895
S. sudanica Sywula, 1970	Northern Province, KwaZulu-Natal, Lesotho	Martens et al. 1999
S. vavrai (G. W. Müller, 1898)	Namibia, KwaZulu-Natal	Martens et al. 1999
S. vinciguerrae (Masi, 1905)	Northern Province, Namibia	Martens unpubl.
Tanycypris Triebel, 1959		
T. clavigera (G.W. Müller, 1898)	KwaZulu-Natal	Martens et al. 1999
T. obtusa (Klie, 1933)	Lake Chrissie (Mpumalanga), Eastern Cape	Klie 1933, Martens et al. In Prep.
Tanycypris sp.	Namibia (identified as *T. clavigera*)	Rome 1965
Mesocypris Daday, 1910		
M. terrestris Harding, 1953	Knysna Forest (Western Cape)	Harding 1953, Danielopol & Betch 1980
Isocypris G. W. Müller, 1908		
(syn.: *Hyalocypris* Brady, 1913)		
I. africana (Brady, 1913)	Free State	Brady 1913
I. nivea Sars, 1924	Western Cape	Sars 1924a
I. perangusta G.W. Müller, 1908	Western Cape	G.W. Müller 1908
I. priomena G. W. Müller, 1908	Eastern & Western Cape, Free State, KwaZulu-Natal	G.W Müller 1908, Sars 1924a, Martens *et al.* 1999, In Prep.
Amphibolocypris Rome, 1965		
A. exigua Rome, 1965	Namibia	Rome 1965
Herpetocypris Brady & Normann, 1889		
H. chevreuxi (Sars 1896)	Eastern & Western Cape	Gonzalez Mozo et al. 1996, Martens et al. In Prep
Ilyodromus Sars, 1894		
I. viridula (Brady, 1886)	Western Cape	Martens et al. 1996
Acocypris (Vavra, 1895)		
A. capillata (Vavra, 1895)	May occur in the north	Vavra 1895
Stenocypris Sars, 1889		
S. major (Baird, 1859)	KwaZulu-Natal	Martens et al. 1999
Parastenocypris Hartmann, 1964		
P. aldabrae (G. W. Müller, 1898)	KwaZulu-Natal	Brady 1907, 1913
P. ametra (G. W. Müller, 1908)	Western Cape	G.W Müller 1908, Sars 1924a
syn.: *P. ametra minor* (G.W. Müller 1908)		
syn.: *P. olivacea* (Sars, 1924)		
P. bispinosa (G. W. Müller, 1914)	Western Cape	G.W.Müller 1908, Sars 1924a
syn.: *P. pardalis* (Sars 1924)		
P. declivis (Sars, 1924)	Western Cape	Sars 1924a
P. fascigera (Sars, 1924)	Ovamboland, Namibia, Kalahari, Botswana	Sars 1924b
P. hodgsoni (Sars, 1924)	Western & Eastern Cape, KwaZulu-Natal	Sars 1924a, Martens et al. 1996
P. pectinata (Sars 1924)	Mpumalanga, KwaZulu-Natal, Eastern Cape	Sars 1924a, Martens et al. 1999, In Prep
P. perarmata (Brady, 1904)	KwaZulu-Natal, Western Cape	Brady 1904, Sars 1924a
P. smaragdina (Sars, 1924)	Eastern & Western Cape	Sars 1924a, Rome 1965, Martens et al. In Prep.
syn.: *P. anisacantha* (Rome, 1965)		
Chrissia Hartmann, 1957		
(syn. Gesa Hartmann 1957 = JUV)		
Chrissia levetzovi Hartmann, 1957	Lake Chrissie (Mpumalanga), KwaZulu-Natal	Hartmann 1957, Martens et al. 1999
Candonocypris Sars, 1894		
C. novaezelandiae (Baird, 1859)	KwaZulu-Natal, Eastern Cape	Martens et al. 1999, In Prep
Hamphlcypris Martens, 1997		
H greenwoodi Martens, 1997	NW Province, KwaZulu-Natal	Martens, 1997, Martens et al. 1999
Liocypris Sars, 1924		
L. grandis Sars, 1924	Stompneus Bay (Western Cape)	Sars 1924a
Cypretta Vavra, 1895	(all are uncertain identifications)	
C. globula (Sars, 1889)	Western Cape	Sars 1924a
C. minna (King, 1855)	Eastern & Western Cape	Sars 1924a, Martens et al. In Prep
C. sarsi Brady, 1902	KwaZulu-Natal	Brady 1902
C. turgida Sars, 1896	Western Cape	Sars 1924a
Bradycypris Sars, 1924		
B. intumescens (Brady, 1907)	Eastern & Western Cape, KwaZulu-Natal	Brady 1907, Sars 1924a, Martens et al. In Prep
syn. *B. radiata* (G. W. Müller, 1908)		

Checklist (cont.)

Genera and species	Specific distribution in southern Africa	References for species
Paracypretta Sars, 1924		
P. acanthifera Sars, 1924	Western Cape, KwaZulu–Natal	Martens *et al.* 1996, 1999
P. aratra (Brady, 1904)	KwaZulu–Natal, Eastern Cape	Brady 1904, Martens et al. In Prep.
P. ampullacea Sars, 1924	Western Cape	Sars 1924a
P. minor (G. W. Müller, 1914) (syn. *P. rubra* Sars, 1924)	Western Cape	G.W.Müller 1914
P. syngramma (G. W. Müller, 1908)	Eastern & Western Cape, KwaZulu–Natal	G.W. Müller 1908, Martens et al. 1999, In Prep.
Potamocypris Brady, 1870 (syn. *Cyprilla* Sars, 1924)		
P. deflexa (Sars, 1924)	Eastern Cape, KwaZulu–Natal	Sars 1924a, Martens et al. 1999, In Prep.
P. gibbula (Sars, 1924)	Western Cape	Sars 1924a
P. humilis (Sars, 1924)	Western Cape	Sars 1924a, Martens *et al.* 1996
P. mastigophora (Methuen, 1910) (syn. *P. producta* (Sars, 1924) (syn. *P. reniformis* (Brady, 1907)	All of Africa, incl. Southern Africa	Methuen 1910, Sars 1924a, Meisch 1985, Martens et al. 1999, In Prep.
P. paludum Gauthier, 1939 (= *P. arcuata* Sars 1924 nec Sars 1903)	Western Cape	Sars 1924a, Gauthier 1939
Cypridopsis Brady, 1868		
C. vidua (O.F. Müller, 1776) (syn. *Pionocypris assimilis* Sars, 1896) (syn. *C. africana* Klie, 1935 = *P. intermedia* Sars, 1924a nec Daday, 1910)) (syn. *C. globuloides* Brady, 1907) (syn. *C. viduella* Sars, 1896)	Eastern & Western Cape, KwaZulu–Natal	Brady 1907, Sars 1924a, Martens et al. In Prep.
Plesiocypridopsis Rome, 1965		
P. aldabrae (G.W. Müller, 1898)	KwaZulu–Natal, Eastern Cape	Martens et al. 1999, In Prep.
P. chrissiensis (Methuen, 1910)	Lake Chrissie (Mpumalanga)	Methuen 1910
P. inaequivalva (Klie, 1933)	Lake Chrissie (Mpumalanga)	Klie 1933
P. sossilona Rome, 1965	Namibia	Rome 1965
Sarscypridopsis McKenzie, 1977	(many uncertain species)	
S. aculeata (Costa, 1847) (syn. *C. spinifera* Sars, 1924) (syn. *C. triquetra* G.W. Müller, 1908)	Eastern & Western Cape, KwaZulu–Natal (cosmopolitan)	Martens et al. 1996, 1999, In Prep.
S. brevis (Sars, 1924)	Western Cape	Sars 1924a
S. clavata (Sars, 1924)	Western Cape	Sars 1924a
S. echinata (G. W. Müller, 1908)	Eastern & Western Cape	G.W.Müller 1908, Sars 1924a, Martens *et al.* In Prep.
S. elizabethae (Sars, 1924)	Eastern Cape, KwaZulu–Natal	Sars 1924a, Martens et al. 1999
S. glabrata (Sars, 1924)	Eastern & Western Cape, Namibia	Martens et al. 1996
S. gregaria (Sars, 1895)	Eastern & Western Cape	Sars 1924a, Martens et al. In Prep.
S. hirsuta (Sars, 1924)	Western Cape	Sars 1924a
S. katesae (Hartmann, 1957)	Namibia	Hartmann 1957
S. ochracea (Sars, 1924)	Eastern & Western Cape, KwaZulu–Natal, Namibia	Martens et al. 1996, 1999, In Prep.
S. pygmaea (Sars, 1924)	Western Cape	Sars 1924a
S. pyramidata (Sars, 1924)	Western Cape	Sars 1924a
S. reniformis (Sars, 1924)	Western Cape	Sars 1924a
S. sarsi (Klie, 1935) (*Cypridopsis tumidula* Sars 1924 nec 1910)	Eastern Cape	Sars 1924a
S. striolata (Sars, 1924)	Western Cape	Sars 1924a
S. tonsa (Sars, 1924)	Western Cape	Sars 1924a
S. trigonella (Sars, 1924)	Eastern & Western Cape, KwaZulu–Natal	Martens et al. 1996, 1999, In Prep.
Kapcypridopsis McKenzie, 1977		
K. barnardi McKenzie, 1977	Table Mountain (Western Cape)	McKenzie 1977
Zonocypris G. W. Müller, 1898		
Z. costata (Vavra, 1897)	KwaZulu–Natal	Martens et al. 1999
Z. cordata Sars, 1924	Western Cape	Martens et al. 1996
Z. tuberosa G. W. Müller, 1908	Eatsern & Western Cape	Martens et al. 1996, In Prep.
INCERTAE SEDIS		
'Cyclocypris'		
C. castanea Brady, 1904	Victoria Falls (Zimbabwe)	Brady 1913
C. pusilla Sars, 1895	Knysna (Western Cape)	Sars 1895
'Cypridopsis'		
C. punctillata Brady, 1907	KwaZulu–Natal	Brady 1907

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CHAPTER 2

COPEPODA

by

N.A. Rayner

Freshwater Copepoda are micro-crustaceans ranging from less than 1 mm to 5 mm in length. Huys & Boxshall (1991) list ten orders of Copepoda, three of which, the Calanoida (Fig. 2.1A), Harpacticoida (Fig. 2.1B) and Cyclopoida (Fig. 2.1C), are important in freshwater habitats. The Cyclopoida are the most abundant and successful freshwater copepods, and include some important parasitic species. The first copepod species to be recorded from South Africa was the large predatory calanoid *Lovenula falcifera*, which was collected by J.H. Wahlberg from a saline pan in Gauteng and described by Lovén in 1845. Sars (1927) and Kiefer (1934) made major contributions to the knowledge of southern African freshwater Copepoda. From 1934 until 1981, there was no taxonomic research on southern African free-living freshwater Copepoda, despite the fact that freshwater copepods had been collected in various surveys and in routine sampling of impoundments. More recently, Rayner (1992) has revised the diaptomid genus *Lovenula*, Rayner & Heeg (1994) have described distribution patterns of the Diaptomidae in southern Africa and Rayner (1994, 1999a) has described three new species of *Tropodiaptomus* and three of *Paradiaptomus*. A review of the Subfamily Paradiaptominae as well as biographical notes on taxonomists and collectors associated with freshwater research in Africa (before 1950) is presented in Rayner (1999b). There has been no taxonomic research on southern African cyclopoids and harpacticoids except for a few species described or mentioned by Brady (1904, 1913), Sars (1927) and Kiefer (1934). This review chapter is concerned mainly with collating all known information on the southern African Calanoida with a summary of the available information on Harpacticoida and Cyclopoida. Unless otherwise stated, illustrations and

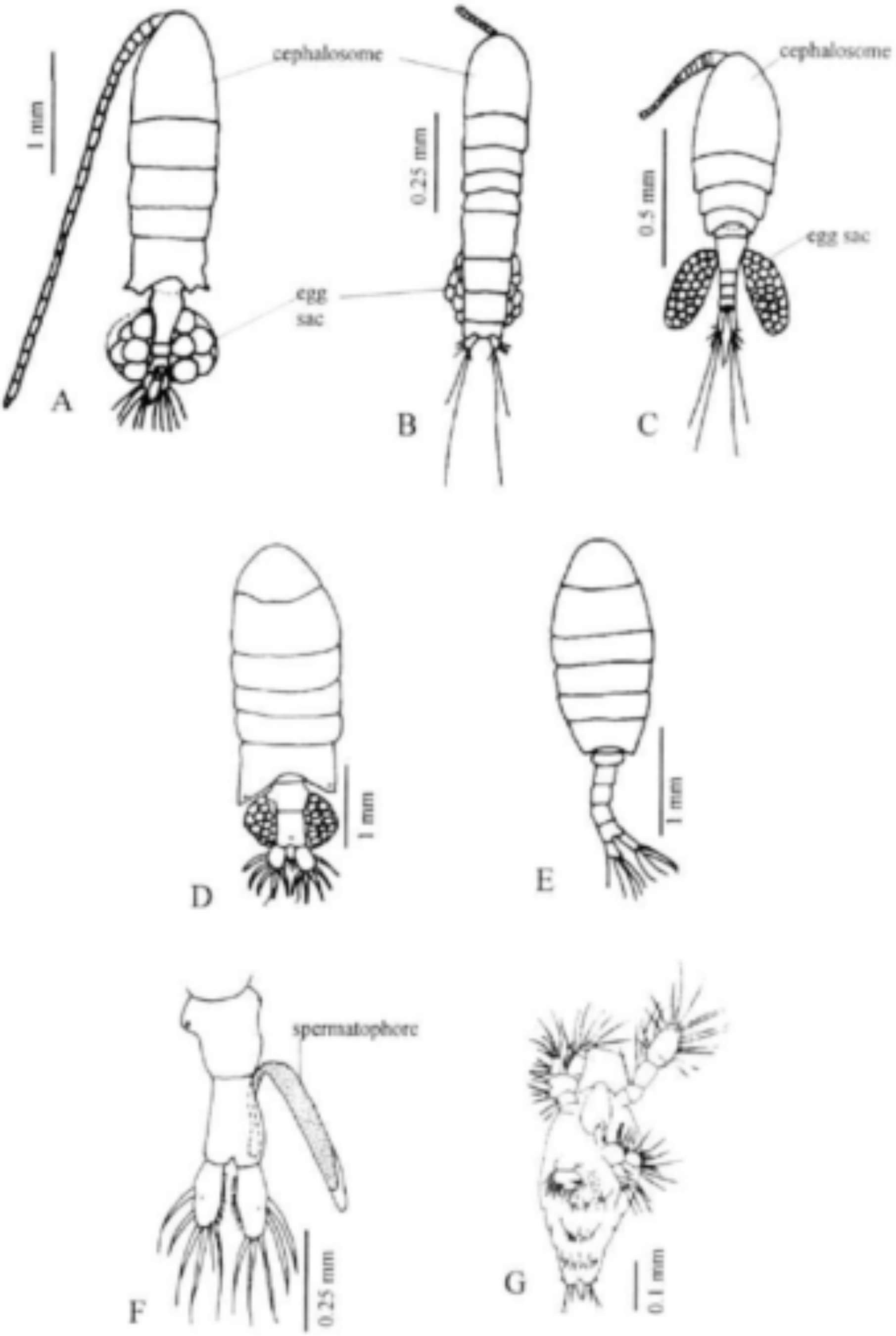

Fig. 2.1: A–C, Typical free-living freshwater Copepoda, dorsal views: A, Calanoida, female; B, Harpacticoida, female; C, Cyclopoida, female. D–G, *Lovenula falcifera*: D, female with single egg sac; E, male habitus; F, female urosome with spermatophore; G, Stage VI nauplius, ventral view. (Figs 1A–C & 1K redrawn from Wilson & Yeatman 1959).

distribution records are based on the author's material and data, or on museum loan material.

Morphology

Although in practice it is relatively straightforward to recognize a copepod, it is difficult to formulate a rigorous definition of the Copepoda because of their ecological adaptability (Huys & Boxshall 1991). In order to identify a copepod, it is important to understand the terminology and to know the important identifying characters.

All adult copepods have a stage exhibiting a cephalosome, a cephalon into which the maxilliped-bearing first thoracic somite is incorporated. The second thoracic somite is, therefore, the first pedigerous somite (Fig. 2.2A).

Details of terminology relating to body somites and appendages are given in Figs 2.2A–D. The term 'somite' refers to body divisions and 'segment' or 'article' to appendage units. 'Total Length' of an adult copepod refers to the length excluding the furcal setae.

The *cephalon* has five pairs of appendages: *antennules* (A1), *antennae* (A2), *mandibles* (Md), *maxillules* (Mx1) and *maxillae* (Mx2). The *first thoracic somite* is fused with the cephalon, forming the cephalosome, and carries a pair of *maxillipeds* (Mxp). The rest of the thorax consists of five somites, although in calanoids the last two may be fused. Each of the first four thoracic somites (numbered 2 to 5) bears a pair of *natatory* (swimming) *legs* and is referred to as a *pedigerous* somite (Pdg1–4). In cyclopoids and most calanoids, the fifth pair of legs (on pedigerous somite 5 = thoracic somite 6) is non-natatory (not used for swimming). The five pairs of legs are referred to as P1–P5 (Fig. 2.2B). There is a hinged articulation between pedigerous somite 5 and the genital somite in calanoids (gymnoplean condition) and between pedigerous somites 4 and 5 in harpacticoids and cyclopoids (podoplean condition), although the harpacticoids tend to appear rather wormlike. This articulation divides the body into the *prosome* and *urosome* (Fig. 2.2A–D). The genital somite is sometimes referred to as a double somite. The term abdomen is not applicable to copepods. The urosome has five somites in male and female cyclopoids. In calanoids the female has two or three urosomal somites and the male has five. The urosome does not have appendages but terminates in a paired *furca*. In calanoids, each *furcal ramus* (FR) bears five strong setae and a sixth slender 'dorsal' seta (Fig. 2.4F), while harpacticoids and cyclopoids have a number of long setae (Figs 2.10A, 2.10F, 2.11A). The somite bearing the furca is the *anal somite* (AS) (Fig. 2.2A), the anus being located between the furcal rami.

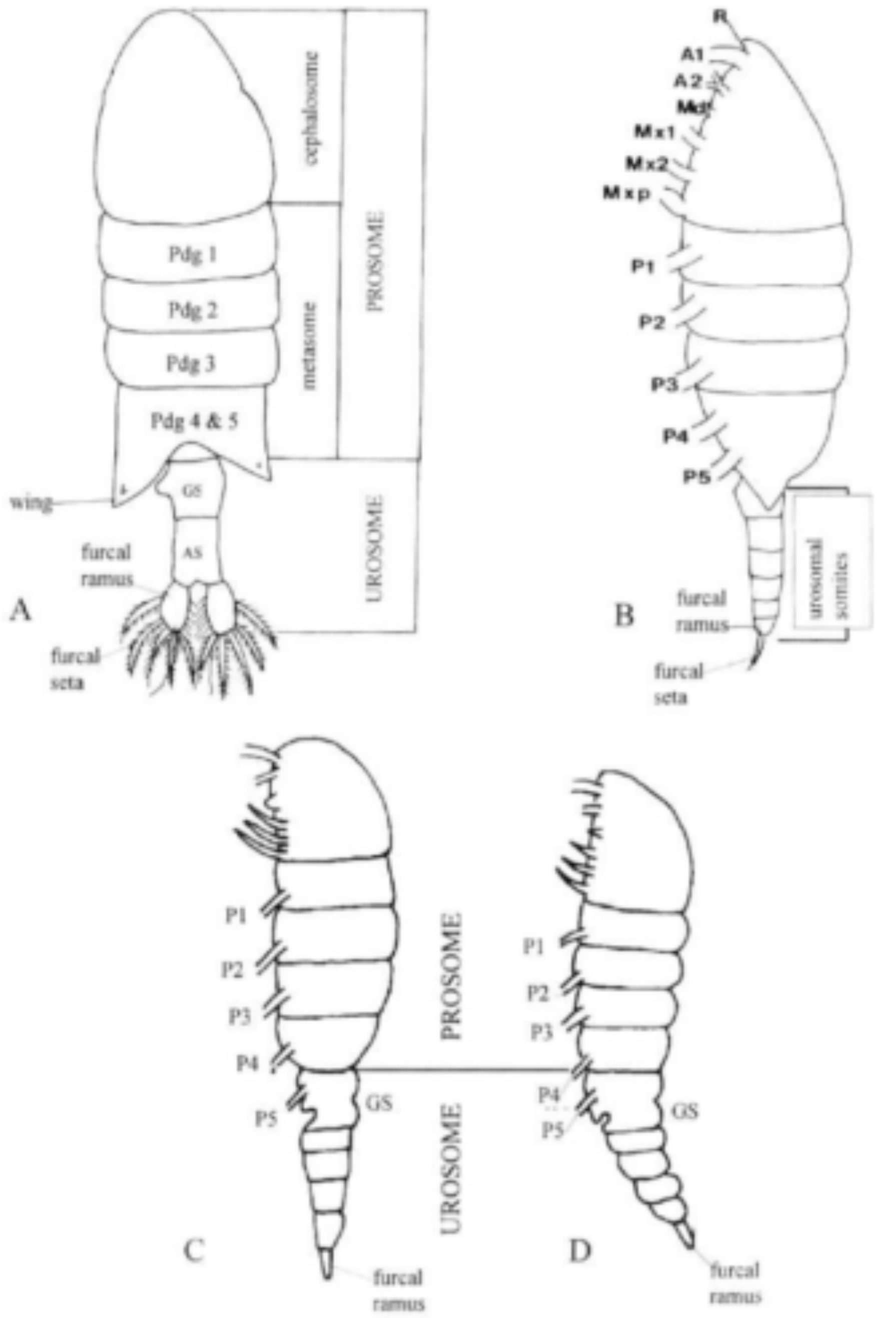

Fig 2.2: Free-living freshwater Copepoda: details of terminology relating to body somites and appendages. A, female calanoid in dorsal view; B, male calanoid in lateral view; C, female cyclopoid in lateral view; D, female harpacticoid in lateral view.

KEY: Pdg 1–5 = pedigerous somites 1–5; GS= genital somite; AS= anal somite; R= rostrum
A1= antennule; A2= antenna; Md= mandible; Mx1= maxillule; Mx2= maxilla; Mxp = maxilliped;
P1–P4= swimming legs; P5= modified non-swimming leg.

A primitive copepod swimming leg (e.g. Fig. 2.6A) has a *coxopodite* (B1) articulating with the body, while the *basipodite* (B2) supports an inner three-segmented *endopodite* (Enp1–3) and a outer three-segmented *exopodite* (Exp1–3) (Figs 2.6A, 2.12A). An *inter-coxal sclerite* or plate ('coupler') (Fig. 2.6A) ensures that the legs of each pair beat synchronously. The inter-coxal 'coupler' is a good diagnostic character for all copepods. Small club-shaped structures called aesthetascs may be present on the antennules and are presumably sensory receptors. On all appendages, and sometimes on the body, there may be spines, spinules, setae and setules, many of which are useful diagnostic characters. Some species are heavily armoured with spiniform processes, spines, 'claws' and other chitinous structures. Calanoids are sometimes heavily pigmented with carotenoids (red, orange, indigo) which are located in fat globules and other structures. Unfortunately, these pigments fade rapidly on preservation of the specimen. Carotenoids are synthesized from β-carotene in the algal diet and may be photo protective against U–V light or involved in energy storage (Ringelberg 1980).

GENERAL BIOLOGY

Habitat Preferences

Freshwater copepods in southern Africa occupy a wide variety of habitats. They may occur in the open water of large impoundments, in a wide range of temporary water bodies, and in backwaters of rivers, marshy areas, vleis and coastal lakes. They do not occur in the main flow of rivers but are often associated with a river system. In southern Africa they occur in all surface freshwater habitats, although, as yet, they have not been recorded from subterranean waters. Some species are important fish parasites.

Feeding

Most calanoids are herbivores, feeding on fine particles, usually phytoplankton. However, all species of *Lovenula* are predators, using their large raptorial maxillipeds (Fig. 2.3J) to capture prey. *Paradiaptomus* species have raptorial maxillipeds but these are not as strongly developed as those in *Lovenula* species. Most species of Cyclopoida are raptorial predators that seize and tear their prey. They catch small zooplankters and prey heavily on copepod copepodites and nauplii as well as on rotifers, small cladocerans and cladoceran nauplii. Harpacticoid species inhabit benthic and interstitial biotopes and have mouthparts adapted for detrital feeding.

Limnetic copepods are preyed on by juvenile fish and phantom midges of the genus *Chaoborus*, as well as by predatory copepods. Benthic and littoral copepods are preyed on by a variety of animals, including water mites and odonate nymphs.

Reproduction

All free-living freshwater Copepoda undergo sexual reproduction. Males and females differ markedly in size and in some calanoid species (e.g. *Metadiaptomus meridianus*) the female may be twice the length of the male. Male and female calanoids have a different number of somites in the urosome (Figs 2.1D–E), and morphological differences in appendages such as the antennules (Figs 2.3A–B) and fifth pair of legs (Fig. 2.6B, 2.7A). To accommodate these differences, especially when identifying calanoids and harpacticoids, keys to both males and females are provided. Keys to the Cyclopoida are based on a suite of characters relating only to adult females.

In calanoids the male captures the female using the geniculate (hinged) right antennule (Fig. 2.3B & Figs 2.4A–D) and modified fifth pair of legs (Figs 2.7A–H, Figs 2.8A–J), then uses a cement-like substance to attach one or more spermatophores on or near her genital opening (Fig. 2.1F). Some diaptomid females have a coupling apparatus or process on one of the urosomal somites (e.g. Fig. 2.5K) to which the spermatophore is attached. Sperm is stored by the female in subcuticular spermathecal sacs referred to as the 'receptaculum seminis' in cyclopoids (Figs. 2.12G–H). The eggs are carried in a single egg sac attached to the ventral side of the female urosome in calanoids and harpacticoids (Figs 2.1A, 2.1B) or in a pair of egg sacs in cyclopoids (Fig. 2.1C), until the nauplii hatch (Fig. 2.1G). Egg development times are correlated strongly with water temperature (Hart 1985). In the ancestral state the life cycle includes six naupliar/metanaupliar stages and five copepodid stages, the sixth copepodite being the adult. In cyclopoids and harpacticoids the number of naupliar stages may be reduced (Gurney 1931). For details of developmental stages see Kiefer (1978) and Dussart & Defaye (1995). Copepods that occur in temporary water bodies have resting eggs or dormant copepodid stages (Hairston & van Brunt 1994) which allow survival during adverse conditions. Diapausing fertilized adult female cyclopoids have been recorded by Næss & Nilssen (1991) from a lake in southern Norway, but no information is available on resting stages of cyclopoids and calanoids in southern Africa.

IDENTIFICATION OF THE COPEPODA OF SOUTHERN AFRICA

Collection, preservation and curation

Limnetic copepods may be collected in zooplankton trawls and vertical hauls. A Clarke-Bumpus plankton sampler may be used for trawling but preference is usually given to a vertical-haul closing net (Schwoerbel 1970) as it is easier to use and does not involve trawling equipment. A vertical-haul net is usually attached to a frame of 30 cm diameter, the length of the net being 1 m. The net, which is available from instrument firms, is scientifically designed, being of a mesh size which will capture the organisms that are targeted. The mesh size should be no greater than 62 µm, or 124 µm at most, as copepods will not be retained by a broader mesh.

Sweeps with a hand-net, especially in the vicinity of macrophytes, may be undertaken in smaller ponds, pans and river margins. Copepods should be fixed in 4% buffered formalin solution or 95% alcohol, and preserved in 70% alcohol to which a few drops of glycerine may be added. Harpacticoids may be collected by scraping up a centimetre of benthic sediment and immersing it in water in the laboratory. Harpacticoids, which appear at the sediment-water interface, can be collected with a pipette. Washing aquatic vegetation may also yield specimens.

Copepods must be dissected for identification and it is important to ensure that only adults and not copepodites are selected. Specimens may be placed in a small quantity of water or glycerine and dissected using jeweller's forceps and very fine dissecting needles. As cyclopoids are very small, dissection is tedious and difficult. It is often preferable to place a number of cyclopoid females on a microscope slide and, under pressure of the cover slip, attempt to display some of the characters required for identification. For better clarity, specimens may be stained before dissection with Chorazol Black E, Rose Bengal or Lignin Pink. All parts of the dissected animal should be mounted on a slide using glycerine jelly, covered with a cover slip and sealed with DPX or a similar preparation. A reasonably permanent mount is thus prepared, but it has the advantage that the seal can be broken, the jelly melted, and the material re-examined. Larger calanoids can be prevented from being crushed by using a square cover slip and raising it off the specimen by placing a 1–2 mm ball of plasticine under each corner of the coverslip.

Whole specimens should be retained as well as the dissected material because, if curated well, they can last indefinitely, whereas microscope slides tend to deteriorate over a period of years. Wet specimens should be stored in alcohol in small vials plugged with cotton wool and the vials submersed in alcohol in a larger container.

For further information on collection, preservation and curation, see Huys & Boxshall (1991), Pennak (1991) and Dussart & Defaye (1995). Detailed accounts of the preparation of glycerine jelly, as well as other techniques used in the preparation of slides, are given by Pennak (1991) and Huys & Boxshall (1991).

KEY TO THE ORDERS OF FRESHWATER COPEPODA

1. Body showing gymnoplean tagmosis, with prosome and urosome divided by a specialized hinge joint between fifth pedigerous and genital somites (Fig. 2.2A, B) .... **Calanoida** (Figs 2.3–2.9)
– Body showing podoplean tagmosis, with prosome and urosome divided by a specialized hinge joint between fourth and fifth pedigerous somites (Figs 2.2C, D) 2

2. Male antennules 14–segmented, female antennules nine-segmented (Figs 2.10B, G); single egg sac (Figs 2.1B, 2.10A, F) ..... **Harpacticoida** (Fig. 2.10)
– Both male antennules geniculate (hinged —Fig. 2.11B), maximum number of segments 17; female antennules up to 26–segmented; egg sacs paired (Fig 2.1C, 2.11A) .... **Cyclopoida** (Figs 2.11, 2.12)

CALANOIDA Sars, 1903

The majority of calanoid copepods are marine. Families which have freshwater, estuarine or coastal lake species are the Centropagidae, Pseudodiaptomidae, Temoridae, Diaptomidae and Acartiidae but the Diaptomidae is the only family which has been recorded from the inland waters of southern Africa. Kiefer (1932) split the Diaptomidae into two subfamilies: the Paradiaptominae (*Lovenula, Paradiaptomus* and *Metadiaptomus*) and the Diaptominae (represented in southern Africa by *Tropodiaptomus* and *Thermodiaptomus*). All African Diaptomidae are endemic to the continent and often have restricted distributions. The Paradiaptominae which, with few exceptions, have been recorded only from Africa, are generally arid-adapted, occurring in temporary water bodies, although a few species (*Lovenula falcifera, Metadiaptomus meridianus* and *M. colonialis*) have colonized man-made impoundments. Species of *Tropodiaptomus* and *Thermodiaptomus* occur in more permanent waters and are found in the warm subtropical waters of northern Namibia, Botswana, Mpumalanga and the East Coast of KwaZulu–Natal (Rayner & Heeg 1994). The majority of freshwater calanoid species are highly specific to their habitats and some species are found within narrow geographical limits (for example, *Metadiaptomus capensis* has been collected only from the saline waters of the western and southern Cape, and *Lovenula excellens* has been recorded only from Lake Chrissie and surrounding pans in Mpumalanga).

Pseudodiaptomus hessei (Pseudodiaptomidae), a species which occurs in the upper reaches of estuaries (e.g. Milnerton) and coastal lakes (e.g. Sibaya), has not been included in this account. See Grindley (1963) for details on the identification of this species.

Family: **Diaptomidae** Baird, 1850

Body length (including furca but not furcal setae): 1–5 mm.
Identification of these calanoids depends on an examination of characters of both sexes.

Females: Pedigerous somites 4 and 5 are often fused (Fig. 2.2A). The urosome of the female has two or three somites (Figs 2.1D, 2.5E–H, Fig. 2.5I) depending on the genus. The lateral or distal expansions of the fifth pedigerous somite of the female are referred to as 'thoracic wings' (Fig.2.2A, Figs 2.5B–I). Both left and right antennules of the female, and the left antennule of the male, are similar, having 25 segments (Figs 2.1A, 2.3A) and sometimes extending to or beyond the furcal rami. The antennae are biramous (Fig. 2.3E). The mandible (Fig. 2.3F), maxillule (Fig. 2.3G), maxilla (Figs 2.3H, 2.3I) and maxilliped (Fig. 2.3J) of *Lovenula falcifera* show the basic pattern of diaptomid mouthparts and are the same in males and females. The fifth pair of legs is modified but the two are symmetrical (Figs 2.6D–F). There is a single egg sac attached to the ventral surface of the female urosome (Figs 2.1A, 2.1D).

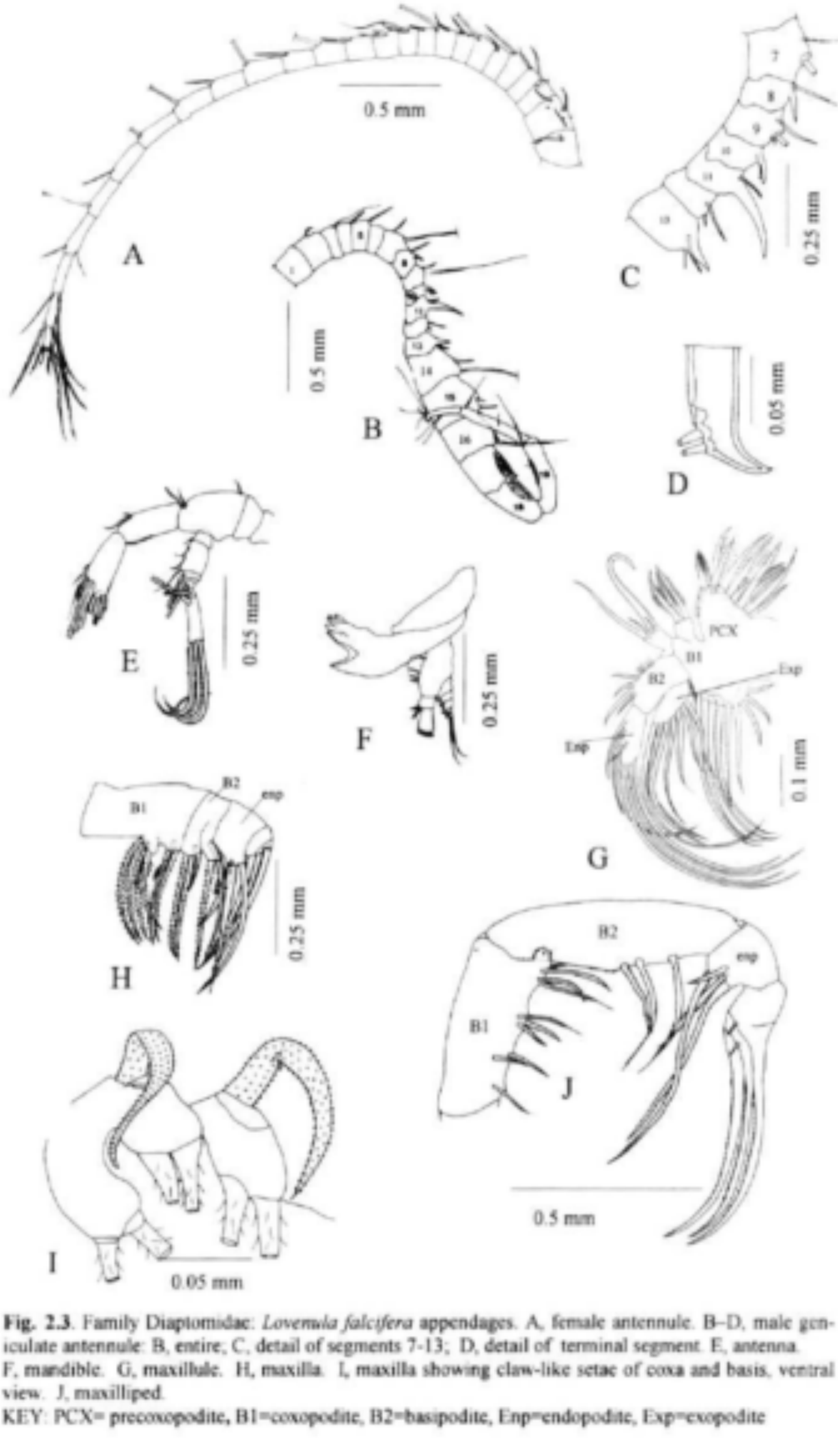

Fig. 2.3. Family Diaptomidae: *Lovenula falcifera* appendages. A, female antennule. B–D, male geniculate antennule: B, entire; C, detail of segments 7-13; D, detail of terminal segment. E, antenna. F, mandible. G, maxillule. H, maxilla. I, maxilla showing claw-like setae of coxa and basis, ventral view. J, maxilliped.

KEY: PCX= precoxopodite, B1=coxopodite, B2=basipodite, Enp=endopodite, Exp=exopodite

Males: The urosome consists of five somites (Figs 2.1E, 2.4G, 2.4H). The right antennule has either 21 or 22 segments and is geniculate, with a hinge between segments 18 and 19 (Fig. 2.3B, Figs 2.4A–D). The middle segments of the antennule are flattened with a spiniform process on each of segments 8, 10, 11 and 13 (Figs 2.3B, 2.3C, 2.4A–C) or segments 10, 11, 13 and 15 (Fig. 2.4D). There is some variability in the presence and size of these processes but their formula (i.e. occurrence, size, shape) is species-specific. Both left and right of the fifth pair of legs are specialized structures, with a long blade-like claw representing the third segment of the exopodite of the right leg (Figs 2.7A–H, Figs 2.8A–J).

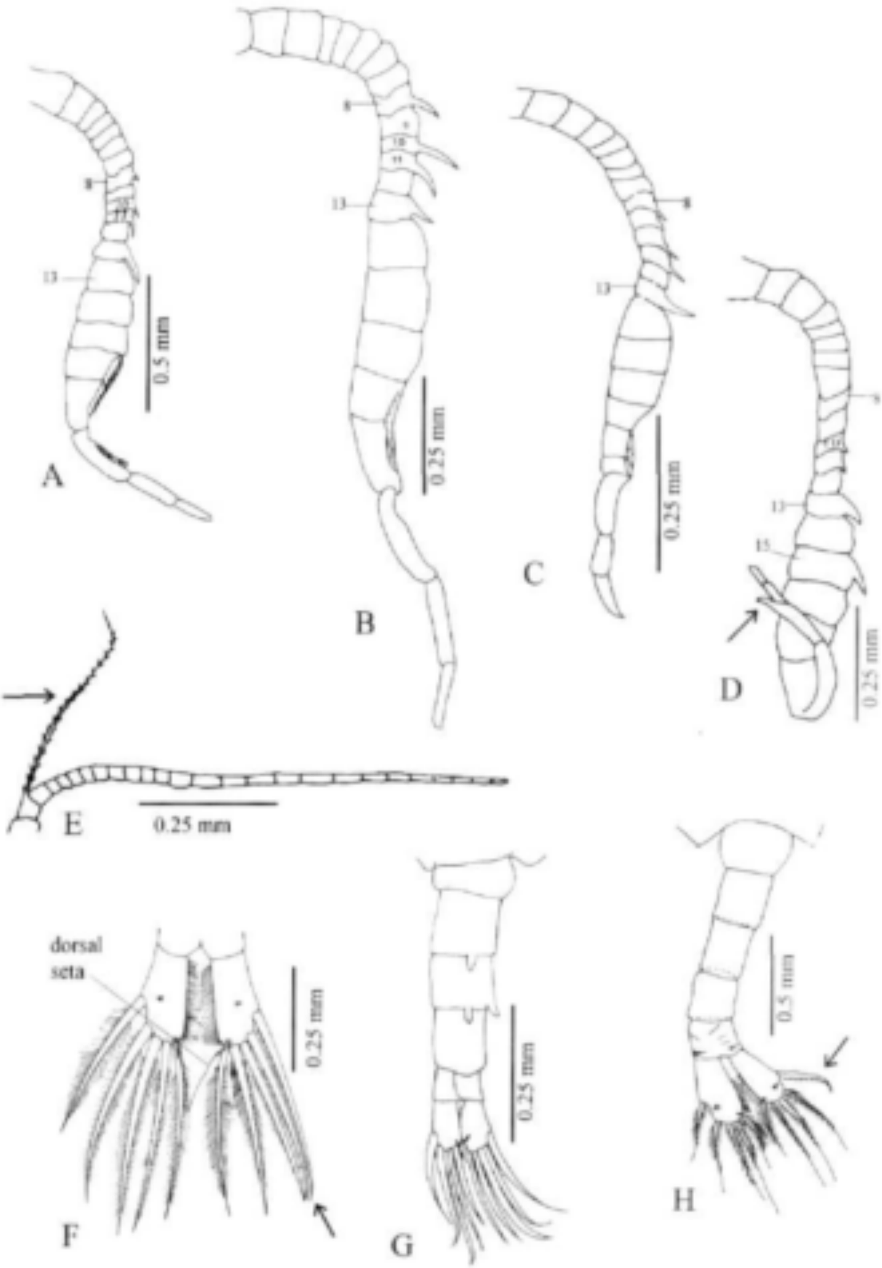

Fig. 2.4: Family Diaptomidae. A–D, examples of male geniculate right antennules: A, *Paradiaptomus lamellatus*; B, *P. natalensis*; C, *Metadiaptomus colonialis*; D, *Tropodiaptomus spectabilis*. E, female antennule of *Metadiaptomus purcelli*, showing long seta (arrowed) on first segment. F–H, Urosome of males: F, *Lovenula falcifera*, modification of the three outer setae of the right furcal ramus (arrowed); G, *Thermodiaptomus congruens*,with spinous processes on urosomal somites 2 & 3; H, *Paradiaptomus lamellatus* showing modified outer seta (arrowed) of right furcal ramus.

KEY TO THE AFRICAN GENERA OF DIAPTOMIDAE

Females

1\. Urosome with two somites (e.g. Fig. 2.5L) 2
– Urosome with three somites (Fig. 2.5I) .... *Metadiaptomus*

2\. Body length usually exceeds 2.0 mm; maxillipeds raptorial (e.g. Fig. 2.3J), endopodite of maxilliped with fewer than five segments 3
– Body length seldom exceeds 2.0 mm; maxillipeds not modified, endopodite of maxilliped with five segments 4

3\. Body length 3.0–4.0 mm; maxillipeds scythe-shaped (Fig. 2.3J); setae of furcal rami not lamelliform and without bulbous bases (Fig. 2.5A) ....*Lovenula*
– Body length 2.0–3.5 mm; maxillipeds raptorial but not scythe-shaped; furcal rami sometimes lamelliform, expanded distally, setae may have bulbous bases (Fig. 2.5E) ....*Paradiaptomus*

4\. Endopodite of fifth leg with two terminal setae (arrowed in Fig 2.6J) .... *Tropodiaptomus*
– Endopodite of fifth leg without terminal setae (arrowed in Fig. 2.6I) ....*Thermodiaptomus*

Males

1\. Right antennule 21–segmented, geniculate between segments 18 and 19, no articulation between segments 20 and 21, diagnostic spiniform processes on segments 8, 10, 11, 13 (Figs 2.3B, 2.3C, 2.4A–C); second exopodite-segment of left fifth leg with well-developed, lateral or medial spiniform process (arrowed in Figs 2.7A–H, 2.8A–F) 2
– Right antennule 22–segmented, geniculate between segments 18 and 19, articulation between segments 20 and 21, diagnostic spiniform processes on segments 10, 11, 13, 15 (Fig. 2.4D); second exopodite-segment of left fifth leg without spiniform process (Figs 2.8G–J) 3

2\. Maxillipeds not raptorial, endopodite with five segments; basipodite of right fifth leg expanded on inner margin and fringed with small knobs, spines or setae (arrowed in Figs 2.8A–F) ....*Metadiaptomus*
– Maxillipeds raptorial (Fig. 2.3J), endopodite with four segments; basipodite of right fifth leg not expanded and without knobs, spines or setae 4

3\. Second segment of exopodite of right fifth leg parallel to the long axis of body with lateral spine adjacent to blade-like claw of third segment (arrowed in Figs 2.8G, 2.8H) .... *Tropodiaptomus*
– Second segment of exopodite of right fifth leg at right angles to long axis of body, with lateral spine widely separated from blade-like claw of third segment (arrowed in Figs 2.8I, 2.8J) ....*Thermodiaptomus*

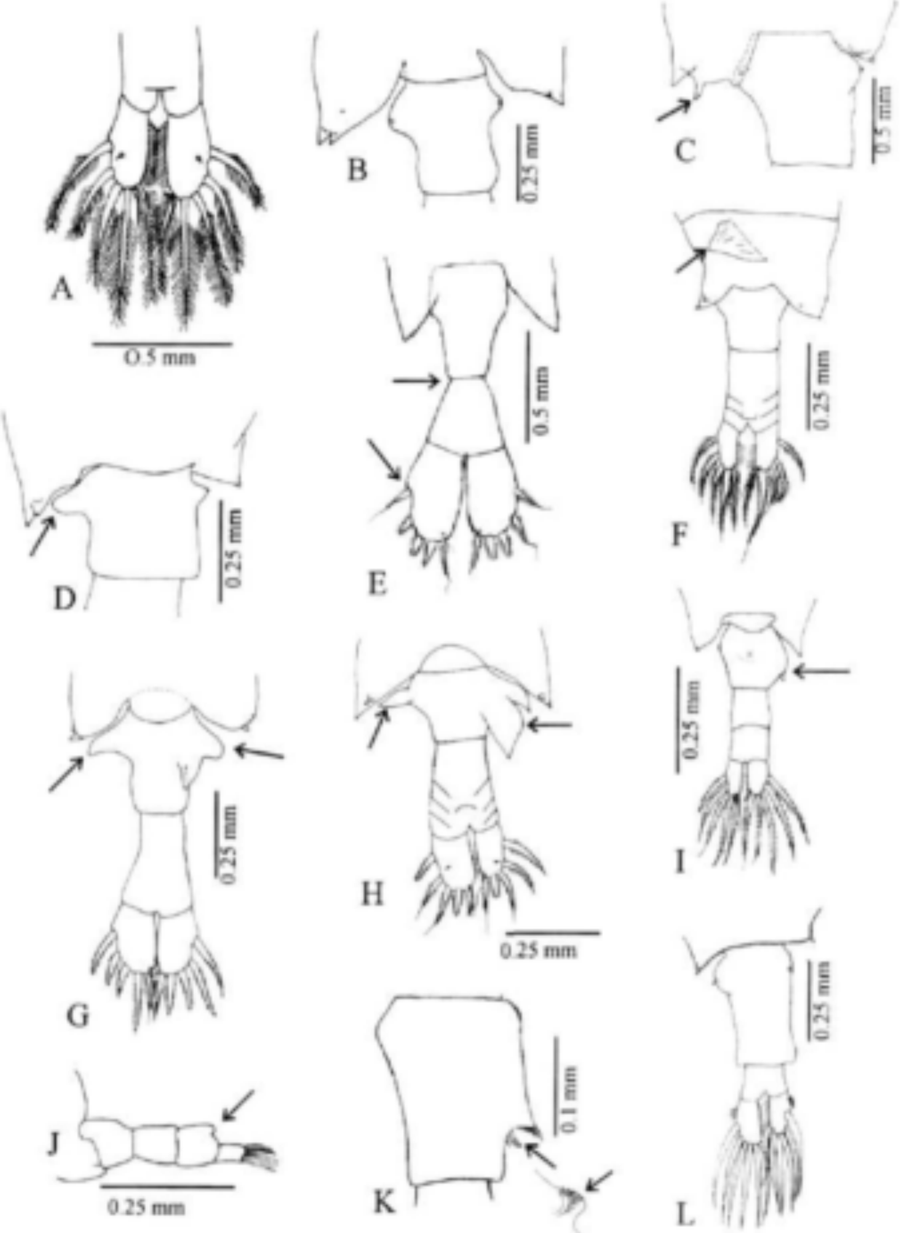

Fig. 2.5. Family Diaptomidae, modifications of the female last thoracic somite and urosome (A–I & K–L = dorsal views; J = lateral view): A, *Lovenula falcifera*, furca; B, *L. falcifera*, genital somite and thoracic wings; C, *L. africana*, genital somite and thoracic wings; D, *L. excellens*, genital somite and thoracic wings; E, *Paradiaptomus lamellatus*, urosome with lamelliform furcal rami; F, *P. natalensis*, urosome and last thoracic somite with fin (arrowed); G, *P. schultzei*, urosome with lobed genital somite; H, *P. similis*, urosome with lobed genital somite; I, *Metadiaptomus capensis*, urosome with asymmetrical genital somite; J, *M. purcelli*, urosome with expanded anal somite, lateral view; K, *M. colonialis*, genital somite showing ring of spines and spermatophore-coupler (both arrowed); L, *Tropodiaptomus schmeili*, urosome with long genital somite.

4. Body length 2.5–4.0 mm; maxillipeds scythe-shaped (Fig. 2.3J); second segment of exopodite on left fifth leg with strong, terminal spiniform process (arrowed in Figs 2.7A–D); setae of right furcal ramus modified with three lateral setae separated from two medial setae (arrowed in Fig. 2.4F) .... *Lovenula*

– Body length 2.0–3.5 mm; maxillipeds not as above; left fifth leg with short lateral spiniform process (arrowed in Figs 2.7E–H); three lateral setae of right furcal ramus not separated, but outermost seta may be set apart and enlarged (arrowed in Fig. 2.4H) .... *Paradiaptomus*

Genus ***Lovenula*** Schmeil, 1898

KEY TO THE SPECIES OF *LOVENULA*

Females

1. Endopodite of leg 5 reaching distal end of first exopodite-segment, with two setae long and spine-like (arrowed in Fig. 2.6B) .... *L. falcifera*
– Endopodite of leg 5 not reaching distal end 2/3 length of first exopodite-segment, with two short setae (Figs 2.6.D, E, F) 2

2. Left Pdg 5 thoracic wing expanded laterally with three processes, one finger-like (arrowed in Fig. 2.5C) .... *L. africana*
– Left Pdg 5 thoracic wing directed backwards, with two pointed processes (Fig. 2.5D) 3

3. Genital somite with left lateral cone-shaped expansion (arrowed in Fig. 2.5D); anal somite same length as genital somite; setae of leg 5 endopodite not reaching to end of first exopodite-segment (arrowed in Fig. 2.6D) .... *L. excellens*
– Genital somite not expanded on left; length of anal somite twice the length of genital somite; setae of leg 5 endopodite reaching to end of first exopodite-segment (arrowed in Fig. 2.6F) .... *L. simplex*

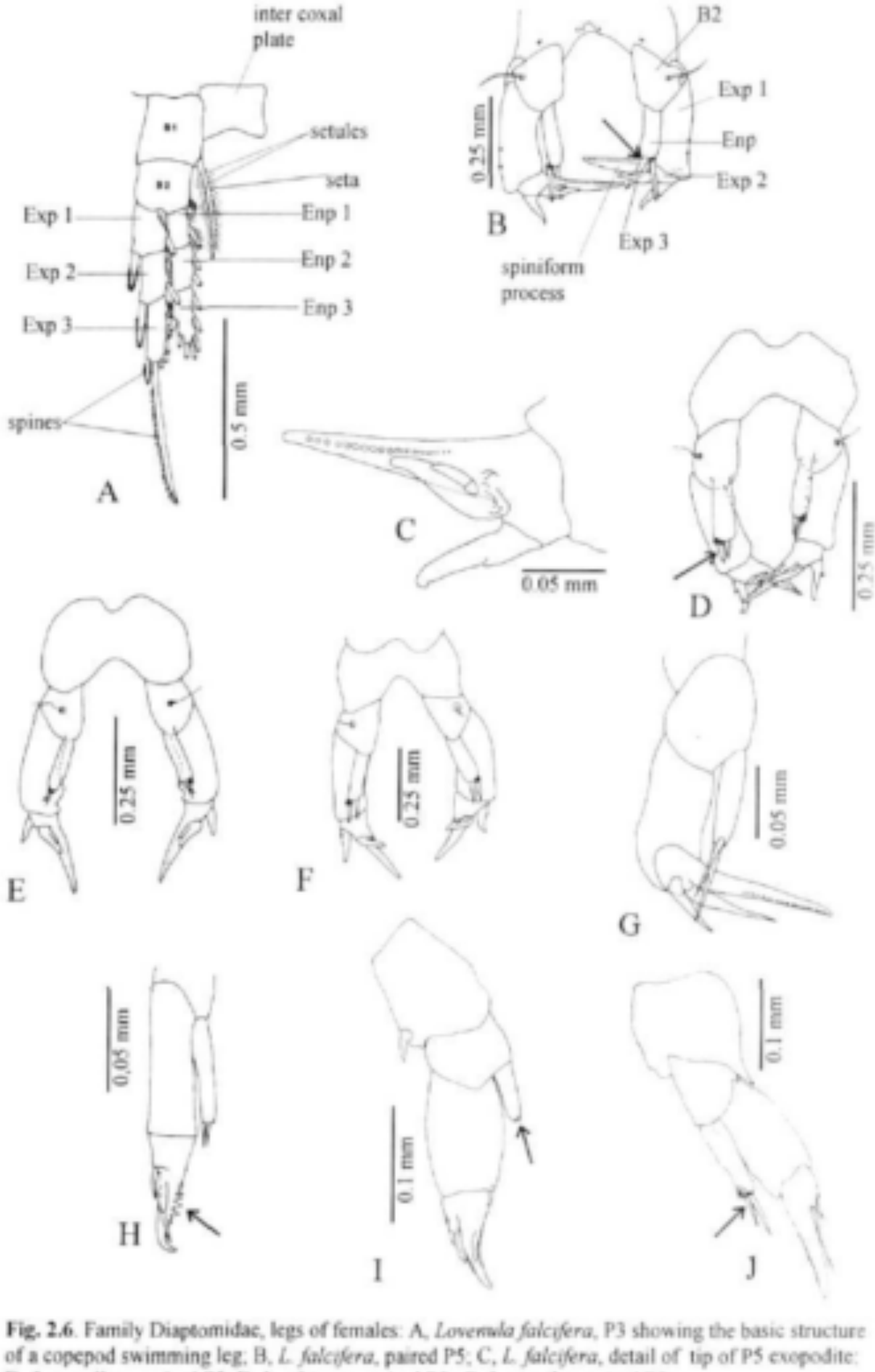

Fig. 2.6. Family Diaptomidae, legs of females: A, *Lovenula falcifera*, P3 showing the basic structure of a copepod swimming leg; B, *L. falcifera*, paired P5; C, *L. falcifera*, detail of tip of P5 exopodite; D. *L. excellens*, paired P5; E, *L. africana*, paired P5; F, *L. simplex*, paired P5; G, *Paradiaptomus natalensis*, P5; H, *Metadiaptomus purcelli*, P5; I, *Thermodiaptomus congruens*, P5; J, *Tropodiaptomus schmeili*, P5.
KEY: B1 = coxopodite; B2 = basipodite; Enp = Endopodite; Exp = Exopodite;
P3 = third swimming leg; P5 = fifth (non-swimming) leg.

Males

1. Right leg 5 with second exopodite-segment narrow, terminal claw long with deep indentation resulting in a slight S–bend (arrowed in Fig. 2.7D) .... *L. simplex*
– Right leg 5 with second exopodite-segment expanded distally, terminal claw uniformly curved and the same length as second exopodite-segment (Figs 2.7A–C) 2

2. Left leg 5 with third exopodite-segment claw smoothly curved, extending to distal border of right leg second exopodite-segment (arrowed in Fig. 2.7A) .... *L. falcifera*
– Left leg 5 with third exopodite-segment claw directed backwards, extending to middle of right leg second exopodite-segment (arrowed in Figs 2.7B, C) 3

3. Left leg 5 with terminal claw slightly curved (arrowed in Fig. 2.7C); combined length of last two segments of right antennule twice the length of the third-last segment .... *L. excellens*
– Left leg 5 with terminal claw straight (arrowed in Fig. 2.7B); combined length of last two segments of right antennule slightly longer than length of third-last segment .... *L. africana*

Lovenula falcifera (Lovén, 1845)

Figs 2.1D–G, 2.3, 2.4F, 2.5A, 2.5B, 2.6A–C, 2.7A

Total length: Female 3.2–5.0 mm; male, 3.1–4.0 mm (Fig. 2.2A, Figs H–J).
Key characters: Leg 5 of female as in Fig. 2.6B; leg 5 of male as in Fig. 2.7A; female thoracic wings as in Fig. 2.5B.
Records: In southern Africa *L. falcifera* occurs in temporary, often brackish waters on the highveld, many Gauteng pans (Hutchinson et al. 1932), and major impoundments on the Orange and Vaal rivers. It has also been recorded from Ovamboland (Sars 1927), Namibia, Kalahari (Barnard 1935), Kenya (van Douwe 1912), Uganda (Lowndes 1931), East African high mountain lakes (Löffler 1964), and Ethiopia (Defaye 1988). *Lovenula falcifera* is widely distributed, especially in drier areas in temporary pools and salt lakes (Seaman *et al.* 1991) but it also has the ability to colonize man-made water bodies (Hart 1987). Despite its wide distribution, it has not been recorded from low-lying areas, vleis, coastal lakes or coastal plains. It appears to be confined to the high plateau of Africa above 1000 m, much of which lies in the 'pan belt' (see place-name glossary). It is obviously well adapted to the extreme temperatures of these regions. *Lovenula falcifera* often co-occurs with a species of *Metadiaptomus*, upon which it preys. In southern Africa, the confusion of *L. falcifera* with *L. simplex* and *L. excellens* has detracted from the correct interpretation of the biology of this important diaptomid.

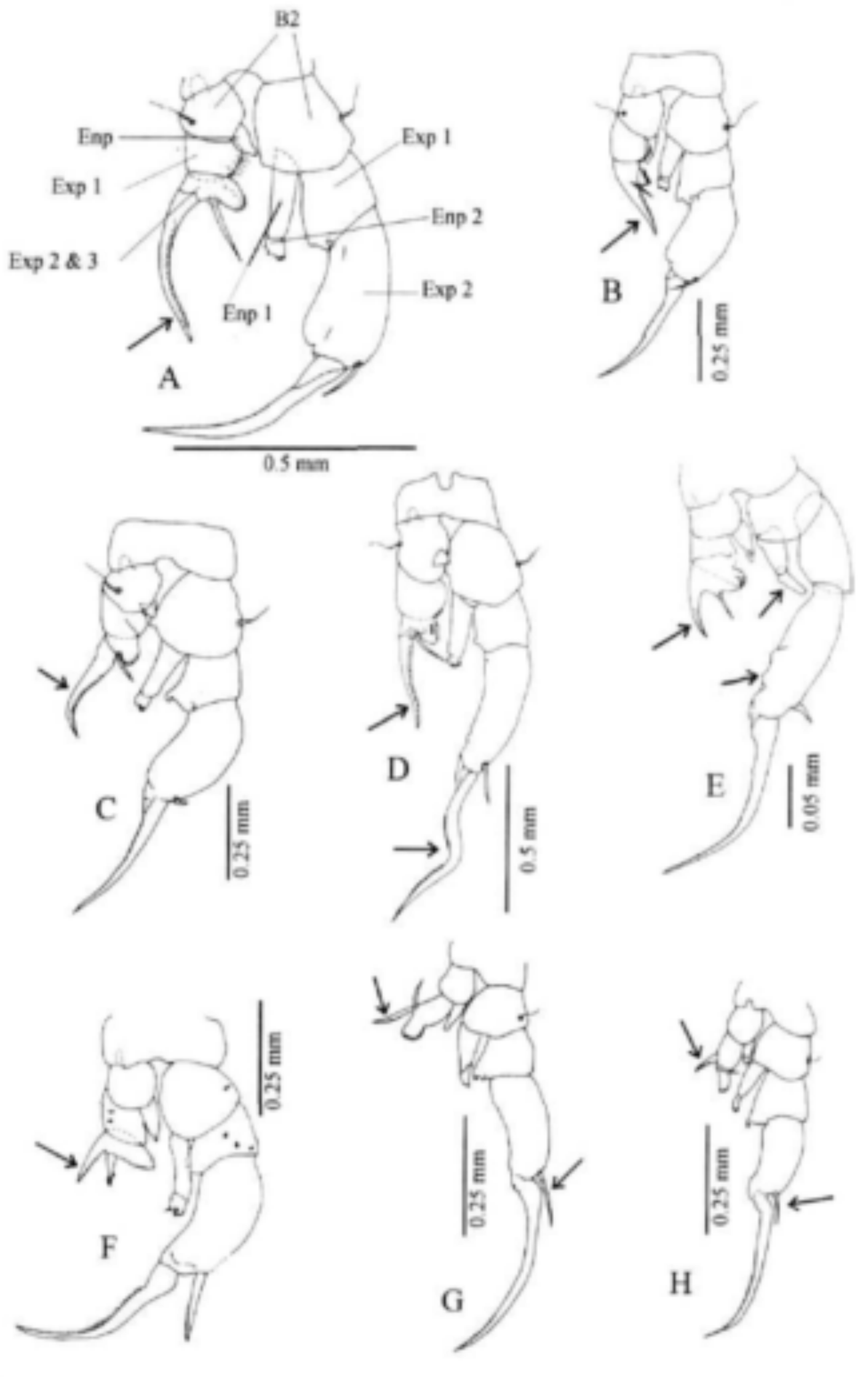

Fig. 2. 7. Family Diaptomidae, fifth pair of legs of male, posterior view: A, *Lovenula falcifera*, B, *L. africana*; C, *L. excellens*; D, *L. simplex*; E, *Paradiaptomus natalensis*; F, *P. lamellatus*; G, *P. similis*; H, *P. schultzei*.
KEY: Enp = Endopodite; Exp = Exopodite.

Lovenula africana (Daday, 1908)
Figs 2.5C, 2.6E, 2.7B

Total length: Female 2.9–3.2 mm; male 2.8–3.0 mm.
Key characters: Left thoracic wing of female as in Fig. 2.5C; leg 5 of male as in Fig. 2.7B.
Records: *Lovenula africana* occurs in waters of high conductivity from Ethiopia (Defaye 1988) through East Africa (LaBarbara & Kilham 1974), the southernmost record being Makgadikgadi Pan (BOTS).

Lovenula excellens Kiefer, 1929
Figs 2.5D, 2.6D, 2.7C

Total length: Female 3.0–3.5 mm; male 3.8–3.9 mm.
Key characters: Shape of genital somite of female as in Fig. 2.5D; leg 5 of female as in Fig. 2.6D; leg 5 of male as in Fig. 2.7C.
Records: Recorded only from the astatic perennial waters of Lake Chrissie and environs (MPL).

Lovenula simplex Kiefer, 1929
Figs 2.6F, 2.7D

Total Length: Female 3.6–4.0 mm; male 2.8–3.7 mm.
Key Characters: Long leg 5 of male, especially claw with S–bend as in Fig. 2.7D; long anal somite of female.
Records: Endemic to vleis of the western and southern Cape.

Genus ***Paradiaptomus*** Sars, 1895

KEY TO THE SPECIES OF *PARADIAPTOMUS*

All nine species of *Paradiaptomus* have been included in the key although *P. rex* (North Africa) and *P. greeni* (India and Sri Lanka) do not occur in southern Africa.

Females

1\. Urosome with three somites .... *P. rex*
– Urosome with two somites (e.g. Fig. 2.5E–H) 2

2\. Genital somite with prominent lateral lobes (arrowed in Fig. 2.5G–H) 3
– Genital somite almost symmetrical, without lobes (Fig. 2.5E, F) 4

3\. Lobes of genital somite pointed (arrowed in Fig. 2.5H) 5
– Lobes of genital somite rounded (arrowed in Fig. 2.5G) .... *P. schultzei*

4\. Pdg somites 4–5 fused and bearing a dorsal 'fin' (arrowed in Fig.2.5F) .... *P.natalensis*
– Pdg somites 4–5 without dorsal 'fin' 6

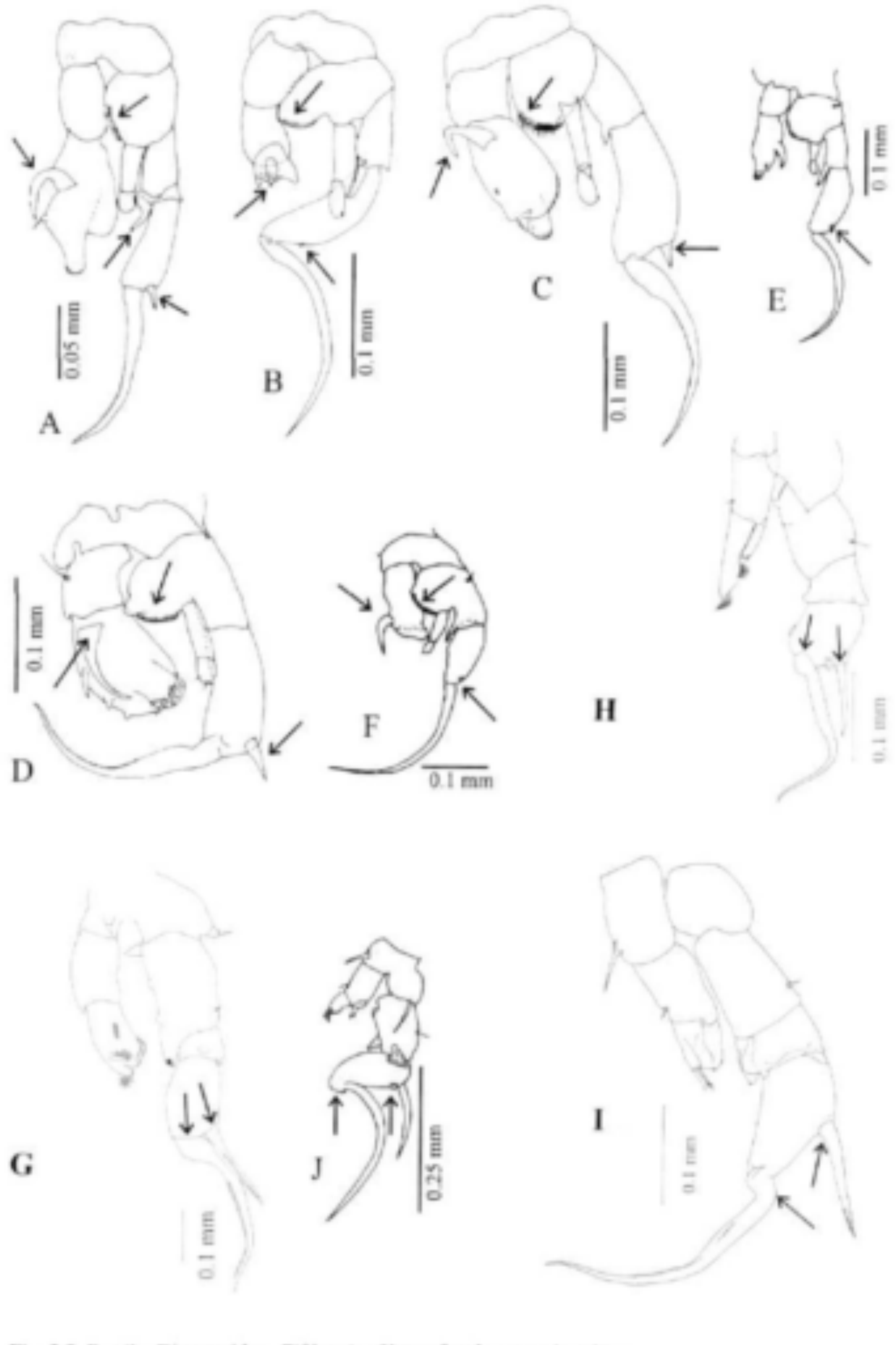

Fig. 2.8. Family Diaptomidae, Fifth pair of legs of male, posterior view: A, *Metadiaptomus purcelli*; B, *M. capensis*; C, *M. transvaalensis*; D, *M. meridianus*; E, *M. colonialis*; F, *M. gauthieri*, G, *Tropodiaptomus schmeili*; H, *T. spectabilis*; I, *Thermodiaptomus congruens*; J, *Thermodiaptomus mixtus*.

5. Adult total length 2.25 mm; lobes on genital somite are large inflated extensions on both sides, right lobe compound, extending one third along anal somite; Pdg 5 wings pointed with two small spines on each wing (Fig. 2.5H) .... *P. similis*
– Adult total length 1.28 mm; lobes of genital somite less well formed on both sides, right lobe compound, only just reaching distal border of genital somite; Pdg 5 wings rounded with two spines on each, upper left spine large, rounded .... *P. greeni*

6. Furcal setae short with widely separated bulbous bases; furcal rami expanded distally (Fig. 2.5E) 7
– Furcal setae long without expanded bases; furcal rami uniform width (Fig. 2.9F); length:breadth ratio = 2:1 8

7. Width of distal border of anal somite twice width of proximal border; furcal rami lamelliform, expanded distally (Fig. 2.5E); leg 5, endopodite two-segmented, weakly developed, not reaching to end of first exopodite-segment .... *P. lamellatus*
– Width of distal border of anal somite slightly greater than width of proximal border; furcal rami slightly expanded distally (Fig. 2.9F); endopodite on leg 5 two-segmented, strongly developed, reaching to end of first exopodite-segment (Fig. 2.9G) .... *P. warreni*

8. Genital somite twice as long as anal somite, three comparatively large spines on left Pdg 5 wing; endopodite on leg 5 weakly developed: excluding setae, half length of first exopodite-segment (Fig. 2.9C) .... *P. hameri*
– Genital somite 1.5 times as long as anal somite, two small spines on left Pdg 5 wing, endopodite on leg 5 strongly developed, as long as first exopodite segment (Fig. 2.9A) .... *P. peninsularis*

Males

1. Outer seta of right furcal ramus enlarged or modified (e.g. Fig. 2.9D) 2
– Outer seta of right furcal ramus not enlarged or modified 6

2. Outer seta of right furcal ramus enlarged, sclerotose, at right angles to ramus (Fig. 2.9 D) .... *P. hameri*
– Outer seta of right fucal ramus enlarged, not at right-angles 3

3. First exopodite-segment on right leg 5, with small processes on inner distal margin 8
– *First exopodite-segment on right leg 5, with no processes on inner distal margin* 4

4. Left leg 5 with proximal spinous process on last exopodite-segment broad-based, directed laterally, distal process directed caudally; outer seta of right furcal ramus not tapered 5
– Left leg 5 with spinous processes on last exopodite-segment both directed caudally (Fig. 2.9B); outer seta of right furcal ramus tapered distally .... *P. peninsularis*

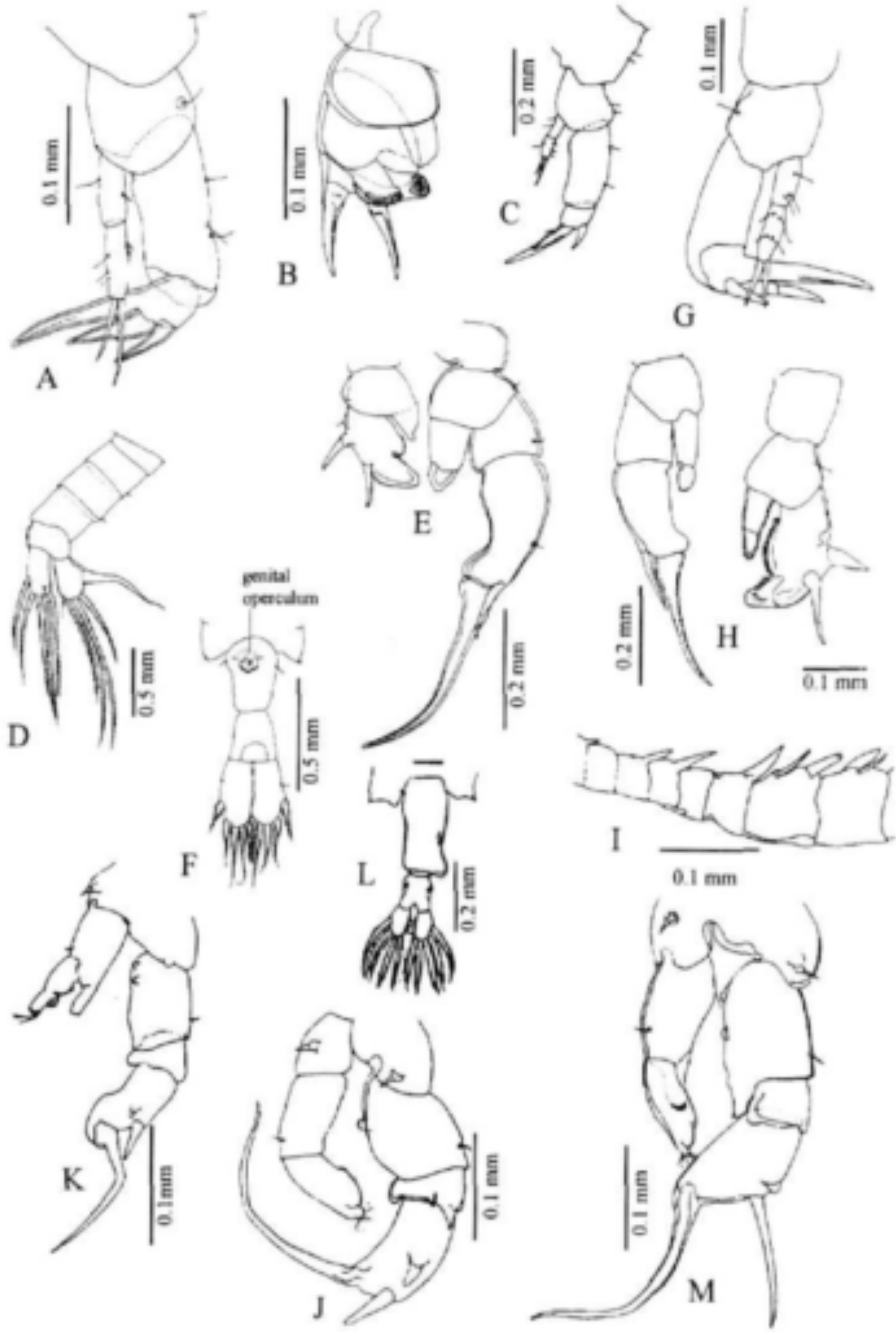

Fig. 2. 9. Some recently described species of *Paradiaptomus* and *Tropodiaptomus*.
A, *Paradiaptomus peninsularis*, leg 5, female. B, *P. peninsularis*, left leg 5, male. C–E, *P. hameri*:
C, leg 5, female; D, urosome of male in dorsal view; E, *P.* both legs 5, male.
F–H, *P. warreni*: F, urosome of female in ventral view; G, leg 5, female. H, both legs 5, male.
I, *Tropodiaptomus zambeziensis*, right antennule, segments 8–15, male. J. *T. zambeziensis*, both legs 5,
male; K. *T. bhangazii*, both legs 5, male; L. *T. capriviensis*, urosome of female in dorsal view.
M. *T. capriviensis*, both legs 5, male.

5. Left leg 5 with sturdy two-segmented endopodite; right leg 5 with second exopodite rectangular in shape with inner curvature (Fig. 2.9H)...*P. warreni*

– Left leg 5 with endopodite one-segmented; right leg 5 with second-exopodite segment short and broad with inner margin almost straight (Fig. 2.7F)..*P. lamellatus*

6. Right leg 5 with second exopodite-segment with inner distal processes, second endopodite-segment rectangular, nearly as long as first endopodite-segment (arrowed in Fig. 2.7E) ....*P. natalensis*

– Right leg 5 with second exopodite-segment without inner distal processes, second endopodite-segment less than half the length of first exopodite-segment 7

7. Right antennule with spiniform process on segment 11 short, less than one third of length of process on segment 13, last segment of antennule beaked; right leg 5 with ratio of length of terminal claw to length of outer spine of second exopodite-segment = 7:1 ....*P. rex*

– Right antennule with spiniform process on segment 11 almost as long as process on segment 13, last segment of antennule not beaked; right leg 5 with ratio of length of terminal claw to length of outer spine of second exopodite-segment = 5:1 (arrowed in Fig. 2.7H) ....*P. schultzei*

8. Total length 1.74 mm; right leg 5 with ratio of length of claw to length of outer spine of second exopodite-segment = 12:1, spine very weak, lying across distal end of second exopodite-segment, claw broad-based, straight, curved distally; right antennule with spinous process on segment 11 long and thin, process on segment 10 a little shorter and directed across process on segment 11, last segment of antennule with beaked process ....*P. greeni*

– Total length 2.00 mm; right leg 5 with ratio of length of claw to length of outer spine of second exopodite-segment = 5:1; spine thin, directed laterally, claw curved uniformly (arrowed in Fig. 2.7G); right antennule with spiniform process on segment 10 short, 1/3 length of spiniform process on segment 11, last segment of antennule beaked ....*P. similis*

Paradiaptomus lamellatus Sars, 1895

Figs 2.4A, H, 2.5E, 2.7F

Total length: Female 2.85– 3.0 mm; male 2.7 mm.
Key characters: Short antennules; lamelliform furcal rami of female as in Fig. 2.5E; right antennule of male as in Fig. 2.4A; leg 5 of male as in Fig. 2.7F; expanded seta of male right furcal ramus as in Fig. 2.4H.
Records: Western, southern and eastern Cape, mainly coastal.

Paradiaptomus natalensis (Cooper, 1906)

syn. *Adiaptomus natalensis* Cooper, 1906
Lovenula natalensis (Cooper, 1906)
Diaptomus pictus Brady, 1913.
Figs 2.4B, 2.5F, 2.6G, 2.7E

Total length: Female 1.74–1.88 mm; male 1.65–1.78 mm.
Key characters: 'Fin' on last thoracic somite of female as in Fig. 2.5F; arrangement of spiniform processes on right antennule of male as in Fig. 2.4B; leg 5 of female as in Fig. 2.6G; leg 5 of male as in Fig. 2.7E.
Records: A rare species, having been recorded only four times: from the type locality (a marsh in Richmond, KwaZulu–Natal), Zululand, a Vaal River backwater and from Boesmanland (Namibia).

Paradiaptomus schultzei van Douwe, 1912

Figs 2.5G, 2.7H

Total length: Female 2.8–2.9 mm; male 2.1–2.8 mm.
Key characters: Shape of genital somite of female as in Fig. 2.5G; leg 5 of male as in Fig. 2.7H.
Records: Widely distributed in Namibia and the other drier areas of southern Africa; also from Ethiopia and Senegal.

Paradiaptomus similis van Douwe, 1912

Figs 2.5H, 2.7G

Total length: Female 2.2–2.3 mm; male 1.9–2.0 mm.
Key characters: Shape of genital somite of female as in Fig. 2.5H; leg 5 of male as in Fig. 2.7G.
Records: Kalahari, Namibia.
Note: This species has been confused with *Paradiaptomus greeni* (Gurney, 1906) which occurs in India and Sri Lanka, and is the only known non-African species in the genus.

Paradiaptomus peninsularis Rayner, 1999
Figs 2.9A, B

Total length: Female 2.72 mm; male 2.26 mm.
Key characters: Male leg 5 as in Fig. 2.9B; female leg 5 as in Fig. 2.9A.
Records: Only from temporary black-water pools near Russouwskop and Klaasjagersberg in the Cape Point Nature Reserve (WC).

Paradiaptomus hameri Rayner, 1999
Figs 2.9C– E

Total length: Female 3.06 mm; male 2.39 mm.
Key characters: Male leg 5 as in Fig. 2.9E; female leg 5 as in Fig. 2.9C; male urosome as in Fig. 2.9D.
Records: Saline Rooipan near Yzerfontein, and other temporary pools near Piketberg on the west Cape coast (WC).

Paradiaptomus warreni Rayner, 1999
Figs 2.9F– H

Total Length: Female 2.90 mm; male 2.69 mm.
Key character: Male leg 5 as in Fig. 2.9H; female leg 5 as in Fig. 2.9G; female urosome as in Fig. 2.9F.
Records: Mountain tarns on the Lesotho–Drakensberg border in the Bushman's Nek, Sehlabatebe Game Reserve, Cobham and Bulwer areas (KZN).

Genus ***Metadiaptomus*** Methuen, 1910

KEY TO THE SPECIES OF *METADIAPTOMUS*

This key includes all the described species of *Metadiaptomus*. Four of these species have not been recorded from southern Africa, but are retained in the key for the sake of uniformity. Details on the morphology and distribution of these species are not given, but the full names together with authors' names and dates of original descriptions, are listed at the end of the chapter.

Females

1. Genital somite asymmetrical (Figs 2.5I, K) 2
– Genital somite almost symmetrical 6

2. Genital somite with prominent expansion on right side (Fig. 2.5K) 3
– Genital somite with lateral, or distal extension 4

3. Genital somite with large round expansion on right side .... *M. chevreuxi*
– Genital somite with half-circle of spines on right side (arrowed in Fig. 2.5K) .... *M. colonialis*

4. Genital somite with lateral expansion on left or right, endopodite on leg 5 as long as first exopodite-segment (e.g. Fig. 2.6H) 5
– Genital somite with distal expansion to the right, endopodite on leg 5 three quarters of length of first exopodite-segment .... *M. asiaticus*

5. Genital somite bulging distally to the right and tipped by a short spine (arrowed in Fig. 2.5I), no extension of anal somite .... *M. capensis*

– Genital somite with beak-like process on left side, slight extension of anal somite (arrowed in Fig. 2.5J) .... *M. purcelli*

6. Genital somite entirely symmetrical 7
– Genital somite with slight asymmetrical expansion 8

7. Anal somite with long operculum .... *M. mauretanicus*
– Anal somite without operculum 9

8. Thoracic wings symmetrical, curved outwards, one spine on each wing; leg 5 with regular denticles on claw .... *M. gauthieri*
– Thoracic wings asymmetrical, with multiple spines on both wings; leg 5 with irregular denticles on claw .... *M. aethiopicus*

9. Ratio of total length of adult female to adult male = 2:1; thoracic wings markedly expanded posteriorly .... *M. transvaalensis*
– Ratio of total length of adult female to adult male = 1.5:1; thoracic wings not markedly expanded .... *M. meridianus*

Males

1. Total length exceeds 2 mm; right leg 5 with prominent proximal process on inner margin of claw; left leg 5, large, extending to middle of claw of right leg 5 .... *M. chevreuxi* (Guerne & Richard, 1894)
– Total length less than 2 mm; right leg 5 with no process on claw; left leg 5 not extending beyond distal border of second exopodite-segment of right leg 5 2

2. Right leg 5 with lateral spine of second exopodite-segment very small or absent 3
– Right leg 5 with lateral spine of second exopodite-segment well-developed.....5

3. Right leg 5 with lateral spine of second exopodite-segment absent (arrowed in Fig. 2.8B) .... *M. capensis*
– Right leg 5 with lateral spine of second exopodite-segment very small (arrowed in Figs 2.8E, F) 4

4. Right leg 5 with basipodite expanded, second exopodite-segment long and narrow with semi-circular claw approximately the length of the segment (Fig. 2.8E) .... *M. colonialis*
– Right leg 5 with basipodite very expanded, second exopodite-segment rectangular with claw more than twice the length of the segment (arrowed in Fig. 2.8F) .... *M. gauthieri*

5. Right leg 5 with basipodite not expanded, claw long, terminating in a right angle .... *M. mauretanicus*
– Right leg with basipodite expanded laterally, claw evenly curved 6

6. Outer seta of right furcal ramus spine-like and devoid of setules 7
– Outer seta of right furcal ramus not modified 8

7. Right leg 5 with comma-shaped process on inner border of first exopodite-segment, second exopodite-segment with straight inner margin (arrowed in Fig. 2.8A) .... *M. purcelli*
– Right leg 5 with no process on inner border of first exopodite-segment, second exopodite-segment with distal process on inner margin .... *M. asiaticus*

8. Right leg 5 with basipodite with fringe of spinules extending beyond distal border of basipodite, endopodite long, slender, two-segmented (arrowed in Fig. 2.8C) .... *M. transvaalensis*
– Right leg 5 with basipodite with fringe of spinules not extending beyond distal border of basipodite, endopodite sturdy, broad, two-segmented 9

9. Left leg 5 with very short endopodite, lateral process sturdy, arising laterally on second exopodite-segment .... *M. aethiopicus*
– Left leg 5 without endopodite, lateral process slender, curved, arising proximally on second exopodite-segment (arrowed in Fig. 2.8D) .... *M. meridianus*

Metadiaptomus transvaalensis Methuen, 1910

Fig. 2.8C

Total length: Female 1.8–2.0 mm; male 1.3 mm.
Key character: Leg 5 of male as in Fig. 2.8C.
Records: Lake Chrissie pans (MPL); Vaal River Catchment; Flamingo Pan (FS); Makgadikgadi Pan (BOTS); Lake Kariba (ZIM).
Note: Adapted to waters of high salinity.

Metadiaptomus capensis (Sars, 1907)

Figs 2.5I, 2.8B

Total length: Female 1.62 mm; male 0.87–0.92 mm.
Key characters: Shape of genital somite of female as in Fig. 2.5I; leg 5 of male as in Fig. 2.8B.
Records: Western and southern Cape, as far as Piketberg on the west coast and de Hoop on the south coast. Often co-occurs with *Lovenula falcifera*.

Metadiaptomus purcelli (Sars, 1907)

Figs 2.4E, 2.5J, 2.6H, 2.8A

Total length: Female 0.7–1.0 mm; male 0.7–0.8 mm.
Key characters: Long seta on first segment of antennules of female (Fig. 2.4E); leg 5 of female as in Fig. 2.6H; operculum on anal somite as in Fig. 2.5J; leg 5 of male as in Fig. 2.8A.
Records: Widely distributed in the Western Cape mainly on the Cape Peninsula and in the vicinity of Cape Town. Its range extends to the lower reaches of the Buffalo River in the Eastern Cape.

Metadiaptomus meridianus (van Douwe, 1912)

Fig. 2.8D

Total length: Female 1.7–1.8 mm; male 1.0–1.28 mm.
Key characters: Leg 5 of male as in Fig. 2.8D; dimorphic —female much larger than male.
Records: A common species which is widely distributed in Namibia, southern Africa and East Africa.
Notes: In South Africa, it has been recorded from temporary pools, pans and mountain tarns as well as man-made lakes. Often associated with *Lovenula falcifera*.

Metadiaptomus colonialis (van Douwe, 1914)

Figs 2.4C, 2.5K, 2.8E

Total length: Female 1.6–1.8 mm; male 1.0–1.2 mm.
Key characters: Spermatophore-coupler on genital somite of female (Fig. 2.5K); right antennule of male as in Fig. 2.4C; leg 5 of male as in Fig. 2.8E.
Records: Widely distributed in Namibian and Gauteng impoundments, the Vaal River Catchment, Zimbabwe and Botswana. Also known from Ethiopia.

Metadiaptomus gauthieri Brehm, 1949

Fig 2.8F

Total length: Female 1.17 mm; male 0.90 mm.
Key character: Leg 5 of male as in Fig. 2.8F.
Records: Rundu Floodplain (Okavango); southern Namibia. Type locality, Senegal.

Genus ***Tropodiaptomus*** Kiefer, 1932

There are more than 30 described species of *Tropodiaptomus* in Africa, eight of these from East and southern Africa. Many of these species have been assigned incorrectly to *Tropodiaptomus kraepilini*, a species originally recorded from Zanzibar. The *T. kraepilini* complex of species requires further investigation. The type species, *T. orientalis*, does not occur in Africa, and the redescription by Dussart *et al.* (1984) resolved the confusion associated with this species (Rayner 1990)

Tropodiaptomus schmeili (Kiefer, 1926)

Figs 2.5L, 2.6J, 2.8G

Total length: Female 2.34 mm; male 2.16 mm.
Key characters: Large size; morphology of female urosome, especially furcal rami (Fig. 2.5L); leg 5 of female as in Fig. 2.6J; leg 5 of male as in Fig. 2.8G.
Records: Namibia; widely distributed in Zimbabwe.

Tropodiaptomus hutchinsoni (Kiefer, 1928)

Total length: Female 1.8 mm; male 1.6 mm.
Key character: Easily recognizable by the very long finger-like process on segment 20 of the male right antennule.
Records: First collected from the Linyande River in Botswana in 1929 and again in 1962/3 from river estuaries in Lake Kariba (ZIM).

Tropodiaptomus spectabilis (Kiefer, 1929)

Figs 2.4D, 2.8H

Total length: Female 1.5–1.7 mm; male 1.4–1.5 mm.
Key character: Right antennule of male as in Fig. 2.4D; leg 5 of male as in Fig. 2.8H.
Records: A common species which occurs in Lakes Midmar and Albert Falls and in permanent waters on the coastal plains of KwaZulu–Natal.

Tropodiaptomus zambeziensis Rayner, 1994

Figs 2.9I, J

Total length: Female 1.3 mm; male 1.2 mm.
Key character: Leg 5 of male as in Fig. 2.9J.
Records: Zambezi Delta (found in a rice paddy); Lake Kariba (ZIM) (in river estuaries).

Tropodiaptomus bhangazii Rayner, 1994

Fig. 2.9K

Total length: Female 1.02 mm; male 0.95 mm.
Key characters: Small size; leg 5 of male as in Fig. 2.9K;
Records: Lake Bhangazi South (KZN).

Tropodiaptomus capriviensis Rayner, 1994

Fis 2.9L, M

Total length: Female 1.66 mm; male 1.54 mm.
Key characters: Urosome of female as in Figs 2.9L; leg 5 of male as in Fig. 2.9M.
Records: Boesmanland, Caprivi, Namibia, Zambia.

Genus *Thermodiaptomus* Kiefer, 1932

Thermodiaptomus mixtus (Sars, 1909)
syn. *T. syngenes* (Kiefer, 1929)
Fig. 2.8J

Total Length: Female 1.28 mm; male 1.27 mm.
Key Characters: Long antennules of female, extending beyond end of furcal rami; leg 5 of male as in Fig. 2.8J.
Records: Hartbeespoort Dam and other Gauteng impoundments; Pongolo floodplain (KZN); Eastern Cape, Lake Kariba and other impoundments in Zimbabwe; Lake Malawi.

*Thermodiaptomus congruens (*Sars, 1927)
syn. *T. acanthus* Kiefer, 1937
Figs 2.4G, 2.6I, 2.8I

Total Length: Female 1.78 mm; male 1.63 mm.
Key Characters: Spinous processes on male urosome (Fig. 2.4G); leg 5 of female as in Fig. 2.6I; leg 5 of male as in Fig. 2.8I.
Records: Angola; Ovamboland and Lake Liambezi (NAM).

Order HARPACTICOIDA Sars 1903

The Harpacticoida are primarily benthic organisms and are the least well known of the freshwater copepods in southern Africa. A few species were recorded and incompletely described prior to 1940, but there is a dearth of information on southern African species. Two species have been used here to illustrate harpacticoid morphology: *Schizopera inopinata* (Figs 2.10A–E) from Lake Tanganyika and *Nitocra dubia* (Figs 2.10F–I) from the Cape Flats (Western Cape). Freshwater species seldom attain 1 mm in length and the antennules of the female are short with not more than nine segments (Fig. 2.10B). Male antennules are modified (Fig. 2.10C). Harpacticoids are usually heavily armoured with a urosome with rows of spines and spinules, and appendages bearing strong spines (Figs 2.10D–E). They differ from calanoids and cyclopoids in having the furcal rami separated (Fig. 2.10H); the anus, which is located between them, may be overlain by a row of spines. The fifth pair of thoracic legs is less reduced than in cyclopoids, is well armoured, and in some species has a biramous appearance (Figs 2.10E, 2.10I). Harpacticoids' small size, short antennules of the female, lack of division between prosome and urosome, and single egg sac, are good identifying characters.

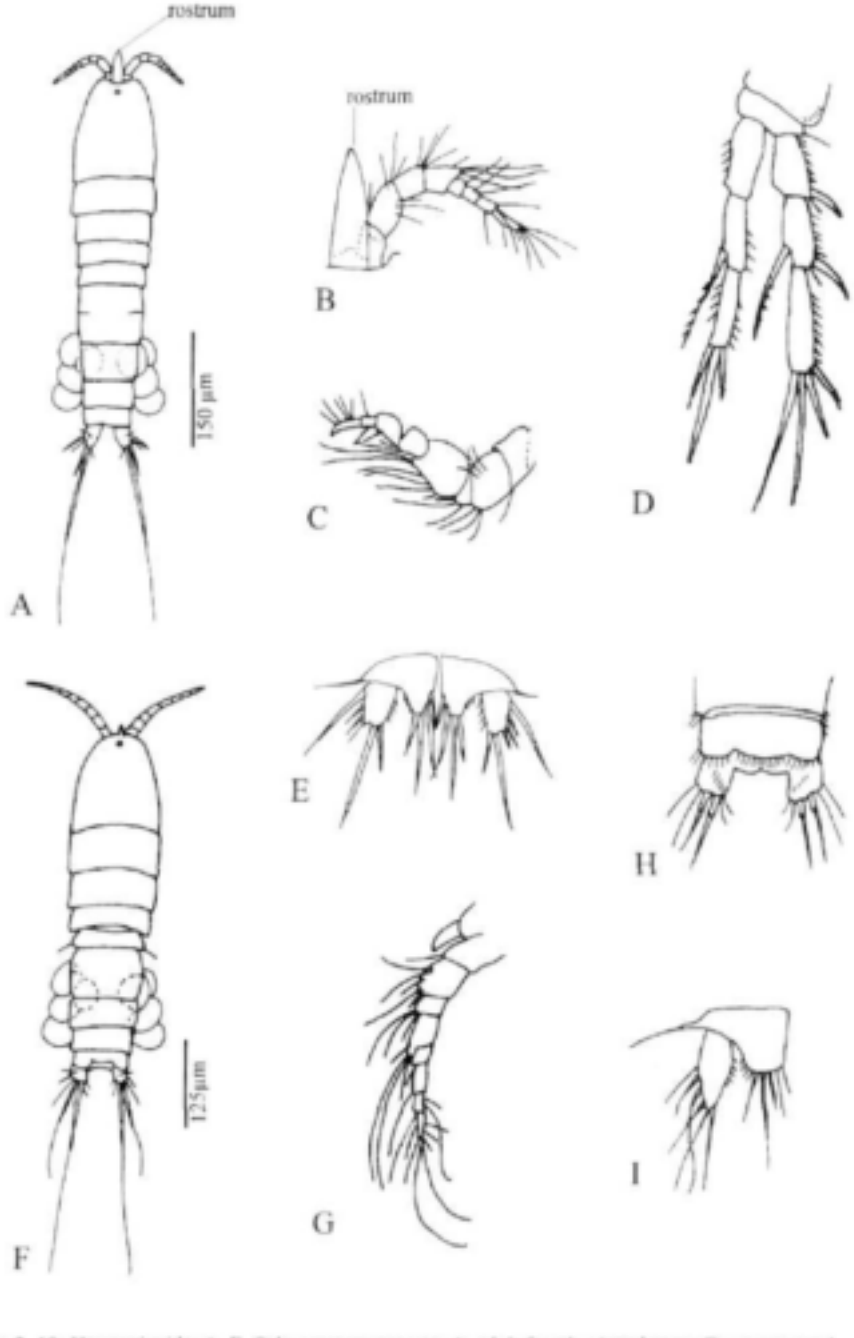

Fig. 2. 10: Harpacticoida. A–E, *Schizopera inopinata*: A, adult female, dorsal view; B, rostrum and antennule, female; C, geniculate antennule, male; D, fourth leg, female; E, fifth pair of legs, female. F–I, *Nitocra dubia*: F, adult female, dorsal view; G, antennule; H, furca; I, fifth leg.
(Redrawn from Sars 1909, 1927)

Order CYCLOPOIDA Burmeister, 1835

Cyclopoids are the most abundant and successful group of freshwater copepods. They occur in all types of habitats such as lakes, ponds, temporary pools, wells, streams and rivers. Cyclopoids are small, varying around 1 mm in length, with a prosome comprising a cephalosome, and four free pedigerous somites and a urosome with six somites in both sexes (Fig. 2.2C). In free-living freshwater genera the female antennules do not exceed 17 segments (Fig. 2.11E), although the ancestral number is 26 (Huys & Boxshall 1991). The antennules of the male are bilaterally geniculate (Fig. 2.11B, 2.11C) and this is the main distinguishing character between males and females. The antennae are uniramous (Fig. 2.11D). Swimming legs 1–4 are biramous (Figs 2.12A, 2.12B), but the fifth pair of legs is uniramous (Figs 2.12C–F). The female carries paired egg sacs (Fig. 2.11A), a good distinguishing character, as calanoids and harpacticoids usually have one egg sac.

KEY TO THE GENERA OF CYCLOPOIDA FROM SOUTHERN AFRICA

Some of the species of Cyclopoida which occur in southern Africa have a worldwide distribution. Identification of cyclopoids to species relies heavily on a suite of characters of mature females, with supplementary information from males. Copepodites do not have the full complement of segments in their appendages and cannot be used in species identification. The number of segments in the antennules of adult females is consistent for a particular genus. Characters which are important in cyclopoid identification are: body length; number of segments in antennules of female; length of female antennules relative to prosome length; structure of female fifth legs; shape of receptaculum seminis (Figs 2.12G–H); the length:breadth ratio of the furcal rami; the relative lengths of furcal terminal setae, and the position of lateral setae on the furcal rami. The *spine formula* refers to the number of spines on the last segment of the exopodite of swimming legs 1–4, and is written as follows: *Mesocyclops* sp., 2:3:3:3. (See Kiefer (1929b), Harding & Smith (1974) and Einslie (1971) for identification guides to genera and cosmopolitan species).

1. Female antennules with 17 segments (Fig. 2.11E) 2
– Female antennules with fewer than 17 segments 5

2. Spine formula 3:4:4:3; leg 5 armature consists of three setae or spines on last segment (Fig. 2.12C) .... *Macrocyclops*
– Spine formula, 2:3:3:3; leg 5 armature consists of a long seta and long spine on last segment (e.g. Figs 2.12E, F), or one apical seta with an inner spinule (Fig. 2.12D) 3

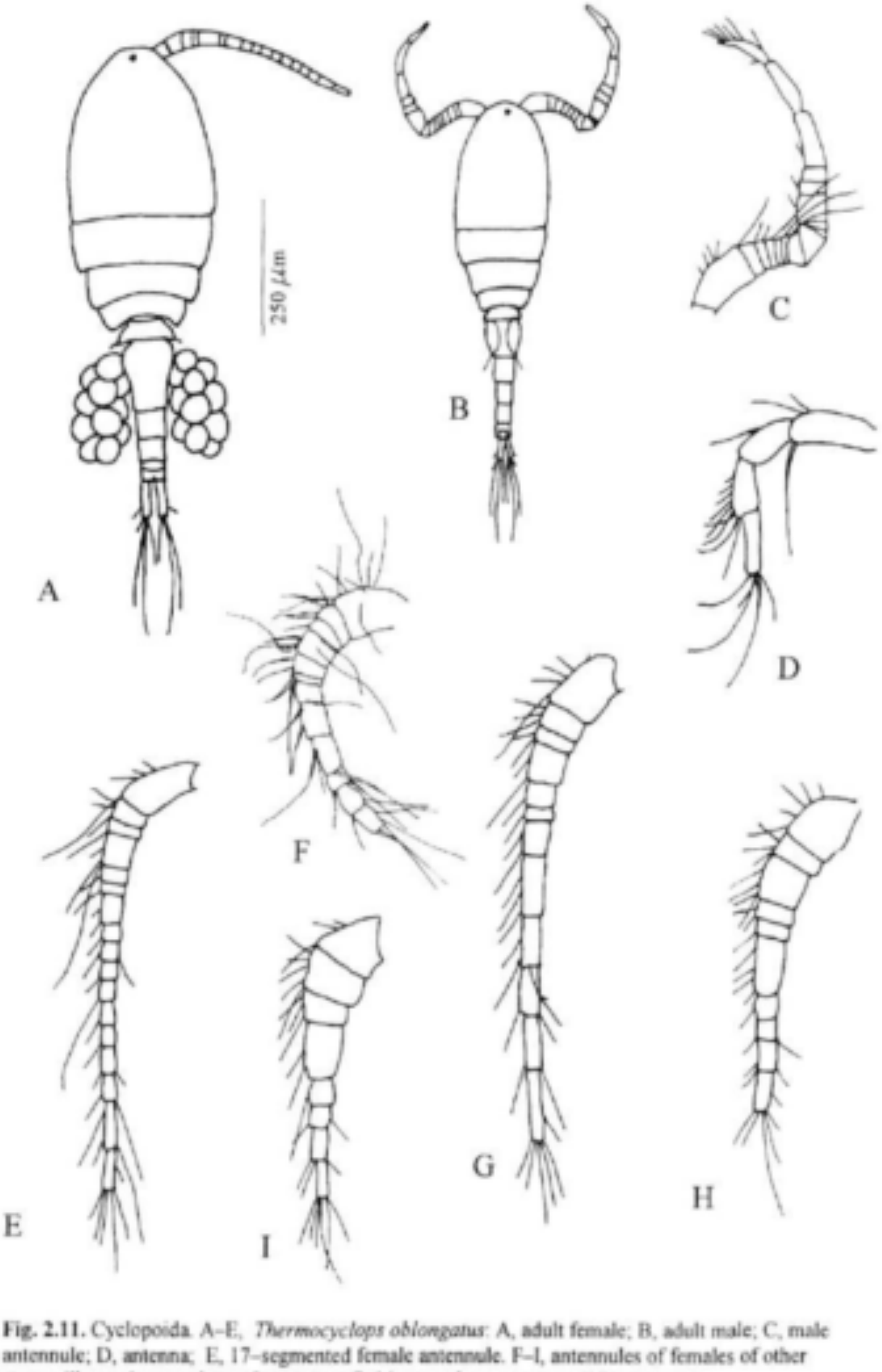

Fig. 2.11. Cyclopoida. A–E, *Thermocyclops oblongatus*: A, adult female; B, adult male; C, male antennule; D, antenna; E, 17–segmented female antennule. F–I, antennules of females of other genera illustrating numbers of segments: F, *Microcyclops crassipes* (12 segments); G, *Eucyclops (Afrocyclops) gibsoni* (12 segments); H. *Ectocyclops phaleratus* (10 segments); I, *Paracyclops poppei* (8 segments). (Except Fig. 9F, all redrawn from Sars1927).

3. Leg 5 with one apical seta and an inner spinule (Fig. 2.12D) .... *Acanthocyclops*
– Leg 5 with a long seta and long spine 4

4. Seta and spine arise at different levels (Fig. 2.12F) .... *Mesocyclops*
– Seta and spine arise apically (Fig. 2.12E) .... *Thermocyclops*

5. Female antennules with 12 segments (Figs 2.11F, G) 6
– Female antennules with fewer than 12 segments 7

6. Swimming legs 1–4 with endopodite and exopodite each with two segments (Fig. 2.12B) .... *Microcyclops*
– Swimming legs 1–4 with endopodite and exopodite each with three segments (Fig. 2.12A) 8

7. Female antennule with 10–11 segments (Fig 2. 11H) .... *Ectocyclops*
– Female antennule with 8 segments (Fig. 2.11I) .... *Paracyclops*

8. Receptaculum seminis (Fig. 2.12G) simple, broad .... *Eucyclops*
– Receptaculum seminis (Fig. 2.12 H) complex, lobed .... *Tropocyclops*

SOME CYCLOPOIDS OCCURING IN SOUTHERN AFRICA

Key characters have not been included, as this identification relates to a suite of characters of the adult female. These characters have been listed above and must be worked through systematically during identification. Note that the authorities (authors and dates) have been not been included next to the names of the genera described below because many species were originally described under a different genus, usually *Cyclops*. Some authors consider the genera listed below as subgenera of *Cyclops*.

Genus ***Macrocyclops***

Macrocyclops albidus (Jurine, 1820)

Fig. 2.12C

Total length: Female 1.8–2.5 mm; male 1.3 mm.
Important character: Fifth leg as in Fig. 2.12C.
Records: Cosmopolitan. In southern Africa recorded from the Linyande River, Okavango; Vaal River Catchment; Western Cape.

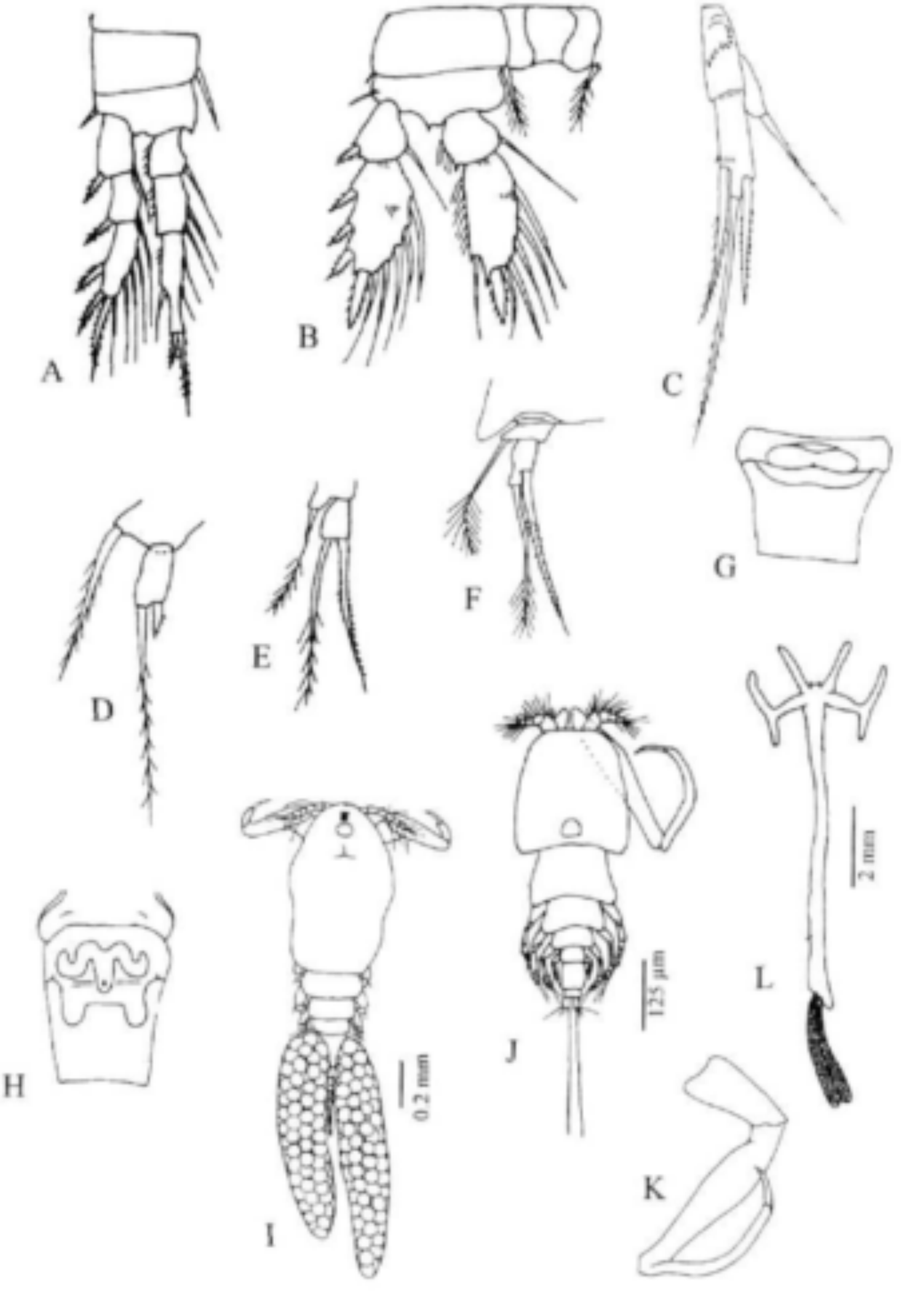

Fig. 2.12. *Cyclopoida*. A, *Thermocyclops oblongatus*, P4 (three-segmented). B, *Microcyclops varicans*, P2 (two–segmented). C, *Macrocyclops albidus*, P5. D, *Acanthocyclops vernalis*, P5. E, *Thermocyclops oblongatus*, P5. F, *Mesocyclops major*, P5. G, *Eucyclops* sp., receptaculum seminis in the genital somite, ventral view. H, *Tropocyclops* sp., receptaculum seminis in the genital somite, ventral view. I–L, parasitic Copepoda: I, *Ergasilus sieboldi*, adult female, dorsal view showing hooked antennae and large paired egg sacs; J, *Ergasiloides macrodactylus*, adult female, dorsal view; K, *E. macrodactylus*, hooked antenna; L, *Lernaea* sp., adult female, showing root-like anterior end and paired egg sacs. (I redrawn from Fryer 1978; J redrawn from Sars 1909).

Genus *Acanthocyclops*

Acanthocyclops vernalis Fischer, 1853

Fig. 2.12D

Total length: Female 1.2–1.7 mm; male 1.0–1.2 mm.
Important character: Fifth leg as in Fig. 2.12D.
Records: Cosmopolitan.

Genus ***Mesocyclops***

Mesocyclops major Sars, 1927

Fig. 2.12F

Total length: Female 1.12–1.58 mm.
Important character: Fifth leg as in Fig. 2.12F.
Records: Widely distributed in southern Africa: Cape Peninsula, KwaZulu–Natal, Eastern Cape, Free State, Gauteng, Namibia, Zimbabwe.
Notes: This species was considered to be a synonym of *M. leuckarti* until van de Velde (1984) established that *M. leuckarti* does not occur in Africa.

Genus ***Thermocyclops***

Thermocyclops oblongatus Sars, 1927

Figs 2.11A–E, 2.12A, E

Total length: Female 0.9 mm.
Records: Widely distributed in southern Africa — particularly in the southern region of the Western Cape and KwaZulu–Natal — but it is probably also confused with other African species of *Thermocyclops*, namely *T. neglectus*, T. *schuurmanae*, *T. macracanthus*, *T. infrequens*, *T. retroversus* and *T. emini*.

Thermocyclops macracanthus Kiefer, 1929

Total length: Female 0.85–1.0 mm.
Records: Namibia, Free State.

Thermocyclops schuurmanae Kiefer, 1928

Total length: Female 0.88 mm.
Records: Vleis of the South Western Cape.

Thermocyclops emini (Mrazek, 1895)

<u>Total length</u>: Female 0.90 mm.
<u>Records</u>: Pongolo Floodplain, Zululand.

Genus ***Microcyclops***

Microcyclops crassipes (Sars, 1927)

Fig. 2.11F

<u>Total length</u>: Female 0.6–0.8mm.
<u>Important character</u>: Antennule as in Fig. 2.11F.
<u>Records</u>: Vleis of the South Western Cape.

Microcyclops inopinatus (Sars, 1927)

<u>Total length</u>: Female 0.7 mm.
<u>Records</u>: Namibia.

Microcyclops varicans (Sars, 1863)

Fig. 2.12B

<u>Total length</u>: Female 0.7–0.8
<u>Important character</u>: Second swimming leg as in Fig. 2.12B.
<u>Records</u>: Cosmopolitan.

Genus ***Metacyclops***

Metacyclops necessarius Kiefer, 1914

[syn. *Cryptocyclops assimilis* Sars, 1927]

<u>Total length</u>: Female 0.9–1.0 mm.
<u>Records</u>: Cape Flats.
<u>Note</u>: This is the only species of *Metacyclops* recorded from Africa and the genus appears to be identical to *Microcyclops*.

Genus ***Eucyclops***

Eucyclops (Afrocyclops) gibsoni (Brady, 1904)

Figs 2.11G, 2.12G

<u>Total length</u>: Female 1.06 mm.
<u>Important character:</u> Antennule as in Fig. 2.11G.
<u>Records</u>: South western Cape, Okavango, Lake Chrissie (MPL), Vaal River Catchment, Namibia.

Eucyclops sublaevis (Sars, 1927)

Total length: Female 1.0–1.3 m.
Records: Botswana, Cape Flats (WC), Vaal River Catchment.

Eucyclops serrulatus (Fischer, 1851)

Total length: Female 0.9–1.4 mm.
Records: Cosmopolitan. In southern Africa only from the south western Cape (WC).

Genus ***Tropocyclops***

Tropocyclops prasinus (Fischer, 1860)

Fig. 2.12H

Total length: Female 0.5–0.9 mm.
Records: Cosmopolitan. In southern Africa recorded only from the south western Cape (WC).

Genus ***Ectocyclops***

Ectocyclops phaleratus (Koch, 1838)

Fig. 2.11H

Total length: Female 0.86 mm.
Important character: Antennule as in Fig. 2.11H.
Records: Cosmopolitan. In southern Africa recorded from the south western Cape (WC) and the Vaal River Catchment.

Genus ***Paracyclops***

Paracyclops poppei (Rehberg, 1880)

Fig. 2.11I

Total length: Female 0.54 mm.
Important character: Antennule as in Fig. 2.11I.
Records: Cosmopolitan. In southern Africa recorded only from the Cape Peninsula (WC).

Paracyclops fimbriatus (Fischer, 1853)

Total Length: Female 0.87 mm.
In this species the ratio of length:breadth of the furcal rami is 6:1, compared with *P. poppei* in which the ratio is 1.3:1.
Records: Cosmopolitan: in southern Africa recorded from the south western Cape (WC) and the Vaal River Catchment.

PARASITIC COPEPODS

Some species of copepods are ecto-parasites of freshwater fish, where they may occur on the body surface, gills or fins. The males and early developmental stages of females are free-living. The female has adaptations for clinging on to the host and feeds on its tissues. Species of the family Ergasilidae (Order Poecilostomatoida) and the family Lernaeidae (Order Cyclopoida) are known from southern Africa. In the Ergasilidae the adult female (Figs 2.12I, J) is the only parasitic stage in the life cycle and the antennae are enlarged, each with a terminal claw for attachment to the host's gills (Fig. 2.12K). The male is never parasitic, and has small antennae and large prehensile maxillipeds. A female *Lernaea* (Fig. 2.12L) is highly modified with a root-like anterior end, a thin body and two long thin egg sacs. In Africa, lernaeids occur on the gills of catfish (Family Clariidae) and cichlids (Family Cichlidae). For additional information see Kensley & Grindley (1973) and Fryer (1978).

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CLASSIFICATION, CHECKLIST AND BROAD DISTRIBUTION OF SOUTHERN AFRICAN FRESHWATER COPEPODA

Phylum: ARTHROPODA
Subphylum: CRUSTACEA
Class: COPEPODA

Order: **CALANOIDA***

Family: Diaptomidae
Subfamily: Paradiaptominae

Genus: ***Lovenula***
Lovenula falcifera (Lovén, 1845): South Africa, Namibia, Kenya, Uganda, Ethiopia
Lovenula africana (Daday, 1908): Botswana, East Africa, Ethiopia
Lovenula excellens Kiefer, 1929: Lake Chrissie and environs (MPL)
Lovenula simplex Kiefer, 1929: Western Cape
Genus: ***Paradiaptomus***
Paradiaptomus lamellatus Sars, 1895: Western Cape
Paradiaptomus natalensis (Cooper, 1906): KwaZulu–Natal, Eastern Cape, Namibia
Paradiaptomus schultzei van Douwe, 1912: southern Africa, Namibia, Ethiopia, Senegal
Paradiaptomus similis van Douwe, 1912: Namibia, North Africa
Paradiaptomus peninsularis Rayner, 1999: Cape Peninsula (WC)
Paradiaptomus hameri Rayner, 1999: Western Cape
Paradiaptomus warreni Rayner, 1999: Drakensberg–Lesotho border
Genus: ***Metadiaptomus***
Metadiaptomus transvaalensis Methuen, 1910: Mpumalanga, Free State, Botswana, Zimbabwe
Metadiaptomus capensis (Sars, 1907): Western Cape
Metadiaptomus purcelli (Sars, 1907): Western Cape
Metadiaptomus meridianus (van Douwe, 1912): South Africa, Namibia, East Africa
Metadiaptomus colonialis (van Douwe, 1914): South Africa, Namibia, Zimbabwe, Ethiopia
Metadiaptomus gauthieri, Brehm, 1949: Namibia, Senegal

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* **Note**: The type species for each calanoid genus is listed first.

Checklist (cont.)

Subfamily: Diaptominae

Genus: ***Tropodiaptomus***

Tropodiaptomus cunningtoni (Sars, 1909): Malawi, Mozambique

Tropodiaptomus schmeili (Kiefer, 1926): Namibia, Zimbabwe

Tropodiaptomus hutchinsoni (Kiefer, 1928): Botswana, Zimbabwe

Tropodiaptomus spectabilis (Kiefer, 1929): KwaZulu–Natal

Tropodiaptomus kissi Dussart, 1977: Botswana

Tropodiaptomus zambeziensis Rayner, 1994: Zimbabwe

Tropodiaptomus bhangazii Rayner, 1994: Lake Bhangazi South, KwaZulu–Natal

Tropodiaptomus capriviensis Rayner, 1994: Namibia, Zambia

Genus: ***Thermodiaptomus***

Thermodiaptomus mixtus (Sars, 1909): Gauteng, KwaZulu–Natal, Eastern Cape, Zimbabwe

Thermodiaptomus congruens (Sars, 1927): Namibia, Botswana, Angola

Order: **HARPACTICOIDA**

Family: Canthocamptidae

Genus: ***Atteyella***

Atteyella natalis Brady, 1904: South Africa

Atteyella warreni Brady, 1913: South Africa

Genus: ***Elaphoidella***

Elaphoidella bidens coronata Kiefer, 1934: Cape Flats (WC)

Family: Harpacticidae

Genus: ***Harpacticus***

Harpacticus meridionalis Sars, 1927: Western Cape

Family: Ameiridae

Genus: ***Nitocra***

Nitocra dubia Sars, 1927: Western Cape

Family: Cletodidae

Genus: ***Cletocamptus***

Cletocamptus confluens meridionalis Kiefer, 1934: Gauteng

Cletocamptus trichotus Kiefer, 1934: Mozambique

Checklist (cont.)

Order **CYCLOPOIDA**

Family: Cyclopidae

Genus: ***Macrocyclops***
Macrocyclops albidus (Jurine, 1820): Cosmopolitan
Genus: ***Acanthocyclops***
Acanthocyclops vernalis Fischer, 1853: Cosmopolitan
Genus: ***Mesocyclops***
Mesocyclops major Sars, 1927: Africa
Genus: ***Thermocyclops***
Thermocyclops oblongatus Sars, 1927: Cosmopolitan
Thermocyclops macracanthus Kiefer, 1929: South Africa, Namibia
Thermocyclops schuurmanae Kiefer, 1928: Western Cape
Thermocyclops emini (Mrazek, 1895): KwaZulu–Natal
Genus: ***Microcyclops***
Microcyclops crassipes (Sars, 1927): Western Cape
Microcyclops inopinatus (Sars, 1927): Namibia
Genus: ***Metacyclops***
Metacyclops necessarius Kiefer, 1914 [syn. *Cryptocyclops assimilis* Sars, 1927]: Cape Flats (WC)
Genus: ***Eucyclops***
Eucyclops (Afrocyclops) gibsoni (Brady, 1904): South Africa, Namibia
Eucyclops sublaevis (Sars, 1927): South Africa
Eucyclops serrulatus (Fischer, 1851): Cosmopolitan
Genus: ***Tropocyclops***
Tropocyclops prasinus (Fischer, 1860): Cosmopolitan
Genus: ***Ectocyclops***
Ectocyclops phaleratus (Koch, 1838): Cosmopolitan
Genus: ***Paracyclops***
Paracyclops poppei (Rehberg, 1880): Cosmopolitan
Paracyclops fimbriatus (Fischer, 1853): Cosmopolitan

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CHAPTER 3

BRANCHIURA

by

J. G. van As & L. L. van As

During the early 1800s, the Branchiura were not recognized as a separate group, but were included in the Copepoda. This classification was used until 1854, when Zenker reassigned the branchiurans to the Branchiopoda, now a separate taxon (Day 1999). Thorell (1864) agreed with the placement in the Branchiopoda, but created the name Branchiura. Clauss (1875) reassigned the Branchiura to the Copepoda, where they remained until Martin (1932) established them as a separate group. It is now generally accepted that the Branchiura, are a subclass of the Maxillopoda (Bowman & Abele 1982; Schram 1986).

All branchiurans are fish parasites, commonly known as fish lice, although some have been reported to also parasitize anuran tadpoles. Representatives are found in marine, freshwater and brackish habitats. Fish lice are ectoparasites found on the skin and fins, in the branchial chambers, on the gill filaments and in the mouth cavities of their hosts. Although generally small, they are visible to the naked eye. Some of them have body coloration which renders them cryptic, either by possessing, or in other cases by lacking, pigmentation.

The Branchiura comprize a single family, the Argulidae, with four genera: *Argulus*, *Dolops*, *Chonopeltis* and *Dipteropeltis*. Some authors (Overstreet et al. 1992) treat *Dipteropeltis* as belonging to a separate family, the Dipteropeltidae, but this is not widely accepted. This genus is represented by a single species known only from freshwater habitats in South America. It is poorly studied and since its original description, based on the female only, has not been recorded again. The carapace of *Dipteropeltis* is characterized by long lateral lobes extending past the tip of the abdomen. The mode of attachment is by means of the maxillules, modified into large suckers.

The genus *Dolops* is represented by 11 known species, all from freshwater habitats. Nine are found in South America, one in Tasmania and a single species (*Dolops ranarum*) has a pan-African distribution south of the Sahara. This species was originally found on and described from tadpoles and subsequently re-described from material collected from freshwater fish in South Africa (Avenant et al. 1989).

The largest genus (*Argulus*) comprises more than 100 species, known from marine, freshwater and brackish habitats. So far 24 species have been recorded from inland waters in Africa (Rushton-Mellor 1994) and a further nine species from marine habitats off the African coast (Avenant-Oldewage 1994a; Rushton-Mellor 1994; van As et al. 1999). Only two freshwater species have been recorded south of the Limpopo River: *A. japonicus* and *A. capensis*.

The genus *Chonopeltis* is endemic to Africa and is represented by 14 known species, all from freshwater habitats. Eight of these occur in southern African waters. The type species *C. inermis*, was described from catfish hosts in Lake Malawi, but has recently also been recorded from the Limpopo System (van As & van As 1993).

A list of branchiuran species found in southern Africa, as well as their distribution and impact on host species, is given in Table 3.1 (p. 154–155).

Collection and preservation

When collecting branchiurans it is necessary to examine freshly caught fish. This may require some kind of field laboratory in close proximity to the collection sites. The identification of the fish hosts is important and can be done by making use of *A Complete Guide to the Freshwater Fishes of Southern Africa* (Skelton 1993). The fish should be anaesthetized using MS 222. The skin and fins can be examined with the aid of a hand lens or dissecting microscope. Branchiurans are not affected by MS 222 and will remain alive on the host for a short period. The movement of the parasites on the host fish aids in their location and they can easily be removed by means of a scalpel and a fine brush. In order to find species that occur in the branchial chambers, the fish must be dissected and the gills removed and examined with a dissecting microscope. Branchiurans fix and preserve very well in 70 % ethanol. It is necessary to note the colour of freshly collected specimens, as this sometimes aids in the identification of species.

MORPHOLOGICAL FEATURES OF THE BRANCHIURA
(Fig. 3.1 — adult: Fig. 3.4 — larva)

Morphology of adult

The basic morphology of the Branchiura, as described below, is based on that of a typical species of *Argulus* (Fig. 3.1). Branchiurans vary in size from 2.5–12 mm. Adult branchiurans are dorso-ventrally flattened, with a prominent carapace covering at least part- or sometimes almost the whole, of the four-segmented thorax. Each thoracic segment carries biramous paired appendages which in the case of females are unspecialized, but in males bear specialized copulatory structures. The abdomen is bilobed and varies from relatively short to lengths equal to that of the body. In branchiurans sexual dimorphism is distinct: males can be identified by the presence of the testes (Fig. 3.1) and females by the spermathecae (Fig. 3.3A) in the abdominal lobes. The ventral surface of the thorax and appendages may be adorned with setae, scales, bristles, spines and spinules, or a combination of these. Two eyes and a single ocellus are dorsally visible anteriorly on the carapace (Fig. 3.3B). Cephalic appendages include the antennules (greatly reduced or absent in *Chonopeltis*), the antennae, and the maxillules, which undergo transformation from hook-like structures in larvae to large disc-shaped suckers in adults of the genera *Chonopeltis* and *Argulus*. In *Dolops* the maxillules remain as large prominent hooks similar to those of the larvae (Fig. 3.2F). Paired maxillae are situated directly posterior to the maxillules. The maxillae (Figs. 3.1, 3.2E, 3.3C, 3.5A) are of varying sizes and prominence in different species. The mouth, with sickle-shaped mandibles and serrated teeth, is situated at the tip of an extended mouth tube (proboscis) in the case of *Argulus* (Fig. 3.1). In *Dolops* and *Chonopeltis* the mouth tube is absent. Unlike other genera, *Argulus* has an eversible stylet sometimes referred to as a preoral or poison spine.

Morphology of larvae

The largest and most prominent features of the first larval stage of *Argulus* spp. (Fig. 3.4C) are the antennae and the mandibular palp. The maxillules are in the form of three-segmented appendages, terminating in sclerotized hooks (Fig. 3.4D). The maxillae, although small, resemble those of the adults. The basal plate of the maxilla is without its characteristic prominent posterior spines. The thoracic legs are undifferentiated, except for the first pair, which is considerably larger than the rest (Fig. 3.4C). At this stage these are the only functional legs. In the first larval

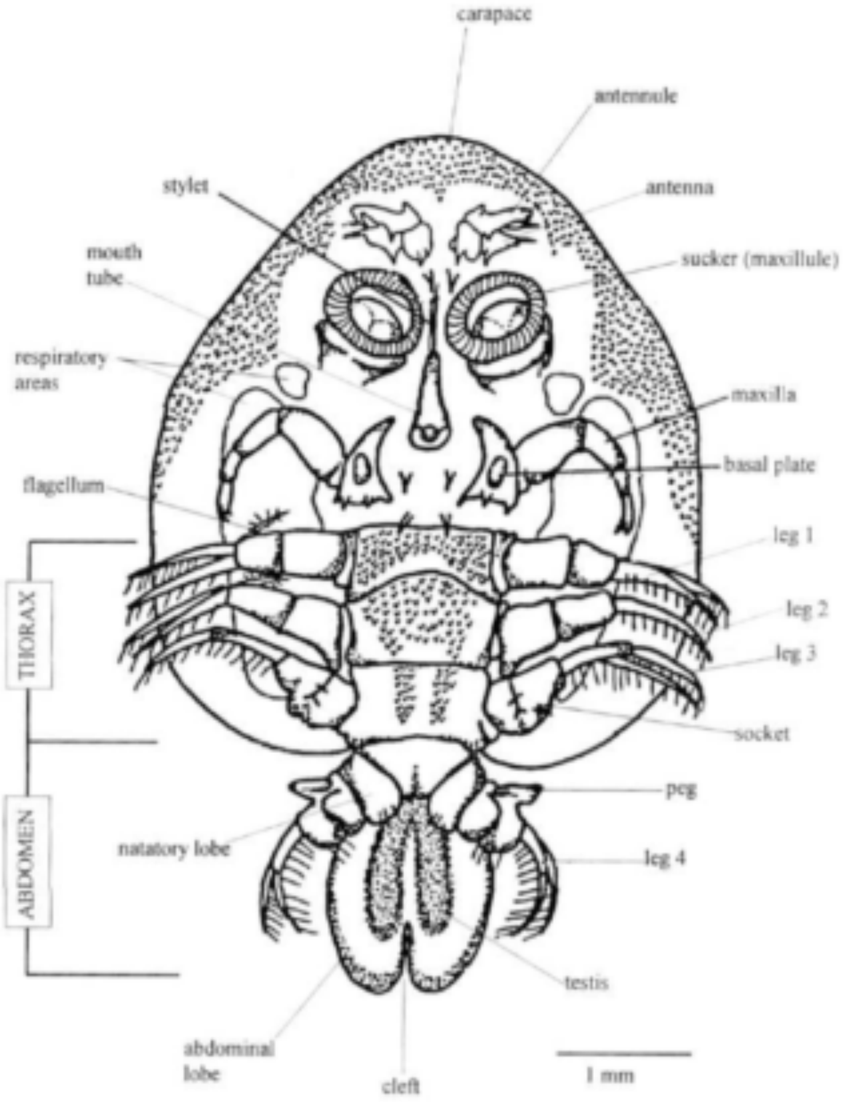

Fig. 3.1. A typical argulid, ventral view.

stage the abdomen is a single lobe (Fig. 3.4C), and the furcal rami are relatively large and occupy the terminal position on the abdomen. In the second larval stage all pairs of legs are differentiated and functional. The antennae are no longer the most prominent cephalic appendages and the developing maxillules, with their terminal pincer-like hooks, now dominate the cephalon. At the third stage the second podomere of the maxillule appears swollen with early signs of the developing sucker (Fig. 3.4E). After seven to eight days the larvae enter the fourth stage, by completing the third moult. By now the sucker is visible, but not yet functional (Fig. 3.4F), the abdomen is divided into two lobes, and the maxillae resemble those of the adult. At the fifth stage the sucker is open and functional with a rudiment of the hook still attached (Fig. 3.4G), whilst at the sixth stage the rudiment of the first hook is further reduced (Fig. 3.4H), to finally disappear in the last moult to adulthood (Fig. 3.4I).

KEY TO THE GENERA OF BRANCHIURA

1. Maxillules in the form of prominent suckers (Figs. 3.3A, E) 2
– Maxillules in the form of prominent ventrally curved hooks (Fig. 3.2C)............ .... *Dolops* (Fig. 3.2)

2. Feeding apparatus consists of extended mouth tube (proboscis) and stylet (preoral spine) (Fig. 3.1); antennules and antennae present (Fig. 3.3D); basal plate of maxilla with spines (Fig. 3.3C) ....*Argulus* (Figs 3.3, 3.4)
– No mouth tube or stylet present; antennule absent; antennae uniramous, four-segmented; basal plate of maxilla without spines (Fig. 3.5A)...................... ....*Chonopeltis* (Figs.3.5–3.15)

Dolops Audouin, 1837

Fig. 3.2

Morphology

Dolops ranarum was originally described by Stuhlmann (1891). It is the only species of this genus found in southern Africa and has been re-described by Avenant et al. (1989). This species is darkly pigmented and its coloration changes with age: young individuals are brownish-yellow, while older individuals are dark green to almost black. In adults a reddish tint is present in the lobes of the carapace, which is probably due to the presence of a respiratory pigment (Fryer 1968). Adult females (Fig. 3.2C) vary in size from 2–11 mm. Males (Figs. 3.2A, B) are

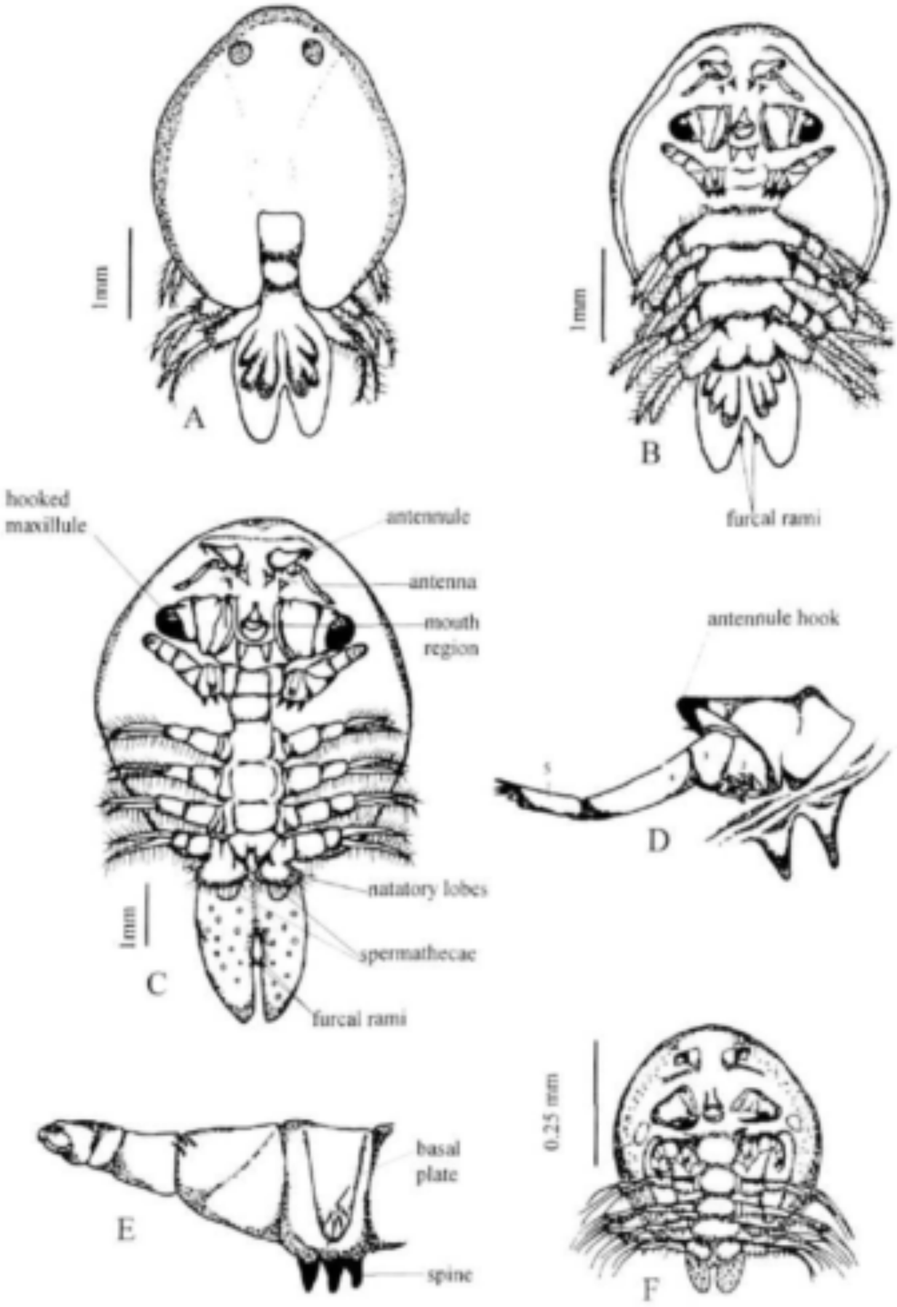

Fig. 3.2. A–F, *Dolops ranarum*: A, male, dorsal view; B, male, ventral view; C, female, ventral view; D, antennule and antenna; E, maxilla; F, first larval stage.
(Redrawn from Avenant *et al.* 1989).

generally smaller, (2–7 mm). The horseshoe-shaped carapace covers most of the cephalothorax. The cephalic segments are completely fused, whilst the thoracic segments are clearly distinguishable.

Respiratory areas cannot be distinguished in *D. ranarum*, but have been reported for other species of the genus (Castro 1950). Both the antennules and the antennae (Fig. 3.2D) in *D. ranarum* are well developed and are situated in a ventral groove on the cephalon. Each of the paired antennules consists of two segments, the terminal segment being a sclerotized hook. Each of the paired antennae consists of five cylindrical segments, terminating in fine setae-like protrusions. The maxillules are well developed, four-segmented appendages, terminating in heavy sclerotized hooks consisting of two segments (Fig. 3.2C). These serve as holdfast organs and are the primary cause of tissue damage to the host. Each maxilla consists of six podomeres, of which the basal podomere bears three prominent, posteriorly-directed spines (Fig. 3.2E). The mouth is situated medially between the maxillules.

The four pairs of thoracic appendages are more or less equal in size and are evenly spaced. The first two legs each bears a flagellum dorsally on the basipodite. These flagella probably serve the dual function of cleaning the respiratory areas and inducing a water current which enhances respiration. The fourth leg bears the so-called natatory lobes on the ventral side of the coxopodite. These lobes probably have a reproductive rather than a locomotory function. The abdomen consists of two kidney-shaped lobes of which the anterior halves are fused. Two round spermathecae are visible in the fused part (Fig. 3.2C). The furcal rami are situated on the inner margin of the abdominal lobes. In males the abdomen constitutes a larger portion of the total body length than in females. A three-lobed testis is clearly visible in the abdomen (Figs 3.2A, B). Another secondary male characteristic is the presence of a scabrous papilla on the basal joint of the third leg, the function of which is to assist in holding the female during copulation.

General biology

Seasonal investigations on the biology of *D. ranarum* indicate that this species, unlike most tropical species, does not breed throughout the year (Avenant & van As 1985; 1986). Gonadal development only starts during early spring when copulation probably takes place. The reproductive system of *D. ranarum* is described in some detail by Avenant-Oldewage & van As (1990a). During the mating process the female is seized by the male using the maxillulary hooks (Fryer 1960). The male positions himself sideways so that the abdomen of the female is gripped between legs two and three. The male then produces a spermatophore, which is transferred to the spermathecae of the female by means of the fourth pair of legs (Fryer 1960). After copulation the male releases the female, now carrying a firmly attached spermatophore. This store of sperm is sufficient to last the female for the rest of her life. There is no indication that females mate more than once in their lifetime.

Field observations by Avenant & van As (1986) indicate that gravid females leave their hosts during late spring to lay eggs on a suitable solid substrate such as stones. A likely place would be the breeding nests of cichlid fish which serve as hosts for *D. ranarum*. Eggs are fertilized individually during oviposition. Each egg passes the abdomen and spermathecae. The egg is penetrated by the spermathecal spine, which injects sperm into the egg. The natatory lobe is probably responsible for pressing the egg against the spermathecal spine and is thereafter instrumental in placing the egg on to the substrate. A single female may deposit as many as 566 eggs in a cluster (Fryer 1959). Avenant et al. (1989) found that small batches of eggs laid by *Dolops* females hatch under laboratory conditions after 57 days at room temperature. The newly-hatched larvae (Fig. 3.2F) have a total length of slightly more than 0.5 mm. Morphologically they resemble adults (Avenant et al. 1989) and progressive moults result in an increase in size without any major morphological changes.

The feeding habits of the newly hatched larvae are still unknown. It may be that these larvae utilize hosts other than those used by the adults. Larvae were first noted on the fish hosts during early summer and they remained associated with these hosts until the next spring. The exact number of consecutive moults in *D. ranarum* is unknown. These parasites remain associated with their hosts until after egg production in spring. Field data suggests that after egg-laying, females are unlikely to infect other hosts (Avenant & van As 1986).

Impact on hosts and distribution

In an extensive survey of the Limpopo–Olifants System, and Orange–Vaal System by Avenant & van As (1985), the sharptooth catfish *Clarias gariepinus*, the Mozambique tilapia *Oreochromis mossambicus*, and to a lesser extent, the largescale yellowfish *Barbus marequensis*, were found to be the most important hosts for *D. ranarum*. *Dolops ranarum* is restricted to habitats where *C. gariepinus* and *O. mossambicus* occur sympatrically. Details of its distribution, as well as its impact on various hosts, are summarized in

Table 3.1. *Dolops ranarum* does not remain permanently attached to a particular site, but can move around on the surface of the host. Distinct lesions are found at attachment sites. Evidence has been found to suggest that *Dolops* does not feed by sucking blood from its host, but rather by extracting tissue particles from the open lesion (Avenant-Oldewage 1994b). Details of the digestive system of *D. ranarum* are described by Avenant-Oldewage & van As (1990b).

Under natural conditions it is unlikely that *D. ranarum* infestations have a significant impact on the host fish, as levels of infestation have been found to be low (Avenant & van As 1985). This species may, however, be of economic importance in aquaculture situations where higher rates of infection can be expected.

General comments

The parasite *D. ranarum* sometimes falls prey to parasitic infestations of the sessile peritrichian (Ciliophora) *Epistylis nympharum* (van As & Viljoen 1984). In some specimens the infestation by these minute ciliophorans is so high as to be visible to the naked eye. Hyperparasitism has so far not been reported from branchiurans other than *Dolops*.

Argulus Müller, 1785

Figs. 3.3–3.4

The basic morphology of members of the genus *Argulus* is similar to that described for *Dolops*. In *Argulus* the carapace is trifoliated with a distinct anterior lobe, sometimes referred to as the frontal region. The carapace covers the whole cephalothorax in some species, e.g. *A. fryeri*, whereas in others only the bases of the first two legs are covered, e.g. *A. branchypeltis*. Pigmentation is present in most *Argulus* species although it is not as dark as that of *Dolops*. The overall size of *Argulus* is in the same order as that of *Dolops*. Respiratory areas consist of two to three clearly demarcated areas on the ventral side of the lateral carapace lobes. The shape of these areas is of specific taxonomic importance. The antennules and antennae in *Argulus* are similar in shape to those of *D. ranarum* although they appear larger in the latter species. The maxillules in *Argulus* larvae are modified as hooks (Fig. 3.4C) which during ontogeny (Figs. 3.4D–H) develop into a pair of large round suckers (as found in the adults – Fig. 3.3A), the rims of which are strengthened by rows of supporting rods consisting of interlinking sclerites (Fig. 3.3E). The number of sclerites and

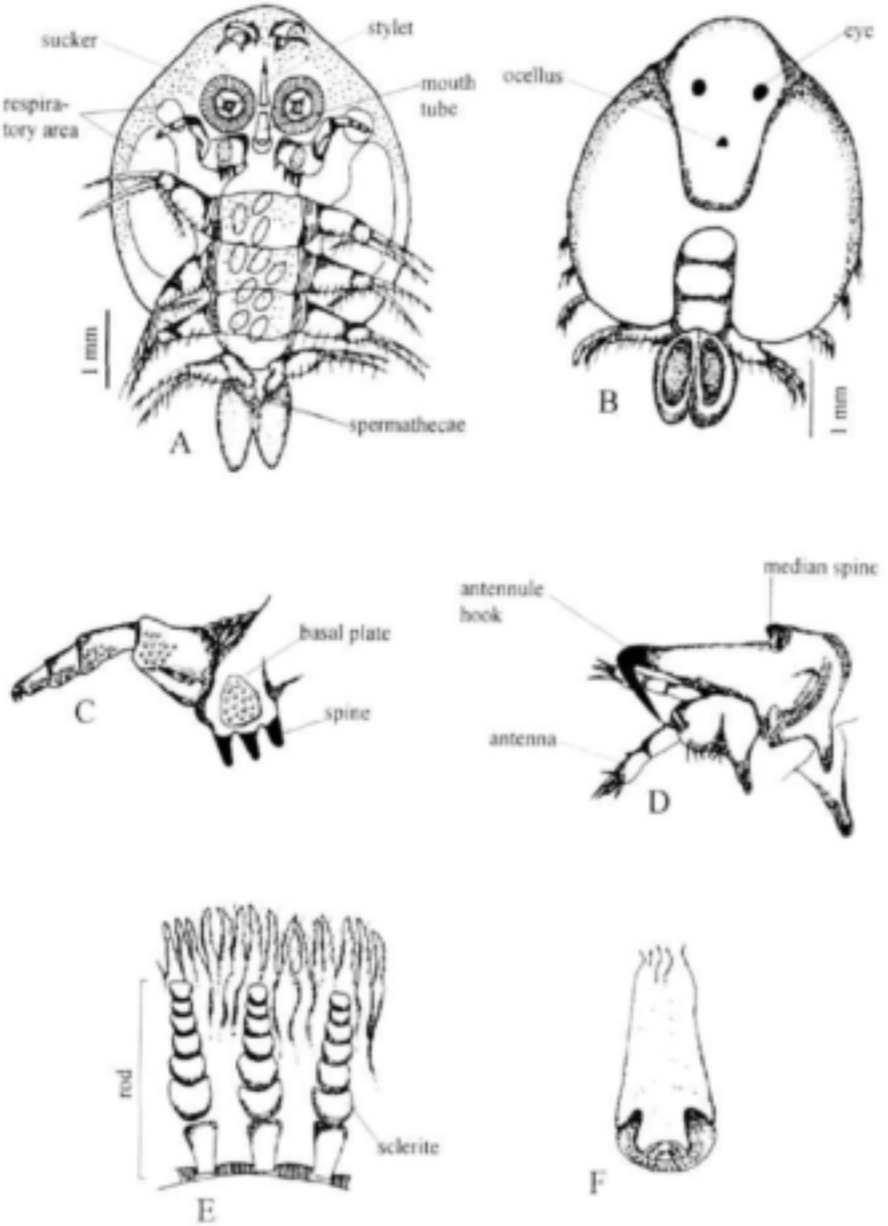

Fig. 3.3 A–F, *Argulus japonicus*. A, female, ventral view; B, male, dorsal view; C, maxilla; D, antennule and antenna; E, rods and sclerites of sucker; F, mouth tube.

their shape is used to differentiate between species.

The maxillae of *Argulus* (Fig. 3.3C) are more or less similar in size to the swimming legs and consist of four podomeres (of which the last three articulate), that bend back on to the first podomere. A striking difference between *Argulus* and *Dolops* is in the basal plate of the maxilla; in *Argulus* this area is covered by specialized scales and spines with prominent projections in both anterior and posterior directions (Fig. 3.3C). The configuration of these spines is used to differentiate between species. The mouth in *Argulus* spp. is situated on the tip of an extended mouth tube (Fig. 3.3F), with the stylet anterior to it. A flagellum is present on legs one and two of some species. In males, a specialized holdfast area is found on the posterior part of leg two, with a corresponding scabrous area anteriorly on leg three (Fig. 3.4A). A sac-like socket, is situated dorsally on leg three and a peg anteriorly on leg four (Fig. 3.4B). The abdomens in different species of *Argulus* vary considerably in shape and size, although not to the same extent as in *Dolops*. Males and females can be distinguished by the presence of either testes or spermathecae in the abdomens. Unlike *D. ranarum*, there is no spermatophore formation in *Argulus*.

Five species of *Argulus* have been recorded from South Africa. Of these three are from marine habitats, and only two species (*A. japonicus* and *A. capensis*) have been recorded in fresh waters. The description of *A. capensis*, based on a single female specimen, is clearly inadequate and provides no basis for comparison. This species has not been recorded since its original description. *Argulus japonicus* is described in detail below.

Argulus japonicus Thiele, 1900
Figs. 3.3–3.4

Adult morphology

In *A. japonicus* the posterior fringe of the carapace extends to cover the fourth leg (Figs. 3.3A, B). The carapace is elliptical with prominent dorsal ridges. The abdomen is relatively short and round. The antennule is small with a hook and a medial spine (Fig. 3.3D). The rim of each sucker is supported by 40–48 rods, each consisting of five to seven interlinking sclerites (Fig. 3.3E). The basal plate of the maxilla has three prominent, evenly spaced and sharply pointed, spines (Fig. 3.3C). The respiratory area consists of two regions: a small round area directly anterior to a larger kidney-shaped area (Fig. 3.3A). The first two pairs of thoracic appendages have dorsal flagella.

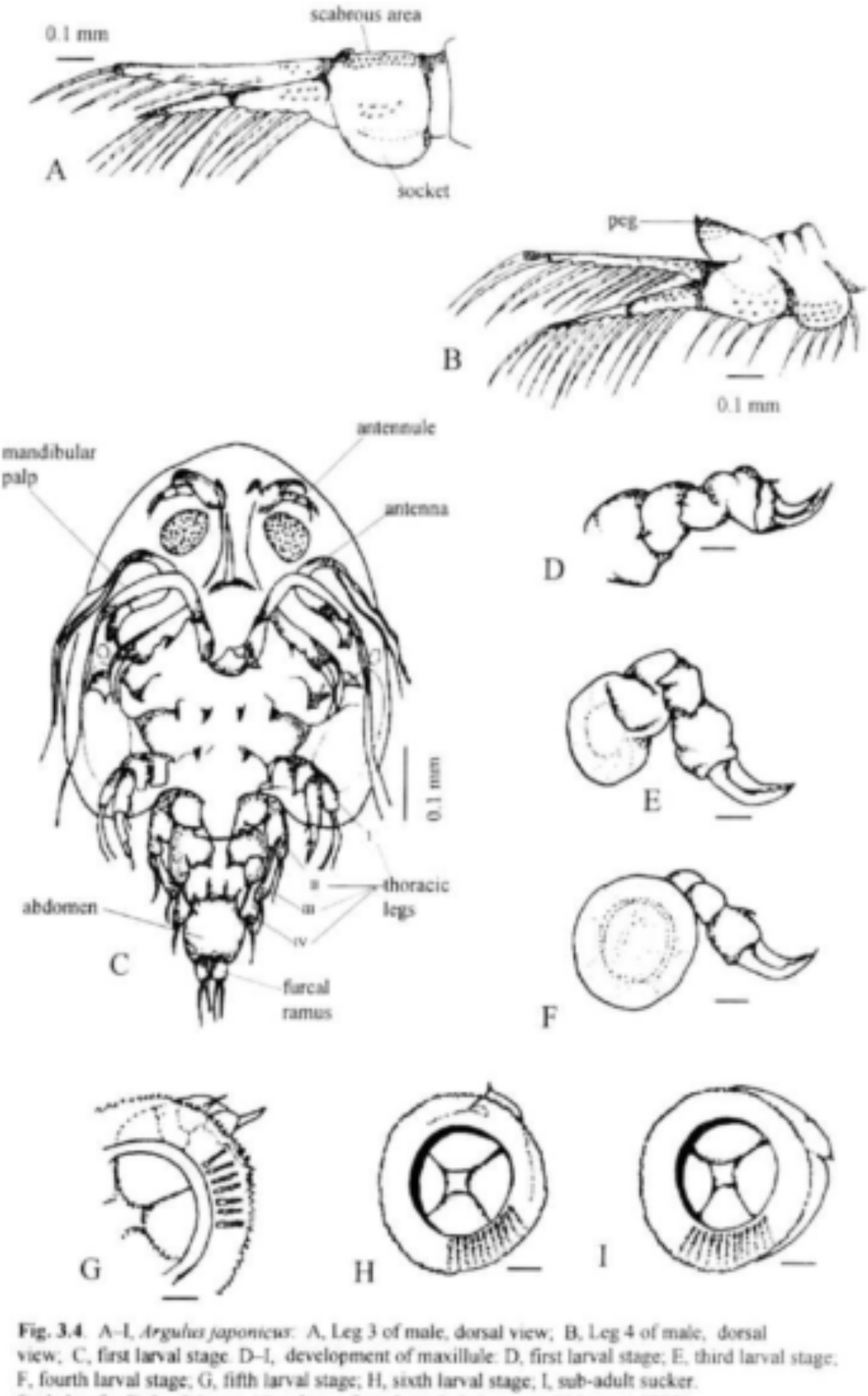

Fig. 3.4. A–I, *Argulus japonicus*: A, Leg 3 of male, dorsal view; B, Leg 4 of male, dorsal view; C, first larval stage. D–I, development of maxillule: D, first larval stage; E, third larval stage; F, fourth larval stage; G, fifth larval stage; H, sixth larval stage; I, sub-adult sucker. Scale bar for D–I = 0.1 mm. (C redrawn from Lutsch & Avenant-Oldewage 1995).

General Biology

Reproduction: All stages of development of this parasite have been found throughout the year in large impoundments (Shafir & Oldewage 1992). The process of copulation in *Argulus* is the same as that described for *Dolops*, but a spermatophore is produced. The spermathecae of females are filled by the males after which females are released. A detailed description of the male reproductive system is given in Avenant-Oldewage & Swanepoel (1993).

Eggs develop in the ovary in an unsynchronized manner (Shafir & van As 1986). Of the 75 egg-laying females monitored by these authors, one to nine strings of eggs were laid, with up to 226 eggs per string arranged in up to six rows.

Feeding and impact on hosts

Argulus japonicus originated from the far East where it is associated with cyprinid hosts, which include the common carp, goldfish, grass- and silver carps. These cyprinids were introduced for aquaculture, the ornamental fish industry and control of eutrophication (Bruton & van As 1986). The translocation of these fish hosts to various parts of the world also distributed the fish louse *A. japonicus*, which has now been reported from Europe, Australasia, Africa, the United States and recently also from the United Kingdom. This opportunistic parasite is now widespread throughout southern Africa and at times threatens indigenous fish species, especially in large impoundments during droughts when water levels are low (Kruger et al. 1983). A summary of the species parasitized by *A. japonicus*, its impact on host species, as well as its distribution in southern Africa, is given in Table 3.1 (p. 154).

Detailed ultrastructural studies of the stylet (Swanepoel & Avenant-Oldewage 1992) and the cephalic appendages (Gresty et al. 1993) have shown that *A. japonicus* uses the stylet to penetrate the epidermis. In this process fragments of the host epithelium are disrupted. The parasite then places the mouth tube over the lesion to draw blood.

Argulus japonicus is without doubt a serious pathogen and a threat to endemic fish species. Its introduction into various parts of the world illustrates the necessity for strict controls over the importation of alien fish species.

Chonopeltis Thiele, 1900
Figs. 3.5–3.15

Morphology

The basic morphology of members of the genus *Chonopeltis* is similar to that described for *Dolops* and *Argulus* on pages 128–130 and 132–134. In the genus *Chonopeltis* the carapace is clearly trifoliated and covers at most the bases of the second legs. The anterior lobe is narrow and rectangular. A thickened rim supports the anterior margin of this lobe, which may have a medial indentation in some species (Fig. 3.9C). In all but two species the anterior lobe is further supported by chitinous rods (Fig 3.8B). The antennae (Fig. 3.5B) are uniramous, four-segmented appendages with little variation between species. The antennule is absent. At the base of each antenna a cluster of 12–15 setae are found (van As 1992). These may represent the rudimentary antennule. In considering this possibility, Fryer (1961) came to the conclusion that the setae, when present, are merely ornamentations as he could not find them in *C. brevis*. These setae have been found in all the species so far studied by SEM. It is possible that Fryer may have missed these setae in *C. brevis*, as they are very small and not easily detected by means of light microscopy.

Members of the genus *Chonopeltis* have no stylet or mouth tube. The maxillules show the same ontogony as in the genus *Argulus*, developing into a large pair of suckers in adults. The rim of each sucker is supported by about 50 rods, each consisting of between 12 and 16 sclerites (Fig. 3.5G). Scanning electron microscopy indicates no significant difference between species in either the number or shape of the sclerites and rods. The maxillae in *Chonopeltis* are robust and more prominent than in the other two genera (Fig. 3.5A). The maxillae of all species are prehensile. In earlier work it had been supposed that in some species the maxillae were not prehensile, but van As (1992) clearly illustrates that this is not the case: modifications in different species relate to the extension or reduction in length of the last three podomeres. The maxillae in all species terminate in two retractable claws (Fig. 3.5A). Scales lacking posterior spines cover the basal plate (Fig. 3.3A) in which no specific differences have been noted.

The basic morphology of thoracic appendages in females resembles that of members of the genus *Argulus*, but flagella are absent. In males, legs two, three, and four bear specialized copulatory structures. In all species these structures are far more complex than those of *Argulus*. Between legs two and three are scabrous areas adapted for holding the female during copulation. The peg- and socket-structures (Figs. 3.8D, E, 3.13C, D) are extremely intricate in some species and may be instrumental in sperm transfer (van As & van As 1993). This is disputed by other authors (e.g. Avenant-Oldewage & Knight 1994) who are of the opinion that these elaborate structures merely serve as holdfast organs during copulation.

The following features are of taxonomic importance: the morphology of the peg and socket; the shape and size of the abdomen; the length of the abdomen relative to the body, and the shape of the testes and spermathecae. The presence or absence of pigmentation in *Chonopeltis* also has taxonomic significance: pigmentation (in the form of bands overlaying the uteri) is found in species that occur on the skin and fins of the host fish, whereas it is absent in species occurring in the branchial chambers of the hosts. Body pigmentation in some species resembles the pigmentation patterns in the scales of the host fish.

Impact on hosts, distribution and feeding

Members of the genus *Chonopeltis* show a high degree of host specificity, not only to the host species, but also to the location on the host. *Chonopeltis* specimens have never been found in large numbers on any host fish. At most a few specimens are found on a single host and there have been no reports of mortalities or pathological effects on hosts caused by *Chonopeltis* infestations. The high level of host specificity and selectivity of attachment sites suggests that these branchiurans have had a long evolutionary association with their hosts.

The distribution of various species of *Chonopeltis* and their hosts provides interesting insights into the evolution and dispersal of a number of fish species in the Orange–Vaal and Limpopo systems. While this topic is beyond the scope of the present publication, it is of interest to note the distribution patterns of various species of *Chonopeltis*, that are summarized in Table 3.1.

Little is known about the feeding habits of *Chonopeltis* species. It is unlikely that they feed on blood, as this would be easy to detect due to their transparent bodies. (In *A. japonicus* and some parasitic copepods, which feed on blood, the red blood pigment can clearly be seen in the digestive tract). The morphology of the mouth parts and the functional morphology of the foregut (van Niekerk & Kok 1989; Swanepoel & Avenant-Oldewage 1993) suggest that *C. australis* does not feed by suction, but probably utilizes the mucus on the skin and in the branchial chambers

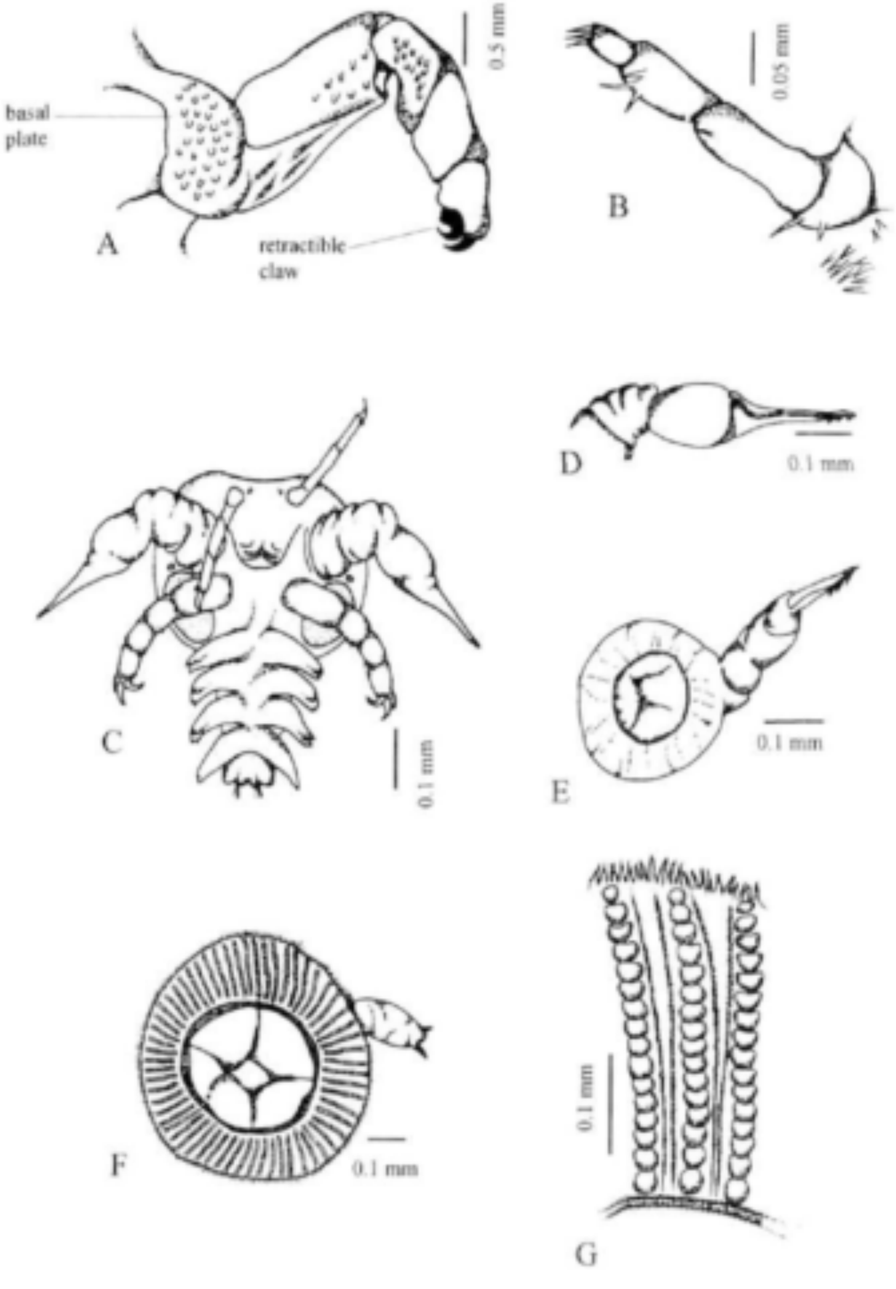

Fig. 3.5. A–G, *Chonopeltis*: A, maxilla; B, antenna with rudimentary setae; C, first larval stage. D–G, ontogeny of the maxillule; D, hook in first larval stage; E, developing sucker and hook in fourth larval stage; F, functional sucker and rudiment of hook in pre-adult; G, rim of sucker with rods consisting of sclerites.
(A redrawn from van As 1992; C from Fryer 1956).

of its host. The absence of a stylet further supports the suggestion that these organisms do not feed on blood. The status of the members of this genus as symbionts is most likely that of commensals rather than of parasites.

Members of the genus *Chonopeltis* are poor swimmers. There is no evidence that they leave their hosts except for laying eggs, after which they most probably do not reinfect other hosts.

General Biology

The most recent keys for species of *Chonopeltis*, were compiled separately for males and females by Fryer (1977). In the key presented below for the species of *Chonopeltis* occurring in southern Africa, characteristics are used which are applicable to males as well as females. The sexes in *Chonopeltis* can easily be distinguished: in males legs two, three and four bear the copulatory structures (Figs. 3.8D, E) and a large testis can be seen in the abdomen; females are generally larger than males, their legs are evenly spaced and undifferentiated, and their abdomens are characterized by the presence of spermathecae.

Reproduction and larval development

Little is known of the mating and breeding habits of *Chonopeltis*, but these are unlikely to differ significantly from those of other branchiuran species. Laboratory experiments on *C. australis* have shown that egg clusters (of up to 26), which adhered to specimen bottles, began to hatch after 28 days. The first information on larval development in the genus *Chonopeltis* was a brief reference to some sub-adult individuals by Barnard (1955).

Since that time a number of workers (Fryer 1956, 1961, 1977; van Niekerk & Kok 1989; van As & van As 1996) have studied the larval development of various *Chonopeltis* species:

In the newly hatched larvae the carapace is undivided and the antennae are large and extend far beyond the carapace margin. The maxillules (which at this stage, are large pincer-like appendages — Fig. 3.5D), dominate the cephalon. The second most prominent appendages are the maxillae. The base of the third podomere of the maxilla is indented and a cluster of brush-like setae is situated in the hollow. In consecutive larval stages this indentation becomes more prominent. The larvae draw their legs through this prehensile joint during grooming. This grooming function is lost in the adult stage since the brush-like setae disappear in the last moult prior to adulthood. The mouth is fully functional in the first larval stage, which suggests that it feeds actively. The legs are undifferentiated and not functional. The abdomen is a single lobe with the furcal rami terminal.

During ontogeny the maxillule transforms into a functional sucker after the fifth moult (Figs. 3.5D–G). At this stage the rudiment of the hook loses its functionality and is finally lost in the last moult. The carapace develops into the typical trifoliated shape towards the pre-adult stage. At this stage the chitinous supporting rods in the anterior carapace are also observed for the first time. Males and females can already be distinguished from the third stage onwards. At about the sixth stage the male reproductive organs are fully developed.

KEY TO THE SOUTHERN AFRICAN SPECIES OF THE GENUS *CHONOPELTIS*

1\. Anterior carapace margin with medial indentation (Fig. 3.9C) 3
– Anterior carapace margin round (Fig. 3.8A) 2

2\. Adult parasitic on the skin and fins of cyprinid fishes in the Orange–Vaal System .... *C. australis* (Fig. 3.6)
– Adults parasitic in branchial chambers of cyprinid fishes in coastal rivers of the Western Cape (not in Orange–Vaal System) .... *C. minutus* (Fig. 3.8) (Synonym *C. australissimus* – Fig. 3.7)

3 Chitinous supporting rods in anterior carapace (Fig. 3.8B) 4
– No chitinous supporting rods in anterior carapace .... *C. fryeri* (Fig. 3.9)

4\. Body with pigment patterns and dorsal pigment bands on thorax 5
– Body without pigmentation 6

5\. Eyes large with pigmented 'tearmarks' towards ocellus (Fig. 3.11A); margin of testis in male crenulated (Fig. 3.11C) .... *C. victori* (Fig. 3.11)
– Eyes not large; no pigmented 'tearmarks' near ocellus 7

6\. Legs one to four more or less of equal length; adult parasitic in mouth and branchial chambers of clariid fishes in the Limpopo and Zambezi systems .... *C. inermis* (Fig. 3.10)
– Legs one to four not of equal length, leg four much shorter the others; adult parasitic in branchial chambers of the mormyrid fish *Mormyrus lacerda*, in the Okavango Delta .... *C. liversedgei* (Fig. 3.15)

7. Distinct pigmentation pattern with clusters of pigment spots on carapace, thorax and abdomen; males with dorsal band of pigmentation (Fig. 3.12C); parasitic on skin of the cyprinid fish *Labeo cylindricus*, in the Zambezi System .... *C. koki* (Fig. 3.12)
– Uniform light pigmentation; males without dorsal pigment band (Fig. 3.13B); parasitic on skin of the cyprinid fish *Labeo rosae*, in the Limpopo System .... *C. meridionalis* (Fig. 3.13)
– Males without dorsal pigment band (Fig. 3.14C) and with two bulbous posterior projection on second legs; parasitic on skin of the mochokid fish, *Synodontis* spp. in the Okavango Delta .... *C. lisikili* (Fig. 3.14)

Chonopeltis australis Boxshall, 1976

Fig 3.6

Individuals of *C. australis* are medium-sized parasites (female 5.6 mm; male 4.4 mm) found on the skin and fins of the Orange River mudfish, *Labeo capensis*, in the Orange–Vaal System. Apart from the two bands overlying the uteri of the females, there is no pigment pattern in this species. The anterior lobe of the carapace is round with prominent supporting rods, but there is no medial indentation in the anterior margin. In females the legs are evenly spaced and the abdomen is straight and constitutes less than one-third of the total body length. The spermathecae are elongated and situated in the fused part of the abdomen (Figs. 3.6A, B). In males the peg of leg four has a straight tip and the straight abdomen constitutes more than one third of the total body length. The testes are elongated, extending slightly past the abdominal cleft (Fig. 3.6C).

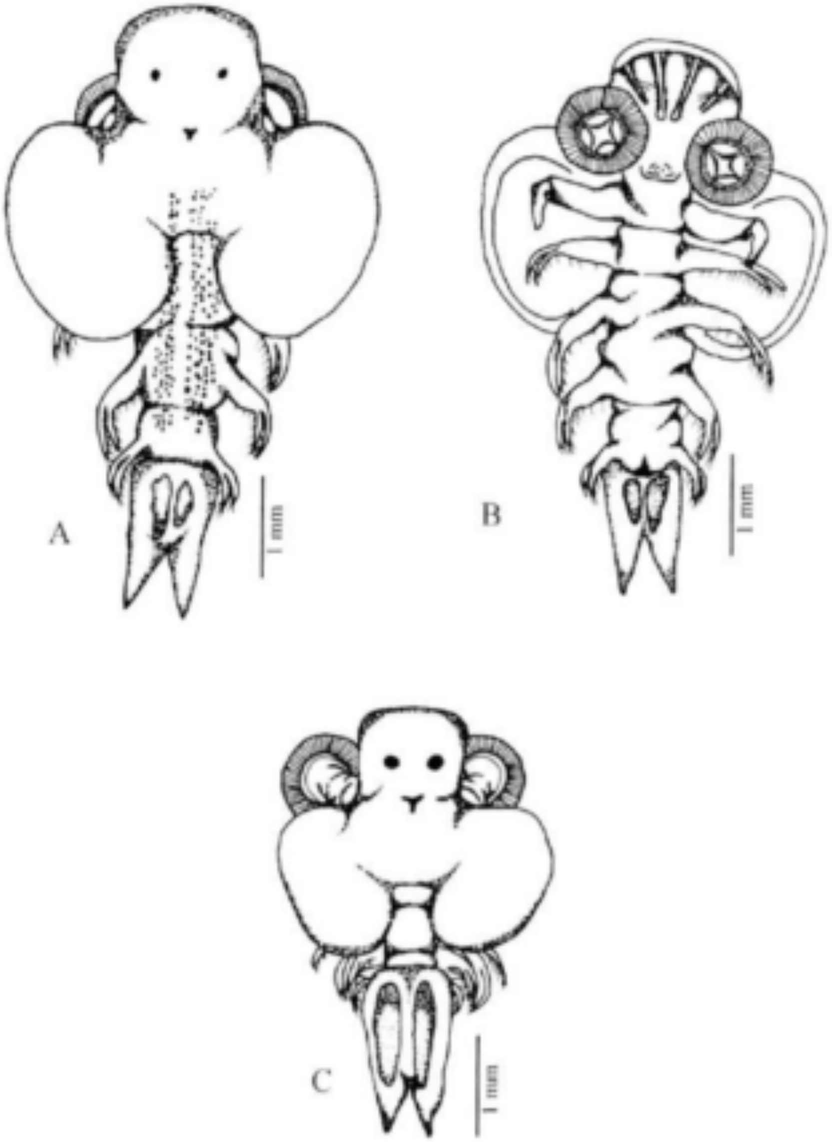

Fig. 3.6. *Chonopeltis australis*. A, female, dorsal view; B, female, ventral view; C, male, dorsal view. (Redrawn from Boxshall 1976).

Chonopeltis minutus Fryer, 1977

Fig. 3.8

(Synonym: *C. australissimus* (Fryer, 1977) Fig. 3.7)

Individuals in this species are very small (female 3.9 mm; male 2.5 mm) and are found in the branchial chambers of the Clanwilliam redfin, *Barbus calidus*, and the Twee River redfin, *B. erubescens* in the Olifants System (Western Cape), and the Berg River redfin, *Pseudobarbus burgi*, in the Great Berg River, Western Cape. The carapace is similar to that of *C. australis*. In females, legs three and four are situated close together (Figs 3.8A, B). The tips of the abdomen are slightly curved outwards and the abdomen constitutes less than one-third of the body length in both sexes (Figs. 3.8A, C). The spermathecae are round and situated in the fused part of the abdomen. In males the peg structure of leg four has a straight tip (Fig. 3.8D). The oval, elongated testes are situated in the fused part of the abdomen.

Chonopeltis australissimus was originally described from *P. burgi*. Recent comparative SEM studies of museum material has revealed that *C. australissimus* (Fig. 3.7) is, in fact, the same species as *C. minutus*, with *C. australissimus* being the junior synonym (van As & van As 1999).

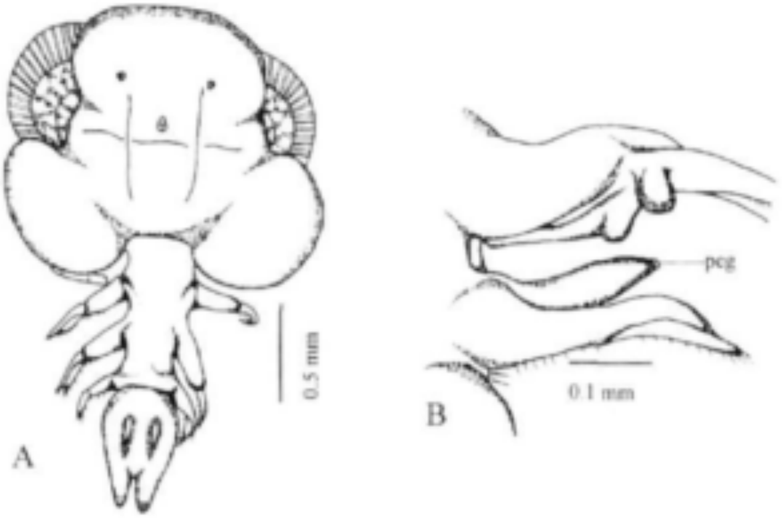

Fig. 3.7. *Chonopeltis australissimus*: A, female, dorsal view; B, copulatory structures on legs 3 and 4 of males, dorsal view. (Redrawn from Fryer 1977).

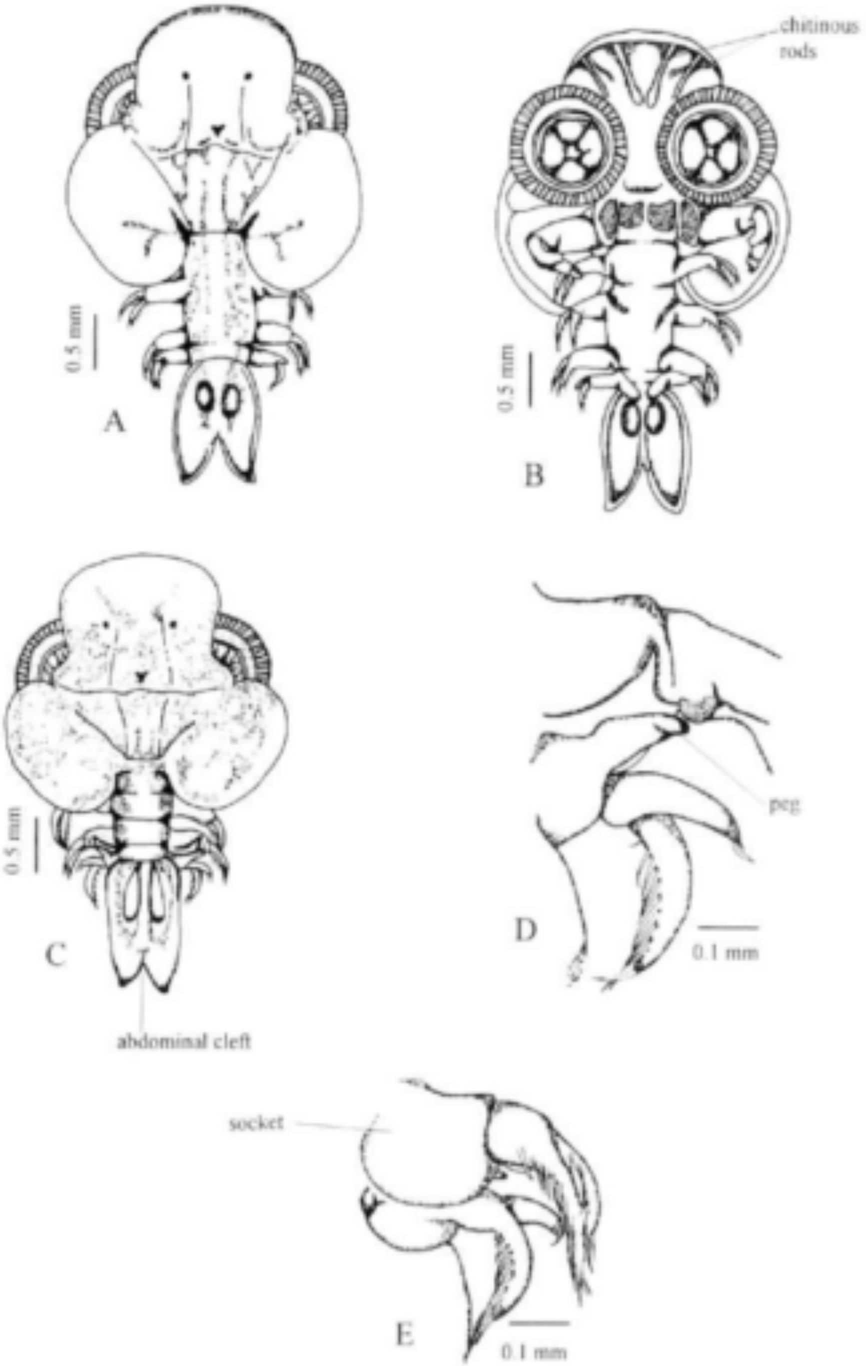

Fig. 3.8. *Chonopeltis minutus*. A, female, dorsal view; B, female, ventral view; C, male, dorsal view. D–E, copulatory structures on legs 3 and 4 of males: D, dorsal view; E, ventral view (Redrawn from Fryer 1977).

Chonopeltis fryeri van As, 1986

Fig. 3.9

Individuals of this species are medium-sized (female 8 mm; male 3.1 mm) and are found in the branchial chambers of their catfish host (*Clarias* spp.) in the Limpopo and Olifants systems in Mpumalanga. This species has no pigmentation. Anteriorly the carapace has a distinct medial indentation, but no chitinous supporting rods. In females the legs are evenly spaced and the abdomen is straight, and constitutes about one-third of the total body length. The oval spermathecae are situated in the fused part of the abdomen (Fig. 3.9A). In males the peg of leg four is curved with a hook-like tip, the abdomen is straight and constitutes more than one third of the total body length. The testes are elongated and extend past the abdominal cleft. The lateral margins of the testes are crenulated (Fig. 3.9C).

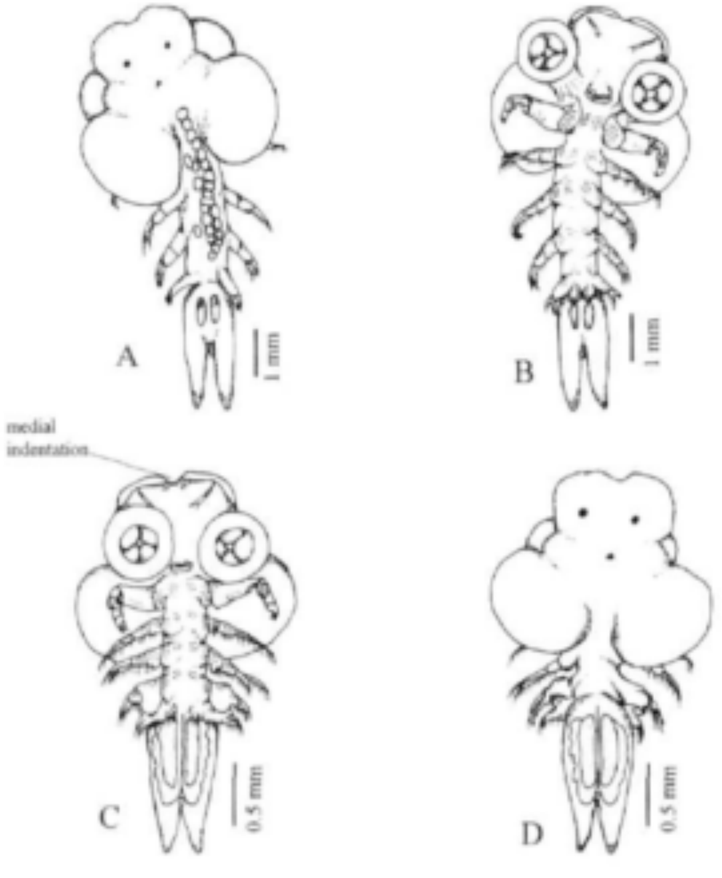

Fig. 3.9. *Chonopeltis fryeri*: A, female, dorsal view; B, female, ventral view; C, male, ventral view; D, male, dorsal view. (Redrawn from van As 1986).

Chonopeltis inermis Thiele, 1900
Fig. 3.10

Individuals of this species are medium-sized (female 7 mm; male 3.6 mm) and are found in the branchial chambers of *Clarias* spp. in the Limpopo and Zambezi systems. They have no pigmentation. The anterior carapace has a distinct medial indention and chitinous supporting rods. In females the legs are evenly spaced and the abdomen, with tips curved outwards, constitutes less than one third of the total body length. The spermathecae are elongated to oval and situated in the fused part of the abdomen (Fig. 3.10A). In males the peg of leg four is broad and straight, and the abdomen, with tips curved outwards, constitutes more than one third of the total body length. The testes are elongated, with crenulated lateral margins (Fig. 3.10C).

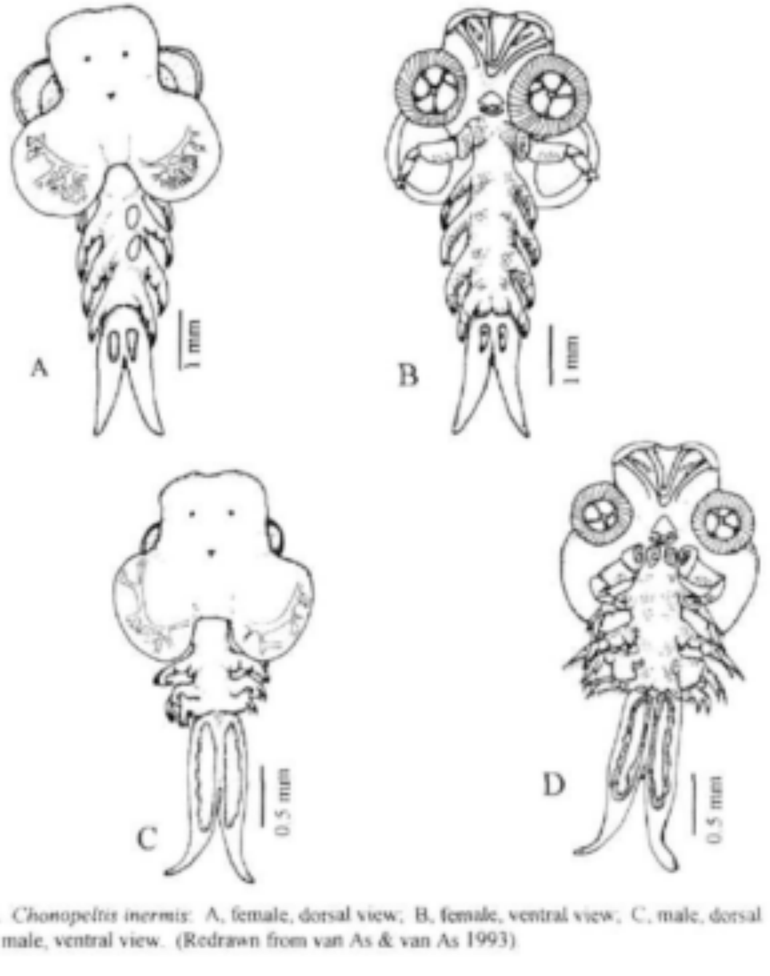

Fig. 3.10. *Chonopeltis inermis*: A, female, dorsal view; B, female, ventral view; C, male, dorsal view; D, male, ventral view. (Redrawn from van As & van As 1993)

Chonopeltis victori Avenant-Oldewage, 1991

Fig. 3.11

Individuals of this species are medium-sized (female 4.8 mm; male 3.1 mm) and are found on the anal and tail fins of *Labeo* spp. in the Olifants and Letaba Rivers, Mpumalanga. The only pigmentation consists of two pigment bands covering the uteri of the females. The anterior carapace has a medial indentation and chitinous supporting rods. In females the legs are evenly spaced and the abdomen constitutes less than one third of the total body length. The spermathecae are elongated and situated in the fused part of the abdomen (Fig. 3.11A). In males the peg of leg four has a curved tip and the abdomen constitutes more than one third of the total body length. The testes are elongated and extend past the cleft of the abdomen. The lateral margins of the testes are crenulated (Fig. 3.11C).

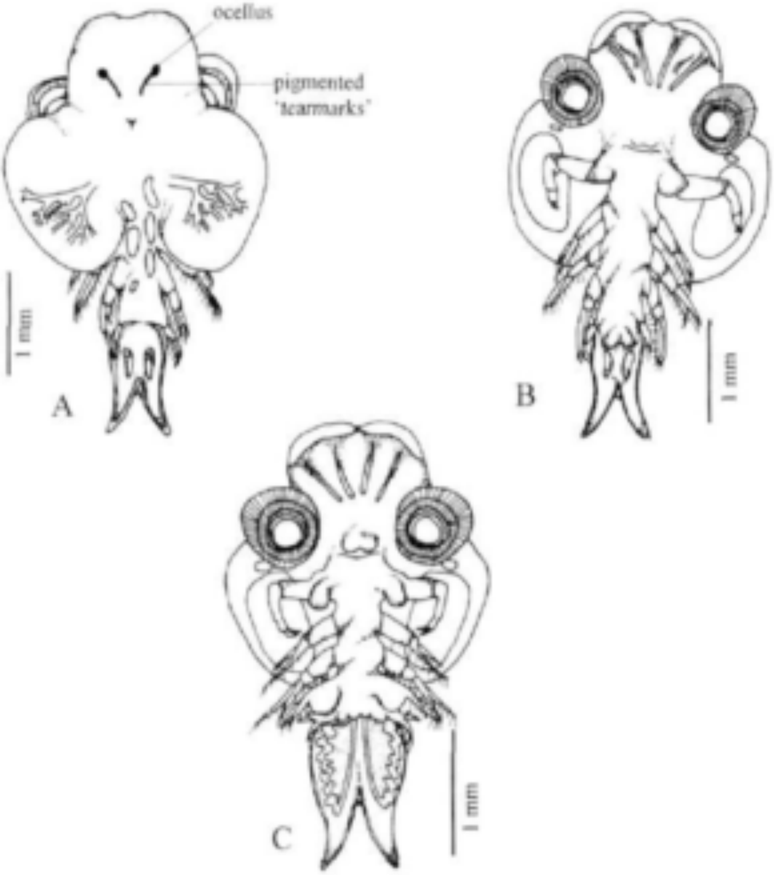

Fig. 3.11. *Chonopeltis victori*: A, female, dorsal view; B, female, ventral view; C, male, ventral view. (Redrawn from Avenant-Oldewage 1991).

Chonopeltis koki van As, 1992

Fig. 3.12

Individuals of *Chonopeltis koki* are medium-sized (female 6 mm; male 4 mm) and are found on the tail fin of the redeye labeo, *Labeo cylindricus*, in the Zambezi System. This species is characterized by pigment patterns similar to those found on the scales of the host. Both females and males have dark pigment bands on the dorsal thorax. Clusters of pigment are found in pits on the abdomen. The anterior carapace has a medial indentation and chitinous supporting rods. In females the legs are evenly spaced and the abdomen, with tips curved outwards, constitutes about one-third of the total body length. The spermathecae are elongated and extend past the abdominal cleft (Fig. 3.12A). In males the peg of leg four has a hook-like tip and the abdomen constitutes more than one third of the total body length. The testes are oval and elongated, extending just past the cleft of the abdomen (Fig. 3.12C).

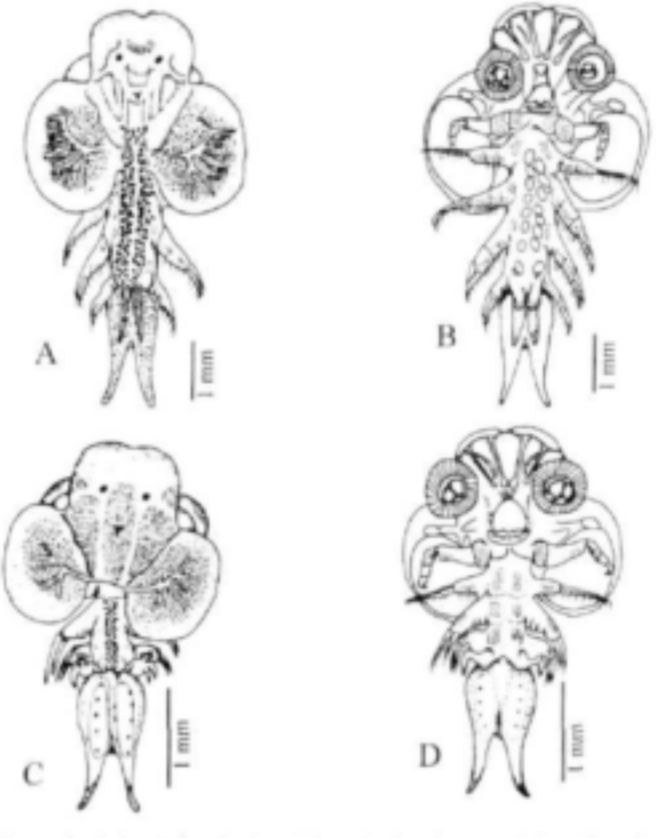

Fig. 3.12. *Chonopeltis koki*: A, female, dorsal view; B, female, ventral view; C, male, dorsal view; D, male, ventral view. (Redrawn from van As 1992)

Chonopeltis meridionalis Fryer, 1964

Fig. 3.13

Individuals of this species are medium-sized (female 6.2 mm; male 3.6 mm) and are found on *Labeo* spp. in the Nuanetzi River, Limpopo System. This species shows some similarity to *C. victori* and *C. koki*. It can be distinguished from *C. koki* by the absence of dorsal pigment bands on the thorax of the males as well as by the absence of the distinct general pigmentation in *C. koki*. *Chonopeltis meridionalis* can be distinguished from *C. victori* by the absence of the 'tearmark' pigmentation (Fig 3.11A). The three species also differ in the shapes of the testes (see Figs. 3.11–3.13).

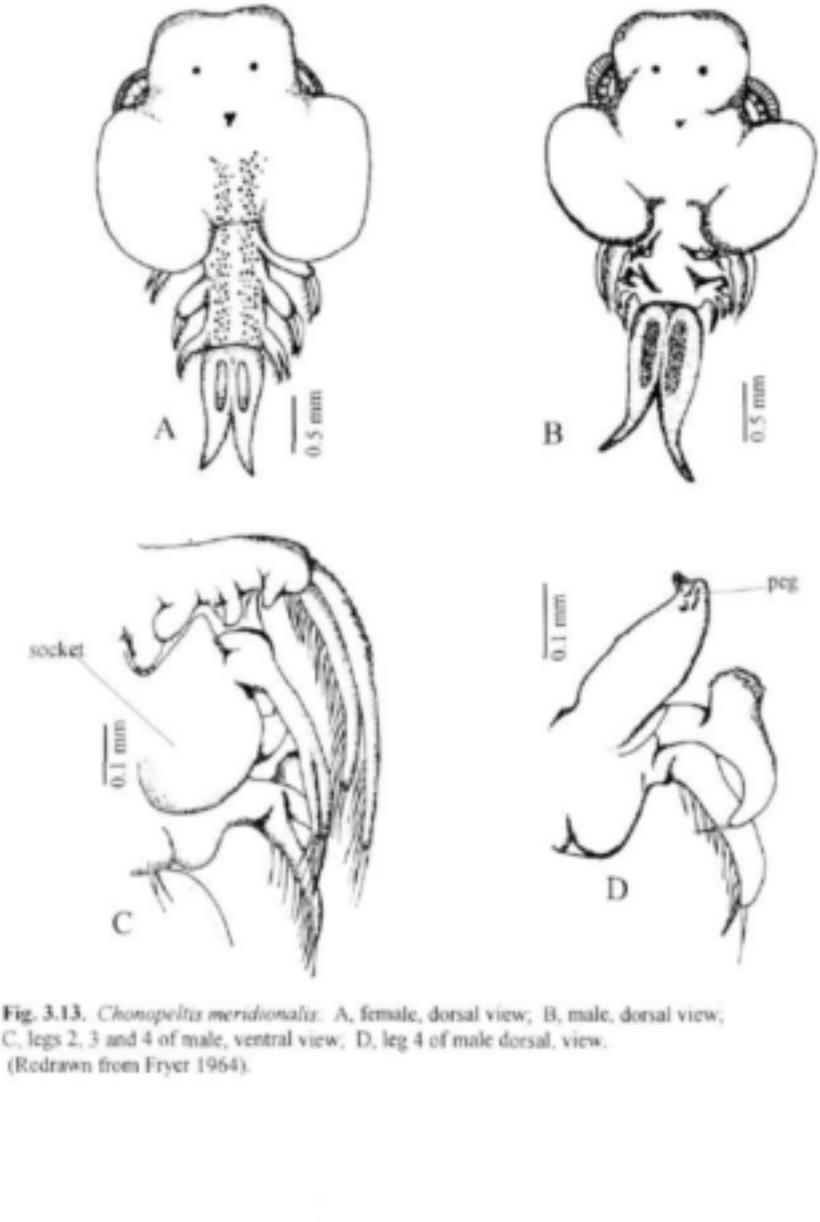

Fig. 3.13. *Chonopeltis meridionalis.* A, female, dorsal view; B, male, dorsal view; C, legs 2, 3 and 4 of male, ventral view; D, leg 4 of male dorsal, view. (Redrawn from Fryer 1964).

Chonopeltis lisikili van As & van As, 1996

Fig. 3.14

Individuals of this species are small. The species was described from sub-adult females (2.3 mm) and young males (2.5 mm) removed from museum material of *Synodontis leopardinus* (leopard squeaker). The hosts were collected from the Okavango Delta and the Zambesi System. Sub-adult females, with eggs in the uteri, still display some larval characteristics such as hook rudiments on the sucker and bristle seta at the prehensile part of the maxilla. The young males do not display any remaining larval characteristics. The anterior carapace has a medial indentation and supporting rods. Pigment bands overlie the uteri in the females. The spermathecae are pear-shaped and situated in the fused part of the abdomen (Fig. 3.14A). Lateral margins of testes are crenulated and situated in the fused part of the abdomen (Fig. 3.14C). This species shows a close resemblance

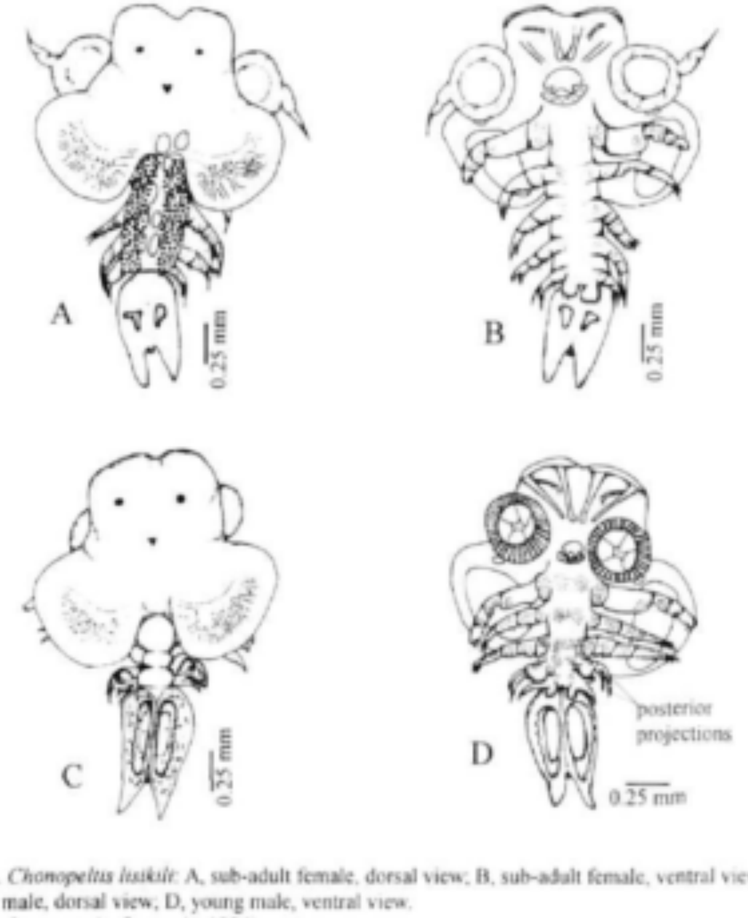

Fig. 3.14. *Chonopeltis lisikili*: A, sub-adult female, dorsal view; B, sub-adult female, ventral view; C, young male, dorsal view; D, young male, ventral view.
(Redrawn from van As & van As 1996).

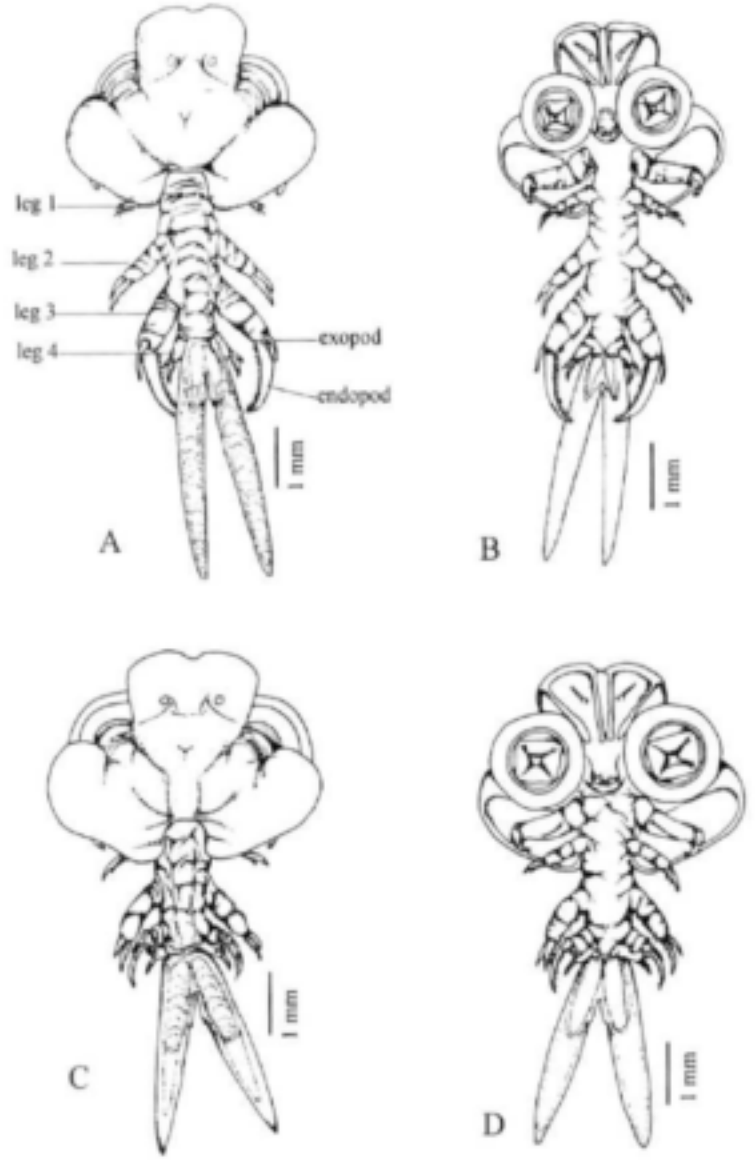

Fig. 3.15. *Chonopeltis liversedgei*: A, female, dorsal view; B, female, ventral view; C, male, dorsal view; D, male, ventral view. (Redrawn from van As, JG & van As, LL 1999).

to *C. meridionalis*, *C. koki*, and *C. victori*. *Chonopeltis lisikili* can however, be distinguished from these species by a wreath of specialized scales found on the base of the hook-like tip of the peg and the presence of only two posterior projections on the second leg of males. Despite an extensive survey in the Zambezi and Okavango rivers, no adult females have so far been found and it is still uncertain which fish species acts as a final host for *C. lisikili*.

Chonopeltis liversedgei van As & van As, 1999

Fig. 3.15

Individuals of this species are slender (female 9 mm; male 6.7 mm) with a long abdomen. They occur on *Mormyrus lacerda* (western bottlenose) found in channels and lagoons in the Okavango Delta. *Chonopletis liversedgei* has a short carapace with a medial indentation and supporting rods. It has no pigmentation. In females legs are unevenly spaced: leg three is huge, the exopod is reduced and the massive scimitar-shaped endopod bears sharp spines (Figs. 3.15A, B). The spermathecae are elongated and pear-shaped, and extend past the abdominal cleft to slightly beyond the furcal rami (Fig. 3.15A). Leg two of the male is large, with two bulbous posterior projections. The elongated, oval-shaped testes extend past the abdominal cleft (Fig. 3.15C). This species can clearly be distinguished from all other southern African species, but shows some resemblance to *C. schoutedeni* from the Congo system. The anterior carapace lobes and leg three of *C. liversedgei* females are, however, more robust than those of *C. schoutedeni* females. The spermathecae of *C. schoutedeni* are shorter and more oval-shaped than those of *C. liversedgei*.

Table 3.1: Branchiuran species which occur in southern Africa: summary of host species, distribution, and impact on hosts

Parasite species	Hosts	Distribution	Impacts of parasitism, highest infection prevalence* and site of attachment
Dolops ranarum	*Clarias gariepinus* *Oreochromis mossambicus*	Restricted to habitats where *C. gariepinus* and *O. mossambicus* coexist: Limpopo and Orange–Vaal systems.	Inflamed lesions found at attachment site. *D. ranarum* does not feed on blood, but on extracted tissue particles from open wounds. *C. gariepinus*: up to 26%; 35 individuals on host; on body and fins. *O. mossambicus*: up to 24%; 18 individuals on host; in mouth cavity.
	O. mortimeri	Lake Kariba (Zambezi System)	
	Barbus marequensis	Records in Pongola flood plain, Zambezi System	
Argulus japonicus	*Barbus aeneus* *B. kimberleyensis* *Clarias gariepinus* *Labeo capensis* *L. umbratus* *Tilapia sparrmanii* *Carassius auratus* (alien fish) *Cyprinus carpio* (alien fish)	Firmly established throughout southern Africa as well as the coastal rivers on the west and south coast	Alien species introduced from the Far East. Opportunistic parasite; feeds on blood; may be responsible for the transmission of dracunculid nematodes (Moravec et al. 1999); no preference for attachment sites; responsible for mortalities at fish farms and is a pest in aquariums; 250 specimens recorded on one *Barbus kimberleyensis* individual in Bloemhof Dam (Kruger et al. 1983).

* Represents the percentage of infected individuals in the fish population. The highest recorded figures are given.

Table 3.1 (cont.)

Parasite species	**Hosts**	**Distribution**	**Impacts of parasitism, highest infection prevalence* and site of attachment**
Chonopeltis australis	*Labeo capensis* *Barbus aeneus*	Orange–Vaal System	No evidence of any pathology so far recorded; association most likely that of benign symbiont. Species in this genus are host-specific and also site-specific. Occur on skin and in gill chamber.
C. minutus (syn. *C. australissimus*)	*Barbus calidus* *B. erubescens* *Pseudobarbus burgi*	Olifants System (W. Cape) Great Berg River (W. Cape)	
C. fryeri	*Clarias theodorae* *C. gariepinus*	Limpopo & Olifants rivers (Limpopo System) (Mpumalanga)	
C. inermis	*Clarias theodorae*	Limpopo System	
C. victori	*Labeo rosae* *L. ruddi* *L. rubropunctatus* *Barbus marequensis*	Olifants River and Letaba rivers (Limpopo System)	
C. koki	*Labeo cylindricus*	Eastern Caprivi (Zambezi System)	
C. meridionalis	*Labeo rosae*	Nuanetzi River (Limpopo System)	
C. lisikili	*Synodontis leopardinus* *S. macrostigma*	Thomalakane, Shashi, Okavango and Kavango rivers (Botswana)	
C. liversedgei	*Mormyrus lacerda*	Okavango River (Botswana)	

* Represents the percentage of infected individuals in the fish population. The highest recorded figures are given.

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GLOSSARY

abdomen	the posterior part of the body of an arthropod
acute	at a sharp angle (less than 90°)
adductor muscle	in bivalved crustaceans, a muscle, or one of a series of muscles, running transversely between the valves (q.v.) and holding them closed
aesthetasc	(= aesthetask): in copepods, a small rod-shaped sense organ on the antennule
ala	a hollow, ventro-lateral wing-like expansion of the carapace in some ostracods
alien species	(= exotic species): a species that has been distributed intentionally or unintentionally by man to areas beyond its native range of distribution
anal somite	in copepods, the last somite of the body, proximal to the furca (q.v.)
antenna	(= Antenna, antenna 2, second antenna): one of the jointed second pair of appendages on the head of a crustacean, often simply called the 'antenna' (cf. *antennule*)
ante-penultimate segment	the third-to-last segment in copepods
antenna 1	see *antennule*
antenna 2	see *antenna*
Antennula	see *antennule*
antennule,	(= Antennula, antenna 1, first antenna): one of the jointed first pair of appendages on the head of a crustacean (cf. *antenna*)
anterior	the ' front' end
anurans	frogs and toads
apex	(*adj.* apical): the tip
appendage	in crustaceans, any of the paired, articulated structures attached to each somite (e.g. antennae, maxillipeds, pereiopods)
armature	protective structures such as spines, knobs, projections and claws
articulation	the flexible connection or joint between articles or somites
article	(= 'segment', 'joint'): a single subdivision of an appendage, such as the coxa or dactyl of a pereiopod, or one of the elements of an antennal flagellum
basal plate	in branchiurans, a plate at the base of the maxillae, often with spines
basis	(= basipodite): the second from the body of the seven articles in a crustacean limb
benthic	pertaining to, or living on, the bottom

bilobed	composed of two lobes
biramous	having two branches
bivalved	having a carapace divided into two 'shells' or valves
branchial	pertaining to respiration, and thus usually to the gills
branchial chamber	the cavity, between the body and the carapace, that houses the gills
bristle	a stout seta (q.v.)
brood cavity	in ostracods, a cavity, contained within the valves, that protects developing eggs, embryos and young larvae

calcified	hardened by the deposition of lime (calcium carbonate)
carapace	a shield-like cuticular structure covering the fused head and thoracic terga in higher crustaceans
cardinal tooth	a tooth of the hinge structure in ostracod valves, fitting into a cardinal socket on the opposite valve; cardinal teeth can either be anterior or posterior and in the left or right valve
caudal	pertaining to the 'tail' or posterior end
caudal furca	the 'tail fork', made up of the last pair of appendages
caudal rami	each of the two branches of the tail fork (see *furcal rami*)
central muscle scars	in ostracods, scars, near the centres of the valves, indicating the positions of muscle attachment sites
cephalon	(*adj*. cephalic): the anterior tagma: the head; in crustaceans, bearing two pairs of antennae and three pairs of mouthparts (usually a pair of mandibles and two pairs of maxillae —q.v.)
cephalothorax	the head and thorax, when fused together
chaetotaxy	the number and arrangement of setae, claws, etc.
chitin	a tough organic compound that forms the bulk of the cuticle of crustaceans; hardening may be enhanced by impregnation with calcium carbonate or by tanning with certain proteins
chitinous	made of chitin (q.v.)
class	a taxon below phylum and above order
commensal	an organism of one species that lives with another of a different species
commensalism	a symbiotic relationship in which one species benefits and a second species is neither helped nor harmed
conspecific	of the same species
copepodite	(= copepodid stage): any of the postnaupliar larval stages in copepod development
copulatory process	in ostracods, part of the hemipenis (internal in Cypridoidea, external in Cytheroidea) which is inserted in the female genital pore
cosmopolitan	of worldwide distribution
coxa	(= coxopodite): the first (proximal) of the articles of the endopodite of the thoracic appendages of many crustaceans
crenulate	with finely-notched margins

DPX	disterene dibutyl phthalate xylene (= distrene plasticiser xylene) 'mountant' for microscope slides
dentate	toothed
denticle	a small tooth
denticulate	bearing small teeth
diagnostic	in this context, providing a definitive character for identification
diapause	a period of suspended development or growth, accompanied by greatly decreased metabolism
dimorphism	the occurrence of two morphologically different forms, usually in the same species, and often between the sexes (= sexual dimorphism)
distal	the part of a structure furthest from the mid-line of the body or the point of its attachment (cf. *proximal*)
dorsal	referring to the upper surface (the 'back') of an organism
dorsal hinge	the hinge between the two valves of an ostracod carapace
ductus ejaculatorius	the duct down which sperm pass to the outside of the body
ectoparasite	a parasite attached to the external surface of its host
egg sac	an external sac containing eggs (e.g. copepods)
embryo dish	a small, heavy glass dish
endemic	referring to organisms found only in a particular area
endite	one of a series of small lobes emerging medially from the protopodite of a crustacean limb
endopod	(= endopodite): the inner of the two rami or branches of a biramous crustacean limb
exopod	(= exopodite): the outer of the two rami or branches of a crustacean limb
extant	in existence
family	a taxonomic category below order and above genus
flagellum	(*pl.* flagella): the multi-articulate distal part of an antenna or exopod
flange	a ridge along the valve margin formed by the projection of the outer lamella as a narrow brim (ostracods)
formalin	a solution of formaldehyde in water (concentrated formalin is 40% formaldehyde)
furca	fork (see *caudal furca*)
furcal attachment	in some ostracods, a stiffened rod attaching the caudal rami to the rest of the body
furcal lobes	setose lobes on the furca in *Gomphocythere* (Ostracoda)
fused zone	the zone of fusion between the outer and inner lamella of a valve (ostracods)

geniculate	bent (like a knee)
genital corner	the part of an ostracod body consisting of the genital lobes and operculum
genital lobe	an expansion of the region of the genital operculum in female ostracods
genital operculum	the plate that closes off the genital aperture
genital somite	in copepods, the somite bearing the genital apertures
genus	a taxonomic category below family and above species
gill	an organ, usually flattened and expanded, used for respiration in water
glans	the distal part of the copulatory process in the hemipenis of male ostracods
globular	rounded, inflated
gravid	filled with eggs
gymnoplean tagmosis	in copepods, the body plan in which prosome and urosome are divided by a joint between the fifth pedigerous and the genital somite (q.v.)
habitat	the combination of biotic and abiotic factors that make up the 'home' of an organism: the specific place where an organism lives
head	the anteriormost tagma (see *cephalon*)
hemipenis	(*pl.* hemipenes): one of the paired copulatory structures of ostracods
hermaphrodite	an individual with both male and female reproductive organs
hinge	in ostracods, the region of articulation between the valves; in one valve consisting of an anterior and a posterior cardinal tooth separated by the cardinal groove; in the other valve of anterior and posterior cardinal sockets (into which the cardinal teeth fit) separated by the intercardinal bar, which fits into the intercardinal groove on the other valve
hirsute	hairy
hyperparasite	a parasite of a parasite
inner lamella	the inner part of an ostracod valve (q.v.)
inner list	a crest on the calcified part of the inner lamella of ostracod valves
inner margin	the margin of the peripheral calcified part of the inner lamella (q.v.) of an ostracod valve (q.v.)
inner spermiduct	part of the sperm-transporting duct within the hemipenis (q.v.) of male ostracods; the labyrinthal part is sclerotized while the tubular part may be coiled or lobed (Ostracoda)
intercoxal sclerite	in copepods, the sternal (ventral) sclerite between a pair of coxae
interstitial	referring to the spaces (interstices) between sediment particles
inner margin	the calcified part of the inner lamella in the valve of an ostracod

instar	a stage of development between moults
intercardinal bar	the bar between the anterior and the posterior cardinal tooth in the hinge of an ostracod valve (see *hinge*)
juvenile	reproductively immature
keel	a ridge or crest
lamella	a thin sheet or plate; ostracod valves consist of an outer and an inner lamella
larva	any juvenile instar of a different form from that of the adult
lateral	of the side of an animal
lateral shield	one of the two distal lobes of the peniferum of male ostracods
limb	an appendage used in locomotion
line of concrescence	the inner margin of the fused zone (q.v.) of the valve of an ostracod
list, inner	a crest on the calcified part of the inner lamella of ostracod valves
list, outer	a crest on the calcified part of the outer lamella of ostracod valves
littoral	referring to the shore of a lake or sea
loculus	a chamber or cavity
lunule	crescentic spaces between the radial septa in the vestibulum (q.v.) of an ostracod valve
mandibles	(*sing.* mandible): the first pair of mouthparts: hardened, laterally moving jaws used for crushing or biting food
mandibular palp	an articulated ramus (q.v.) on the mandible
margin	in an ostracod, the edge of the valve
marginal pore canal	an opening through the fused zone (q.v.) in the valve of an ostracod
mastigatory process	the sclerotized part of the mandible of ostracods
maxilla 1	see *maxillule*
maxilla 2	see *maxillae*
maxillae	(*sing.* maxilla) (= Maxilla, maxilla 2, second maxilla): the two pairs of mouthparts behind the mandibles; the first pair usually called the maxillules (q.v.) and the second pair the maxillae
maxilliped	one of up to three pairs of accessory feeding appendages formed by the modification of the anterior thoracic appendages
Maxillula	see *maxillule*
maxillule	(= Maxillula, first maxilla, maxilla 1): one of the first pair of mouthparts behind the mandibles (see *maxilla)*

medial shield	the middle lobe of the peniferum of male ostracods
median	in the middle or the mid-line
metanauplius	(*pl.* metanauplii): the larval stage after the nauplius
metamorphosis	the change from one form to another, e.g. from larva to adult
monotypic	(= monospecific): of a genus, with a single species
morphological	(*n.* morphology): pertaining to form and structure
moulting	the process whereby arthropods shed their exoskeletons
mouthparts	appendages modified for feeding: mandibles, maxillae and maxillipeds
mouth tube	in branchiurans, the trunk-like process on the ventral side of the head
MS-222	trade name for a commercial anaesthetic for fish
muscle scar	see *central muscle scars*
natatory	used for swimming (of setae, long and usually feathery)
natatory lobe	a posterior extension of the first podomere of leg 4 in branchiurans (in fact it has no swimming function)
nauplius	(*pl.* nauplii): the diagnostic first larval stage of crustaceans with a rounded, unsegmented body, three pairs of appendages (two pairs of antennae and one pair of mandibles) and a simple median nauplius eye or ocellus
obsolete	reduced or lost
ocellus	a simple eye or eyespot
ontogeny	the development and growth of an individual
order	a taxonomic category below class and above family
outer list	a crest on the calcified part of the outer lamella (q.v.) of ostracod valves
outer lamella	the outer of the two lamellae or sheets that make up the valve of an ostracod: the outer surface of the valve
ovarian	related to the ovaries
ovigerous	bearing eggs
oviposition	the laying of eggs
paedomorphic	with juvenile features in the adult
palp	an articulated ramus, usually of a mouthpart, reduced to one to three segments
pan	a large, flat depression in the landscape, periodically holding water
papilla	a small lobe or nipple
parthenogenesis	asexual reproduction in which an egg develops without fertilization
pedigerous somite	literally, a foot-bearing segment; in copepods, a thoracic somite bearing a pair of swimming legs

peg	in branchiurans, a tube-like structure situated on leg 4 of males and used during copulation
periphyton	the organisms attached to aquatic plants
pilose	covered with fine, soft hairs
plankton	a collective term for the small organisms living suspended in the water column and at the mercy of currents
podoplean tagmosis	in copepods, the body plan in which prosome and urosome are divided by a hinge joint between the fourth and fifth pedigerous somites
pore canal, marginal	a fine canal running inward radially from the margin of a valve in ostracods
postabdomen	a tubular annex of abdomen in ostracods
posterior	at the tail end
prehensile	adapted for grasping or clinging
proboscis	a trunk-like projection bearing the mouth at its tip
process	a projection
prosome	in copepods, the complete body section anterior to the major articulation
protopodite	the proximal part of any crustacean limb, usually consisting of the coxa and basis
proximal	towards the point of attachment (cf. *distal*)
radial septum	a septum between the calcified inner lamella and the outer lamella in the vestibulum of an ostracod valve spaces between them are lunules
ramus	a branch of a crustacean appendage
raptorial	grasping: of a limb, usually z-shaped and able to be extended and retracted very rapidly
receptaculum seminis	(= seminal receptacle, spermatheca) : an organ in females used for storing sperm
reniform	kidney-shaped
resting egg	an egg, usually in a protective cyst, undergoing diapause (q.v.)
robust	stout, sturdy
rostrum	a pointed anterior extension of the carapace
salinity	a measure of the saltiness of water
scabrous	roughened
sclerite	a chitinous plate or other part of the exoskeleton
sclerotized	hardened by deposition of proteins that tan chitin
second antenna	see *antenna*
second maxilla	see *maxilla*
segment	one of the primary divisions of the body of an arthropod
selvage	in ostracods, the inwardly displaced margin of each valve that contacts the other when the valves are closed
septum	a partition between two cavities

serrate, serrated	toothed: with a saw-like edge
sessile	permanently attached to the substratum
seta	a relatively long flexible bristle-like process
setule	a very fine or small seta (q.v.)
sexual dimorphism	difference in form between male and female of the same species
socket	a sac-like structure, situated on leg 3 of male branchiurans, used during copulation
somite	one of the metameric divisions of the body of a crustacean
spatulate	spoon-shaped
special setae	in ostracods: — d1 and d2 setae on the first and second article respectively of the second thoracopod in Cypridoidea — S1 and S2: large setae on the mandibular palp of Cyprididae and of importance in the identification of Megalocyprididae — y and z setae on the mandibular palp of Darwinulids
speciation	the process of species formation
species	a group of interbreeding individuals reproductively isolated from other such groups: the unit of biological diversity
speciose	rich in species
spermatheca	(= seminal receptacle, receptaculum seminis): an organ in the female used for storing received sperm
spermatophore	a capsule, containing sperm, transferred from the male to the female
spermatophore - coupler	in copepods, a raised area or a specific structure on the female genital somite for attachment of a spermatophore
spermiduct	in ostracods, the duct carrying sperm from the testis: consists of a sclerotized labyrinthal part and a coiled tubular part
spine	a pointed, tooth-like expansion of the integument, in copepods often armed with a row of small denticles
stylet	(= preoral spine): a tube with an eversible spine anterior to mouth tube in branchiurans such as *Argulus*
sub	a prefix indicating ' almost' or ' not quite'
subequal	almost equal
subspecies	in animals, the only recognized taxon below species: populations that are morphologically distinguishable from each other but that are able to interbreed
subterminal	almost at the tip
sucker	in certain branchiurans, an attachment organ formed from the maxillules
sulcus	a groove
synonym	in taxonomy, a second (previous or subsequent) name for the same species
synapomorphy	a derived character state shared by several lineages

taxon	any taxonomic category (e.g. species, class, phylum)
telson	the terminal part of the body, behind the last abdominal somite and usually bearing the anus
testicular tube	one of four, usually spiralled, components of the testis of ostracods
thoracic	pertaining to the thorax (q.v.)
thorax	the middle of the three tagmata of most crustaceans
thoracic wing	in female calanoid copepods, the lateral expansion of the last prosomal somite to form a wing-like process
thoracopod	any of the appendages of the thorax
torpor	a state of decreased metabolism in which individuals can survive for extended periods during unfavourable conditions
trabecule	in ostracods, an elongated structure on some cytheroid hemipenes
transverse	running from one side of an animal to the other
Triebel's loop	a diagnostic structure distal in the furcal attachment of cypricercin ostracods
tubercle	a small rounded protuberance
type species	the species designated to define the genus
uniramous	consisting of a single ramus or branch
uropod	one of the last pair of abdominal appendages (rarely the last three)
urosome	in copepods, the body section posterior to the major articulation, the first somite being the non-pedigerous genital somite
valve	the lateral part of a divided carapace: one of the two 'shells' of ostracods
ventral	referring to the underside of the body
ventral ala	wing-like ventro-lateral expansions of the valves in ostracods
vestibulum	in ostracods, the space between the outer lamella and the calcified part of the inner lamella (q.v.)
vlei	a wetland or a riverine reed-bed
Zenker's organ	the muscular ejaculatory tube of male ostracods
zoobenthos	bottom-dwelling animals: the animal component of the benthos
zoogeography	the natural distribution of animals on Earth
zooplankton	animals living suspended in the water: the animal component of the plankton (q.v.)

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
Northern Province (NP)	formerly the 'northern Transvaal'
North West (NW)	formerly the 'western Transvaal'
Western Cape (WC)	formerly the 'western Cape'

* **Note** the following conventions regarding capitalization of regional names:

'*Western Cape*' (capitilized) refers to the provincial name, whereas compound place references such as '*western, southern and eastern Cape*' (lower case) refer to particular regions within the former Cape Province.

Formal terms such as '*West Africa*' take the capital, whereas terms such as such '*west and south coast*' refer to geographic regions and take the lower case.

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 Province; 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
Okavango	region of Botswana into which the Okavango and Choebe rivers flow forming a swampy inland delta
Orange Free State	One of the four former provinces of South Africa, now known as the Free State
Owamboland (Ovamboland)	Northern region of Namibia
Pan Belt	Region, about 900 km long and 500 km wide, in which many pans occur, stretching NNE from Calvinia through the Northern Cape and the western Free State to Gauteng with branches in Namibia and Botswana and an outlying patch near Lake Chrissie (Mpumalanga)
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 Northern 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

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