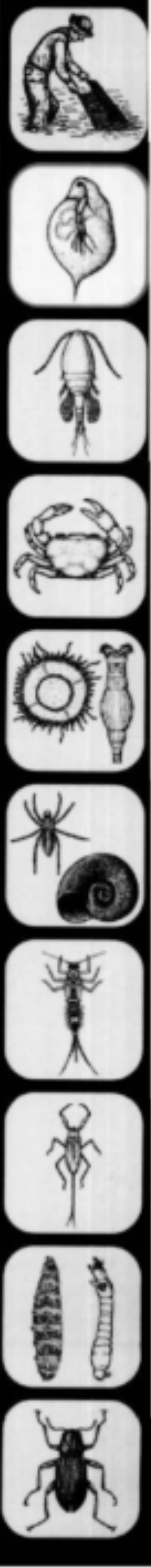
Guides to the

Freshwater Invertebrates of Southern Africa



Crustacea I

Notostraca, Anostraca, Conchostraca and Cladocera

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

TT 121/00

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CONTENTS

PREFACE

This identification guide is one of a series of ten books that include keys to most of the fresh- and brackish-water invertebrates in Southern Africa. The paucity of identification guides suitable for non-specialists has become a yawning gap in the tools available to scientists, managers and scholars concerned with the assessment and management of water resources. It is hoped that the present guides will be of value to these and other users, and that the environment will benefit as a result. The principle aim of this series is therefore 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It is a truism that identification guides are perpetually out of date, particularly in terms of nomenclature, due to advances in systematics.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/departments/zooento/Martin/Aquatics.html).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 book containing general information and a key to the families of invertebrates. Subsequent books contain keys to different invertebrate groups, most often logically clustered together but in some instances the need for cost-effectiveness has resulted in the creation of some rather uncomfortable 'bedfellows', such as the arachnids and molluscs that are combined in Book 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 books in the series are the culmination of years of effort by a large number of people and organizations: Shirley Bethune, Jenny Day, Barbara Stewart, Nancy Rayner and Maitland Seaman started the project in 1986; Jenny Day, Bryan Davies and Jackie King initiated contact with authors and began the editing process, and Barbara Stewart and Elizabeth Louw later became involved in editing the Crustacea chapters. A decade later, Chris Dickens successfully obtained funding from the Water Research Commission for the completion of the project, and later took on the job of Project Leader; Steve Mitchell managed the project from the Water Research Commission, 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 book, 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

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

The following people and organisations 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; 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 of the Water Research Commission for her advice on printing and text layout.

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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, focussed 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 120), 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

BRANCHIOPOD CRUSTACEANS

by

J.A. Day

As well as familiar animals like crabs, rock lobsters and shrimps, the Crustacea include, amongst others, the less well known brine shrimps, fairy shrimps, clam shrimps, shield shrimps and water fleas, which are the subjects of this volume. These few pages serve as a brief introduction to the branchiopods as a group. Some general information on the biology of invertebrates from inland waters will be provided in Volume I of this series and specific details of the biology of each of the orders within the branchiopods are given in the appropriate chapter below.

SYSTEMATIC POSITION OF THE BRANCHIOPODA

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 (e.g. Schram 1986). Indeed, they do not even agree whether the Crustacea should be included in the largest of all phyla, the Arthropoda, or whether it should itself be elevated to the level of phylum: the phylum Crustacea (e.g. Manton 1977). Since arthropod systematists have not yet settled the issue, in these volumes we treat the Arthropoda as a single phylum and the taxa Crustacea, Chelicerata and Insecta as subphyla. Whatever the final answer may be, the four groups treated in the present volume are generally recognized as being relatively closely related to each other, as well as being some of the most ancient living crustaceans.

The Class Branchiopoda includes all those crustaceans with leaf-like (phyllopodous) locomotory trunk limbs, compound eyes and reduced mouthparts. The Branchiopoda themselves are divided into two Divisions:

the Eubranchiopoda (commonly called the 'large branchiopods') with elongate, distinctly segmented bodies, 10 or more pairs of trunk limbs and (meta)naupliar larval stages; and the Cladocera (sometimes called the Oligobranchiopoda), with short, apparently unsegmented bodies, six or fewer pairs of trunk limbs, a reduced abdomen and direct development. The three Orders within the Eubranchiopoda are the Notostraca or shield shrimps, the Anostraca or fairy and brine shrimps, and the Conchostraca or clam shrimps. The second Division within the Class Branchiopoda is the Cladocera, which includes the familiar water fleas as well as a few unusual forms that do not occur in Southern Africa.

On occasion, crustacean systematists revise their views on the relationships between the higher taxa within the subphylum and come up with new names for some of them. The term 'Phyllopoda', for instance, is used by Schram (1986) to include the branchiopods and a number of other forms although branchiopod systematists generally use the word as a common name for the branchiopods but consider it to be of no formal taxonomic significance. More recently, Fryer (1987) suggested that the Conchostraca be divided into two Orders, the Laevicaudata (small-tailed clam shrimps of the present family Lynceidae) and the Spinicaudata (the large-tailed clam shrimps: all the other conchostracan families), and that the Cladocera be disbanded and placed into four separate orders: the Ctenopoda (represented in this volume only by the genus *Sida*), the Anomopoda (all the typical water fleas), and two uncommon orders (the Onychopoda and Haplopoda), which are not included here. In this volume, though, we stick to the older system that recognizes the four orders listed above.

BIOLOGY OF THE BRANCHIOPODA

Feeding and locomotion

The name 'branchiopod' means 'gill-foot' and all of its members are characterized by having flattened, leaf-like limbs called phyllopods that are used for feeding, respiration and locomotion, and sometimes even in the process of reproduction. These limbs are quite unlike the locomotory appendages of the other crustaceans, which tend to be more or less cylindrical and are primitively used for walking. These remarkable phyllopodous limbs are lined up one behind the other, one pair per segment, on many or all of the trunk segments. The limbs waft back and forth, generating a current of water that sweeps particles of food into the ventral midline of the animal, where the toothed gnathobases of each pair of limbs work against each other to grind the food and pass it forwards to the mouth.

The water current also brings oxygen to, and removes carbon dioxide from, the limbs, which thus act as gills. The limbs also serve as locomotory appendages, moving the animals from place to place as they themselves beat back and forth. A few species of branchiopod, such as the notostracans and the American anostracan *Branchinecta gigas*, are omnivorous or carnivorous. Details are provided in later chapters.

Reproduction

With the exception of a few species of anostracans that can reproduce parthenogenetically, the *eubranchiopods* normally reproduce sexually. The fertilized female retains her eggs in an ovisac (or, in the case of the conchostracans, attached to one or two pairs of specialized limbs) until they have developed a tough, sclerotized shell. In most cases the embryo develops through one or more naupliar stages within the shell, after which development ceases. The eggs are laid but each embryo remains in the shell (now known as a cyst) right through the dry phase of the pond, emerging only when it is again inundated. Almost without exception, the cysts of Southern African eubranchiopods require a period of desiccation before they can hatch. In contrast, *cladocerans* tend to have long periods of parthenogenesis interspersed with short periods of sexual reproduction. Most produce resting eggs during periods of unfavourable environmental conditions. In some species these resting eggs are able to resist desiccation.

ECOLOGY OF THE BRANCHIOPODA

Habitat requirements

Many crustacean groups are exclusively marine but a few, including the Eubranchiopoda, are restricted to inland waters worldwide. The eubranchiopods are probably the most characteristic invertebrates of small, temporary pools and pans. Indeed, with the exception of *Artemia salina*, the brine shrimp, few species in Southern Africa occur anywhere other than in temporary waters. Some species of cladocerans occur in temporary waters but many are typically found in permanent lakes, reservoirs and wetlands. It is an intriguing and unexplained fact that no eubranchiopods are found in the sea; a few rather bizarre species of cladocerans are, but not in Southern African waters.

Biogeography and biodiversity

Branchiopods vary enormously in the extent of their geographical distribution patterns. Some, such as *Artemia salina* (which is possibly a suite of sibling species), occur worldwide in saline lakes and salt works, while others, such as certain other species of anostracans, seem to have very limited distributions. Details of the distribution patterns of the more northerly species in Southern Africa are often confounded by the geographical limitations of collecting effort, however, while the taxonomic equivalence (or otherwise) of well known species from Europe and northern America with local species has been questioned. Frey (1982) for instance, argued that the apparently cosmopolitan nature of many species of chydorid cladocerans is not borne out by detailed examination, which reveals small but consistent differences in the morphology of single 'species' from continent to continent.

Given that the cysts of many branchiopods are resistant to desiccation, it is likely that they are easily dispersed by wind or on the feet of terrestrial vertebrates visiting drying water sources. Theories of island biogeography suggest that the species living in small, isolated systems will easily migrate to, and become eliminated from, them (e.g. Day 1990), so that the suite of species occupying a particular pond may vary noticeably from time to time.

Records exist of the apparent 'introductions' of cladocerans (e.g. *Daphnia lumholtzi* into the USA: Havel & Hebert 1993). It is difficult to tell if this is the natural outcome of the ease of dispersal of taxa like this, or whether it is a result of human activities.

COLLECTION, PRESERVATION AND REARING OF BRANCHIOPODS

Branchiopods are easily collected with a fine-meshed net. Although meshes of 1 mm or so will retain larger specimens, a mesh of 0.1 mm or less is necessary for collecting cladocerans and the larvae of eubranchiopods. Since different species live in different parts of a pond or lake, 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.

Samples should be fixed in 4% neutralized formaldehyde (one part of concentrated formalin to nine parts of water, neutralized with a few broken sticks of blackboard chalk or a couple of spoonsful of powdered chalk per litre of fixative). After 24–48 hours, the formalin solution should be replaced with a solution of 70% 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. An appendage may appear sufficiently detailed only under a compound microscope at magnifications between 100 and 400-times, in which case it must be mounted in water or glycerine (alcohol tends to evaporate very rapidly) on a microscope slide under a coverslip.

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

IDENTIFICATION OF BRANCHIOPODS

Branchiopods can be recognized as *arthropods* by their chitinous exoskeletons and the series of paired jointed appendages (e.g. Figs 2.1A, 2.1B, 3.1B) on most somites (segments) of the body. Externally, they can be recognized as *crustaceans* by their two pairs of biramous antennae (Figs. 2.1A & 4.1A) (the first pair of which is much reduced, especially in the notostracans), and as *branchiopods* by their flattened phyllopodous limbs (e.g. Figs 1.1H, 2.1C, 3.1I), compound eyes and simple mouthparts.

As in most crustaceans, the segments behind the mouth bear, in order, a pair of mandibles (e.g. Fig. 3.1D), a pair of maxillules (sometimes called 'first maxillae' or 'maxilla 1', e.g. Fig. 3.1G) and a pair of maxillae (sometimes called 'second maxillae' or 'maxilla 2', Fig. 3.1H). In most branchiopods, though, the maxillae are very reduced and not easy to find. All of the phyllopodous limbs down the length of the body are similar to each other, except in the notostracans, where a couple of the anterior-most pairs are produced to form sensory 'feelers' (Fig. 1.1G). The basal attachment points (endites) of each pair of phyllopods may form food-handling gnathobase-like structures (proximal endites in Fig. 2.1C) that meet in a midventral food groove (visible in Fig. 3.2A).

KEY TO THE ORDERS OF BRANCHIOPODA

1A. Body enclosed in a bean-shaped, bivalved shell or carapace (Figs 3.1A, 4.1A)..2

1B. Body elongate, not enclosed in a bivalved carapace (Figs. 1.1A, 1.1 D, 2.1A, 2.1B)..3

2A. No more than six pairs of flattened trunk limbs; head not enclosed by the carapace; adults < 4 mm long, usually transparent and fragile (Fig. 4.1).. **Cladocera** (Chapter 4, p. 81)

2B. At least 10 pairs of flattened trunk limbs; head enclosed within the carapace; adults normally >5 mm long, usually opaque and solid-looking (Figs 3.1A, 3.1B, 3.2A) ....**Conchostraca** (Chapter 3, p. 59)

3A. Large, flat, shield-shaped carapace covering anterior part of trunk; heavy, opaque, stout-bodied benthic animals; some adults reaching 50 mm in length (Figs 1.1A, 1.1D) ....**Notostraca** (Chapter 1, p.7)

3B. No carapace; delicate, transparent or translucent, planktonic animals; adults seldom >25 mm in length (Figs 2.1A, 2.1B) ...... **Anostraca** (Chapter 2, p.14)

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CHAPTER 1

NOTOSTRACA

by

N.A. Rayner

The Notostraca (tadpole shrimps) are branchiopod Crustacea that have been known since the Triassic Period and, because of their primitive nature and long fossil record, are sometimes referred to as living fossils (Fryer 1988). There are two notostracan genera, *Triops* and *Lepidurus*, the latter being distinguished from *Triops* by the presence of the supra-anal plate, a dorsal spatulate extension of the telson which is usually at least twice the length of the telson. In Africa, *Lepidurus* has been recorded only as a fossil form, *Lepidurus stormbergensis* Haughton 1924, from the Cave Sandstone beds of the Stormberg Series of the Upper Triassic (Barnard 1929). In his revision of the South African Branchiopoda, *Triops* (then known as *Apus*) was assigned four species by Barnard (1929) but Longhurst (1955) referred these to two species, *Triops cancriformis* (Bosc 1801) and *T. granarius* (Lucas 1864). In 1958, the generic name of *Apus* was changed to *Triops* because of confusion with the avian genus *Apus* (Opinion 502 1958). This account deals with the two species of *Triops* known from Southern Africa.

Morphology

Linder (1952) and Fryer (1988) gave a detailed account of the functional morphology of the Notostraca. The shield-shaped carapace of *Triops* is attached only at the head region and varies from oval to round in shape (Fig. 1.1A, D). The surface may be smooth and polished, finely granular, or covered with small spines. The number of denticles on the posterior sinus (Fig. 1.1A) is variable. The carapace is horn or amber in colour (Barnard 1929) but in laboratory specimens reared by Rayner & Bowland (1985b) the males were pink and the females light brown. There are 35 to 71 pairs of phyllopodous (leaf-like) legs, which are used for swimming and respiration. The thorax and abdomen are free and made up of a number of somites or body rings. These rings are telescopic and somites can be drawn out to nearly double their length by picking up a specimen by the caudal rami (Barnard 1929). The thorax consists of the first 11 body somites each bearing one pair of appendages ventrally. The number of abdominal somites is variable, with each of the anterior somites bearing a pair of appendages. The posterior abdominal somites lack appendages and are referred to as the apodal somites (Fig. 1.1 A, D). On the dorsal surface of the head in adult Notostraca there are two sessile compound eyes, a very small ocellus and the nuchal (dorsal) organ. The shape of the nuchal organ varies from round to oval to triangular and appears to be correlated with body somite number rather than being a species-specific character. The mouthparts consist of a mandible and first and second maxilla. The efferent duct of the shell gland arises at the base of the second maxilla and, as this duct is drawn out as a tube in males, it is a good character for sex determination. Males are also distinguished from females by the non-differentiation of the 11th thoracic appendages as brood pouches and, for a given population, a proportionally higher number of apodal somites. The endites of the first thoracic appendage are filamentous with the longest, the fifth endite, being antenna-like (Fig. 1.1G). The ratio of 5th endite length to carapace length has been used in systematics and tends to be higher in males than in females of the same population.

Habitat preferences

Species of *Triops* inhabit temporary pools of fresh or brackish water, especially in arid and semi-arid regions. They have never been recorded from lakes and are seldom found in water bodies exceeding one hectare in extent (Pennak 1989). They can tolerate wide temperature changes and low oxygen concentrations and, in contrast to species of *Lepidurus*, favour warmer, often muddier, waters (Barnard 1929). In Southern Africa, *Triops* species have been collected mainly in an area bounded by the 500 mm mean rainfall isohyet (Meintjes *et al.* 1994). Most of the western records lie between the 100 and 200 isohyets and others are in locally arid areas. *Triops* species are associated with temporary habitats in drier areas.

Feeding

Triops species are usually benthic, swimming and crawling over the bottom sediment. They feed on organic matter such as dead tadpoles and sometimes burrow in search of small organisms. In the laboratory, Rayner & Bowland (1985a) reared *T. granarius* on TETRAMIN fish food sprinkled on the surface of the water. Food was located by the endites of the first thoracic appendage with the *Triops* swimming ventral surface uppermost.

Reproduction

In the highly unstable conditions in which these animals live, they must develop swiftly and reproduce before conditions become intolerable for life (Louw & Seely 1982). The female bears two egg pouches that are a modification of the 11th pair of thoracic limbs (Fig.1.1H). Eggs are bright pink to red in colour and protected by an outer cortex and a thick alveolar layer. Eggs can withstand extreme environmental conditions of desiccation, high temperatures and freezing (Thiery 1985). Seaman *et al.* (1991) in laboratory experiments, stated that desiccation was not necessary for hatching of eggs (of *T. granarius*) but undesiccated eggs could take as long as 20 days to hatch. Laboratory experiments have shown that there is differential hatching, as not all eggs hatch in the first hydration of sediment (M. L. Hamer pers. comm.). Preliminary investigations by Carlisle (1968) indicated that not only is a prolonged period of desiccation required for hatching eggs of *T. granarius* but also that they require exposure to temperatures exceeding 50°C. Thiery (1985) reported that, in Morocco, eggs of *T. granarius* were laid in clusters of from 5 to 50 and more than 80 % were glued to gravel on the bottom of the pond. This negates the formerly accepted theory that drought-resistant diapausing eggs are dispersed by wind or biological means. Eggs thus remain in a habitat of proven suitability. The egg hatches as a nauplius larva and development is very rapid; the fifth instar may occur less than two days after hydration of the eggs (Fryer 1988).

There is some evidence that species of *Lepidurus* occur in temporary pools. However, Brauer (1877) believed that the eggs of *Lepidurus* could not withstand desiccation. Longhurst (1955) contended that representatives of the genus may occur in temporary pools and Linder (1952) recorded *L. apus* in temporary pools in Sweden.

Identification

Longhurst (1955) recognized four species of *Triops* worldwide –*Triops cancriformis* (Bosc 1801), *T. granarius* (Lucas 1864), *T. longicaudatus* (LeConte 1846) and *T. australiensis* (Spencer & Hall 1895).

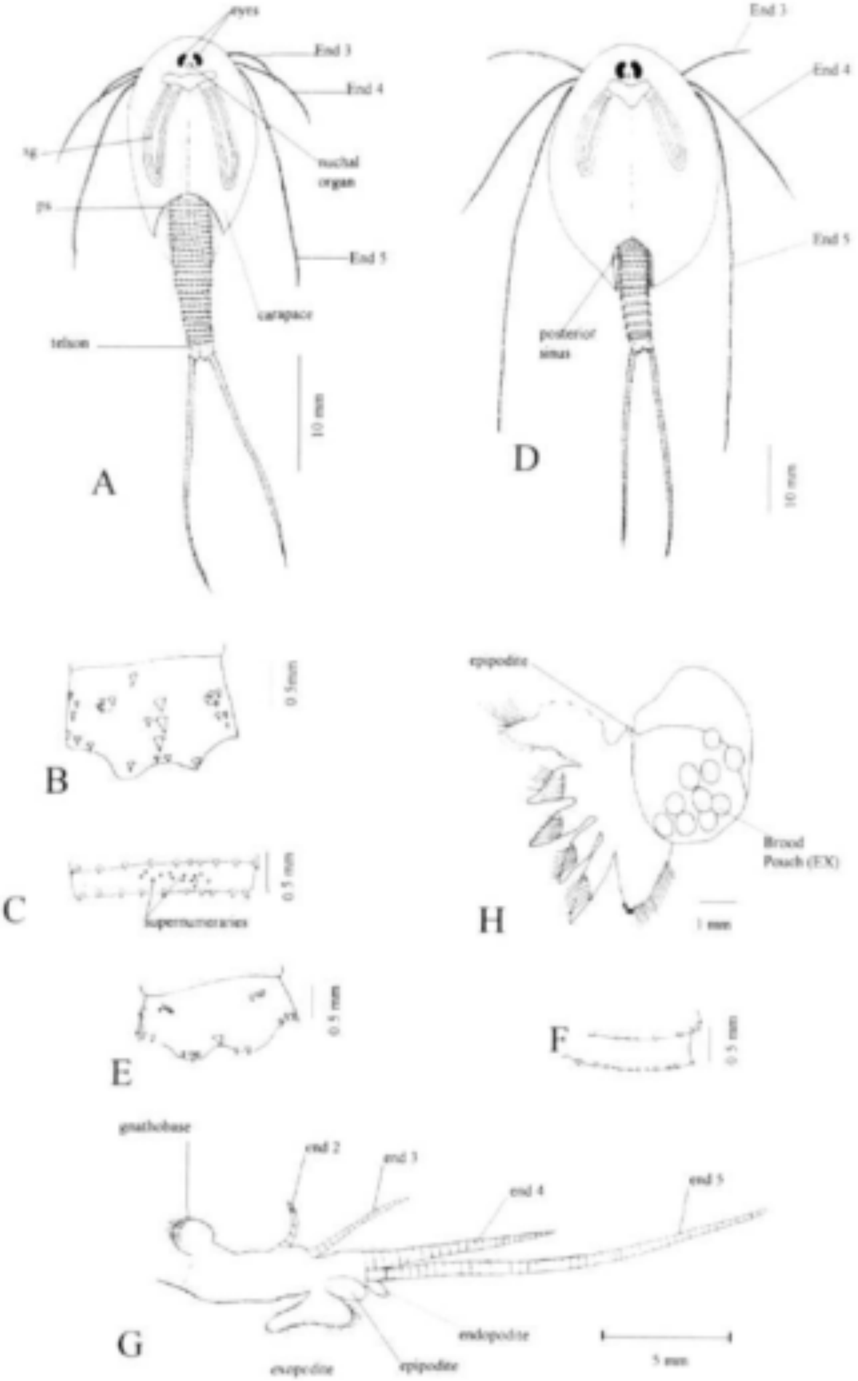

Fig. 1.1. General morphology of the Notostraca. A–C. *Triops granarius*. A. Female, dorsal view. B. Telson. C. Apodal somites with supernumeraries, ventral view . D–F. *Triops cancriformis*. D. Female, dorsal view. E. Telson. F. Apodal somites without supernumeraries, ventral view (without supernumeraries). G–H. *Triops granarius*. G. First thoracic appendage. H. Eleventh thoracic appendage modified as a brood pouch.
(KEY: End 2-5–endites; EX–exopodite; PS–posterior sinus; SG–shell gland)

Triops cancriformis and *T. granarius* possess a second maxilla, which is absent in *T. longicaudatus* and *T. australiensis*. Barnard (1929, 1935) recognized four species in Southern Africa – *T. numidicus* (Grube 1865), *T. namaquensis* (Richters 1886), *T. sudanicus* (Brauer 1877) and *T. cancriformis* [= *T. ovamboensis* (Barnard 1924)] but Longhurst (1955) considered that the first three species were all *T. granarius*. Hamer & Rayner (1995) confirmed that both *T. cancriformis* (Fig. 1.1 D) and *T. granarius* (Fig. 1.1A) occur in Southern Africa. *Triops cancriformis* is much less common than *T. granarius*, Barnard (1935) having only recorded this species from Ovamboland and the Kalahari. There are numerous records of *T. granarius* in Southern Africa (Barnard 1929; Rayner & Bowland 1985a, 1985b; Meintjies 1992; Meintjes *et al*. 1994; Hamer & Rayner 1995, 1996). These two species are distinguished from each other by the presence (*T. granarius*) or absence (*T. cancriformis*) of supernumerary spines on the apodal somites (Fig. 1.1C, F), the armature of the telson (Fig. 1.1B, E), the length of the fifth endite of the first thoracic limb (Fig. 1.1D, G), and the very long caudal rami of *T. cancriformis* (Fig. 1.1D). Many of the characters, such as carapace shape and number of apodal somites that Barnard (1929) considered to be important, were rejected by Longhurst (1955) because of their variability. *Triops* species have been known since the days of Linnaeus and their taxonomic relationships are still not fully understood.

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CHAPTER 2

ANOSTRACA

by

M. Hamer

The Anostraca, or fairy shrimps, are among the most primitive of extant crustaceans and comprise one of the orders of the class Branchiopoda. These animals range in length from 6–100 mm at maturity. The anostracans are a relatively small group, with about 270 species in 23 genera (Belk & Brtek 1997), distributed among eight families. They have an almost worldwide distribution and are absent only from the polar regions.

Habitat preferences

The anostracans are largely restricted to ephemeral, inland, aquatic habitats. Their occurrence in these stressful habitats (in terms of predictability and stability), represents a strategy to avoid predation, particularly by fish. Temporary pools in Southern Africa that are inhabited by anostracans include small rockpools (common on rocky outcrops or in mountain ranges), game wallows, and pans ranging in magnitude from a few metres to a number of kilometres. Anostracans also occur in roadside ditches, ephemeral farm dams and vleis, and in pools in dried riverbeds. Most of these habitats are dependent on rainfall and the period for which they hold water ranges from a few days to months. Some of the large pans in the Northern Cape and Free State fill only during infrequent, episodic flooding.

Biology

Anostracans are able to survive the dry period of their habitat in the form of a drought-resistant egg or cyst, which can remain in the sediments of a dry pool for many years. These eggs hatch 12 to 48 hours after hydration. The growth rate of anostracans is very rapid, and sexual maturity can be reached as early as five days after hatching (Hamer &

Appleton 1991). The fact that the eggs only hatch soon after the inundation of the habitat, after which hatching ceases, and that the eggs usually require a period of desiccation before they are able to hatch, means that only one generation is produced at the start of each wet phase of the pool. This provides the maximum time for reaching sexual maturity and for successful reproduction. A reserve of eggs is maintained in the sediment as a result of some eggs hatching at their first hydration, whereas others require two or more hydrations before they hatch. This ensures that if a cohort does not reproduce before the pool dries out, the population will not be entirely destroyed. Such adaptations to unpredictable and unstable habitats have resulted in the fairy shrimps frequently being the quantitatively dominant fauna in temporary pools, particularly soon after re-filling.

Feeding

Anostracans are filter-feeders. They usually swim with the ventral surface facing upwards. As they swim, small particles of food, including bacteria, algae, protozoans and detritus are collected by their flattened, setose legs. Some species may turn over and scrape food particles off firm surfaces with their thoracic legs. A single predatory species (*Branchinecta gigas*) is known from North America.

Reproduction

Sexes are separate and reproduction is usually sexual, although some populations of *Artemia* are parthenogenetic. Copulation involves active pursuit of females by males. They make use of specially developed antennae to clasp the female and during this period sperm is transmitted via the paired penes of the male into the egg sac of the female. A brood of eggs, varying in number from 20 to about 300, is produced every one to five days throughout the life of the female. It is necessary for each brood to be fertilized individually. Eggs hatch into nauplii or metanauplii which add segments and appendages as they moult and develop into adults. Anostracans continue to increase in size throughout their life, although growth does slow down once maturity is reached.

Economic importance

The brine shrimp *Artemia* is cultured in salt pans in Europe and the United States. Both eggs and adults are harvested on a large scale for sale to aquarists as fish food. In addition, these animals play an important role in commercial salt works by clearing the water through filter-feeding, which facilitates the rapid evaporation of the water from the salt pans. Recent research has indicated the usefulness of anostracan larvae and adults as indicators of water toxicity. Because fairy shrimps are relatively easily and inexpensively cultured, possibilities exist for their use as fish feed in aquaculture, in the field of wastewater treatment and as a stock feed supplement (Mitchell 1989).

Southern African anostracans

Based on material sent to them, Sars (1895, 1899, 1905) and Daday (1908, 1910) described a number of anostracan species from Southern Africa. It was, however, K. H. Barnard of the South African Museum who made the largest contribution to anostracan systematics in his publications of 1924, 1929 and 1935. During the 1990s, an effort by various individuals was made to sample temporary pools and to update distribution and diversity data. To date, 46 species, belonging to six described genera, and at least one undescribed genus, distributed in four families, have been recorded from Southern Africa. Relative to its area, southern Africa has one of the richest anostracan faunas in the world (Hamer & Brendonck 1997). In addition, 80% of the fauna is endemic to Southern Africa. Our knowledge of the fauna is, however, still incomplete with many areas remaining unsampled. This can be attributed to the short life span of these animals: some species live for only two to three weeks, whereas others live for eight to twelve weeks. In addition, certain species may be present in a particular pool during one year but could be absent in subsequent years.

Collection and preservation

Fairy shrimps are easily collected by sweeping a hand-held aquarium net through the water of temporary pools. Alternatively, the upper layer of dried sediment can be collected and hydrated using de-ionized or distilled water in the laboratory. Specimens are best fixed in four per cent formalin, and later stored in 70–80% ethyl alcohol. Only fully mature adult males are useful for identification to species level.

Conservation

In the 1996 IUCN Red Data assessment of the Southern African Anostraca, two species were categorized as 'Critically Endangered', four 'Endangered', and three 'Vulnerable'. Thirteen species were considered

'Data Deficient', implying that there is inadequate information available to assess the risk of extinction of the species. Allocation to these categories is based on the known range of the species, the number of existing populations and the probability of extinction in the wild. For the 23 species known only from one to three localities, those that occur in remote, poorly-sampled areas are considered 'Data Deficient', while those recorded from areas which have undergone extensive habitat alteration are described as either 'Critically Endangered', 'Endangered' or 'Vulnerable'. The status of any species can of course suddenly alter, as new threats develop, or more data become available.

Almost 50% of the Southern African species of anostracans are known to occur in formally conserved areas, 22% have been collected from a single locality, and 11% were last collected before 1950 (Hamer & Brendonck 1997).

The greatest threat to anostracans is habitat destruction through agriculture, urbanization, and pollution. Even ecotourism can act as a threat: a monotypic genus, *Rhinobranchipus*, represented by *R. martensi*, has only been collected from the type locality, a wallow in the Thomas Baines Nature Reserve near Grahamstown. The pool from which the population was collected has since been turned into a permanent waterbody to attract birds. The destruction of this habitat may have resulted in the extinction of this genus (Martens & de Moor 1995).

GENERAL DESCRIPTION OF THE ANOSTRACA

The feature of the anostracans that distinguishes them from the other members of the Branchiopoda is the absence of a carapace. The anostracan body is cylindrical and elongate, with 19–27 trunk segments and a telson with a pair of caudal furcae or cercopods (Figs 2.1A, 2.1B). Each thoracic segment has a pair of flattened, leaf-like legs, often referred to as phyllopods. These legs are composed of an epipodite, one or two proximal exites and a distal exopodite, together with a series of five endites and an endopodite. The margins of the endites, endopodite and exopodite usually have a distinctive arrangement of setae (Fig. 2.1C).

Posterior to the thoracic limbs are two partly fused abdominal segments containing the genitalia, which extend into the abdomen and forward into the preceding thoracic segments. The paired ovaries of the female discharge into the egg- or ovisac on the ventral surface of the first genital segment (Fig. 2.1A). The testes of the male lead through paired vasa deferentia into a pair of penes on the ventral surface of the genital segment. The penes are composed of a proximal, usually rigid, basal part and an apical retractable part (Fig. 2.1D).

The most conspicuous feature of the head of male anostracans is a pair of well-developed, two-jointed antennae (Fig. 2.1B). Each antenna is composed of a basal and a terminal joint, on each of which may be various processes or projections (see Figs 2.2A, 2.7A and glossary for illustrations and definitions). The form of the antennae and associated processes are the main taxonomic characters used in anostracan identification. In some members of the group, a process on each antenna migrates to the region between the two antennae during larval development. The two processes fuse, forming a frontal appendage (Fig. 2.2A); the extent to which this is developed, and its structure, are often important in species identification.

The female antennae are simple, unjointed structures that are not taxonomically important. The antennules of both sexes are simple, tubular structures (Figs 2.1A, 2.1B). A pair of conspicuous, stalked compound eyes is present, as well as a small, pigmented, dorso-medial ocellus (Fig. 2.1B). The labrum is large, as are the mandibles, whereas the maxillae and maxillules are reduced.

Since anostracans continue to grow throughout their life, and because size depends on various environmental factors, this is generally not a useful character in identifying species, but there are genera or species that are typically smaller than others. Adult anostracans usually fall within the size range of 6–40 mm, although one North American species reaches a length of 100 mm.

Colours of fairy shrimps include green-blue, violet, orange and red, or they may be translucent, but this is influenced by the environment, and colour is most common in animals inhabiting water of low turbidity. The cercopods are often bright orange: in the genus *Branchipodopsis*, the egg sacs of females can be a bright cobalt blue, a deep blue and red striped, or red. Unfortunately, colour is lost in preserved material.

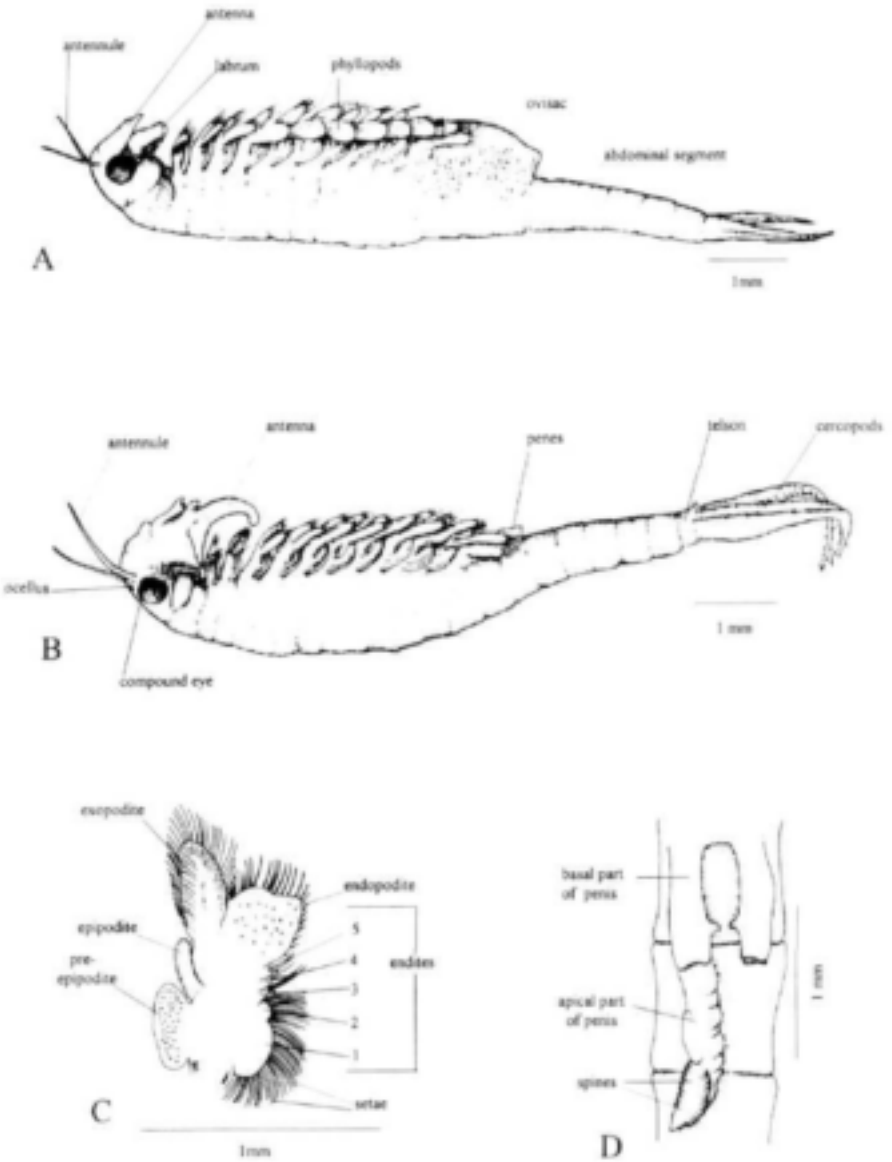

Fig. 2.1. A–D. *Branchipodopsis* sp. showing the typical anostracan body plan. A. Female, lateral view . B. Male, lateral view. C. Phyllopod structure. D. Generalised structure of penes, ventral view.

KEY TO THE SOUTHERN AFRICAN FAMILIES (ADULTS)

1A. Antennal process from basal joint well developed, S-shaped, terminating in hand-like, cheliform structure; terminal joint simple, shorter than antennal process (Fig. 2.2). Females with elongated, slender egg sac, reaching at least the fifth abdominal segment.................... **Streptocephalidae** (p. 20, Fig. 2.2)

1B. Antennal process from basal joint not obvious, shorter or only very slightly longer than terminal joint. Females with short bulbous, or flask-shaped egg sac, not usually reaching beyond fifth abdominal segment. 2

2A. Terminal joint broad, flattened and blade-like; basal joint with small, round, knob-shaped process on inner margin (Fig. 2.10A). Female egg sac with two lateral lobes and a pair of ventral spines ....**Artemiidae** (p. 55, Fig. 2.10A)

2B. Terminal joint slender and more-or-less tubular; process on basal joint varying in shape and position. Female egg sac oval or flask-shaped, without lateral spines 3

3A. Basal joints fused for at least half their length, one to three processes situated on the anterior, medial margin; antennae more heavily sclerotized than remainder of body Female egg sac short and oval .... **Branchipodidae** (p. 37, Figs 2.6, 2.7)

3B. Basal joints may be fused for a portion of their length, but fused region not heavily sclerotized; frontal appendage of variable length, attached on dorsomedial surface of fused basal joints; no basal process on anterior medial margin of basal joints. Female egg sac usually flask-shaped, with narrow distal region ....**Thamnocephalidae** (p. 52, Figs 2.10B–F)

Family **Streptocephalidae** Daday 1910

This is a monogeneric family that occurs in Eurasia, North America, possibly Australia, and in Africa. The genus *Streptocephalus,* which includes about 60 species, is the most common and widespread genus in Southern Africa. The 22 species represented here occur in most temporary pool habitats, excluding small, high altitude rockpools.

The males are easily distinguished by the long, S-shaped antennal process, which terminates in a cheliform 'hand' region composed of a 'thumb' and 'finger' (Figs 2.2A–B). A frontal appendage, varying in the extent to which it is developed, is present between the basal joints of the two antennae (Fig. 2.2A). The abdominal segments may have species-specific spinose processes and the cercopod shape and setation can also be useful in identification. The females have an elongated egg sac. The eggs of the Southern African members of the genus can in some cases be used to identify females to species level (Brendonck & Coomans 1994).

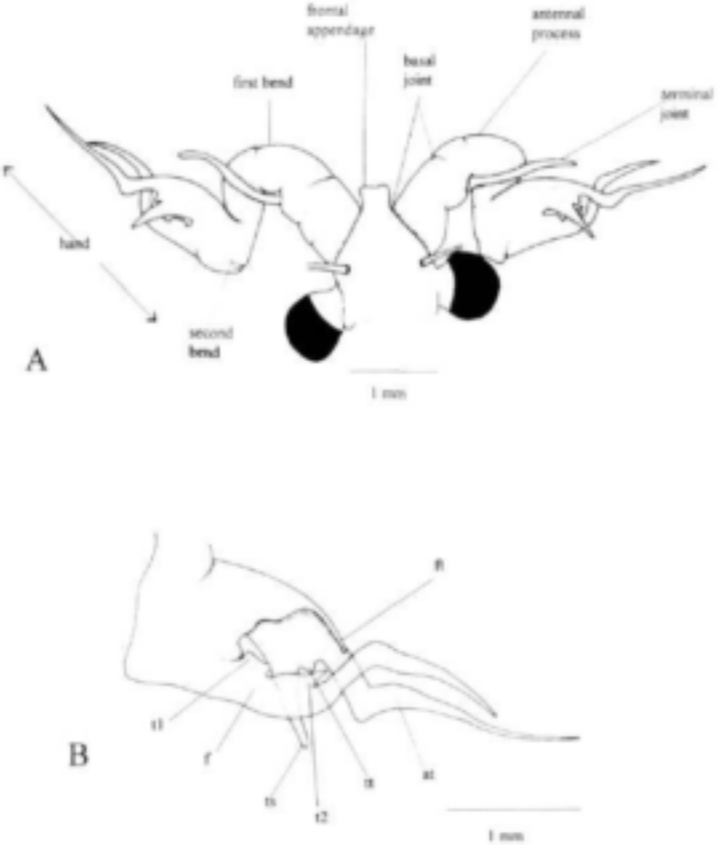

Fig. 2.2. A–B. *Streptocephalus*. A. Dorsal view of head region showing antennal form. B. Medial view of hand region of antennal process.
KEY: at = anterior region of thumb; f = finger; ft = fold in thumb produced to form a tooth;
t1 = proximal tooth on dorsal surface of finger (low rectangular shape);
t2 = distal tooth on dorsal surface of finger (digitiform shape); ts = thumb spur; tt = tooth between anterior region of thumb and thumb spur.

KEY TO THE SOUTHERN AFRICAN SPECIES OF *STREPTOCEPHALUS*

(Adult males)

1A. Thumb with ventral (Fig. 2.2B) or anterior marginal spur (Fig. 2.4F) 3
1B. Thumb without any form of spur 2

2A. Tooth between finger and thumb blunt, triangular, peg-like (Fig. 2.3A); telsonic segment with smooth lateral margins .... *S. purcelli*
2B. Tooth between finger and thumb absent (Fig. 2.3B); telsonic segment with three to four processes on lateral margins (Fig. 2.3C) .... *S. dendyi*

3A. Finger apically blunt and slightly expanded ventrally; spines or processes on hind margins of abdominal segments 3–7 4
3B. Finger apically acute or subacute, if blunt not with ventral expansion; spines or processes on abdominal segments, if present, not restricted to hind margins 6

4A. Dorsal margin of finger without tooth but with low bulge (Fig. 2.3D); anterior region of thumb bent ventrally .... *S. cirratus*
4B. Dorsal margin of finger with one or two distinct teeth; anterior region of thumb bent upwards 5

5A. Dorsal margin of finger with single tooth, followed by low bulge; antennal process just proximal to hand region with distinct triangular flap on medial surface (Fig. 2.3E) .... *S. dregei*
5B. Dorsal margin of finger with two large teeth (Fig. 2.3F); antennal process without triangular flap on medial surface .... *S. spinicaudatus*

6A. Antennal process with digitiform or triangular processes on medial or anterior surface at, or proximal to, first bend 14
6B. Antennal process without distinct processes on medial or anterior surface at, or distal to, first bend 7

7A. Finger with many minute spinules on dorsal surface; no tooth between thumb and thumb spur; frontal appendage conical and short 8
7B. Finger may have large teeth or processes on dorsal surface, but never with minute spinules; tooth between thumb and spur may be present; frontal appendage elaborate or simple 9

8A. Thumb with distinct, proximal heel; finger with two teeth on dorsal margin .... *S. zuluensis* (Fig. 2.3G)
8B. Thumb without heel; finger without teeth on dorsal margin .... *S. kaokoensis* (Fig. 2.3H)

9A. Frontal appendage short or medium length and simple; one or two teeth separating thumb and spur 10
9B. Frontal appendage large and elaborate; teeth between thumb and spur absent 13

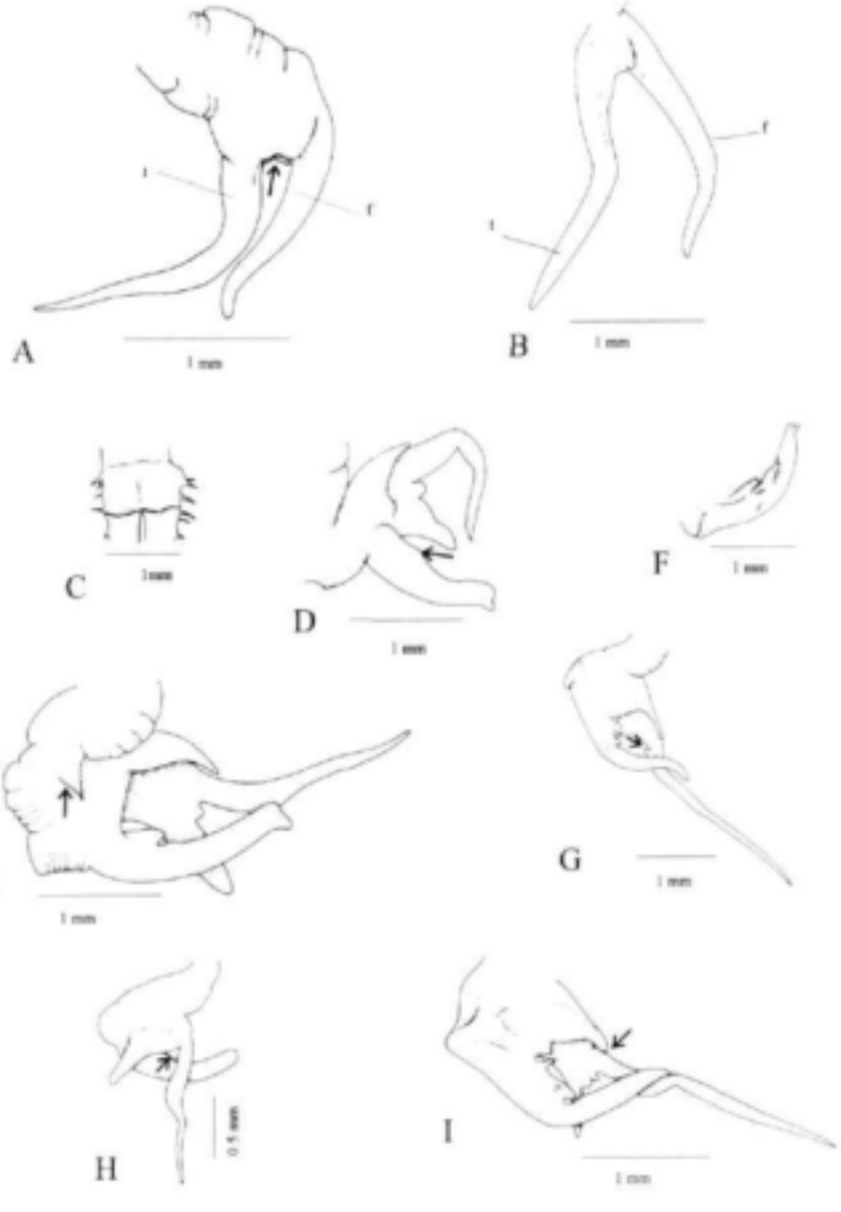

Fig. 2.3 Species of *Streptocephalus*. A. *S. purcelli*, lateral view of antennal process: arrow indicates peg-like tooth between finger and thumb. B–C. *S. dendyi*. B. Lateral view of hand region. C. Telsonic segment illustrating processes on lateral margins. D. *S. cirratus*, medial view of hand region: arrow indicates low bulge on dorsal surface of finger. E. *S. dregei*, medial view of hand region: arrow indicates triangular process proximal to hand. F. *S. spinicaudatus*, medial view of finger showing two teeth on dorsal surface. G. *S. zuluensis* , medial view of hand region: arrow indicates heel on proximal, anterior part of thumb. H. *S. kaokoensis*, lateral view of hand region: arrow indicates spinules on anterior margin of finger. I. *S. vitreus*, medial view of hand region: arrow indicates minimally-produced fold of thumb.

KEY: f = finger; t = thumb.

10A. Small tooth separating thumb and spur; single large triangular tooth on dorsal margin of finger .... *S. wirminghausi* (Figs 2.5 H–I)

10B. Two rounded teeth separating thumb and spur; tooth/ teeth on dorsal margin of finger not triangular 11

11A. Oval, flattened tooth with small medial digitiform process on dorsal margin of finger .... *S. macrourus* (Fig. 2.4A)

11B. Two digitiform teeth on dorsal margin of finger; distal one with small process on medial surface 12

12A. Two almost equal-sized digitiform teeth on dorsal margin of finger; thumb folded, produced to form prominent tooth projecting past thumb margin .... S. *bidentatus* (Fig. 2.4B)

12B. Proximal tooth on dorsal margin of finger much smaller than distal tooth; thumb fold not projecting past thumb margin .... *S. vitreus* (Fig. 2.3I)

13A. Angle between thumb and spur acute; finger two-thirds length of thumb; small rounded tooth on dorsal surface of finger or two teeth – proximal larger and roughly triangular, distal slender and digitiform .... *S. cladophorus* (Figs 2.4C–D)

13B. Angle between thumb and spur 90°; finger a third the length of thumb; single, rectangular tooth on dorsal surface of finger .... *S. dendrophorus* (Fig. 2.4E)

14A. Finger with ventral spur (Fig. 2.4F–H); teeth on dorsal margin of finger absent 15

14B. Finger without ventral spur; one or two teeth present on dorsal margin of finger 16

15A. Antennal process with numerous long processes in middle section; finger and thumb with rows of long papillae .... *S. papillatus* (Fig. 2.4F)

15B. Antennal process with four to five papillae on middle section; finger and thumb with or without few small papillae .... *S. gracilis* (Figs 2.4G–H)

16A. Frontal appendage well developed, more than a third the length of antennal process 17

16B. Frontal process less than a third the length of antennal process 19

17A. Frontal appendage trifid, branches without lateral or ventral processes .... *S. trifidus* (Fig. 2.4I)

17B. Frontal appendage with single branch, only apically bifid, with numerous

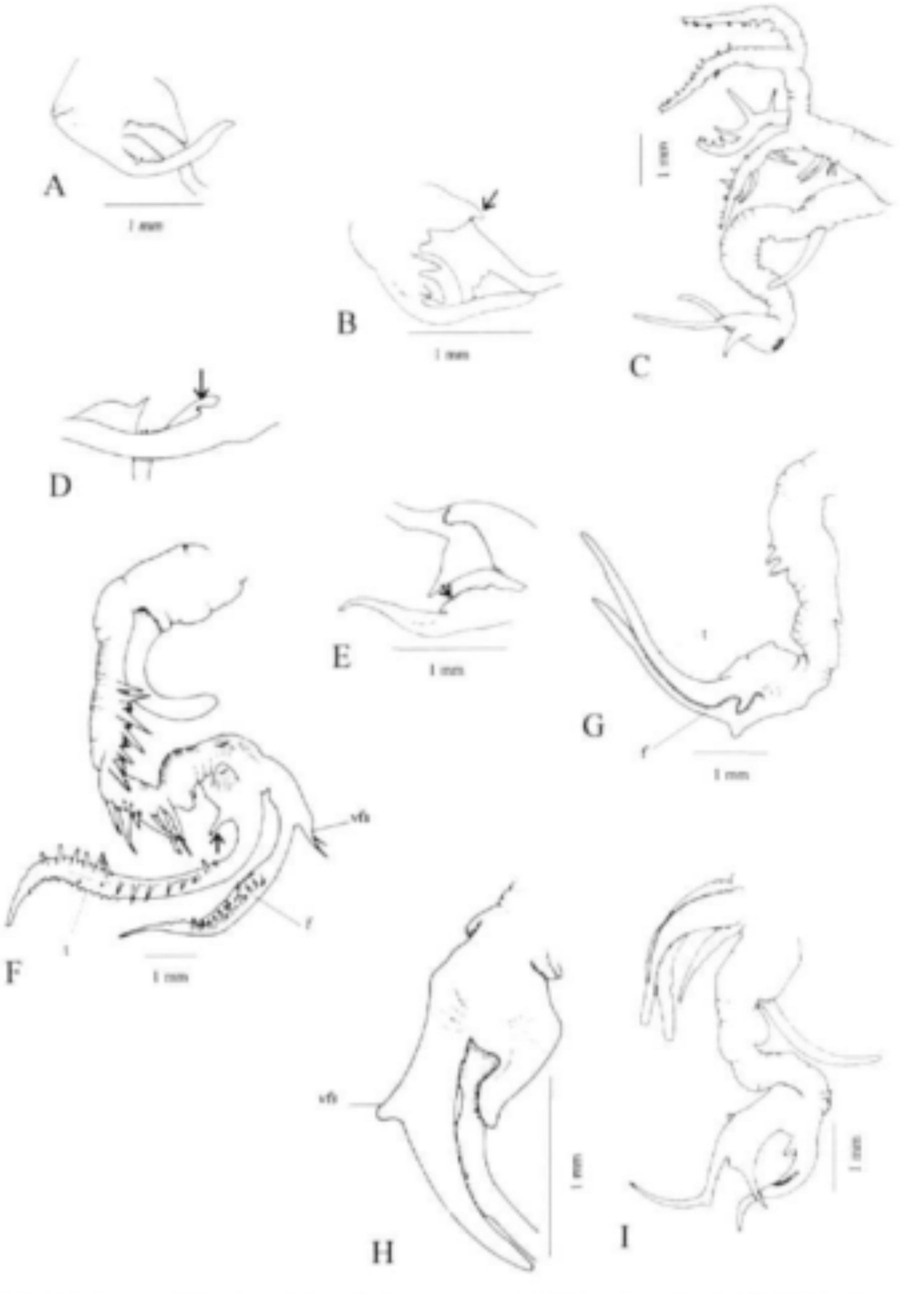

Fig. 2.4. Species of *Streptocephalus*. A. *S. macrourus*, medial view of hand region. B. *S. bidentatus*, medial view of hand region: arrow indicates fold in thumb produced to form distinct tooth.
C–D. *S. cladophorus* C. Lateral view of antenna and frontal appendage. D. Medial view of thumb and finger region: arrow indicates small, rounded tooth of some specimens. E. *S. dendrophorus*, medial view of thumb and finger region: arrow indicates rectangular tooth on dorsal surface of finger. F. *S. papillatus*, lateral view of antenna: arrow indicates anterior thumb spur. G–H. *S. gracilis*. G. Lateral view of antennal process. H. Medial view of hand region. I. *S. trifidus*, lateral view of antenna and frontal appendage. (KEY: f = finger; t = thumb; vfs = ventral finger spur)

18A. Proximal tooth on dorsal surface of finger stout and angular, broader than distal tooth; antennal process with nine to ten digitiform processes on anterior surface at first bend .... *S. proboscideus* (Figs 2.5A–B)
18B. Two digitiform teeth on dorsal surface of finger (Fig. 2.5C); antennal process with digitiform processes distal to bend only .... *S. namibiensis*

19A. Medial row of eight to ten conical processes on middle part of antennal process (Fig. 2.5D); thumb spinose .... *S. ovamboensis*
19B. Processes on S-shaped antennal process not conical but triangular or tooth-shaped; thumb not spinose 20

20A. Antennal process with large, triangular process just distal to insertion of terminal joint on medial surface; finger and thumb geniculate 21
20B. Antennal process without large triangular process distal to terminal joint insertion but with few small processes on anterior margin just proximal to hand; finger gently curved but not geniculate .... *S. bourquinii* (Figs 2.5J–K)

21A. Process with serrated margin found on either side of the frontal appendage; frontal appendage apically bifid or trifid .... *S. cafer* (Figs 2.5E–F)
21B. Processes on either side of frontal appendage absent; frontal appendage short and rectangular .... *S. indistinctus* (Fig. 2.5G)

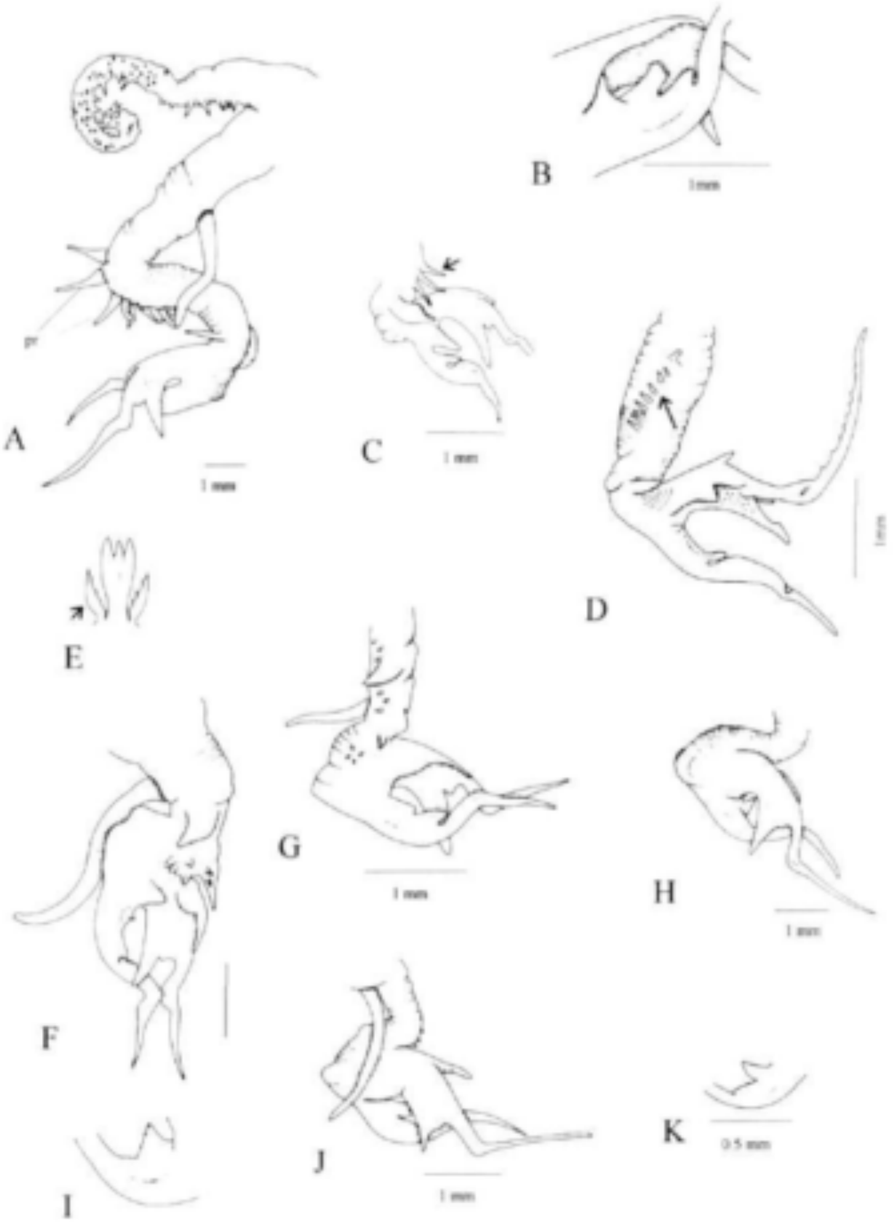

Fig. 2.5. Species of *Streptocephalus*. A–B. *S. proboscideus*. A. Lateral view of antenna and frontal appendage. B. Medial view of hand region. C. *S. namibiensis*, medial view of hand region: arrow indicates digitiform projections found proximal to hand region only. D. *S. ovamboensis*, medial view of distal region of antennal process: arrow indicates projections distal to first bend of antennal process. E–F. *S. cafer*. E. Dorsal view of frontal appendage: arrow indicates basal process found on either side of frontal appendage. F. Medial view of antenna. G. *S. indistinctus*, medial view of antenna. H–I. *S. wirminghausi*. H. Lateral view of distal part of antennal process. I. Detail of tooth on dorsal surface of finger. J–K. *S. bourquinii*. J. Lateral view of antenna. K. Detail of tooth on dorsal surface of finger.

KEY: pr = digitiform projections at first bend of antennal process.

Streptocephalus bidentatus Hamer & Appleton 1993
(Fig. 2.4B)

Characteristic features

Hand region of antenna very similar in shape to that of *S. vitreus* and *S. macrourus*. Antennal process without projections. Basal region of thumb folded and fold produced to form a tooth. Two rounded teeth between thumb and thumb spur. Two prominent teeth, the second one with a small medial digitiform projection, on anterior margin of finger. Outer margin of cercopods convexly curved. Plumose setae along margins, replaced by strong, widely spaced spines on distal third of inner margin.

Records

Common species in north-eastern part of Southern Africa, from the Hluhluwe area (KZN) in the south to Swaziland, the Kruger National Park (MPL) and southern Zimbabwe in the north.

Red Data category

Low risk (last collected in 1994).

Streptocephalus bourquinii Hamer & Appleton 1993
(Figs 2.5J–K)

Characteristic features

Antenna very similar to *S. wirminghausi*, but the presence of two teeth on the anterior margin of the finger in *S. bourquinii* and only one in *S. wirminghausi*, distinguishes the two species. Three to four triangular processes followed by a larger irregular process just distal to first bend on medial surface of antennal process. Base of thumb folded, with fold produced to form a narrow projection. Tooth between thumb and spur obscure. Frontal appendage rounded with apical indentation. Cercopods straight, with plumose setae along both margins.

Records

Specimens collected from Tshaneni (SWZ), Hluhluwe Game Reserve (KZN) and Fanies Island and False Bay Park at St Lucia (KZN).

Red Data category

Low risk (last collected in 1996).

Streptocephalus cafer (Loven 1847)

(Figs 2.5E–F)

Characteristic features

Anterior and medial margin of antennal process with series of triangular processes along its length. Anterior margin of finger with proximal ridge, ending in a small, peak-like tooth, followed by a flattened, oval (in dorsal view) tooth. Thumb folded basally. Frontal appendage bifid or trifid. A small process with a serrated margin on either side of frontal appendage. Cercopods with plumose setae along both margins, dorsal surface of distal third with a row of eight to ten strong, upright spines.

Records

Widespread and common throughout Southern Africa: recorded from the Eastern Cape, Northern Cape, Karoo, north-eastern KwaZulu/Natal, Mpumalanga, the Northern Province, Free State, Namibia and Zimbabwe.

Red Data Category

Low risk (last collected in 1998).

Streptocephalus cirratus Daday 1908

(Fig. 2.3D)

Characteristic features

Frontal appendage short, narrow and apically bifid with a small flap on either side. Hand region of antenna with short thumb, and apically blunt finger with low bulge on dorsal surface. Thumb folded basally, and anterior region separated from spur by a rounded tooth. Cercopods with outer margins strongly convex, inner margins of distal region with short, thick setae of irregular length. Posterior margins of abdominal segments 5–7 with a row of spines.

Records

Recorded from Heidelburg (GT), Dewetsdorp and Bloemfontein (FS), Rhodes (EC) and Potfontein and Richmond (NC) in the Karoo.

Red Data category

Low risk (last collected in 1998).

Streptocephalus cladophorus Barnard 1924
(Figs 2.4C–D)

Characteristic features

Antennal process without projections. Antenna without a tooth between thumb and spur; thumb and finger long and slender. Basal region of thumb with elongated fold. Anterior margin of finger either with small rounded tooth, or with two teeth, the first larger and roughly triangular, and the second slender and digitiform. Frontal appendage a third the length of body and elaborate with four ornamented arms. Small, triangular or bifid process ventrally at the base of each antenna. Cercopods short and stout, with plumose setae along both margins.

Records

Relatively common in northern Ovamboland (NAM), and a few specimens collected from Vryburg (NC), Heidelberg (GT) and the Kazuma Depression (ZIM).

Red Data category

Low risk (last collected in 1996).

Streptocephalus dendrophorus Hamer & Appleton 1993
(Fig. 2.4E)

Characteristic features

Very similar to *S. cladophorus*, with the same frontal appendage and cercopod morphology but hand region of antennal process distinct, with a wider angle between thumb and spur and a shorter finger in *S. dendrophorus*. An anteriorly-pointed, convex ridge present on anterior surface of finger.

Records

Uncommon. A few specimens have been collected from vegetated shallow regions of pans on the Makatini Flats and the Ndumu Game Reserve (KZN).

Red Data category

Endangered (last collected in 1994).

Streptocephalus dendyi Barnard 1929
(Figs 2.3B–C)

Characteristic features

Antenna simple. Thumb without spur and no tooth between finger and thumb. Cercopods with distal part curved outwards. Frontal process very short. A series of three to four processes on lateral margins of telson.

Records

Recorded only from Cape Town and the Cape Agulhas region (WC) and Port Elizabeth (EC).

Red Data category

Endangered (last collected in 1990).

Streptocephalus dregei Sars 1899
(Fig. 2.3E)

Characteristic features

Antennal process with triangular flap medially just proximal to hand region. Hand region of antenna with short, blunt finger with broad digitiform process on anterior margin. Frontal appendage short, apically rounded, with small, narrow basal process present on either side. Cercopods with outer margins strongly convex; inner margin with short, broad setae. Hind margins of abdominal segments 2–7 with spines.

Records

Common species in the Eastern Cape, not further than 200 km inland and between 31°S and 34°S .

Red Data category

Low risk (last collected in 1993).

Streptocephalus gracilis Sars 1898
(Figs 2.4G–H)

Characteristic features

Antennal process with three to four variable projections just distal to first bend. Finger of antenna without teeth on anterior margin, but a short spur present on ventral surface. Thumb spur reduced; tooth between thumb and spur absent. Short, rounded frontal appendage. Cercopods short and stout and set with plumose setae. Numerous small spiniform papillae on the dorso-lateral surface of the abdominal segments.

Records

Uncommon species, collected only from Cape Town (WP) and Port Elizabeth (EC).

Red Data category

Data deficient (last collected in 1898).

Streptocephalus indistinctus Barnard 1924
(Fig. 2.5G)

Characteristic features

Antennal process with large triangular flap and triangular outgrowths medially, distal to origin of terminal joint. Large triangular process proximal to hand, followed by a series of smaller ones. Thumb folded basally and separated from spur by a rounded or triangular tooth. Anterior margin of finger with low, flat tooth, followed by blunt, anteriorly directed digitiform tooth. Cercopods with straight margins and with plumose setae.

Records

Distributed mainly north of 29°S in Mpumalanga, Northern Province, Zimbabwe and northern Namibia.

Red Data category

Low risk (last collected in 1996).

Streptocephalus kaokoensis Barnard 1929
(Fig. 2.3H)

Characteristic features

Like *S. zuluensis*, this species has spinules on the finger and pyramid-shaped eggs, and lacks a tooth between the thumb and spur. The frontal appendage is short and conical and cercopods are setiferous along the entire length of the margins.

Records

Only recorded once from the Kaokoveld, north of Kamanyab (NAM).

Red Data category

Data deficient (last collected in 1923).

Streptocephalus macrourus Daday 1908

(Fig. 2.4A)

Characteristic features

Base of thumb folded medially. Anterior part of thumb separated from spur by two rounded teeth. Anterior margin of finger with large, flattened tooth with a small medial digitiform process on its margin. Cercopods long and slender, proximal half with convex outer margin, distal half concave; proximal half of inner margin with plumose setae, distally replaced by short, irregular-length spines.

Records

Relatively common in Ovamboland (NAM). Also recorded from Kimberley (NC), Brakpan (GT), Bloemfontein (FS), the North West/ Botswana border and Tsotsoroga (BOTS).

Red Data category

Low risk (last collected in 1996).

Streptocephalus namibiensis Hamer & Brendonck 1993

(Fig. 2.5C)

Characteristic features

Frontal process very long with numerous short, digitiform processes along ventral surface; antennal process with three digitiform processes on antero-medial surface just proximal to hand; large leaf-shaped process and a smaller process distally on medial surface; anterior margin of finger of antennal process with two prominent teeth; cercopods with long plumose setae along both margins.

Records

Recorded from Benoni and Heidelberg (GT), Vaalbos Game Reserve (NC), Gobabis and Bushmanland (NAM) and the Makgadikgadi Pan area (BOTS).

Red Data category

Low risk (last collected in 1992).

Streptocephalus ovamboensis Barnard 1924
(Fig. 2.5D)

Characteristic features

Antennal process with series of digitiform processes along medial surface. Anterior margin of thumb with prominent spinous spur; distally thumb with a row of spines along anterior margin. Ventral thumb spur distally foot-shaped. Finger with a tongue-like process on anterior margin. Frontal appendage moderate length, rectangular with slight medial indentation. Cercopods stout, with straight margins set with plumose setae.

Records

Common species in the arid Karoo, extending northwestwards to Groblershoop (NC) and the Namib desert, Bushmanland and Ovamboland (NAM).

Red Data category

Low risk (last collected in 1993).

Streptocephalus papillatus Sars 1905
(Fig. 2.4F)

Characteristic features

Antennal process about three-quarters the length of body, with numerous long processes on anterior and ventral margins. Regular thumb spur absent, but a spur-like process present on anterior margin of thumb. Finger also with a spur but this positioned ventrally. Both anterior part of thumb and finger long and with numerous digitiform processes. Frontal appendage short, rounded and apically bilobed. Cercopods short and stout with distal third curved inwards, with widely-spaced stout, curved setae decreasing in length towards apex on outer margin. First third of inner margin with plumose setae but these replaced by thick, curved setae, and distal third with very short spines on dorsal surface. Abdominal segments 3–6 with numerous irregular papillae along lateral margins; sixth segment with large dorso-medial bifid process and seventh segment with small, unbranched process.

Records

Restricted to arid Karoo. Collected from a pool in a dried out river bed in Grootvloer Pan, south of Kenhardt (NC) as well as Beaufort West (WC) and Williston (NC).

Red Data category

Low risk (last collected in 1992).

Streptocephalus proboscideus (Frauenfeld 1873)
(Figs 2.5A–B)

Characteristic features

Frontal appendage long with numerous digitiform projections and bifid apex; usually held rolled up between antennae. Antennal process with numerous digitiform processes at first bend, and a large triangular process medially, just proximal to hand. Two broad, digitiform teeth on anterior margin of finger. Cercopods with straight margins and plumose setae.

Records

Common in Namibia, including Ovamboland, Bushmanland and Etosha and north of Upington (NC). Also in North Africa.

Red Data category

Low risk (last collected in 1994).

Streptocephalus purcelli Sars 1898
(Fig. 2.3A)

Characteristic features

Antenna simple with antennal process smooth and thumb without a spur. Finger without anterior teeth or processes. Small peg-like tooth between finger and thumb. Frontal process very short. Cercopods with setae replaced by spines on distal two-thirds of margins.

Records

Common species from Cape Town (WC) northwards along the coastal and Namaqualand regions (NC) to just south of the Namibian border.

Red Data category

Low risk (last collected in 1994).

Streptocephalus spinicaudatus Hamer & Appleton 1993
(Fig. 2.3F)

Characteristic features

Very similar to *S. dregei*, but basal processes on either side of frontal appendage absent; a second, prominent digitiform tooth present on anterior margin of finger; spines on abdominal segment more prominent, and broad setae on cercopods less regular in *S. spinicaudatus*.

Records

Relatively common in the high altitude regions of Dordrecht, Queenstown and Sterkstroom (EC). Also recorded from the Umtata Dam area (Transkei, EC).

Red Data category

Low risk (last collected in 1998).

Streptocephalus trifidus Hartland-Rowe 1969
(Fig. 2.4I)

Characteristic features

Antennal process with a row of 10–15 digitiform processes on medial surface proximal to hand. Two teeth present on anterior margin of finger: proximal tooth large, angular and folded; distal tooth digitiform and apically-directed. Frontal appendage long and trifid. Cercopods with plumose setae along proximal two-thirds of both margins, replaced by wide-set spines distally on outer margin; inner margin naked.

Records

Common in Zimbabwe, including Hwange, Bulawayo, South of Chivhu, Lake Manyame and southern Zambia.

Red Data category

Low risk (last collected in 1992).

Streptocephalus vitreus (Brauer 1877)
(Fig. 2.3I)

Characteristic features

Very similar to *S. bidentatus*: both species have two rounded teeth separating thumb and spur, two teeth on the dorsal margin of the finger and spinose cercopods. In *S. vitreus* the teeth on the finger are much lower and less distinct, the cercopods have fewer spines and the frontal appendage is slender and apically rounded or with a medial indentation

Records

Common in Central and East Africa, but to date only recorded from Hwange Game Reserve (ZIM) in Southern Africa.

Red Data category

Low risk (last collected in 1981).

Streptocephalus wirminghausi Hamer 1994
(Figs 2.5H–I)

Characteristic features

Similar to *S. bourquinii*. Antennal process smooth, lacking projections.

Anterior region of thumb folded but fold not extended. Thumb separated from spur by a small tooth. Finger of antennal hand region with large triangular tooth on anterior margin. Frontal appendage narrow and with pointed apex. Cercopods with plumose setae.

Records

Only recorded from the north-western region of Zimbabwe, close to the Zambian border.

Red Data category

Data deficient (last collected in 1992).

Streptocephalus zuluensis Brendonck & Hamer 1992
(Fig. 2.3G)

Characteristic features

Anterior part of thumb very long. No tooth between thumb and spur, but these two structures separated by a wide smooth angle. Posterior margin of basal part of thumb with proximal acute heel. Anterior margin of finger with two prominent, rounded teeth, followed by a series of very small spines. Frontal process narrow and apically pointed. Cercopods short and broad with long, plumose setae along both margins. Egg sac of females particularly short; eggs pyramid-shaped.

Records

Restricted to the north-eastern regions of Southern Africa. Only recorded from the Makatini Flats (KZN) and Southern Zimbabwe.

Red Data category

Endangered (last collected in 1992).

Family **Branchipodidae** Baird 1852

During recent studies on the Southern African Branchipodidae five new species of the genus *Branchipodopsis* were described (Hamer & Appleton 1996) the known species were revised (Hamer & Appleton 1996), and two new monotypic genera were described (Brendonck 1995; Hamer & Brendonck 1995). A third new genus of this family from northern KwaZulu/Natal is still to be formally described. Brehm (1958) illustrated specimens from Middelburg in the Karoo which probably represent yet another undescribed genus of the family (Fig. 2.6D) but unfortunately, these specimens cannot be located to allow further investigation.

KEY TO THE SOUTHERN AFRICAN GENERA OF BRANCHIPODIDAE
(Adult males)

1A. Single medial process on anterior margin of fused basal joints; large bifid, spinose frontal appendage positioned posteriorly on dorso-medial surface of fused basal joints. Female egg sac distally tapered and reaching fourth abdominal segment .... *Pumilibranchipus deserti* (Fig. 2.6C)

1B. One or two processes anteriorly and medially on fused basal joints; if a frontal process is present between these, it is always small and in a ventromedial position. Female egg sac ovate and not reaching beyond third abdominal segment 2

2A. Single large to very large process on anterior margin of basal joint; no lamelliform process at distal margin of basal joint. Genital segments of female laterally swollen, more than twice as wide as other abdominal segments 3

2B. Two basal processes; often with medial ventral process on anterior margin of basal joints; lamelliform process at distal margin of each basal joint. Genital segments of female not laterally swollen, a lthough pouches may be present dorsally or laterally (Figs 2.7 B–C) .... *Branchipodopsis* (Figs 2.7A, 2.8A–P, 2.9A–H)

3A. Medial process on anterior margin of basal joints large and tongue-like, with smaller, angular process attached ventrally on either side; a pair of transparent rounded processes on dorsal surface of clypeus. Female with two large, dorsal, transparent membranous flaps on segments 10 and 11, and abdominal segments 5–8 each with a pair of ventral spines .... *Rhinobranchipus martensi* (Fig. 2.6B)

3B. Medial process on basal joints very broad, more or less rectangular, with long and short digitiform processes at each distal corner; transparent processes absent from dorsal surface of basal joints. Females with smooth abdominal segments.. Genus A (Fig. 2.6A)

Pumilibranchipus deserti Hamer & Brendonck 1995
(Fig. 2.6C)

Characteristic features

Only the type material is known. This genus is characterized by having a single medial process, a digitiform process distally on each basal joint, and a long frontal appendage that is bifurcate with the branches fused basally. The specimens are small (mean length of males = 8,7 mm), but are sexually mature, and eggs are present in the slightly elongate and slender egg sac of females.

Records

Red Pond, Kaukausib River (NAM).

Red Data category

Data deficient (only collected in 1986).

Rhinobranchipus martensi Brendonck 1995

(Fig. 2.6B)

Characteristic features

A single species, *R. martensi*, is known. This genus is characterized by the form of the clypeus (described in the above key), and by a pair of spines on the ventral surface of the abdominal segments. The penes have a characteristic pair of sickle-shaped processes proximally on the basal part. The egg sac of the female is oval.

Records

Temporary pool at Rhino Ridge, Thomas Baines Nature Reserve, Grahamstown (EC).

Red Data category

Critically endangered (last collected in 1989).

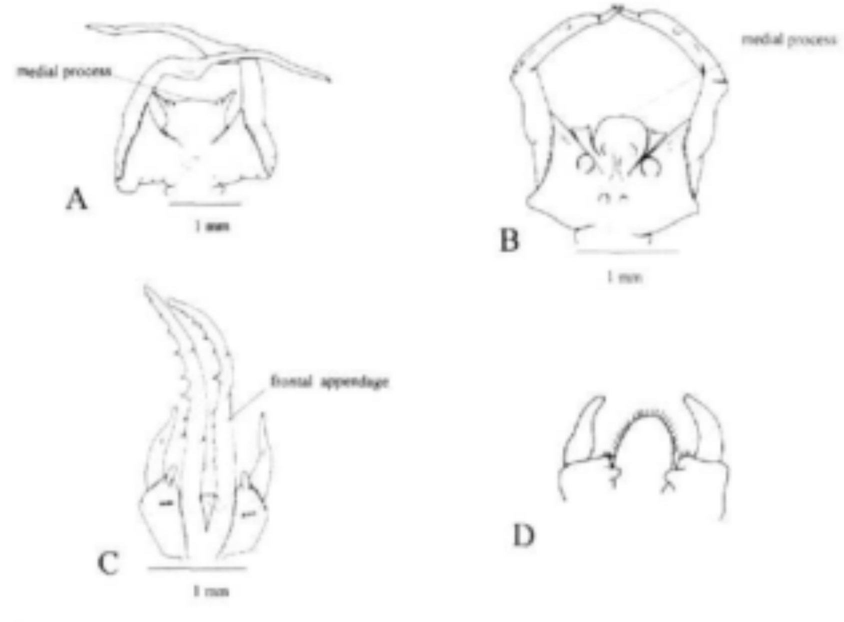

Fig. 2.6. Branchipodidae: A. Branchipodidae Genus A, dorsal view of clypeus. B. *Rhinobranchipus martensi*, dorsal view of clypeus. C. *Pumilibranchipus deserti*, dorsal view of clypeus and frontal appendage. D. Clypeus from Brehm's (1958) specimen collected from Middelburg in the Karoo.

Genus A

(Fig. 2.6 A)

Characteristic features

This genus is very similar to the North African genus *Metabranchipus* Masi 1910. The main difference is the absence of the large median antennal process in *Metabranchipus*, but the terminal joints, the structure of the penes and the egg sac of the female are almost identical. Specimens of the South African genus have a distinctive wine-red colour before preservation and are relatively small, reaching a maximum of about 10 mm. Males have a notably large clypeus with very long terminal joints, as well as expanded genital segments and prominent penes. The basal region of the penes is broad, with an infolding about halfway along inner margin and a leaf-like projection proximally on the dorsal surface. A slender, bifid process is present mid-ventrally on the fourth abdominal segment. Cercopods short, broad and almost straight with plumose setae. Females have an oval egg sac. It appears that the genus is represented by only one species in Southern Africa.

Records

Makatini Flats and Mkuze Game Reserve (KZN).

Red Data category

Vulnerable (last collected in 1994).

Branchipodopsis Sars 1898

Branchipodopsis is the second most speciose genus of Anostraca in Southern Africa, and sixteen of the approximately 20 described species occur here. A single species has been recorded from central Africa, and some controversy exists regarding the generic identity of the remaining three species which are found in the Orient.The basal joint is broad, with a basal process on the anterior medial region and another, setose and lamelliform process distally. The terminal joint is slender and curved inwards. A round or oval medial ventral process may be present at the junction between the two basal joints (Fig. 2.7A). The last abdominal segment of some species has a pair of small spines on the ventral surface, but otherwise the abdominal segments are smooth. The cercopods are relatively uniform throughout the genus. Plumose setae are found along most of the length of the margin, but the distal region usually has a number of widely-spaced spines.

The females have a short, oval egg sac that is often brightly coloured. An unusual feature of some species which occur in high altitude rockpools is the extension of the genital segments of the females to form pouches or bulbous structures, either on the lateral, or dorsal surface of the segments (Figs 2.7B–C). The significance of these structures is unknown, but they can be useful in separating closely-related species.

Individuals of *Branchipodopsis* species are able to inhabit small, highly ephemeral habitats such as rockpools in mountain ranges and on granite outcrops (Hamer & Martens 1998). This is largely because of their early maturation and rapid growth rate which ensures successful reproduction before the pool dries out. In larger pans they are usually found in the shallow, peripheral and vegetated areas.

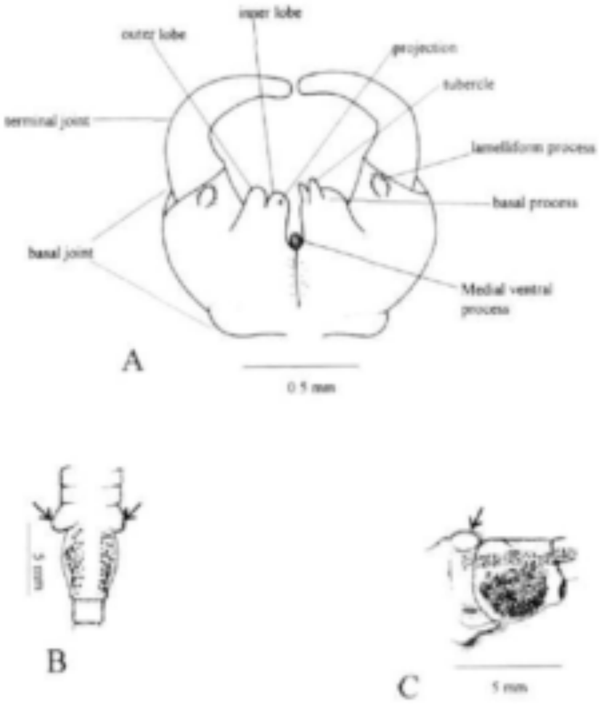

Fig. 2.7. A. *Branchipodopsis*, dorsal view of clypeus. B. *B. natalensis*, dorsal view of female genital segments showing pouches (indicated by arrow). C. *B. barnardi*, lateral view of female genital segments showing bulbous structure (indicated by arrow).

KEY TO THE MALE *BRANCHIPODOPSIS* SPECIES OF SOUTHERN AFRICA

1A. Basal process distinctly apically lobed; lobes of similar height, positioned adjacent to each other and broadly rounded 2

1B. Basal process either unlobed apically, or if lobed, lobes are either of distinctly different heights or not broadly rounded 5

2A. Basal process with tubercle on medial dorsal surface and smaller projection on medial margin of inner lobe 3

2B. Basal process with small projection on medial margin of inner lobe only 4

3A. Lobes of basal process equal in width and shape, apex of terminal joint blunt; lamelliform process broadly oval; medial ventral process prominent and oval .... *B. hutchinsoni* (Fig. 2.8A)

3B. Basal process with inner lobe narrower than outer; apex of terminal joint peg-like or rounded; lamelliform process narrowly oval; medial ventral process basally broad and distally narrow .... *B. natalensis* (Fig. 2.8B)

4A. Inner lobe of basal process more conical than rounded; lamelliform process small and round; distal region of terminal joint flask-shaped .... *B. dayae* (Fig. 2.8C)

4B. Both lobes of basal process rounded; lamelliform process large and oval; distal region of terminal joint with slight inflation and blunt apically .... *B. karroensis* (Fig. 2.8D)

5A. Basal process with large, spine-like process attached proximally on dorsal surface 6

5B. Basal process without large, dorsal, spine-like process 9

6A. Basal process with three distinct lobes; inner and outer lobes similar in size and smaller than medial lobe .... *B. kaokoensis* (Fig. 2.8E)

6B. Basal process with only one or two distinct lobes, in the latter case these of unequal height 7

7A. Basal process very slender; if two lobes present, inner lobe narrow with small apical projection; medial ventral process prominent 8

7B. Basal process broad with two lobes; inner lobe oblong and apically flattened; medial ventral process vestigial or absent .... *B. tridens* (Figs 2.8F, 2.9A–B)

8A. Basal process bilobed, longer than lamelliform process; apex of terminal joint rounded but not inflated .... *B. drakensbergensis* (Fig. 2.8G)

8B. Basal process with single digitiform lobe, shorter than lamelliform process; terminal joint with apex inflated .... *B. underbergensis* (Fig. 2.8H)

9A. Basal process with one or more apical tubercles or projections or with a dorsal keel-like structure 10

9B. Basal process without apical tubercles or projections 13

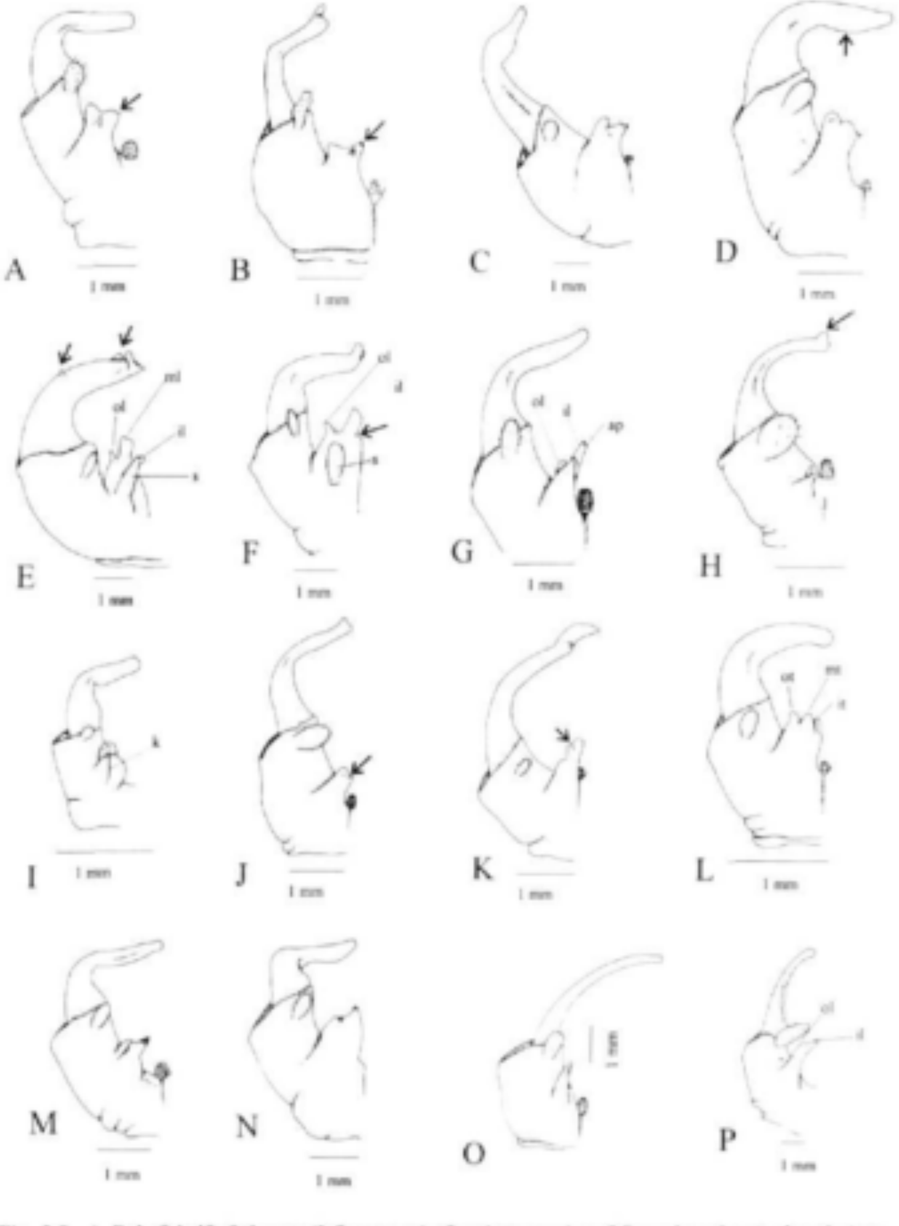

Fig. 2.8. A–P. Left half of clypeus (left antenna) of various species of *Branchipodopsis*, dorsal view. A. *B. hutchinsoni*: arrow indicates small process at apex of inner lobe. B. *B. natalensis*: arrow indicates small process at apex of inner lobe. C. *B. dayae*. D. *B. karroensis*: arrow indicates inflation in terminal joint. E. *B. kaokoensis*: arrows indicate processes on terminal joint. F. *B. tridens*, left half of clypeus, arrow indicates indentation in medial margin of basal process. G. *B. drakensbergensis*. H. *B. underbergensis*: arrow indicates inflation at apex of terminal joint. I. *B. simplex*. J. *B. browni*: arrow indicates small projection on inner margin of basal process. K. *B. drepane*: arrow indicates outer lobe. L. *B. wolfi*. M. *B. hodgsoni*. N. *B. kalaharensis*, O. *B. scambus*. P. *B. barnardi*.
KEY: ap = apical process; i = inner lobe; it = inner tubercle; k = keel, m = medial lobe; mt = medial tubercle; o = outer lobe; ot = outer tubercle; s = spinous process.

10A. Basal process with proximal region broad and inflated and with keel-like structure dorsally .... *B. simplex* (Fig. 2.8I)
10B. Basal process without keel, but with one or two tubercles or projections near or at apex 11

11A. Basal process with hooked projection on inner margin and small dorsal apical projection; terminal joint weakly curved inwards .... *B. browni* (Fig. 2.8J)
11B. Basal process with two to three apical tubercles; terminal joint strongly inwardly curved, with distinct bend about halfway along length 12

12A. Basal process with three tubercles in distal region, inner generally larger than outer and medial; apex of basal process as high as, or higher than lamelliform process .... *B. wolfi* (Figs 2.8L, 2.9C–G)
12B. Basal process with two acute tubercles positioned on a dorsal lobe; basal process situated low on basal joint with apex much below lamelliform process .... *B. hodgsoni* (Figs 2.8M, 2.9H)

13A. Basal process width greater than or equal to height; apex with two acute peaks; terminal joint stout and strongly curved inwards with distinct bend .... *B. kalaharensis* (Fig. 2.8N)
13B. Basal process longer than wide; terminal joint slender, weakly curved and without distinct bend 14

14A. Basal process simple and spine-like .... *B. scambus* (Fig. 2.8O)
14B. Basal process long and slender and with two lobes of distinctly different height and width 15

15A. Terminal joint apically rounded, medial ventral process absent, and lamelliform process very large and elliptical .... *B. barnardi* (Fig. 2.8P)
15B. Terminal joint apically hook-shaped and acute, medial ventral process present, lamelliform process small and oval .... *B. drepane* (Fig. 2.8K)

Branchipodopsis barnardi Hamer & Appleton 1996
(Fig. 2.8P)

Characteristic features

Basal process long and slender, apically with digitiform inner lobe and short, flat outer lobe. Lamelliform process long, prominent and elliptical. Medial ventral process absent. Terminal joints long, slender and not strongly curved. Pair of short, blunt spines on last abdominal segment. Females with a pair of prominent, oval extensions on dorsal surface of last thoracic segment (Fig. 2.7C).

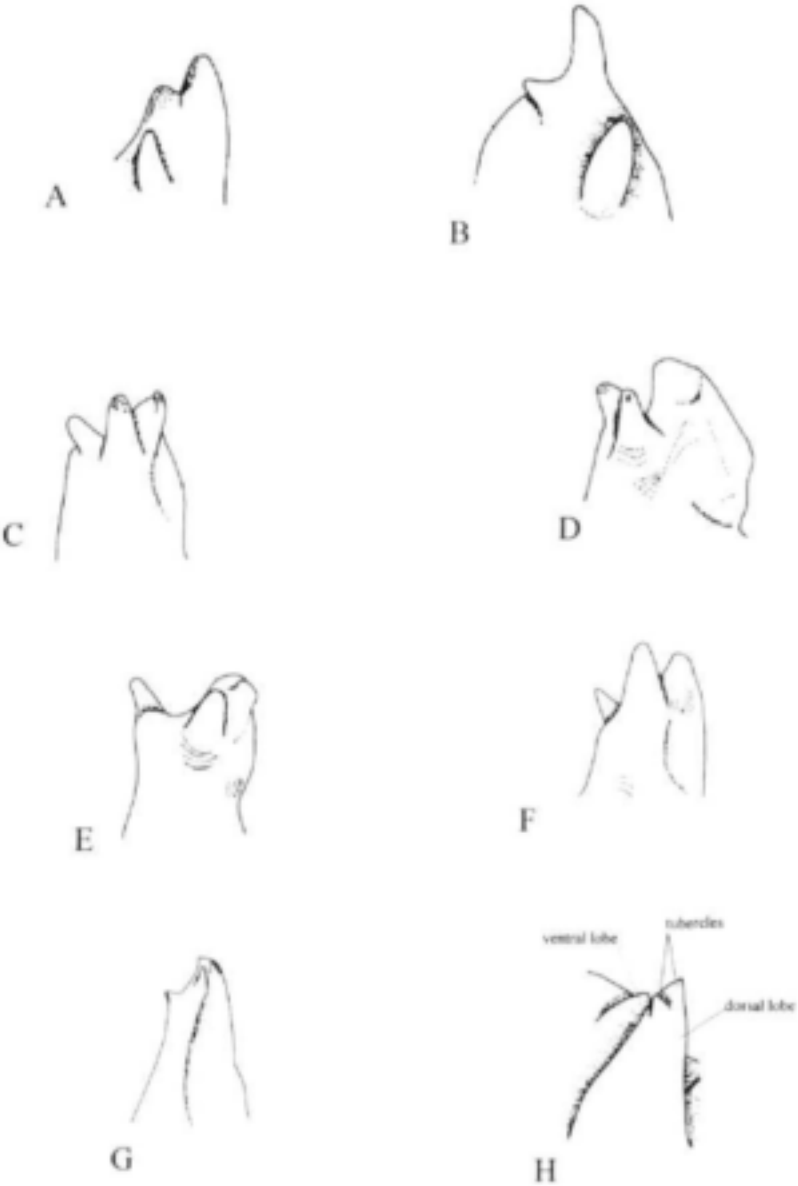

Fig. 2.9. Detail of basal process of clypeus for some species of *Branchipodopsis*.
A—B. *B. tridens*, left basal process of specimens from two different localities, showing variation in the shape of the lobes. C—G *B. wolfi*, left basal process from specimens from different localities showing variation in shape of tubercles. H. *B. hodgsoni*. Detail of apical region of basal process.

Records

Only collected from rockpools in the Sehlabatebe region of the Drakensberg (LES).

Red Data category

Vulnerable (last collected in 1996).

Branchipodopsis browni Barnard 1924
(Fig. 2.8J)

Characteristic features

Basal process conical proximally, apically broadened and bluntly-rounded, with a series of small denticles on apex. Acute, hooked projection on inner margin of basal process and another small process on dorso-medial surface, near apex. Medial ventral process very large and oval. Two small spines on ventral surface of last abdominal segment.

Records

Collected from Williston, Carnarvon and Fraserburg in the Karoo (NC). Type locality given as 'Great Namaqualand, Kalkfontein South' which is probably in southern Namibia. The Carnarvon habitat is a large, shallow, turbid and sparsely-grassed pool.

Red Data category

Low risk (last collected in 1993).

Branchipodopsis dayae Hamer & Appleton 1996
(Fig. 2.8C)

Characteristic features

Basal process with outer lobe rounded, inner lobe more acute, small pointed apical process medially. Apex of terminal joint flask-shaped. Medial ventral process small and round. Ventral surface of last abdominal segment with pair of blunt spines.

Records

Hatched from sediment collected from Koppieskraal Pan (NC) and a few specimens collected from Elands Bay (WC).

Red Data category

Data deficient (last collected in 1992).

Branchipodopsis drakensbergensis Hamer & Appleton 1996

(Fig. 2.8G)

Characteristic features

Basal process with inner lobe twice as long as outer; both lobes narrow and apically rounded. Inner lobe with one or two small processes on apex. Large spinous process on dorsal surface of basal process. Medial ventral process oval, with spines apically. Pair of prominent spines on ventral surface of last abdominal segment. There is some variation in the shape of the processes on the apex of the inner lobe.

Records

Recorded from various localities in the Drakensberg, including Loteni and Giant's Castle (KZN), as well as the Prentjiesberg (EC). In these localities this species is confined to shallow rockpools. Also recorded from Benoni (GT), but the habitat type at this site is unknown.

Red Data category

Low risk (last collected in 1996).

Branchipodopsis drepane Barnard 1929

(Fig. 2.8K)

Characteristic features

Basal process with distinct indentation in outer margin, and slender distal region. Rounded inner lobe, and smaller outer lobe present apically. Terminal joint with distinct, hooked apex. Medial ventral process obovate, apically flat and with surface covered with small spines. Pair of large, blunt spines on ventral surface of last abdominal segment.

Records

Only collected from the type locality in the Fish River near Gibeon (NAM).

Red Data Category

Data deficient (last collected in 1929).

Branchipodopsis hodgsoni Sars 1898

(Figs 2.8M, 2.9H)

Characteristic features

Basal process formed by two lobes, the second of which is situated slightly ventral to the first. Two tubercles present apically on dorsal lobe. Medial ventral process large and oval. Spines on last abdominal segment absent.

Records

Fairly common species along the south-eastern coastal region of South Africa including locatities at Kenton-on-Sea and Port Elizabeth (EC), Ashton (WC) and Bredasdorp (WC).

Red Data category

Low risk (last collected in 1990).

Branchipodopsis hutchinsoni Hamer & Appleton 1996

(Fig. 2.8A)

Characteristic features

Basal process with two equal-sized, rounded lobes. A small acute process on medial margin of inner lobe and a second on the dorsal surface of this lobe. Last abdominal segment without distinct spines but a pair of blunt, rounded processes present.

Records

Collected in large numbers from a heavily-vegetated roadside ditch in the Hutchinson area of the Karoo (NC)

Red Data category

Data deficient (last collected in 1990).

Branchipodopsis kalaharensis Daday 1910

(Fig. 2.8N)

Characteristic features

Basal process apically with two peaks, the inner one much larger than the outer. Medial ventral process obscure or absent. Last abdominal segment without spines.

Records

Only collected from Kanke Pan near Molepole and Sunnyside in central Botswana.

Red Data category

Data deficient (last collected in 1930).

Branchipodopsis kaokoensis Barnard 1929

(Fig. 2.8E)

Characteristic features

Basal process with three lobes, the middle one largest and apically flat, the two lateral lobes digitiform. A *prominent dorsal spinous projection* attached proximally and dorsally on each basal process. Short, spiniform process present on dorsal surface of terminal joint, followed by a larger, triangular process ventro-laterally just proximal to apex. Medial ventral process absent. Last abdominal segment with pair of strong spines ventrally.

Records

Only recorded once from the Kaokoveld, north of Kamanyab (NAM).

Red Data category

Data deficient (last collected in 1929).

Branchipodopsis karroensis Barnard 1929

(Fig. 2.8D)

Characteristic features

Basal process with two equal-sized and apically rounded lobes. A small, acute process on the medial margin of inner lobe. Medial ventral process with broad base and distally narrow. Last abdominal segment with pair of short but strong spines.

Records

Only recorded from Karoo, Beaufort West region (WC).

Red Data category

Data deficient (last collected in 1929).

Branchipodopsis natalensis Barnard 1929

(Fig. 2.8B)

Characteristic features

Basal process with narrow inner lobe and broadly rounded outer lobe; inner lobe with an apical and a dorsal acute projection. Spines on ventral surface of last abdominal segment very small. Females with posterior margin of last thoracic segment extended laterally to form a distinct pouch on each side of genital region (Fig. 2.7B).

Records

Originally recorded from Van Reenen (FS/KZN border) but type material has disintegrated. Recently specimens resembling the type description were collected from rockpools in the Sehlabatebe region (LES), from the Sani Pass area (KZN), Fika Patso (Drakensberg) and at Harrismith (FS).

Red Data category

Low risk (last collected in 1998).

Branchipodopsis scambus Barnard 1929
(Fig. 2.8O)

Characteristic features

Basal process slender, spine-shaped. Terminal joints long and slender, not strongly curved. Medial ventral process oval, with long spines distally. Cercopods unusual for the genus: short and straight, with plumose setae along entire length of both margins. A pair of spines is present on ventral surface of last abdominal segment.

Records

Appears to be restricted to the Grahamstown region (EC).

Red Data category

Endangered (last collected in 1989).

Branchipodopsis simplex Barnard 1924
(Fig. 2.8I)

Characteristic features

Basal process with inflated proximal region and a medial keel, apically narrower and rounded with a small acute projection medio-dorsally. Medial ventral process absent. Spines on ventral surface of last abdominal segment absent.

Records

Only collected from Eunda (Ovamboland, NAM).

Red Data category

Data deficient (last collected in 1924).

Branchipodopsis tridens Daday 1910
(Figs 2.8F, 2.9A–B)

Characteristic features

Medial margin of basal process with distinct indentation. Basal process with two lobes; inner one angular, outer much shorter and conical. A dorsal spinous projection attached proximally on each basal process. Much variation in the prominence of the medial margin indentation, the shape and relative length of the lobes of the basal process, and the relative size of the spinous projection on the dorsal surface. Medial ventral process vestigial or absent. Pair of spines present on ventral surface of last abdominal segment.

Records

Widespread in the arid south-western regions of Southern Africa including Namibia, Northern Cape and Botswana. Occurs in a wide range of habitats, including shallow rockpools at Augrabies Falls (NC).

Red Data category

Low risk (last collected in 1992).

Branchipodopsis underbergensis Hamer & Appleton 1996
(Fig. 2.8H)

Characteristic features

Basal process similar to that of *B. drakensbergensis*, but much smaller in relation to clypeus, and with a single, rather than two lobes. The lamelliform processes are also much larger in *B. underbergensis*. Medial ventral process more round than oval. Spines present on ventral surface of last abdominal segment. Females with a pair of small pouches dorsally on penultimate thoracic segment and lateral surfaces of last thoracic segment extended.

Records

Currently only recorded from rockpools in the Underberg and Bamboo Mountain regions in the Drakensberg (KZN).

Red Data category

Low risk (last collected in 1996).

Branchipodopsis wolfi Daday 1910
(Figs 2.8L, 2.9C–G)

Characteristic features

Basal process with three apical tubercles, inner one the most prominent. Much variation in the relative sizes and shapes of these tubercles. Medial ventral process round or oval. Ventral surface of last abdominal segment with a pair of spines. A number of species are probably represented, but these are difficult to differentiate based purely on gross morphological characters.

Records

Widespread. Southern African records from Zimbabwe, northern and southern Namibia, Northern Cape, Mpumalanga, Northern Province and Lesotho. Recorded from the Umfolozi Game Reserve (KZN). Also from Central Africa.

Red Data category

Data deficient (last collected in 1998).

Family **Thamnocephalidae** Linder 1941

Three genera are included in this family, but only one, *Branchinella*, is represented in Southern Africa. This genus is concentrated in Australia, but also occurs in North and South America, Europe, Asia and Africa. Three species, two of which are African endemics, are found in Southern Africa. The members of *Branchinella* are characterized by having the basal joints of the antennae more-or-less fused proximally, no more sclerotized than the rest of the body, and a relatively simple terminal joint. In most species a frontal appendage, which ranges from small to longer than the antennae, is present and is attached on the dorso-medial surface between the basal joints of the antennae. The basal part of the penes is usually fully retractable. In Southern Africa individuals of *Branchinella* species have not been collected in large numbers, and the species appear to have discontinuous distributions.

The following key to the Southern African members of the genus *Branchinella* is based on the frontal appendage and second antenna of the male.

KEY TO MALE *BRANCHINELLA* OF SOUTHERN AFRICA

1A. Frontal appendage longer than total antennal length; bifid and arms with lateral or apical branches 2
1B. Frontal appendage shorter than total antennal length, apically bifid but arms without lateral branches .... *B. spinosa* (Fig. 2.10B)

2A. Basal joint of antenna with four slender, digitiform-processes of varying length along anterior margins; frontal appendage very long with numerous long processes on ventro-lateral surface; trunk divides into two arms, each with two apical branches .... *B. ondanguae* (Figs 2.10E–F)
2B. Basal joint of antenna without digitiform processes along anterior margins; each arm of frontal appendage with six lateral /medial, and two apical branches .... *B. ornata* (Figs 2.10C–D).

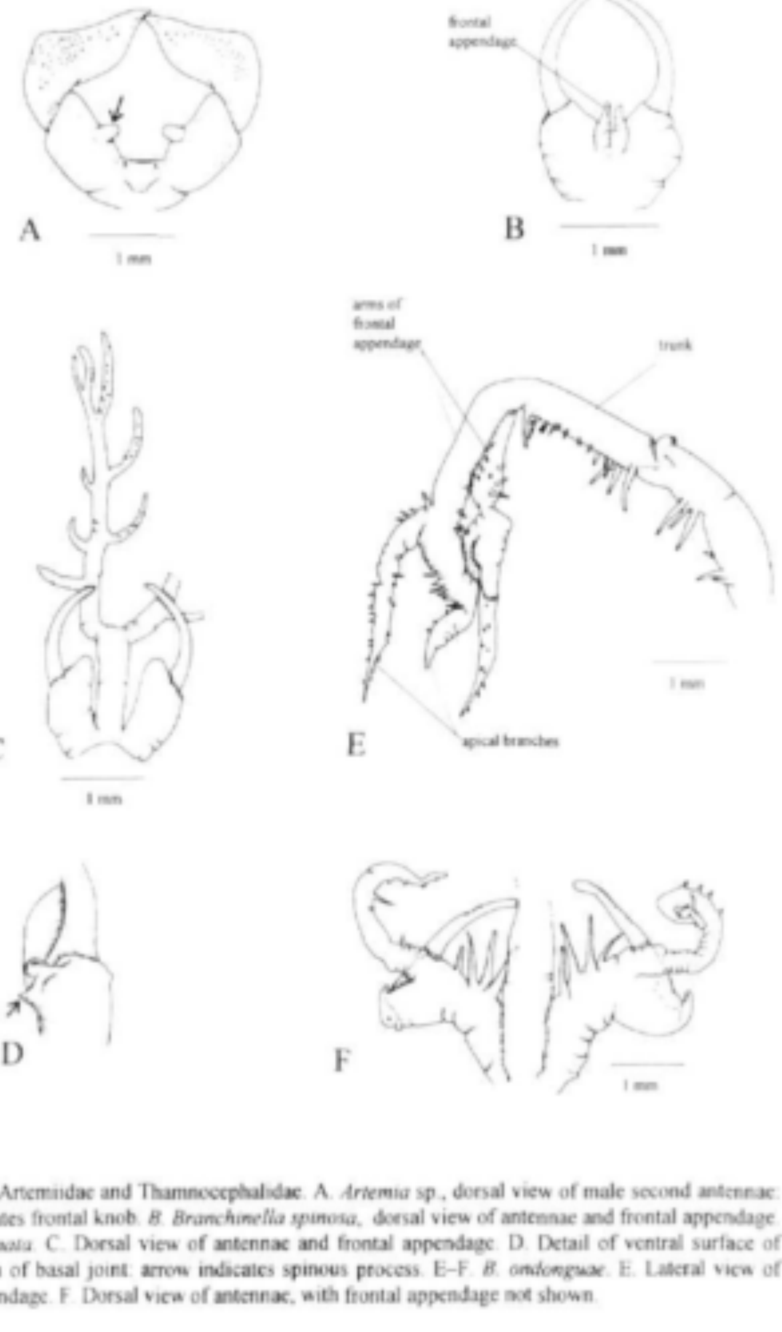

Fig 2.10. Artemiidae and Thamnocephalidae. A. *Artemia* sp., dorsal view of male second antennae: arrow indicates frontal knob. *B. Branchinella spinosa*, dorsal view of antennae and frontal appendage. C–D. *B. ornata*. C. Dorsal view of antennae and frontal appendage. D. Detail of ventral surface of distal region of basal joint: arrow indicates spinous process. E–F. *B. ondonguae*. E. Lateral view of frontal appendage. F. Dorsal view of antennae, with frontal appendage not shown.

Branchinella ondonguae Barnard 1924
(Figs 2.10E–F)

Characteristic features

Antenna and frontal appendage as described in above key. In addition, basal joint with long, papillate antennal process apically near terminal joint. Basal region of penes with leaf-shaped, lateral extension and with proximal, small triangular process medially.

Records

Hatched from clay pan sediments collected in the northern Kruger National Park (NP). Also from Ondangua and Ongka (NAM). Recorded in Somalia.

Red Data category

Low risk (last collected in 1990).

Branchinella ornata Daday 1910
(Figs 2.10C–D)

Characteristic features

Ventro-medial surface of basal joint with acute, triangular projection (Fig. 2.10D). Frontal appendage as described in key. Penes with a prominent, triangular process ventrally.

Records

Recorded from the Kalahari and Makgadikgadi Pans (BOTS), Gautscha Pan (Bushmanland, NAM) and Potchefstroom (NW).

Red Data category

Low risk (last collected in 1994).

Branchinella spinosa (Milne-Edwards 1840)
(Fig. 2.10B)

Characteristic features

Basal joint of antenna broad, without any processes. Frontal appendage relatively short, bifurcate, with each arm tapering to an acute point. Ventral surface of abdomen with prominent, paired spines on each segment, these decreasing in size and progressively more medially positioned towards the telson. Third abdominal segment with small, bifurcate spine in ventro-medial position.

Records

Recorded from Europe, Siberia, Rumania and Afghanistan, as well as North Africa. In Southern Africa only collected from Makgadikgadi and Sowa Pans (BOTS).

Remarks

Reported to be able to tolerate very high levels of salinity.

Red Data category

Low risk (last collected in 1994).

Family **Artemiidae** Grochowski 1896

This family includes a single genus, *Artemia*, which has an almost cosmopolitan distribution. This genus is unusual amongst the Anostraca in that it is restricted to hypersaline habitats including salt lakes and commercial salt pans. In Southern Africa, specimens are small (6–10 mm). The males of the genus are characterized by the broad, flattened terminal joints of the antennae (Fig. 2.10A). The females have a small, oval egg sac.

Artemia includes six sexual and one parthenogenetic species, *A. parthenogenetica*. The sexual species cannot be distinguished by gross morphological characters. These sibling species are isolated from each other by virtue of different numbers of chromosomes, by their extreme adaptations to the conditions in a single habitat, or by other means of reproductive isolation. Most populations of the genus in the Old World are parthenogenetic, while most of those in the New World are sexual (Browne 1993). Strangely, most of the known *Artemia* populations from Southern Africa appear to be sexual.

The *Artemia* of Southern Africa were examined by Barnard (1929) who referred to all specimens as *A. salina* but assigned them to different subspecies, none of which are accepted today. Since no genetic or isolation experiments have been carried out on the Southern African *Artemia*, it is not known which species are represented by the local sexual populations. It is possible that they are *A. tunisiana*, which is the most common species in the Mediterranean and North Africa, but more research is necessary to verify the identity of these populations.

A sample, consisting of 12 female specimens was collected from Swakopmund in Namibia. As a result, *A. parthenogenetica* has been quoted as occurring in Southern Africa (Browne 1993), but again, more evidence is required before this record can be accepted.

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CHAPTER 3

CONCHOSTRACA

by

L. Brendonck

The Conchostraca (clam shrimps) are primitive, small, freshwater crustaceans with representatives known from as far back as the Devonian Period (Rennie 1934), and they probably originated in pre-Devonian times (Tasch 1969; Fryer 1987). They occur on all continents except Antarctica (Belk 1982). The order consists of five extant families: Cyclestheriidae Sars, 1899 (monotypic), Cyzicidae Stebbing, 1910 (four genera), Leptestheriidae Daday, 1923 (five genera), Limnadiidae Baird, 1849 (six genera), and Lynceidae Stebbing, 1902 (three genera) (Martin 1992).

Fryer (1987) abandoned the name 'Conchostraca' as a taxonomic unit but still considered it useful for descriptive purposes. He placed the 'conchostracan' taxa into two orders, the Laevicaudata (consisting of the family Lynceidae) and Spinicaudata (which included all of the other families formerly included as conchostracans). However, recent ontogenetic findings on lynceids by Sassaman (pers. comm.) suggest that the term Conchostraca should be retained, and this usage will be followed here.

Although conchostracans are common world wide, they have not been the subject of intense study. A few detailed investigations have assessed the feeding and reproductive biology, and limited work has focused on other aspects of their biology. Most attention has been devoted to the systematics of these animals and *c*. 200 species are currently recognized.

Habitat preferences

Conchostracans, like anostracans and notostracans, generally live in temporary rain-water pools that periodically dry up completely or partially. Such waters are common in Southern Africa, especially in the more arid regions where rainfall is erratic and sparse. Sometimes pools fill up for only a few days. Some species (e.g. *Cyclestheria hislopi*) may occasionally occur in the littoral zone of lakes and in river systems and some species have extremely local distributions. Temperature is a significant factor controlling the occurrence of conchostracans (Mattox & Velardo 1950; Horne 1971; Belk & Belk 1975).

Feeding

Conchostracans are mainly benthic. Some species burrow into the substratum and lie with their ventral surfaces pointed upwards, feeding on detritus in suspension. They are non-selective algal and detritus feeders (Karande & Inamdar 1961; Royan 1976; Belk 1982). In view of the short-lived shallow environments in which they occur, it is advantageous for these organisms to adopt a wide trophic spectrum for their successful survival and propagation. The feeding currents, necessary for drawing food particles from the surrounding medium into the mid-ventral food groove, are produced by the metachronal beating of the thoracic limbs (Cannon 1933). Particles carried in the food groove are mechanically passed towards the mouth region by strong spines and setae on the thoracopod coxal lobes (Martin 1989a). Different aspects of the feeding biology and feeding structures in conchostracans were meticulously reviewed by Martin (1989a).

Reproduction

Propagation is generally bisexual, but some species are parthenogenetic (e.g. *Cyclestheria hislopi*) or hermaphroditic (e.g. some Limnadiidae). In the North American *Eulimnadia texana*, both males and self-compatible hermaphrodites occur (Sassaman & Weeks 1993). During out-crossing in *Eulimnadia*, a spermatophore-like package of sperm is transferred from the male to the hermaphrodite (Strenth 1977). With the exception of certain taxa, such as *Cyclestheria*, fertilized eggs are generally brooded between the female's body and the carapace valves for a short period. In some species, eggs are massed by a cement that glues the eggs together (Scanabissi Sabelli & Tommasini 1992). Packages of 'resting eggs' (see glossary) are usually shed when the female moults. Breeding occurs continuously throughout the adult stage. Some species spend most of their time *in copula* (Karande & Inamdar 1961): the male holds the female carapace with his claspers and antennae while his abdomen is inserted between the female valves. Detailed information is available on early female gametogenesis and egg shell formation in Leptestheriidae (Zeni & Zaffagnini 1989; Tommasini & Scanabissi Sabelli 1989, 1992; Scanabissi Sabelli & Tommasini 1990) and Limnadiidae (Zaffagnini 1969, 1971).

Cysts can survive extremely unfavourable circumstances. The production of resting eggs synchronizes life-cycles to the variations that occur in the habitat and provides indirect ways for dispersal, such as transportation by wind, by waterfowl, and by humans. (For a review of this phenomenon in eubranchiopods see Brendonck *et al.* 1990; Brendonck & Riddoch 1999). Hatching time is often variable and is triggered by specific environmental conditions (Zinn & Dexter 1962; Bishop 1967, 1968; Belk 1972; Belk & Belk 1975; Brendonck *et al.* 1993). In large branchiopods (eubranchiopods) in semi-arid and arid regions there is a general tendency for some of the eggs not to hatch after the first inundation following rains. This results in the formation of an egg bank. Delayed hatching of part of the egg bank may serve as a hedge against subsequent episodes of drought-related reproductive failure (Brendonck *et al.* 1998).

The external morphology of the resting eggs of conchostracans is a useful additional taxonomic character in the American *Eulimnadia* species (Belk 1989; Martin & Belk 1989). In some cases the pattern of egg-shell sculpturing is species-specific (Belk 1989). Since no such information is available for the South African species, future species re-descriptions should include egg morphology.

Cysts hatch into typical free-swimming nauplius larvae bearing three pairs of appendages and a median eye. Development proceeds through about five nauplius larval stages (Anderson 1967; Bishop 1968; Zaffagnini 1971; Strenth & Sissom 1975).

From the moment of hatching it is a race against time for the organism to attain sexual maturity and to produce the maximum number of cysts before pools dry up through evaporation. Adaptations allowing species from temporary pools in arid regions to make more effective use of the wet phase include a high reproductive capacity, and rapid development and growth (Brendonck & Persoone 1993). In a comparative laboratory study of large branchiopod life cycles, conchostracans were more fecund (in terms of numbers of eggs produced) than anostracans raised under similar conditions (Brendonck *et al.* 1993). This may reflect different ecological strategies in the two groups exploiting similar habitats. Conchostracans are mainly benthic and may be exposed at an early stage to declining oxygen levels near the bottom when pools dry up (Brendonck *et al.* 1993). Unlike the fairy shrimps, the weak-swimming clam shrimps are not able to utilize the small amount of oxygen available in the sub-surface layer, because of the high energy expenditure required to swim to the air-water interface (Moore & Burn 1968). Although clam shrimps have an extremely high resistance to oxygen stress (Moore & Burn 1968; Horne 1971; Eriksen & Brown 1980), they may have relatively less time for growth and reproduction in comparison to fairy shrimps, and may therefore experience increased density-independent mortality. According to MacArthur & Wilson (1967) such a situation results in a shift in the r–K continuum towards an r–selected reproductive strategy. The fecundity of clam shrimps thus tends to be higher than that of fairy shrimps (Brendonck *et al.* 1993).

Collection

Adult conchostracans are easily collected from temporary ponds with a 1-mm bottom net. Free swimming larval stages are about 300–400 µm long and can be sampled with a 50 µm plankton net. To study the organisms under laboratory conditions, mud from the centre of a dry pool can be collected and rehydrated in the laboratory with distilled water at a temperature of about 25°C. After about two weeks animals should be adult and can be identified and their biological characteristics studied.

Conchostraca in Southern Africa

The Southern African conchostracan fauna, although abundant in temporary pools and pans and commonly found with other branchiopod species, have been poorly studied. Such an ancient group undoubtedly has undergone considerable adaptive radiation, but species differences are masked by a combination of evolutionary stasis and age- and environment-related morphological variability (Martin 1992). This makes it difficult to distinguish species on the basis of morphology alone. Many of the characters traditionally used for species discrimination are variable and unreliable. As a consequence, many of the formerly accepted species were later synonymized in the Limnadiidae (Straskraba 1965*a*), Lynceidae and Cyzicidae (Straskraba 1965*b*), and Leptestheriidae (Straskraba 1966). The lack of reliable characters must also be the reason why, since the works of Sars (1898, 1899, 1905), Gurney (1904), Brady (1913), Daday (1914, 1923, 1925, 1926, 1927), Barnard (1924, 1929, 1935), and Brehm (1958), no taxonomists have tackled the systematics of Southern African conchostracans. Besides the morphology of adults and resting eggs, future systematic research should also use molecular techniques to reflect more clearly the diversity and phyletic affinities of the component groups. The present chapter aims at presenting the current knowledge on Southern African conchostracans. It is hoped that this will encourage local studies on these fascinating organisms that are amongst the most primitive of extant crustaceans.

A checklist of species which have been found in Southern Africa, together with authors and dates of original descriptions and general distribution records is given at the end of this chapter (p. 76).

Morphological features of the Conchostraca

Most conchostracans are laterally compressed, with a bivalved carapace that completely envelops the body and limbs (Fig. 3.1A). They measure between 3 mm and 18 mm in length. Valves are generally marked by an umbo and concentric lines of growth. In the Lynceidae, however, the bivalved carapace is globose and lacks an umbo or any growth lines (Fig. 3.2A). The valves are hinged in the Lynceidae and simply folded in other families. The carapace is connected to the dorsum of the head by a ligament and is closed by a powerful adductor muscle in the head region (Fig. 3.1B). The body can move freely in the carapace chamber, even when the valves are closed.

The head region is enormous in Lynceidae (Fig. 3.2A), and is relatively small in other families (Fig. 3.1B). The head is dorsally subtriangular in shape, and bears the compound eyes (Fig. 3.1C). Posterior to the eyes, on the dorsal surface, a club-like stalked organ (frontal organ) is present in the Limnadiidae (Fig. 3.4A, C–D). A subtriangular rostrum is situated on the ventral side of the head, anterior to the labrum from which it is separated by a groove (Fig. 3.1B, D). The nauplius eye is embedded in tissue beneath the surface of the rostrum.

The antennules (Fig. 3.1D–E) flank the rostrum and are short and uniramous, bearing sensory setae distally. The biramous antennae (Fig. 3.1B) are large and are used for swimming and burrowing, and as an aid to males in clasping females. The basal part is marked by a series of annulae, each of which is equipped with a row of spine-like setae. The two distal flagella have 10–25 segments, each bearing a set of brush-like setae posteriorly and a set of simple spine-like setae anteriorly.

The labrum (Fig. 3.1D) is a sub-rectangular structure, of which the free edge is often marked by a prominent spine-like process. The labrum forms a large space (*atrium oris*) in which the molar processes of the mandibles are located. The mandibles (Fig. 3.1F) are lobate gnathobases with ridged molar processes. The maxillules (Fig. 3.1G) are reduced. The margin of the main lobe bears long setae. The posterior side has a row of comb-like setae. The maxillae (Fig. 3.1H) are reduced to tiny setose lobes.

The trunk (Fig. 3.1B) is generally composed of 10–32 segments, each bearing a pair of foliaceous limbs, used for locomotion and feeding. These trunk appendages (thoracopods) (Fig. 3.1B) decrease in size posteriorly. The thoracopods are divided into an exopod, epipod, and endopod (Fig. 3.1I). Each endopod has five broad setose endites. The proximal endite is more distinct than the others and is usually referred to as the coxal lobe. The endopodite is a distinctly articulated paddle-like lobe, often considered as a sixth endite. The exopod has a dorsal and ventral lobe. Thoracopods 9–11 in the females often have modified dorsal lobes of exopods (= 'dorsal filaments'). These structures facilitate support of the egg mass. There is an additional fleshy epipodite arising near the base of the exopod. In males, the first one or two trunk limbs lose their phyllopodous lobes and bear hook-like endites (claspers) (Fig. 3.1B) that assist in grasping females during copulation.

The telson (Fig. 3.1B, J) is large and directed ventrally. Except in the Lynceidae, its dorsal surface bears a double row of stout spines, and terminally, a pair of blade-like anal spines. A pair of serrate and spinose caudal rami (furcae) flank the anus. In the Lynceidae, the trunk terminates in an anal somite that bears telsonal filaments but lacks furcae (Fig. 3.2A).

KEY TO THE SOUTHERN AFRICAN FAMILIES OF CONCHOSTRACA

1A. Shell globular and smooth, without growth lines; head region very large (in relation to overall body size); caudal furcae absent (Fig. 3.2A) .... **Lynceidae** (p. 66)
1B. Shell laterally compressed, growth lines visible; head region small (in relation to overall body size); caudal furcae present (Fig. 3.1A, B) 2

2A. Shell with few indistinct growth lines 3
2B. Shell with numerous distinct growth lines 4

3A. Shell almost circular in lateral view (Fig. 3.3A); no dorsal appendage (frontal organ) on head (Fig. 3.3B) .... **Cyclestheriidae** (p. 66)
3B. Shell ovate in side view (Fig. 3.4B); head with dorsal appendage (frontal organ) (Fig.3.4A) .... **Limnadiidae** (p. 68)

4A. Rostrum (in adults) unarmed (Fig. 3.5C, D) or with a minute spine in the female; foremost spine on the upper margin of telson enlarged (Fig. 3.5B) .... **Cyzicidae** (p. 68)
4B. Rostrum armed with a distinct apical spine in both sexes (Fig. 3.6D, E); foremost spine on upper margin of telson not larger than the others (Fig. 3.6A) .... **Leptestheriidae** (p. 72)

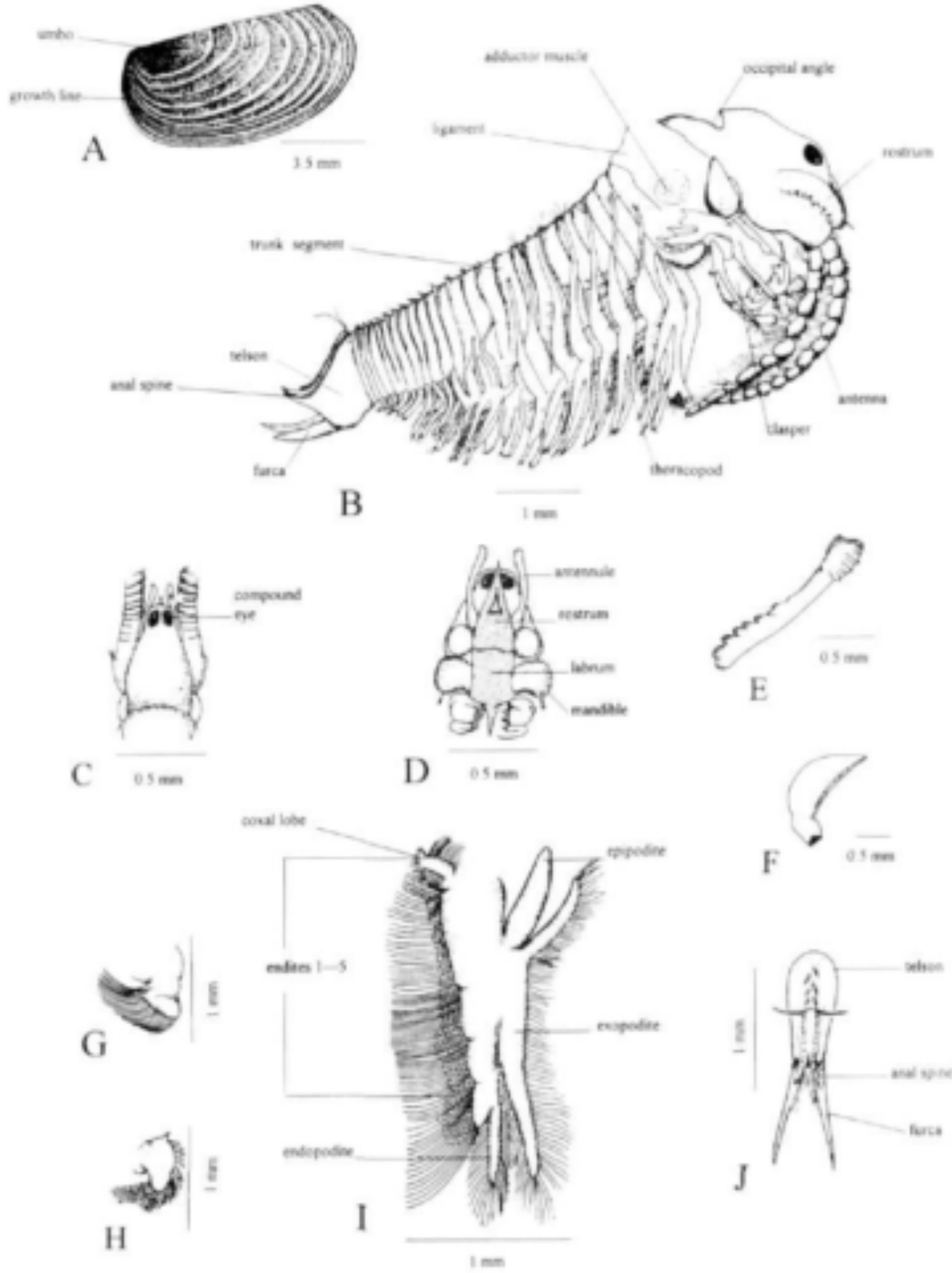

Fig. 3.1. A–H. *Leptestheria* sp., illustrating the general morphology of Conchostraca. A. Lateral view of male left valve. B. Right lateral view of adult male with valves removed. C. Dorsal view of head. D. Ventral view of head. E. Antennule. F. Mandible. G. Maxillule. H. Maxilla. I. Thoracopod. J. Telson with furcae. (A, B after Brendonck *et al.* 1989; C–J after Schram 1986).

Family **Lynceidae**

This family contains three genera and approximately 40 species (Martin & Belk 1988; Martin 1992). The valves are pealike and lack growth lines. Lynceids are usually small to medium-sized (to about 8 mm) and are mainly benthic. They feed primarily by scraping, scavenging, or grazing on detritus (Martin *et al.* 1986; Martin & Belk 1988; Martin 1989a). A unique morphological feature is the absence of a furca (Belk 1982). Species are known from temporary pools and occasionally streams on all continents except Antarctica.

Only one genus, *Lynceus* O. F. Müller 1776, occurs in South Africa. Representatives of this genus also occur in Eurasia, Japan, the Americas, and Australia. Martin *et al.* (1986), and Martin & Belk (1988) are important recent works on non-African Lynceidae.

KEY TO SPECIES OF *LYNCEUS*

1A. Two dorsal rostral keels in both sexes (Fig. 3.2B).. 2
1B. Dorsal rostral keel single in both sexes (Fig. 3.2C) 3

2A. Fornix (lateral groove on rostrum) reaches apex of the spatulate rostra in both sexes (Fig. 3.2D); male clasper (Fig. 3.2E) with distal trapezoidal segment .... *L. bicarinatus*
2B. Fornix reaches apex of the spatulate female rostrum (Fig. 3.2G), but it ends on the ventral margin of the male truncate rostrum (Fig. 3.2F); male clasper (Fig. 3.2H) with oblong distal segment .... *L. pachydactylus*

3A. Rostrum truncate in both sexes (Fig. 3.2I, J) 4
3B. Rostrum truncate only in female (Fig. 3.2L, M) ....*L. triangularis*

4A. Proximal segment of male first leg (Fig. 3.2K) with numerous transverse rows of minute granules on margin facing exopod .... *L. truncatus*
4B. Proximal segment of male first leg without rows of granules on margin facing exopod .... *L. lobatsianus*

The species *L. wahlbergi* (Loven 1847), from the Free State, has been omitted from this key because of the uncertainty of the status of this taxon.

Family **Cyclestheriidae**

This family contains one species, *Cyclestheria hislopi* (Baird 1859) (Fig. 3.3). The valves are almost circular in side-view and have growth lines. The species is unique in having the compound eyes fused into one structure (Belk 1982). The species is distributed world-wide in tropical

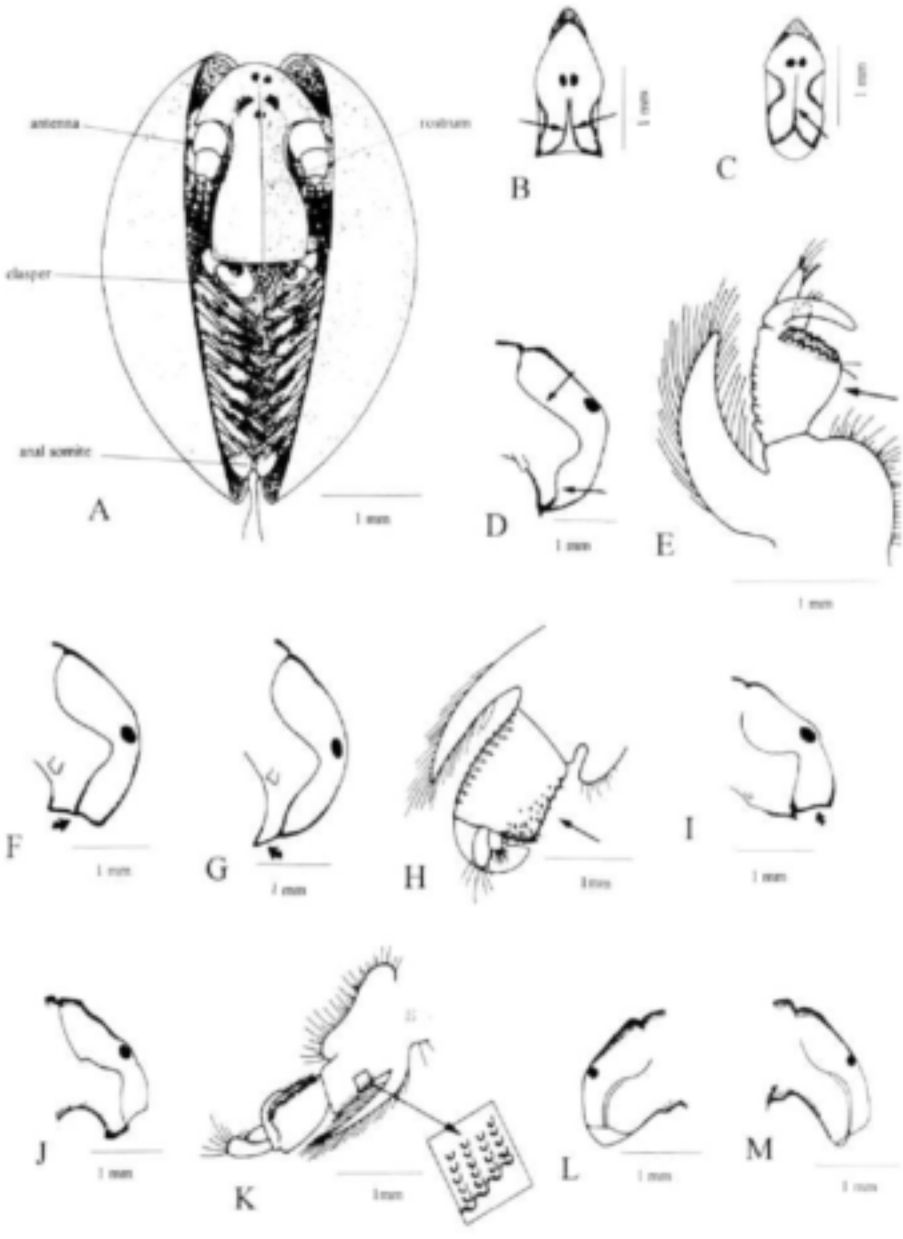

Fig. 3.2. *Lynceus*. A. Ventral view of a male. B. Dorsal view of head with double rostral keel. C–E. *Lynceus bicarinatus*. C. Dorsal view of head with single rostral keel. D. Lateral view of male head. E. Male clasper. F–H. *Lynceus pachydactylus*. F. Lateral view of male head. G. Lateral view of female head. H. Male clasper. I–K. *Lynceus truncatus*. I. Lateral view of male head. J. Lateral view of female head. K. Male clasper with detail of rows of granules. L–M. *Lynceus triangularis*. L. Lateral view of male head. M. Lateral view of female head. (A re-drawn from Martin *et al.* 1986; B–D, J redrawn from Barnard 1924; E–I, K redrawn from Barnard 1929; L, M redrawn from Daday 1927).

and subtropical regions where it inhabits temporary and permanent waters. In Southern Africa *C. hislopi* has been recorded from Zimbabwe and Namibia. It differs in many aspects from the other South African conchostracans: it is the only species with a pantropical distribution and has been collected from both temporary and permanent waters (see Barnard 1929; Battish 1981; Curtis 1991). Its life-cycle is unique and reveals affinities with 'Cladocera' (see Chapter 4), being a predominantly parthenogenetic ovoviviparous form in which the eggs hatch out in the brood pouch. Sexual production of resting eggs only takes place under certain environmental conditions (Roessler 1995).

Family **Limnadiidae**

This family contains six genera. The ovate valves have very few, if any, faint growth lines. The members of this family are unique in having a large frontal organ located on the mid-dorsal surface of the head. The family is cosmopolitan, except for Antarctica (Belk 1982). Only one genus, *Eulimnadia* Packard 1874, has been found in South Africa. Other representatives of this genus occur in Eurasia, the Americas and Australia.

The hinge line of the shell is not serrate, there are 18 or 20 pairs of legs and the lower distal angle of the telson is produced to form an acute point (Fig. 3.4A, C).

Martin (1989b) and Belk (1989) have completed important recent works on non-African *Eulimnadia*. These include coverage of the general morphology of adults and of resting eggs.

KEY TO SPECIES OF *EULIMNADIA*

1A. Last 10 trunk segments dorsolaterally armed with spines .... *E. alluaudi* (Fig. 3.4)

1B. Last 12 trunk segments dorsolaterally armed with spines .... *E. africana* (Fig. 3.4)

Eulimnadia victoriae, described by Brady (1913) from Zimbabwe, is identical to *Cyclestheria hislopi* (Sandor 1929), and is thus not included in the above key.

Family **Cyzicidae**

This family contains four genera. The valves have numerous distinct growth lines and there is usually no terminal spine on the rostrum of adults. Species occur in Europe, Asia, Africa, Australia and the Americas. Representatives of two genera are known from Southern Africa.

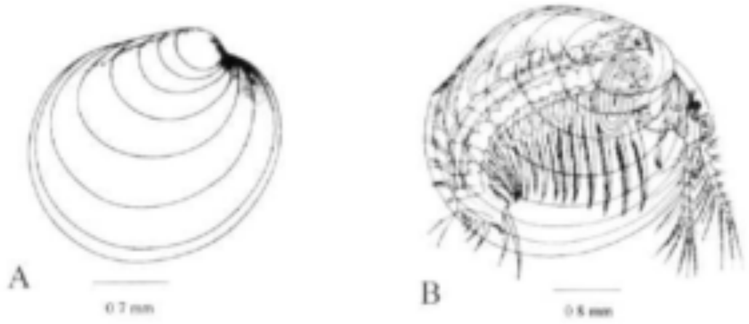

Fig. 3.3. A–B. *Cyclestheria hislopi*. A. Right valve of adult female. B. Adult female without young in the incubatory cavity. (Redrawn from Sars 1887).

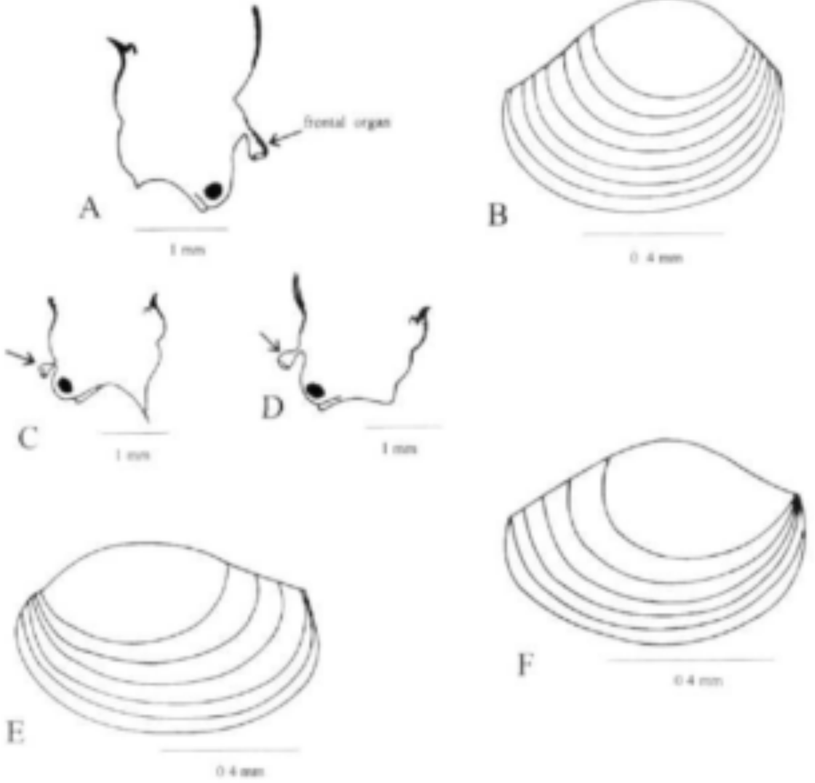

Fig. 3.4. A–B. *Eulimnadia alluaudi*. A. Lateral view of female head. B. Lateral view of female valve. C–F. *Eulimnadia africana*. C. Lateral view of male head. D. Lateral view of female head. E. Lateral view of male valve. F. Lateral view of female valve.
(All redrawn from Daday 1926).

KEY TO GENERA (ADULT SPECIMENS ONLY)

1A. Rostrum acute in both sexes (Fig. 3.5C–D); occipital angle of head (Fig. 3.1B) pointed (Fig. 3.5C–D); teeth and spines on telson margin spinulose .... *Cyzicus*

1B. Rostrum acute in female (Fig. 3.5F), apically dilated in male (Fig. 3.5E); occipital angle more or less rounded (Fig. 3.5E–F); teeth and spines on telson margin simple, smooth .... *Eocyzicus*

Genus *Cyzicus* Audouin 1837

(formerly *Caenestheriella* Daday 1914)

It is not possible to find reliable differences between the three South African species (*C. vidua, C. joubini* and *C. elizabethae*) described by Daday (1914). According to Barnard (1929), all three are synonyms of *C. australis* (Fig. 3.5C–D). *Cyzicus australis* is one of the commonest and most widespread South African phyllopods, being recorded from the Eastern Cape, Western Cape, Northern Cape, North West Province, Free State, Gauteng, Botswana, Zimbabwe, Greater Namaqualand, Damaraland, Ovamboland, and the Kaokoveld (see p. 76 for details on distributions).

The animals in this genus tend to be more sedentary than most other conchostracans, and have a habit of lying embedded in the mud, with the dorsal surface orientated downwards. Representatives of this genus also occur in Eurasia, the Americas, and Australia.

Genus *Eocyzicus* Daday 1913

There are three species currently accepted from South Africa. Brehm (1958) has also described an additional species, *Eocyzicus minor*, which is closely related to, but smaller than *E. gigas*. However, Durga Prasad *et al.* (1981) regard this description as being too obscure, and do not recognize *E. minor* as a valid species. Representatives of this genus also occur in Eurasia and the Americas.

KEY TO SPECIES OF *EOCYZICUS*

1A. Margin of male clasper with small notch (Fig. 3.5G) .... *E. obliquus* (Fig. 3.5E–H)

1B. Margin of male clasper with deep notch (Fig. 3.5J) 2

2A. Telson with strong denticles (Fig. 3.5K); length about 6–7 mm .... *E. dentatus* (Fig. 3.5I–K)

2B. Telson with numerous fine denticles (Fig. 3.5N); length about 13 mm .... *E. gigas* (Fig. 3.5L–N)

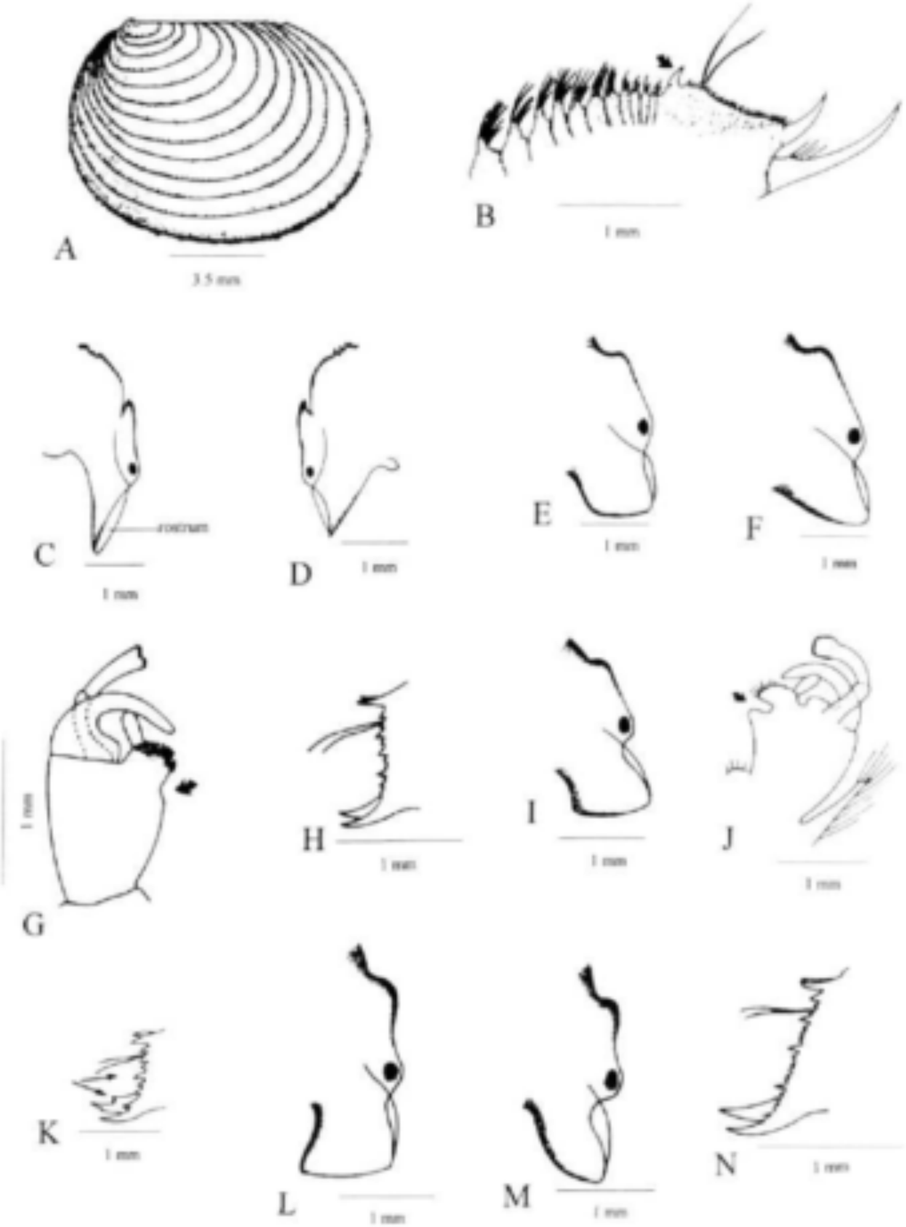

Fig. 3.5. Cyzicidae. A. Right shell of female specimen. B. Dorsal armature of the last body segments and telson. C–D. *Cyzicus australis*. C. Lateral view of male head. D. Lateral view of female head. E–H. *Eocyzicus obliquus*. E. Lateral view of male head. F. Lateral view of female head. G. Apical part of first male clasper. H. Telson. I–K. *Eocyzicus dentatus*. I. Lateral view of male head. J. Apical part of first male clasper. K. Telson. L–N. *Eocyzicus gigas*. L. Lateral view of male head. M. Lateral view of female head. N. Telson.

(A–B redrawn from Alonso 1985; C–D, G redrawn from Daday 1914; E–F, H–N redrawn from Barnard 1929).

Family **Leptestheriidae**

This family contains five genera. All family members are characterized by the unique presence of a triangular epipodal lamina on the legs and a spine on the apex of the rostrum of both sexes. The first character is certainly distinctive, but the second loses much of its value because a similar and evidently homologous spine occurs in larvae of at least two of Dadays' species of *Caenestheriella* (= *Cyzicus* Audouin 1837). If it persists at all in *Cyzicus*, it is only in a reduced or vestigial form. Leptestheriids occur in Europe, Asia, Africa, and the Americas. Two genera are currently known from Southern Africa.

KEY TO GENERA

1A. Margin of the exopods of the legs entire, without digitate, setiferous processes (Fig. 3.6B) .... *Leptestheria*

1B. Margin of the exopods with digitate, setiferous processes (Fig. 3.7A) .... *Leptestheriella*

Genus *Leptestheria* Sars 1898

Head with occipital angle acutely produced (Fig. 3.6C); rostrum often broader in male than in female (Fig. 3.6G–H), but this sexual dimorphism is usually not pronounced; 22–26 pairs of legs; dorsal lobe of exopod cylindrical on two or more of the 10th–15th pairs of legs in the female. Representatives of this genus also occur in Eurasia and the Americas.

KEY TO SPECIES OF *LEPTESTHERIA*

1A. Rostrum very short; occipital angle considerably produced (Fig. 3.6C) .... *L. brevirostris*

1B. Rostrum moderately long; occipital angle moderately produced (Fig. 3.6D).................... 2

2A. Shell sculpturing reticulate or areolate (Fig. 3.6F).................... *L. rubidgei* (Fig. 3.6D–F)

2B. Shell sculpturing striate (Fig. 3.6I) .... *L. striatoconcha* (Fig. 3.6G–I)

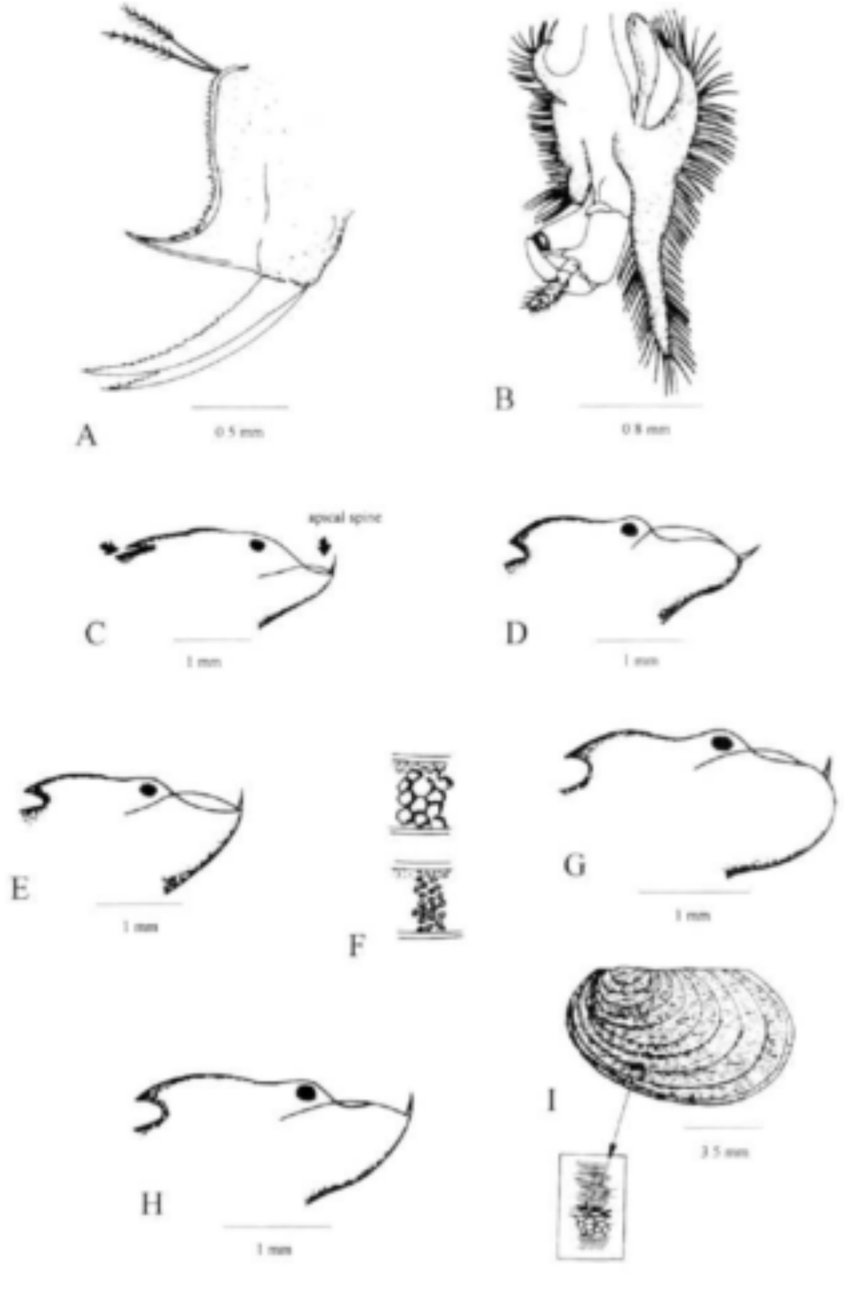

Fig. 3.6. Leptestheriidae. A. Telson with furcae. B. *Leptestheria*, first thoracopod of male. C. *Leptestheria brevirostris*, lateral view of head. D–F. *Leptestheria rubidgei*. D. Lateral view of male head. E. Lateral view of female head. F. Young (above) and old portions of shell scalpturing.
G–I. *Leptestheria striatoconcha*. G. Lateral view of male head. H. Lateral view of female head. *I. Lateral view of shell with detail of sculpturing.*
(A redrawn from Alonso 1985; B redrawn from Battish 1981; C–H redrawn from Barnard 1929;
I redrawn from Barnard 1924, 1929).

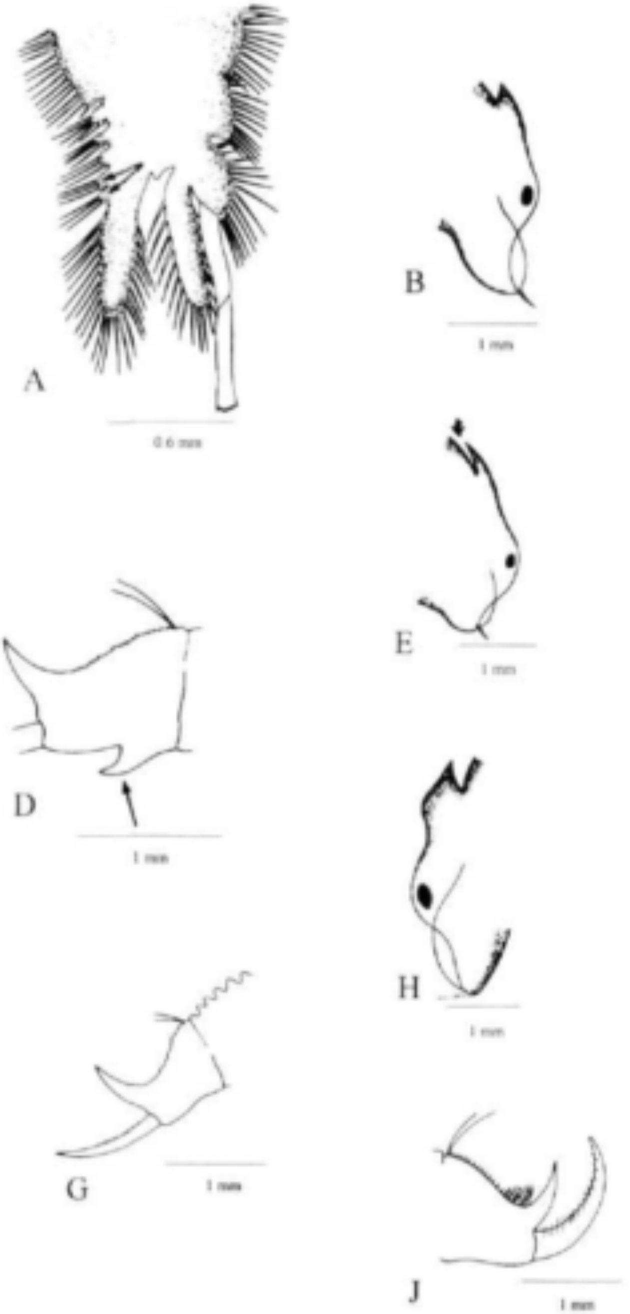

Fig. 3.7. A. *Leptestheriella*, distal part of male third leg. B–D. *Leptestheriella calcarata*. B. Lateral view of male head. C. Lateral view of female head. D. Telson. E–G. *Leptestheriella inermis*. E. Lateral view of male head. F. Lateral view of female head. G. Telson. H–J. *Leptestheriella setosa*. H. Lateral view of female head. I. Exopod of third leg. J. Telson.

(A redrawn from Nayar & Nair 1968; B–G redrawn from Barnard 1929; H–J redrawn from Barnard 1935).

Genus *Leptestheriella* Daday 1913

Head with occipital angle acutely produced (Fig. 3.7E); rostrum often broader in male than in female (Fig. 3.7E–F); 22–32 pairs of legs; margin of exopods of the legs with lobate or digitiform processes (Fig. 3.7A); dorsal lobe of exopod in female cylindrical on 10th and 11th pair of thoracopods. Representatives of this genus also occur in India.

KEY TO SPECIES OF *LEPTESTHERIELLA*

1A. Strong tooth on ventral surface of telson (Fig. 3.7D) .... *L. calcarata* (Fig. 3.7B–D)
1B. No tooth on ventral surface of telson (Fig. 3.7G, J) 2

2A. Occipital angle considerably produced (Fig. 3.7E–F) .... *L. inermis*
2B. Occipital angle little produced (Fig. 3.7H) .... *L. setosa* (Fig. 3.7H–J)

According to Barnard (1935), the rostral spine is absent from all specimens of *L. setosa.* A slight indentation however, shows where it could be inserted. The elongate setae on the upper margin of the telson and the feebly developed processes on the margin of the exopod (Fig. 3.7I) show a similarity to *Leptestheria.*

SPECIES LIST AND DISTRIBUTION RECORDS OF CONCHOSTRACA IN SOUTHERN AFRICA

Lynceus bicarinatus Barnard 1924: Ovamboland, Free State.

L. pachydactylus Barnard 1929: Heidelberg & Rietfontein (GT).

L. triangularis Wolf (*in litteris*, see Daday 1927): Port Elizabeth (EC).

L. truncatus Barnard 1924: Ovamboland, KZN.

L. lobatsianus Barnard 1929: Botswana.

Eulimnadia alluaudi Daday 1926: Kalahari.

E. africana (Brauer 1877): The former Transvaal, Heidelberg (GT), Kimberley (NC), Zimbabwe, Botswana, Greater Namaqualand, Ovamboland, Kaokoveld.

Eocyzicus obliquus (Sars 1905): The former Cape Province, Hanover (EC), Potchefstroom (NW).

E. dentatus Barnard 1929: Hanover (EC).

E. gigas Barnard 1924: Ovamboland.

Leptestheria. brevirostris Barnard 1924: Damaraland.

L. rubidgei (Baird 1862): Widespread: Cape Town, Cape Flats, Pacaltsdorp & Prinskraal (WC), Namaqualand (NC), Port Elizabeth, Hanover & Grahamstown (EC), Pofadder & Upington (NC), Gouritz River (Southern Cape), Heidelberg (GT), Botswana, Lesotho, Greater Namaqualand.

L. striatoconcha Barnard 1924: Heidelberg (GT), Ovamboland.

Leptestheriella calcarata Daday 1923: Botswana, Greater Namaqualand.

L. inermis Barnard 1929: Between Upington and Keimoes (NC).

L. setosa Barnard 1935: Northern Kalahari.

Cyclestheria hislopi (Baird 1859): Botswana, Namibia, Zimbabwe.

Cyzicus australis (Loven 1847): Widespread: Port Elizabeth, Hanover, Queenstown, Molteno (EC), Prince Albert, Beaufort West (WC), Hutchinson, Kimberley, Prieska, Kenhardt, Langklip (NC), Wolmaranstad (NW), Kroonstad, Bloemfontein (FS), Witbank, Brakpan, Heidelberg (GT), Greater Namaqualand, Damaraland, Ovamboland, Kaokoveld, Botswana, Zimbabwe.

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CHAPTER 4

CLADOCERA

by

M.T. Seaman, D.J. Kok & M. Watson

Commonly known as 'water fleas', the Cladocera by no means form a homogeneous group. There are indications that the order is polyphyletic and that it should therefore consist of four separate orders, named the Anomopoda, the Ctenopoda (treated here as the Sididae), the Haplopoda and the Onychopoda by Fryer (1987). For convenience these four orders are treated here as a single group. Nearly all South African species belong to the Anomopoda, the only exceptions being species in the genus *Diaphanosoma* of the Ctenopoda.

Most of the world's 400 or so species of Cladocera are found in freshwater at pH values between 6.5 and 8.5. *Moina micrura* and a few other opportunist species can be found in brackish water.

Most of the Southern African species of *Daphnia*, as well as *Diaphanosoma excisum, Bosmina longirostris* and *Ceriodaphnia reticulata*, are limnetic. *Moina micrura, Ceriodaphnia rigaudi, Daphnia magna, Daphnia coronata*, the Chydoridae, and the Macrothricidae are all most commonly found in ponds or temporary waters. The last two families are associated with vegetation and sediments.

The most important early taxonomist of South African cladocerans, G.O. Sars, examined material from both the central Highveld plateau and the Western Cape, and suggested that species are widely spread within South Africa. However, an important dividing line through the country appears to be west to east through Pretoria, separating the Highveld from a more sub-tropical region to the north. This line continues south-eastward, separating most of KwaZulu/Natal from the cooler inland areas and finally reaches the coast somewhere in the Eastern Cape Province. It roughly corresponds with the limits of distribution of a fish, the Mozambique tilapia *Oreochromis mossambicus*, as well as of the freshwater snails, *Biomphalaria* spp. and *Bulinus (Physopsis)* spp., which are the intermediate hosts of bilharzia. The South African form of *Daphnia laevis* is found only on the 'warm' side of this line, while *Daphnia carinata,* which appears to be a highveld or temperate species, is found only on the 'cold' side of the line. It is further suspected that the Western Cape should be rich in endemic species.

In the last two years of his life, David Frey had begun to look at South African chydorids and, had he lived, a number of articles would surely have arisen from this work. We are fortunate that he was able to comment on the present chapter and allowed us to incorporate some of his ideas.

Morphological features of the cladocerans (Fig. 4.1A–B)

Cladocerans vary in length from <1 mm to nearly 5 mm. For instance, *Bosmina longirostris* reaches about 0.3 mm in length, whereas *Daphnia carinata* and *Daphnia magna* can exceed 4.0 mm.

The head (the anterior part of the body not covered by a carapace) is prominent and is sometimes produced between the antennules to form a rostrum, as in the genus *Daphnia* (Fig. 4.1A). There is one median compound eye consisting of a mass of pigment cells surrounded by a small number of lenses. Muscles attached to the eye move it continuously in what appears to be part of an orientation process relative to incident light. A single ocellus, which is particularly prominent in the Chydoridae (e.g. Fig. 4.3A), lies anterior or ventral to the compound eye.

The antennules are small and usually uniramous, and are situated below the rostrum. The antennae are large and biramous and are the primary organs of locomotion, plumose setae aiding in the swimming process in limnetic forms. The fornix is a ridge anterodorsal to and around the insertion of the antennae. The antennae are situated laterally, near the posterior margin of the head. Each consists of a stout basal segment and two segmented rami.

The mouthparts are small, simple and well hidden ventrally at the junction between the head and the body. The most obvious are a pair of sclerotized mandibles. The rest, consisting of a labrum (upper lip), one pair of maxillae and a labium, are hardly noticeable.

Pores (Fig. 4.4K) on the surface of the head are of uncertain function but are of taxonomic value, particularly in the Chydoridae.

The body is covered by a folded but unhinged carapace, which is also known as the shell, consisting of two valves. Dorsally the carapace forms a brood chamber into which eggs are laid. The five or six pairs of leaf-like thoracic limbs are greatly modified for food gathering, which in the

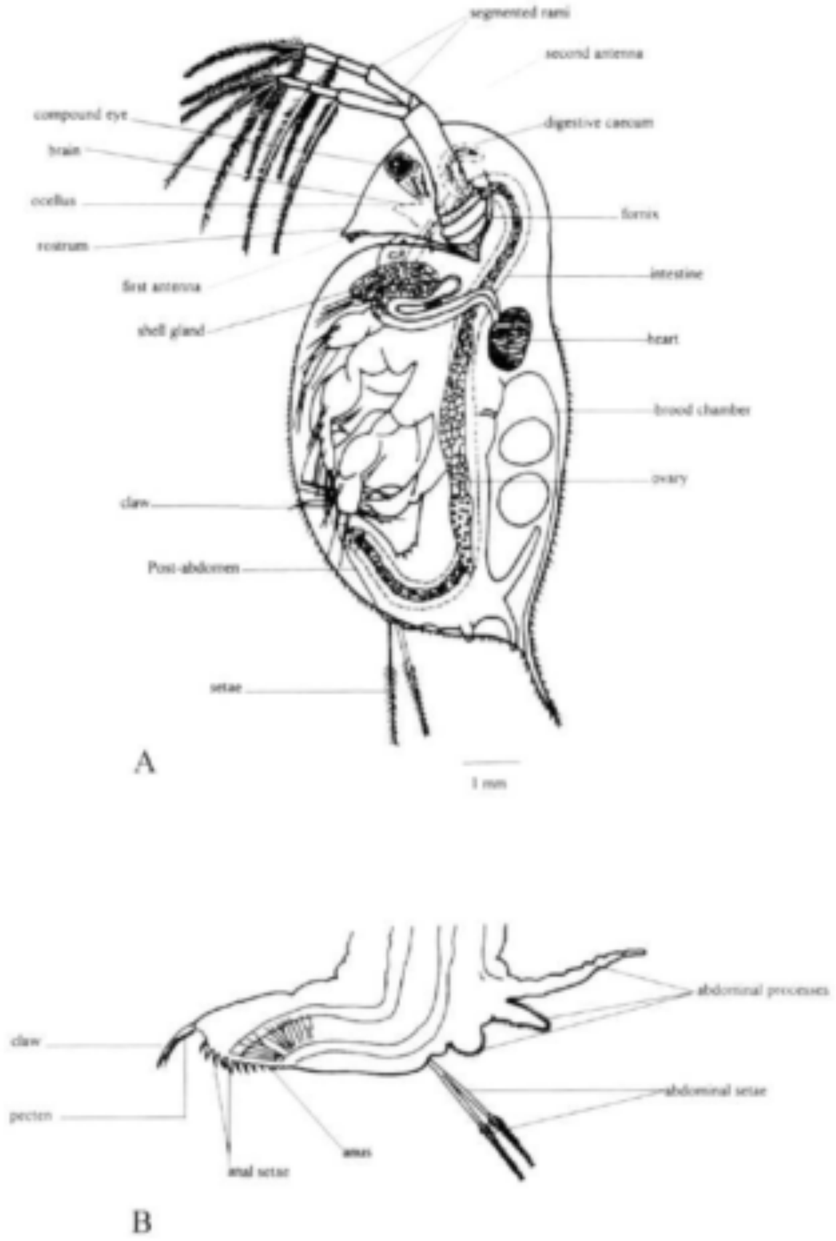

Fig. 4.1. *Daphnia pulex*, showing general anatomical details used in the identification of Cladocera.
A. Adult. B. Post-abdomen.
(A redrawn from Pennak, 1978; B redrawn from Noble & Schaefer, 1967a).

Sididae, Daphiniidae and Bosminidae is by filter-feeding, and in all the other local species by scraping. In the Sididae, all the legs are similar; in the other families the first two pairs may be modified to enable the organisms to cling to the substratum. A characteristic post-abdomen usually bends forward ventrally. Proximally, on its dorsal side, the post-abdomen bears two abdominal setae. At the end of the post-abdomen are two terminal claws.

The concave side of each terminal claw is provided with spines and teeth of various sizes and arrangements. Where there are only a few large spines, they occur near the base of the claw and are referred to as basal spines. Where the spines are minute and of the same length along the greater part of the claw, that part of the claw is said to be denticulate. When spines are intermediate in size between these two extremes they are usually grouped into a row called a pecten or comb. A claw may bear a pecten of intermediate-sized teeth located between the large basal spines and distal denticulation, or (as in *Daphnia*), there may be three pectens with teeth of the same or different sizes. In the Sididae, Halopedidae and Daphnidae, the spines in a single row on either side of the post-abdomen are called the anal spines. The Bosminidae lack these spines, while in the Macrothricidae and Chydoridae there may be one or more rows of lateral spines in addition to the marginal anal spines.

The intestine is simple but may be relatively straight or convoluted. In many species, one or two digestive hepatic caeca lead out of the gut in the head region.

Most individuals are females. Males, which are usually much smaller than females, occur at particular times, or are absent from some populations. Morphologically, males have larger antennules, a shorter rostrum and a hooked first leg, all of which are associated with mating.

Littoral taxa like the chydorids and *Simocephalus* tend to be pigmented, whereas limnetic taxa like *Daphnia pulex* and *Diaphanosoma* are hyaline (i.e. transparent).

The phenomenon of cyclomorphosis, where individuals of a population change the shape of the head throughout a season, has not been found in Southern African populations and seems to be more characteristic of the cold-temperate regions. Considerable variation has, however, been found within some species. The best example is *Daphnia carinata,* formerly known as *D. gibba* in South Africa. Its multiplicity of forms here and elsewhere make this *Daphnia* a taxonomist's nightmare. It can occur in a simple form but may have elaboration of the dorsal surface of the carapace and head. In the most exceptional form, the dorsal surface is produced into a broad crest or extension (Fig. 4.6L). Such an individual was the model for the emblem of the Limnological Society of Southern Africa (forerunner of the present Southern African Society of Aquatic Scientists).

Biology

Most cladocerans are filter-feeders, but some epiphytic and benthic forms are scrapers. Filter-feeding is carried out by means of the thoracic legs, which beat metachronally, so drawing suspensoid-laden water in at the front of the carapace and through the filtering chamber created by the legs within the carapace. Food particles of up to about 50 mm diameter (larger in some of the *Daphnia* species) are filtered from the water. Larger particles are rejected by the post-abdomen. Food is sieved from the water by an imperfectly-understood process involving the setae on the legs and is channeled into a mid-ventral food groove. The concentrated food travels anteriorly along the food groove to the mouth. The mouthparts do not masticate the food but merely direct it into the mouth. Passage through the gut can take as little as seven minutes when food is abundant but much longer passage times are normal and allow for more thorough digestion. When present, hepatic caeca consist of one or two sacs attached to the intestine. They probably store and digest food.

The paired ovaries are elongate and lie alongside the intestine. Eggs are squeezed into highly elongate shapes through the oviduct and into the brood chamber, where they attain their normal shape. The paired testes open near the end of the post-abdomen, which may be modified to form a copulatory organ.

Reproduction is usually parthenogenetic, in which case subitaneous eggs (which have no resting stage) are released into the brood chamber, where they develop. After a few days the juveniles, which look much like small adults, are released into the surrounding water. Two or three days later, the young female individuals may produce eggs in their own brood pouches. Species like *Bosmina longirostris*, in which individuals are small, are known to have fewer offspring. (Up to four relatively large young are produced within three days of their own birth). Species of *Daphnia*, in which individuals are larger, may take five days to produce as many as 20 relatively small young. The numbers of subsequent clutches and of adult instars vary with the population and with environmental characteristics. *Daphnia* females often go through more than 20 instars.

Males are usually produced during times of stress. Mating results in the production of fertilized (resting) eggs, which are surrounded by a hard, resistant shell. In the Sididae (e.g. *Diaphanosoma*) these eggs are released from the brood pouch and sink to the bottom of the water body. In the other families dealt with here the protective shell is known as the ephippium (from the Greek for 'saddle'), which is protected by the moulted carapace of the mother, or part thereof. Some of these sink to the bottom, although in late spring *Daphnia* ephippia commonly float to the surface and are found in large numbers along the shorelines of water bodies, including our larger impoundments.

Parthenogenetic, or asexual, reproduction results in the formation of clones. Consequently, two or more genetically different populations of the same species may occur in adjacent water bodies or even within the same water body. The extent and effect of cloning on genetic diversity is determined by the period between sexual reproduction. Sexual reproduction has not yet been recorded in certain populations in the United States. On the other hand, hybridization between species has been shown to occur naturally. In such cases, large clonal hybrid populations with confusing morphological characteristics can develop.

Throughout the world, species of *Daphnia* seem to be most common in spring. Other taxa are also seasonal. For example, *Diaphanosoma excisum* is associated with the heat of summer, whereas *Moina micrura* is common in very turbid waters soon after heavy summer rains.

Collection and preservation

After preliminary sorting by means of a dissecting microscope, a compound microscope is used for further identification. In most cases, whole specimens can be mounted on their sides on microscope slides, either temporarily in water or lactophenol, or permanently in resin.

In the special case of chydorids, where the head pores are taxonomically important, it is necessary either to use exuviae (empty moulted exoskeletons) or to prepare preserved specimens by boiling them in a 10% solution of KOH for ten minutes. (Note that KOH is caustic and should be used with great caution). Thereafter the specimens are mounted on a slide in a skewed position so that the head-pores can be seen. Even so, the symmetry of the head will not be clear and separation of the head capsule from the rest of the body by microdissection may be necessary.

Systematics of the Southern African Cladocera

The taxonomic position of the Cladocera of Southern Africa is much the same as when Noble & Shaeffer (1967a, 1967b) drew up keys to some of the families and genera of the region. They wrote: 'Several cladoceran genera and species urgently need taxonomic re-evaluation and revision....' This still applies, particularly to the Chydoridae and Daphniidae.

We have followed the policy of selecting all the reliable records of species found in South Africa. Synonymies have been sorted out and the most recent taxonomic divisions have been used. Keys are based on female characteristics only, as males are always uncommon and occur in smaller numbers in almost every sample. The figures given in this chapter are therefore all of adult females. The full taxonomic names as well as a brief overview of distributions and habitat preferences (where these are known) have been summarized in Table 4.1 at the end of this chapter. Note that the distribution records given for each species may be much narrower than the actual distribution ranges.

KEY TO FAMILIES (FEMALES)

1A. Antenna relatively very large, often reaching posterior border of carapace, one branch three-segmented and the other two-segmented (Fig. 4.2A, C); six pairs of thoracic limbs; limnetic .... **Sididae** (p. 88)

1B. Antenna variable in size, seldom reaching posterior border of carapace, both branches at least three-segmented (e.g. Fig. 4.2B–4.3B, D, H); five or six pairs of thoracic limbs; limnetic or benthic 2

2A. Antennule relatively large, fixed, with a non-terminal tuft of olfactory setae (Fig. 4.2B); body small (less than 0.5 mm long); limnetic .... **Bosminidae** (p. 88)

2B. Antennule movable, variable in size, with a terminal tuft of setae (e.g. Fig. 4.3 A, B, D, H); body size variable; limnetic or benthic 3

3A. Rostrum and fornix jointly forming a rounded beak that projects ventrally in front of the antennules; antennae with both branches three-segmented (Figs 4.3A, 4.3L–4.5K); benthic .... **Chydoridae** (p. 89)

3B. Rostrum, if present, not projected into a beak; one antennal branch four-segmented and the other three-segmented (e.g. Fig. 4.3B, D, H); benthic or limnetic 4

4A. Rostrum prominent (with the exception of *Ceriodaphnia*, in which the rostrum is not prominent – Figs 4.7L, 4.8 A,B, D, E, G, H, J, K); antennules small and inconspicuous (Figs 4.3B, 4.6A–4.8L); limnetic .... **Daphniidae** (p. 96)

4B. Rostrum not prominent; antennules large and conspicuous (Fig. 4.3D, H) 5

5A. Head prominent; antennules long, thin and cigar-shaped, inserted ventrally; post-abdomen bearing lateral feathered setae (Figs 4.3D–G, 4.8 M–S); limnetic or benthic .... **Moinidae** (p. 102)

5B. Head not prominent; antennules large and inserted anteroventrally on the head (except in the atypical *Ilyocryptus* Fig. 4.9A); post-abdominal setae simple (Figs 4.3H, I, 4.9A–G); benthic .... **Macrothricidae** (p. 104)

Family **Sididae**

Fig. 4.2A, C

Based on the characteristic number (six) and structure of the thoracic limbs, the Sididae and Holopedidae (not present in South Africa) are grouped together under the Ctenopoda (superfamily Sidoidea in the old classification). Seven genera are recognized within the Sididae. Of these, only the genus *Diaphanosoma* is presently known from South Africa. This genus is characterized by a prominent head with no rostrum, antennules with terminal sensory setae, and a thin, naked flagellum; the ventral part of the valves is inflected and bordered with setae; the female post-abdomen is without anal denticles; the post-abdominal claw has three basal spines; the dorsal antennal ramus is two-segmented, the ventral-three-segmented.

Species identification within the genus is complex and the study of its diversity has long been neglected. Neither of the species known from Southern Africa is endemic.

KEY TO THE SOUTHERN AFRICAN SPECIES OF THE FAMILY SIDIDAE

1A. Ventral part of the carapace inflected, forming a broad, free, inwardly-directed flap; carapace margin with 5–18 posteroventral spinules (Fig. 4.2A).. .... *Diaphanosoma excisum*

1B. Ventral part of carapace gradually inflected without a broad free flap; carapace margin with 9–12 posteroventral spinules (Fig. 4.2C) .... *D. perarmatum*

Family **Bosminidae**

Fig.4.2B

The antennules are continuous with the rostrum, immovable and with prominent olfactory setae either in a lateral (i.e. non-terminal) tuft or scattered on the anteroventral surface. The dorsal antennal ramus is four-segmented and the ventral ramus three-segmented. There is only one South African genus, *Bosmina* Baird, 1845, which can be differentiated into four subgenera (*Bosmina, Neobosmina, Eubosmina* and *Sinobosmina*). *Eubosmina* and *Sinobosmina* do not occur in Africa, *Neobosmina* has been found in West Africa and *Bosmina* is distributed worldwide.

Bosmina is characterized by the post-abdominal claw of the female bearing 4–12 fine long setae in the pecten (Fig. 4.2B) and a distal row of 7–10 tiny spines. The elongate lateral head pores are at the edge of the head shell, above the bases of the antennae.

Only one species, *Bosmina (Bosmina) longirostris* (Fig. 4.2B) is recognized within the subgenus. This cosmopolitan species is widespread in Southern Africa. Varieties described are probably ecomorphs.

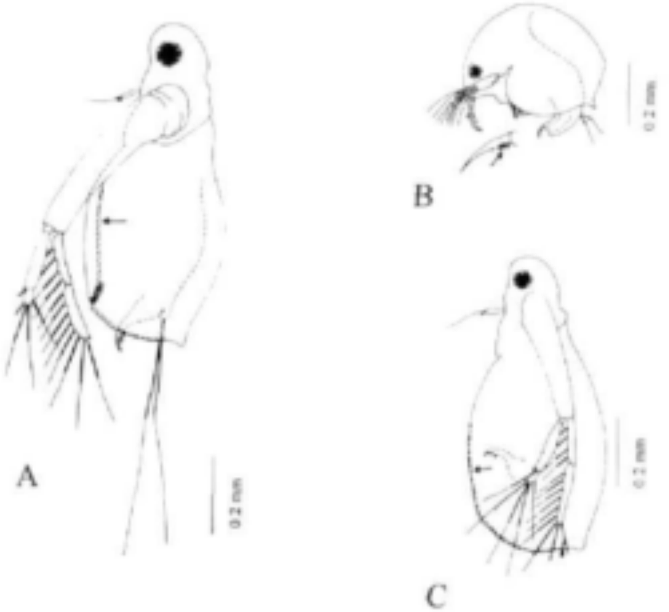

Fig. 4.2. A. *Diaphanosoma excisum*, adult. B. *Bosmina longirostris*, adult. C. *Diaphanosoma perarmatum*, adult.
(A–B redrawn from Noble & Schaefer, 1967a; C redrawn from Brehm, 1933)

Family **Chydoridae**

Figs 4.3A, 4.3L–4.5K

The antennae are small, with three-segmented rami. The intestine is convoluted.

This is taxonomically the most confusing family of cladocerans, because many more species exist than have been described. In a number of cases, what was formerly considered to be a single cosmopolitan species has now been shown to be a group of morphologically similar species on the different continents. In other cases there is doubt about the identity of local species. Until the taxonomy of local species is examined in detail, identification must remain uncertain. To reduce the possibility of adding to the taxonomic confusion, this key is to genera only. Species known to occur in South Africa are mentioned in square brackets. The abbreviations 'gr.' and 'cf.' are according to the late D.G. Frey (pers. comm.), who vetted and added to our list of chydorids found in South Africa.

The term 'gr.' indicates that the species belongs to a group of morphologically similar species and 'cf.' to a taxon that is close to the named form but has not been studied and may in fact be new. '*Chydorus* gr. *sphaericus*', for instance, indicates that the trivial name is known to apply to a species from elsewhere. Most of the taxonomic collections were made in the Western Cape, with a few from north of the Vaal River, especially in the present Gauteng. Actual distributions are probably much wider. David Frey also collected chydorids in KwaZulu/Natal.

KEY TO GENERA OF CHYDORIDAE KNOWN FROM SOUTHERN AFRICA

1A. Anus terminal (Fig. 4.3K); two hepatic caeca; many resting eggs in ephippium or many subitaneous eggs in brood chamber (Fig. 4.3J) .... *Eurycercus* [*E.* gr. *lamellatus*]

1B. Anus sub-terminal (Fig. 4.3L); no hepatic caeca; one egg in ephippium or two subitaneous eggs in brood chamber 2

2A. Compound eye absent, only ocellus present (Fig. 4.3L) .... *Monospilus* [*M. dispar*]

2B. Compound eye present 3

3A. Posterior margin of valves near maximum height (e.g. Fig. 4.4R); most commonly three, sometimes two, major pores on the midline, nearly always connected by a narrow channel and two minor pores widely lateral in position (Fig. 4.4K) 4

3B. Posterior margin of valves much less than maximum height (Fig. 4.5C); only two widely separated major pores, not connected by any kind of channel, and two minor pores located close together on the midline between the two major pores (Fig 4.4A) 11

4A. Post-abdomen very long, slender (Fig. 4.3N), with numerous marginal denticles and lateral scales (Fig. 4.3M) .... *Camptocercus* [probably *C. australis*]

4B. Post-abdomen not very long and slender 5

5A. Valves gaping anteriorly 6

5B. Valves flattened laterally 7

6A. Antennule with very prominent lateral tubercle (Fig 4.4D) bearing sensory setae; two median head pores joined broadly in truncated, hour-glass configuration; lateral pores close in (Fig. 4.4C); setae on ventral margins of valves shortest near gape (Fig. 4.4B) .... *Tretocephala* [*T. colletti*]

6B. Antennule lacking tubercle; two to three major headpores on midline, usually connected by a double sclerotized ridge resembling a channel; minor head pore lateral to these; setae on valve border shortest anterior to gape (Fig. 4.4G) .... *Euryalona* [*E. orientalis*]

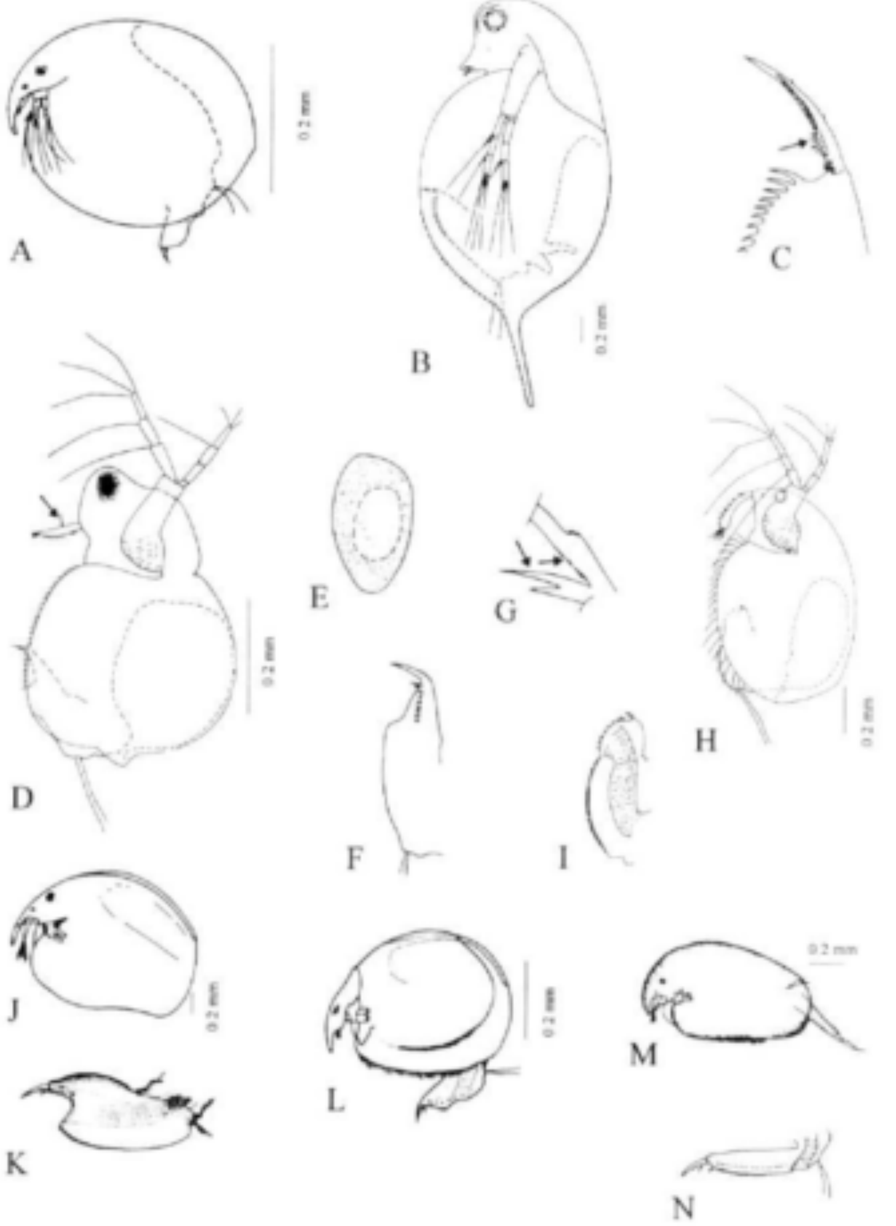

Fig. 4.3. A. *Chydorus sphaericus*, adult. B–C. *Daphnia pulex*. B. Adult. C. Abdominal claw. D–G. *Moina micrura*. D. Adult. E. Egg. F. Post-abdomen. G. Abdominal claw. H– I. *Macrothrix propinqua*. H. Adult. I. Post-abdomen. J–K. *Eurycercus gr. lamellatus*. J. Adult. K. Post-abdomen. L. *Monospilus dispar*, adult. M–N. *Camptocercus australis*. M. Adult. N. Post-abdomen. (A–C & H–I redrawn from Noble & Schaefer, 1967a; D–G redrawn from Goulden, 1968; J–K redrawn from Pennak, 1978; L–N redrawn from Brooks, 1959).

7A. Marginal denticles of post-abdomen greatly reduced, but a lateral row of scales present (Fig. 4.4I); dorsal surface of head and carapace produced into an extension, or crest (Fig. 4.4H) .... *Acroperus* [*A.* gr. *harpae*]

7B. Both marginal and lateral denticles present on post-abdomen (Fig. 4.4L); neither head nor carapace crested 8

8A. Rostrum slightly upturned (Fig. 4.4J); ventroposterior angle of carapace with two teeth; carapace and head with conspicuous reticulation .... *Graptoleberis* [*G.* gr. *testudinaria*]

8B. Rostrum downturned; carapace smooth or sculptured but not reticulate........ 9

9A. Post-abdomen large, broad, flattened, almost semicircular, with post-anal part much expanded and lateral clusters of large spines up to half length of claw (Fig. 4.4N); compound eye smaller than ocellus (Fig. 4.4M) .... *Leydigia*
[possibly *L. macrodonta, L. microps, L. propinqua* or *L. africana*]

9B. Post-abdomen elongate and rather narrow, post-anal part not exceptionally expanded, without clusters of spines (Fig. 4.4 P, Q); compound eye larger than ocellus 10

10A. Post-abdomen slender and narrower distally (Fig. 4.4P), marginal denticles very short proximally, increasing in length distally to three very long curved denticles; terminal claw almost straight with one large bifurcate spine attached distal to base of claw (Fig. 4.4Q) .... *Oxyurella* [*O.* cf. *tenuicaudis*]

10B. Post-abdomen robust and broader distally, distal denticles not conspicuously larger than marginal denticles, terminal claw with a slender basal spine (Fig. 4.4S) .... *Alona*
[possibly *A.* gr. *affinis, A. bukobensis, A. arcuata, A. crassicauda, A.* gr. *diaphana, A. harpularia, A.* gr. *intermedia, A.* gr. *karua, A.* gr. *pulchella, A. striolata, A.* near *guttata, A.* cf. *monacantha* or *A.* cf. *rustica*] (Fig. 4.4 R)

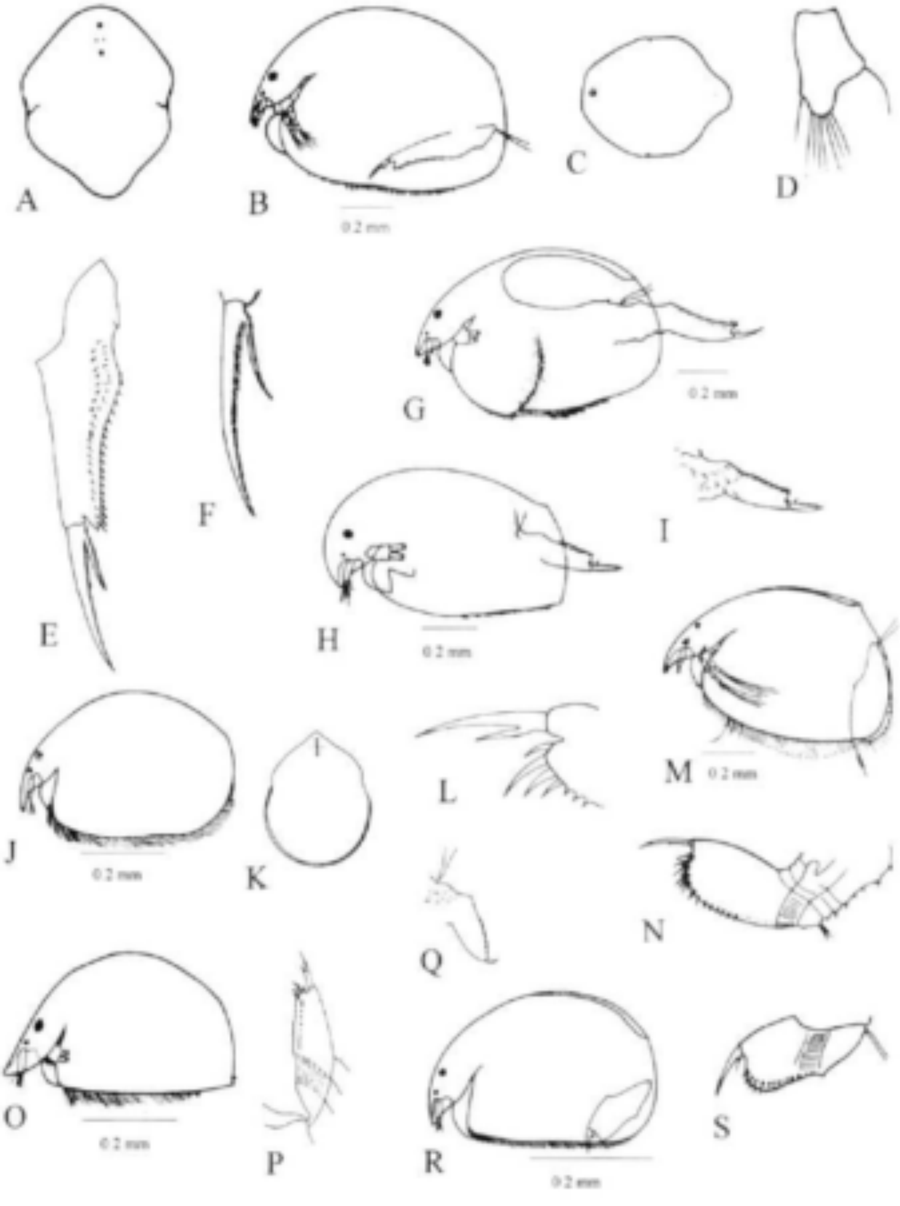

Fig 4.4. A. *Dunhevedia gr.crassa*, carapace, dorsal view. B–F. *Tretocephala colletti*. B. Adult. C. Carapace, dorsal view. D. Antennule of female. E. Post-abdomen. F. Abdominal claw. G. *Euryalona orientalis*, adult. H–I. *Acroperus harpae*. H. Adult. I. Post-abdomen. J–L. *Graptoleberis gr. testudinaria*. J. Adult. K. Carapace, dorsal view. L. Post-abdomen. M–N. *Leydigia macrodonta*. M. Adult . N post abdomen. O–Q. *Oxyurella* cf. *tenuicaudus*. O. Adult. P. Post-abdomen. Q. Abdominal claw. R–S. *Alona gr. affinis*. R. Adult. S. Post-abdomen. (B redrawn from Sars, 1916; A redrawn from Frey, 1962, C, D, E redrawn from Frey, 1965, F redrawn from Harding, 1957, G– L, O–Q, R–S redrawn from Brooks, 1959; N redrawn from Sars, 1916).

11A. Rostrum short, extending only slightly, if at all, beyond the tips of the terminal olfactory setae; post-abdomen robust and broadest immediately behind anus, with many fine marginal denticles and scattered small groups of setae laterally (Fig 4.5 A,B) .... *Dunhevedia* [*D.* gr. *crassa*]
11B. Rostrum long, extending well beyond the tips of the terminal olfactory setae (Fig. 4.5 C,F); post-abdomen variable, with variable size and number of marginal denticles, but lateral setae either clearly in a single row (Fig. 4.5I) or absent (Fig. 4.5 E, H) 12

12A. Body longer than high (Fig. 4.5C); other structures extremely variable 13
12B. Body almost globose (Fig. 4.5 F,J) 14

13A. Two median pores located less than one interpore distance from the posterior edge of the head (Fig. 4.5C, D) .... *Alonella*
[see Table 4.1 for possible species]
13B. Two median pores (Fig. 4.5G) usually located more than one inter-pore distance from the posterior edge of the head (Fig 4.5 F, G–H) ....
....*Pleuroxus* [see Table 4.1 for possible species]

14A. Post-abdomen elongate and roughly rectangular in the region distal to anus; claws with two prominent basal spines of which the distal one is slender and about one-third length of claw; lateral surface with row of fascicle (bundle)-like clusters of setae (Fig. 4.5 I) ....
....*Pseudochydorus* [probably *P.* gr. *globosus*]
14B. Post-abdomen not rectangular, marginal denticles and laterally with crescentic clusters of short spines, which do not resemble fascicles; first basal spine minute (Fig. 4.5 K) 15

15A. Labrum serrated, with four teeth; denticles of post-abdomen shortest in middle row (Fig. 4.5K); posteroventral angle of carapace toothed or with spine-like setae (Fig. 4.5J) ....
....*Ephemeroporus* [probably *E.* gr. *barroisi*]
15B. Labrum smooth; denticles of post-abdomen not markedly dissimilar; posterior ventral angle of carapace smooth and rounded (Fig. 4.3A) ....
.... *Chydorus* [see Table 4.1 for possible species]

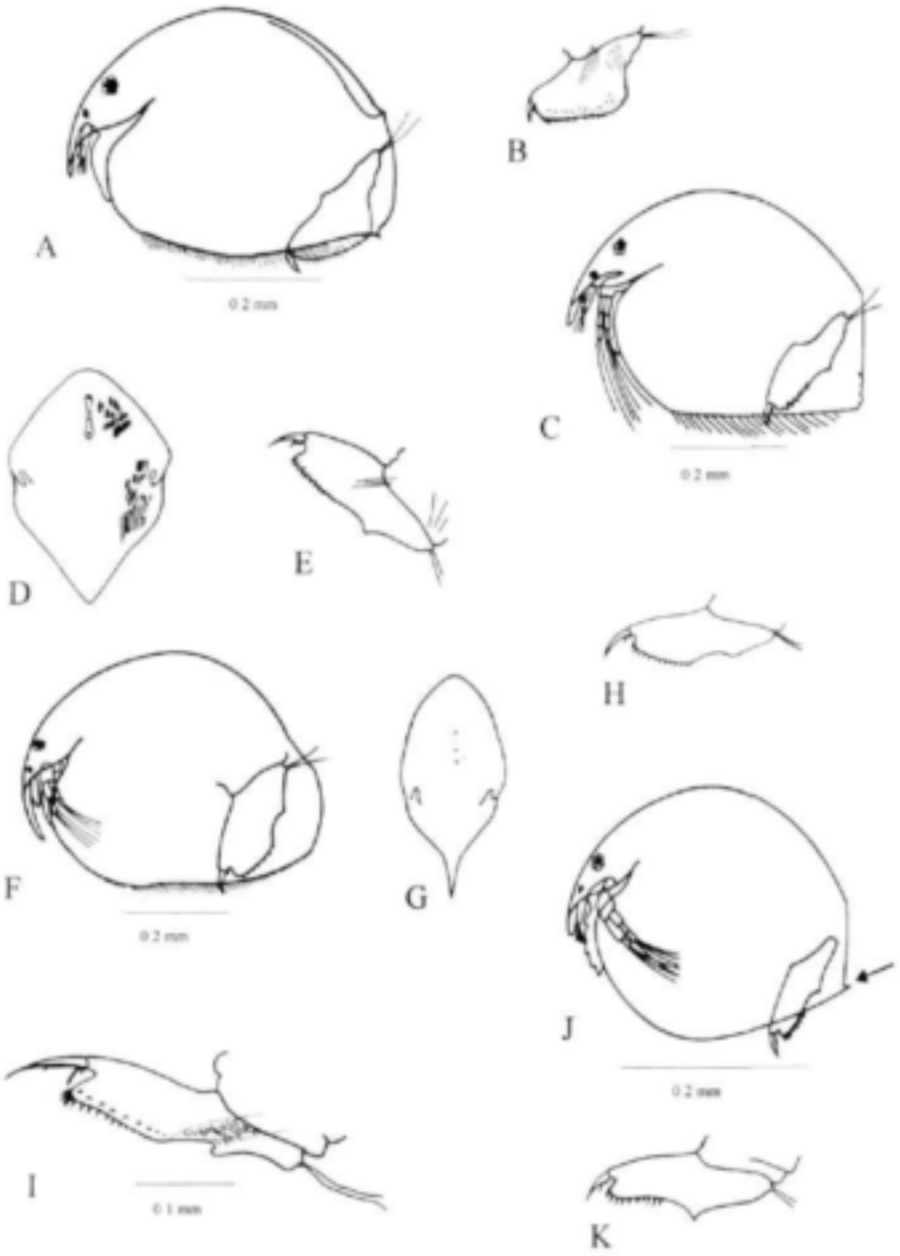

Fig. 4.5. A–B. *Dunhevedia* gr. *crassa*. A. Adult. B. Post-abdomen. C–E. *Alonella* gr. *excisa*. C. Adult. D. Carapace, dorsal view. E. Post-abdomen. F. *Pleuroxus* gr. *aduncus*, adult. G–H. *Pleuroxus laevis*. G. Carapace, dorsal view. H. Post-abdomen. I. *Pseudochydorus* gr. *globosus*, post-abdomen. J–K. *Ephemeroporus* gr. *barroisi*. J. Adult. K. Post-abdomen.
(A–C, E, H redrawn from Sars 1916; I–K redrawn from Brooks, 1959; D,G redrawn from Frey 1962).

Family **Daphniidae**

Fig. 4.1 A–B, 4.3B–C, 4.6A– 4.8L

The antennules are normally small or rudimentary but, when large, are not at the anterior extremity of the head; the dorsal and ventral rami of the antenna are four- and three-segmented respectively; the intestine is not convoluted and has two caeca; the ephippium contains either one or two eggs.

This family contains the best-known cladocerans. The key separates the species of the five genera found in South Africa, of which *Daphnia* is the most speciose. Species of *Daphnia* are predominantly limnetic forms, whereas those of *Simocephalus*, at the other end of the scale, are littoral. The species of the other three genera (*Ceriodaphnia, Scapholeberis* and *Megafenestra*) live in a variety of habitats.

The key initially separates the genera, after which the three polyspecific genera are subdivided into species. The key for the genus *Daphnia* largely follows that of Noble & Schaeffer (1967b), but their *Daphnia gibba* is now named *D. carinata* according to the most recent arguments: its synonymy is very complicated (Benzie 1987). There is uncertainty over the conspecificity of *D. laevis* and *D. longispina* and their namesakes in America, but they are apparently clear entities in the South African context. Among the Daphniidae, the *D. longispina* and *D. laevis* forms found here are different from their 'conspecifics' elsewhere. A thorough study will probably indicate a majority of endemic species.

KEY TO THE SOUTHERN AFRICAN SPECIES OF DAPHNIIDAE

1A. Rostrum prominent; head rounded, total length usually exceeds 1mm (e.g. Fig. 4.3B) 2

1B. Rostrum not prominent; head depressed and small with notch in neck region; total length rarely exceeding 1mm (Figs 4.7L–4.8 L) (*Ceriodaphnia*) 17

2A. Ventral margin of carapace straight and folded inward, modified into an adhesive anchor-plate (Fig. 4.6A, B) 3

2B. Ventral margin of carapace convex, not so modified (e.g. Fig. 4.3B) 4

3A. Ocellus elongate; dorsum of head-shield with a large median window-shaped oval plate; ridge from fornix, over eye, to rostrum; head straight in lateral outline in front of eye (Fig. 4.6A) .... *Megafenestra aurita*

3B. Ocellus rounded; fornix ridge not extended beyond eye, but second ridge below eye extends from fornix to rostrum; head concave in lateral outline in front of eye (Fig. 4.6B) .... *Scapholeberis kingi*

4A. Cervical notch present (arrowed in e.g. Fig. 4.7H); head small, rostrum reduced; one ephippial egg (*Simocephalus*) 15

4B. Cervical notch absent, or if present, together with a long shell spine (at least four times as long as it is broad); head large and rounded, rostrum obvious (e.g. Fig. 4.3B); two ephippial eggs (*Daphnia*) 5

5A. Carapace continuing anteriorly on to head along mid-dorsal line as median strip between halves of head-shield (Fig 4.6O); head-shield never extending posteriorly; fornix projecting laterally; eggs lying obliquely to the dorsal margin of the ephippium (Fig. 4.6C) (subgenus *Ctenodaphnia*) 6

5B. Apex of head-shield projecting posteriorly along mid-dorsal line on to carapace, head-shield ending posteriorly in the mid-dorsal line as a backwardly-directed point; fornix not projecting laterally; eggs perpendicular to dorsal margin of ephippium (Fig. 4.3B) (subgenus *Daphnia*) 12

6A. Marked indentation of post-abdomen at level of anus (Fig. 4.6D, G); weak extension of carapace on to head 7

6B. No indentation or slight indentation of post-abdomen at level of anus; very marked extension of carapace on to head 8

7A. Posterior margin of post-abdomen deeply indented at level of anus, at which point marginal teeth briefly interrupted (Fig. 4.6D); head with longitudinal ridge on either side of mid-line (Fig. 4.6C); females up to five mm long .... *Daphnia magna*

7B. Posterior margin of post-abdomen somewhat indented at level of anus, marginal teeth on post-abdomen not interrupted at the anus (Fig. 4.6G); head may (Fig. 4.6E) or may not (Fig. 4.6F) be produced as a pointed helmet; females up to four mm long .... *Daphnia lumholtzi*

8A. A characteristic terminal broadening of the carapace extension on to the head in the form of a small button or a large plate (Fig. 4.6J, position arrowed in Fig. 4.6H, K); head usually pointed anterodorsally 9

8B. Carapace extension into head tapers to a point, but may first broaden (Fig. 4.6L) 10

9A. Rostrum with a row of spines forming a 'moustache'; mid-dorsal extension of carapace terminating in a slightly expanded button (Fig. 4.6I), a ridge running down from the apex of the head almost to the insertion of the antenna (Fig. 4.6H); females up to 1.8 mm long.......... *Daphnia barbata*

9B. Rostrum with no 'moustache'; mid-dorsal extension of carapace into head forming a broad plate, sometimes extending laterally as far as the level of the antennal origins; well-developed fornix terminating anterior to the eye and contiguous posteriorly with a well-developed spinose lateral ridge on the carapace (Fig. 4.6J); females up to three mm long .... *Daphnia coronata*

10A. Head rounded in lateral view (Fig. 4.6L); in cyclomorphic forms, the dorsal margin of both head and carapace extend as a thin keel in the plane of symmetry (Fig. 4.6K); spinules on the dorsal shell margin extending only a short distance in front of the spine; females up to 4 mm long.......... *Daphnia carinata*

10B. Head rounded or flattened anteriorly or slightly indented behind the eye; spinules on dorsal shell margin extending anteriorly to level of head (Fig 4.6M) 11

11A. Tip of rostrum slightly rounded; antennular setae reaching tip of rostrum; head slightly indented anteriorly dorsal to eye (Fig. 4.6M); females up to 3 mm long .... *Daphnia dolichocephala*

11B. Tip of rostrum acutely pointed; antennular setae not reaching tip of rostrum; head not indented (Fig. 4.6N); females up to 3.5 mm long .... *Daphnia similis*

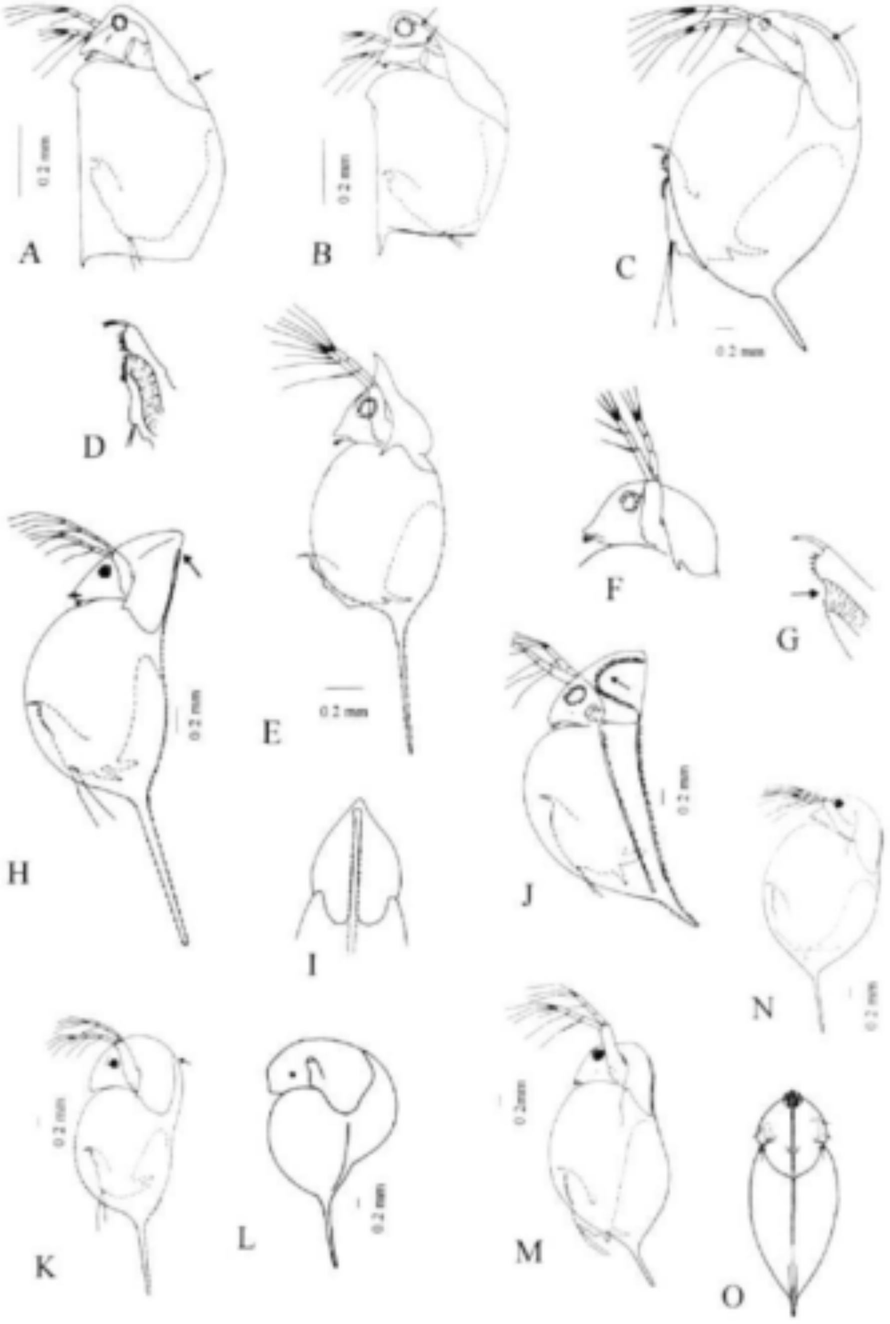

Fig. 4.6. A. *Megafenestra aurita*, adult. B. *Scapholeberis kingi*, adult. C–D. *Daphnia magna*. C. Adult. D. Post-abdomen. E–G. *Daphnia lumholtzi*. E. Adult. F. Head. G. Post-abdomen. H–I. *Daphnia barbata*.
H. Adult. I. Head, dorsal view. J. *Daphnia coronata*, adult. K–L. *Daphnia carinata*. K. Adult.
L. Adult., cyclomorphic form. M. *Daphnia dolichocephala*, adult . N. *Daphnia similis*, adult.
O. *Ctenodaphnia* carapace, dorsal view.
(A–N redrawn from Noble & Schaefer, 1967*a*, O redrawn from Brooks, 1959).

12A. Post-abdominal claw with teeth of the proximal, middle and distal pectens more or less equal in length (Fig. 4.7B); females up to 2 mm long 13
12B. Post-abdominal claw with teeth of the middle pecten much longer than those of the proximal and distal pectens (Fig. 4.3C); females up to 3 mm long 14

13A. Head without crest and deeper dorsoventrally than long anteroposteriorly; ventral margin of head concave in lateral view; antennular setae reaching tip of rostrum (Fig. 4.7A) .... *Daphnia longispina*
13B. Head usually crested and longer than broad; ventral margin of head more or less straight in lateral view and posterodorsal margin of head concave; antennular setae not reaching tip of rostrum (Fig. 4.7C)......... *Daphnia laevis*

14A. Inner mid-ventral margin of carapace bearing a short row of long setae (Fig. 4.7E); antennule on a distinct prominence (Fig. 4.7D) ....*Daphnia obtusa*
14B. Inner ventral margin of carapace smooth; antennule arising simply (Fig. 4.3B) ....*Daphnia pulex*

15A. Postabdominal claw with lateral pecten proximally; ocellus round or rhomboidal (Fig. 4.7F, G)................ *Simocephalus exspinosus*
15B. Postabdominal claw with uniformly short teeth along entire length, ocellus elongate (Fig. 4.7I) or rhomboidal (Fig. 4.7G) or triangular (Fig. 4.7K) 16

16A. Vertex ('top' of head) evenly rounded about eye and without serrations or spinules (Fig. 4.7H); ocellus elongate (Fig. 4.7I) ....*Simocephalus vetulus*
16B. Vertex more or less angulate with serrations or spinules in front of or below the eye (Fig. 4.7J); ocellus triangular (Fig. 4.7K).. *Simocephalus serrulatus*

17A. Posterior part of post-abdomen obliquely truncated (Fig. 4.7N) 18
17B. Post-abdomen protuberant at level of anus (Fig. 4.8C, F) 19

18A. Head produced in front of antennules into a short, horn-like process (Fig. 4.7L, M); post-abdomen with 5–6 anal spines (Fig. 4.7N) ....*Ceriodaphnia rigaudi*
18B. Head not produced (Fig. 4.7O, P); post-abdomen dilated between anus and claw, with 8–11 anal spines (Fig. 4.7Q); animal may be bright red in colour.................... *Ceriodaphnia laticaudata*

19A. Post-abdominal claw with proximal pecten (e.g. upper arrow in Fig. 4.8F) 20
19B. Post-abdominal claw without pecten (arrow in Fig. 4.8I) 21

20A. Posterior angle of carapace produced into a short, conspicuous conical spine (Fig. 4.8A) .... *Ceriodaphnia producta*
20B. Posterior angle of carapace evident but not produced into a spine (Fig. 4.8D) ....*Ceriodaphnia reticulata*

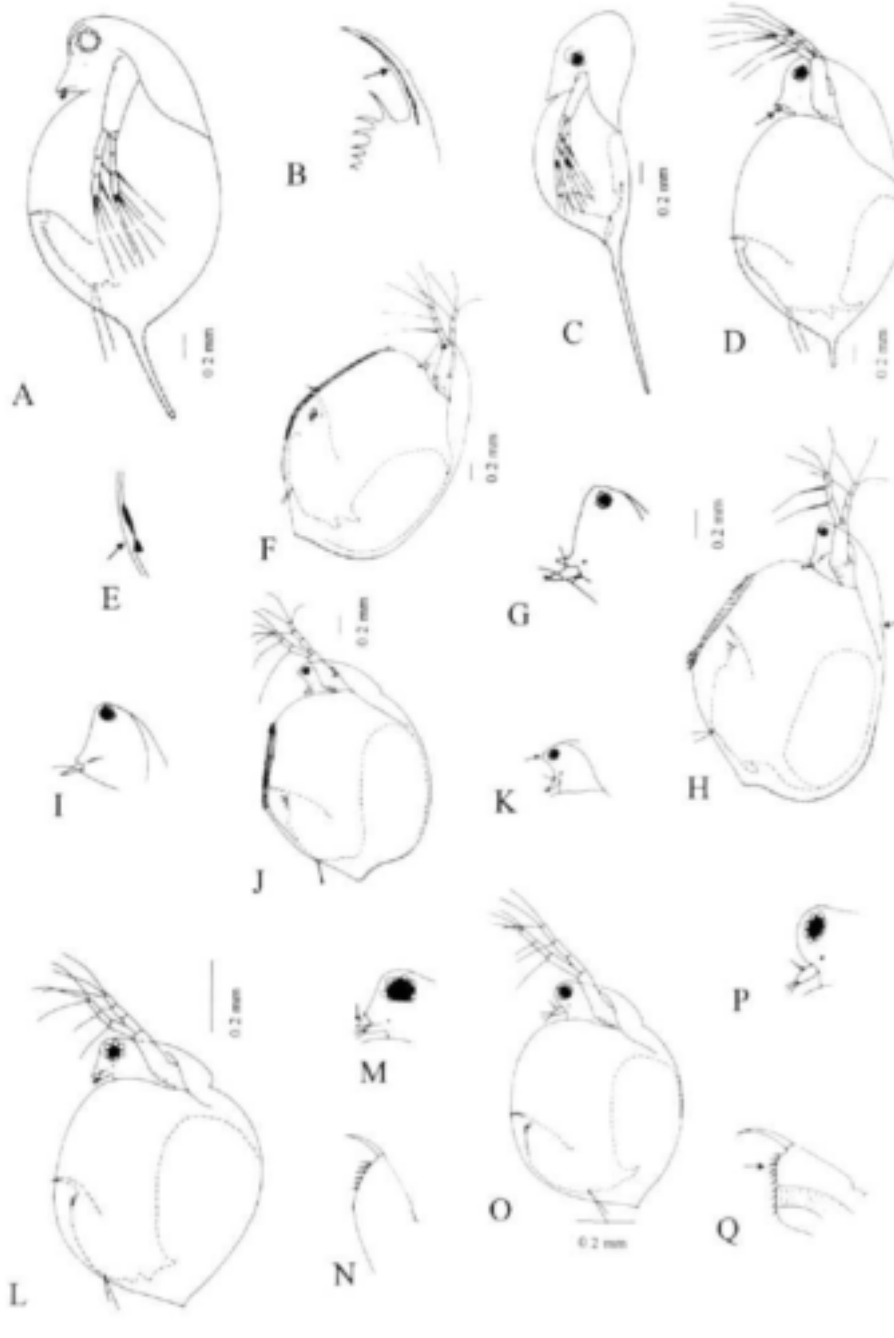

Fig. 4.7. A–B *Daphnia longispina*. A. Adult. B. Abdominal claw. C. *Daphnia laevis*. Adult. D–E. *Daphnia obtusa*. D. Adult. E. Carapace with setae. F–G. *Simocephalus exspinosus*. F. Adult. G. Head. H–I. *Simocephalus vetulus*. H. Adult. I. Head. J–K. *Simocephalus serrulatus*. J. Adult. K. Head. L–N. *Ceriodaphnia rigaudi*. L. Adult. M. Head. N. Post-abdomen. O–Q. *Ceriodaphnia laticaudata*. O. Adult. P. Head. Q. Post-abdomen.

(A–E redrawn from Noble & Schaefer, 1967a; F–Q redrawn from Sars, 1916)

21A. Anal spines approximately eight in number (Fig. 4.8I); posterior angle of carapace well dorsal of midline of body, which has a quadrangular appearance as a result (Fig. 4.8G) .... *Ceriodaphnia quadrangula*

21B. Anal spines approximately 10 in number (Fig. 4.8L); posterior angle of carapace only slightly dorsal of midlane of bady, where the posterior angle tends to point directly backwards, rather than upward. (Fig. 4.8J).. *Ceriodaphnia dubia*

Family **Moinidae**

Fig. 4.3D–G, 4.8M–S

The long thin antennules, arise from the ventral margin of the prominent head, which lacks a rostrum. There is a single, non-terminal sensory seta anteriorly on the antennule (Fig. 4.8R). The post-abdomen has a row of lateral feathered setae (Fig. 4.3F) and one distal bidentate tooth (Fig. 4.3G). The abdominal process(es) found in Daphniidae (Fig. 4.1B) are completely absent in the Moinidae. In old females a horseshoe-shaped ridge is found which closes the brood cavity.

Two genera are recognized, namely *Moina* and *Moinodaphnia*, but only *Moina* occurs in South Africa. The majority of *Moina* species are restricted to small temporary pools or saline or alkaline water bodies.

Although many species have been described, only about 20 are now considered valid. Four species are known from South Africa.

KEY TO THE SOUTHERN AFRICAN SPECIES OF MOINA

1A. Long hairs on head and carapace; setae on posterior carapace rim of equal size and ungrouped (Figs. 4.8M, P); head without a distinct supra-ocular depression (Fig. 4.8M, P); two eggs in ephippium (Fig. 4.8N) 2

1B. Long hairs only on ventral surface of head or completely absent; setae on posterior carapace rim in groups; head with distinct supra-ocular depression (Fig. 4.8R); one egg in ephippium (Fig. 4.3E) 3

2A. Abdominal claw without pecten (Fig. 4.8O) .... *Moina belli*

2B. Abdominal claw with distinct pecten (Fig. 4.8Q) .... *Moina tenuicornis*

3A. Hairs present only on ventral surface of head behind antennules; pecten on abdominal claw very large (Fig. 4.8S); body length 1.2—1.6 mm .... *Moina brachiata*

3B. Hairs completely absent from head (Fig. 4.3D); pecten on abdominal claw short (Fig. 4.3G), body length less than 1.2 mm .... *Moina micrura*

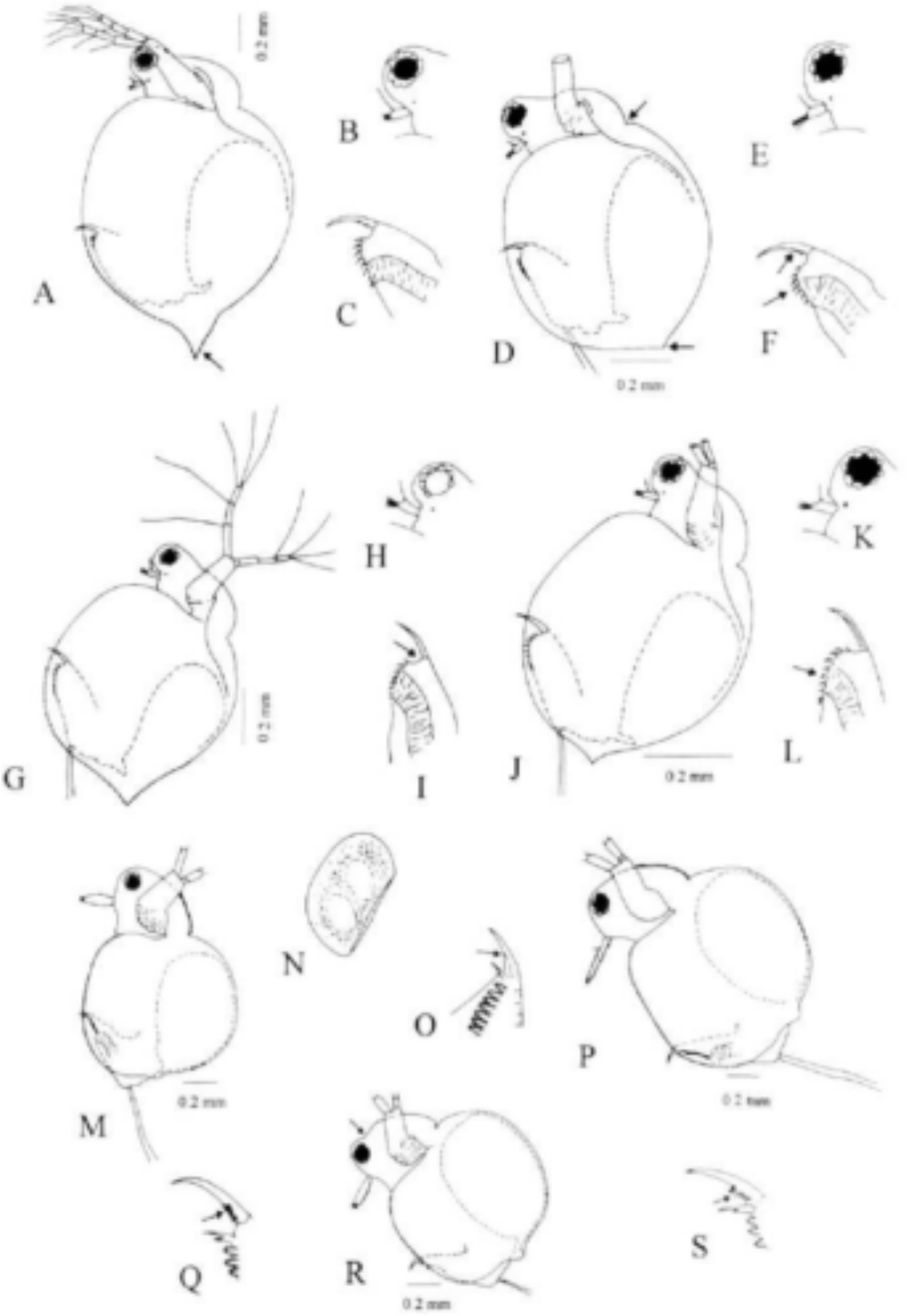

Fig. 4.8. A–C. *Ceriodaphnia producta.* A. Adult. B. Head. C. Post-abdomen. D–F. *Ceriodaphnia reticulata.* D. Adult. E. Head. F. Post-abdomen. G–I. *Ceriodaphnia quadrangula.* G. Adult. H. Head. I. Post-abdomen. J–L. *Ceriodaphnia dubia.* J. Adult. K. Head. L. Post-abdomen. M–O. *Moina belli.* M. Adult. N. Egg. O. Abdominal claw. P–Q. *Moina tenuicornis.* P. Adult. Q. Abdominal claw. R–S. *Moina brachiata.* R. Adult. S. Abdominal claw.
(All figures redrawn from Sars, 1916).

Family **Macrothricidae**

Fig. 4.3H–I, 4.9A–G

Macrothricids are found mostly in vegetated littoral areas, often on or near the bottoms of lakes and wetlands. The large moveable antennules are conspicuous and are usually inserted at or near the anterior end of the ventral surface of the head, except in *Ilyocryptus* (Fig. 4.9A) which is somewhat atypical.

Three genera and five species are presently known from Southern Africa.

KEY TO THE SOUTHERN AFRICAN SPECIES OF MACROTHRICIDAE

1A. Abdominal claw nearly as long as the antennules with two long slender basal spines; antennules inserted posterior to rostrum, two-segmented (Fig. 4.9A) (*Ilyocryptus*) 2

1B. Abdominal claws shorter than half the length of the antennules; basal spines of abdominal claws absent (Figs 4.3I, 4.9E, G); antennules inserted at antero-ventral extremity of head; antennules one-segmented (Figs 4.3H, 4.9D, F) 3

2A. Dorsal edge of post-abdomen indented at position of anus, anus opening in middle of dorsal margin (Fig. 4.9B) .... *Ilyocryptus sordidus*

2B. Dorsal edge of post-abdomen a continuous curve, anus opening almost terminally (Fig. 4.9C*)* .... *Ilyocryptus acutifrons*

3A. Antennules nearly a straight rod, slender and not broadened at tip (Fig. 4.9D); head with anterolateral ridges and a conspicuous bulge in the ventral edge immediately behind the antennules (Fig. 4.9D) .... *Echinisca* (species name uncertain)

3B. Antennules slightly curved, broadened at tip; head without anterolateral ridges or ventral bulge (Figs 4.3H, 4.9F) (*Macrothrix*) 4

4A. Surface of carapace shell smooth (Fig. 4.3H); body close to 1 mm long .... *Macrothrix propinqua*

4B. Surface of carapace sculptured with closely set squamous ridges (Fig. 4.9F); body about 0.5 mm long .... *Macrothrix spinosa*

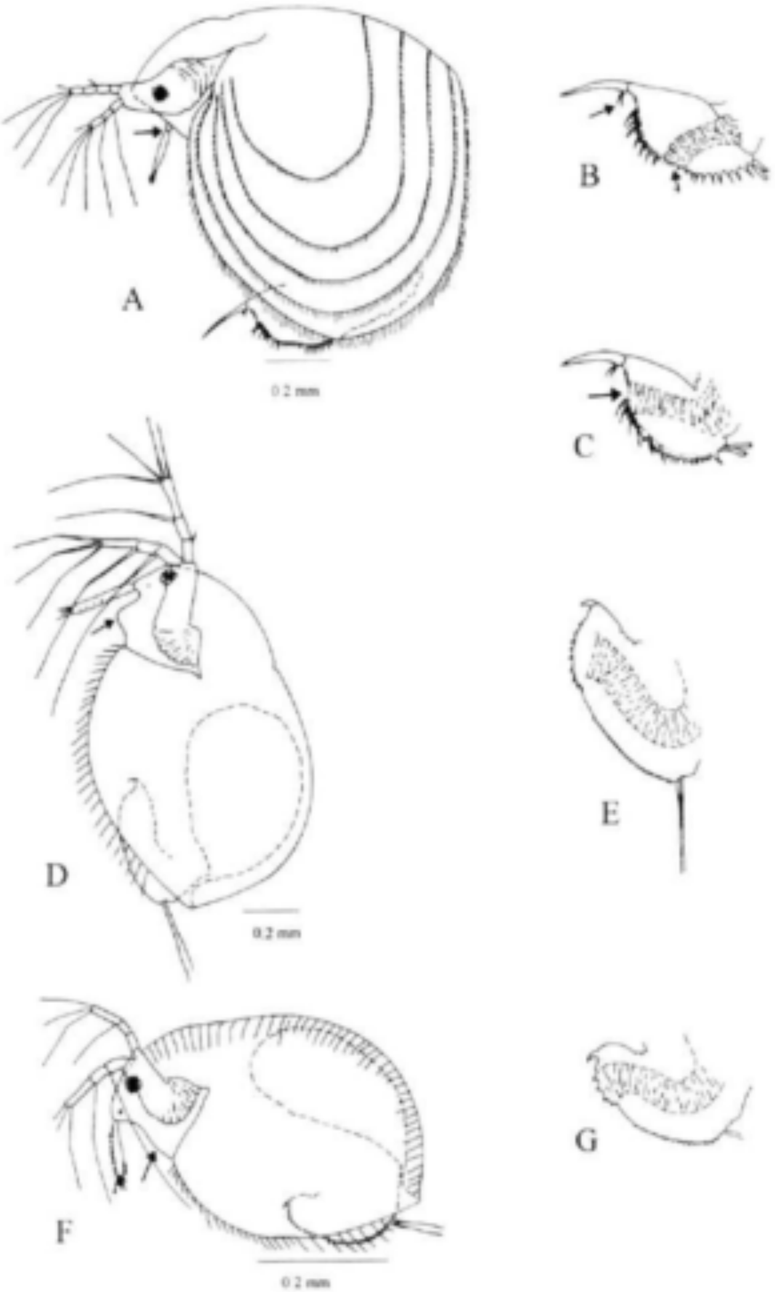

Fig. 4.9. A–B. *Illyocryptus sordidus*. A. Adult. B. Post-abdomen. C. *Illyocryptus acutifrons*., post-abdomen. D–E. *Echinisca*. D. Adult. E. Post-abdomen. F–G. *Macrothrix spinosa*. F. Adult. G. Post-abdomen.
(A–B & D–G redrawn from Sars, 1916; C redrawn from Brooks, 1959.)

Table 4.1. List* of taxa mentioned in this chapter together with notes on distribution and habitat preference (where such information is available). (See ** for key to symbols).

Taxon	**Systematics, distribution and habitat preferences**
Diaphanosoma excisum Sars 1886	Cosmopolitan
Diaphanosoma perarmatum Brehm 1933	Namibia
Eurycercus [*E.* gr. *lamellatus* (O.F. Müller 1776)]	
Monospilus [*M. dispar* Sars 1861]	
Camptocercus [probably *C. australis Sars* 1885*]*	
Tretocephala [*T. colletti* (Sars 1895)]	
Euryalona [*E. orientalis* (Daday 1898)]	
Acroperus [*A.* gr. *harpae* Baird 1843]	
Graptoleberis [*G.* gr. *testudinaria* (Fischer 1848)]	
Leydigia (Kurz 1874)	Possibly *L. macrodonta, L. microps, L. propinqua* or *L. africana*
Oxyurella [*O. cf tenuicaudis* (Sars 1862)]	

* This table must NOT be regarded as a checklist of all cladoceran species in southern Africa

** KEY
Square brackets [ ] = Species known to occur in South Africa
'gr' = species belongs to a group of morphologically similar species
'cf' = a taxon that is close to the named form but has not been studied and may represent a new species

Table 4.1 (Cont.)

Taxon	**Systematics, distribution and habitat preferences**
Alona Baird 1850	[Possibly *A.* gr. *affinis*, *A. bukobensis*, *A. arcuata*, *A. crassicauda*, *A.* gr. *diaphana*, *A. harpularia*, *A.* gr. *intermedia*, *A.* gr. *karua*, *A.* gr. *pulchella*, *A. striolata*, *A.* near *guttata*, *A.* cf. *monacantha* or *A.* cf. *rustica*]
Dunhevedia [*D.* gr. *crassa* King 1853]	
Alonella Sars 1862	[Possibly *A.* gr. *excisa*, *A.* gr. *hamulata*]
Pleuroxus Baird 1843	[Possibly *P.* gr. *aduncus* or *P.* gr. *laevis*]
Pseudochydorus [probably *P.* gr. *globosus* (Baird 1843)]	
Ephemeroporus [probably *E.* gr. *barroisi* (Richard 1894)]	
Chydorus Leach 1843	[Possibly *C.* gr. *sphaericus*, *C.* gr. *piger* or *C. pubescens*]
Megafenestra [only one local species, *M. aurita* (Fischer 1849)]	Cosmopolitan
Scapholeberis [only one local species, *S. kingi* Sars 1903]	Cosmopolitan
Daphnia magna Strauss 1820	Cosmopolitan in temperate areas. Common in ponds.
Daphnia lumholtzi Sars 1885	Tropical Africa, Australia, Asia
Daphnia barbata Weltner 1897	Widespread in Africa
Daphnia coronata Sars 1916	Cosmopolitan. Locally in organically-rich Highveld pans.
Daphnia carinata King 1853	South-east Asia, common limnetic dominant in Highveld impoundments with calanoid copepods *Lovenula* and *Metadiaptomus*
Daphnia dolichocephala Sars 1895	Africa
Daphnia similis Claus 1876	Cosmopolitan

Table 4.1 (Cont.)

Taxon	**Systematics, distribution and habitat preferences**
Daphnia longispina O.F. Müller 1785	Europe, Asia and Africa. Common limnetic dominant with *D. pulex*.
Daphnia laevis Birge 1878	North and Central America, Africa
Daphnia obtusa Kurz 1874	Temperate North and South America, Europe, Asia and southern Africa
Daphnia pulex Leydig 1860	Cosmopolitan. Most common limnetic dominant.
Simocephalus exspinosus (Koch 1841)	Cosmopolitan, littoral
Simocephalus vetulus Schödler 1858	Cosmopolitan, littoral
Simocephalus serrulatus (Koch 1841)	Cosmopolitan, littoral
Ceriodaphnia rigaudi Richard 1894	Cosmopolitan. Ponds.
Ceriodaphnia laticaudata P.E. Müller 1867	Cosmopolitan. Ponds.
Ceriodaphnia producta Sars 1896	Cape Flats (WC). Ponds.
Ceriodaphnia reticulata (Jurine 1820)	Cosmopolitan. Limnetic, common in impoundments.
Ceriodaphnia quadrangula (O.F. Müller 1785)	Cosmopolitan. Ponds.
Ceriodaphnia dubia Richard 1895	South-east Asia, Australia, New Zealand, Africa. Ponds.
Moina belli Gurney 1904	Africa, Middle East. Temporary waters.
Moina tenuicornis Sars 1896	Southern Africa, Australia. Ponds.

Table 4.1 (Cont.)

Taxon	**Systematics, distribution and habitat preferences**
Moina brachiata (Jurine 1820)	Europe, Asia, Africa. Ponds.
Moina micrura Kurz 1874	Cosmopolitan. Tropical and sub-tropical, common in temporary waters, ponds and impoundments. Some tolerance for salinity.
Ilyocryptus sordidus (Liéven 1848)	Cosmopolitan. In bottom sediments.
Ilyocryptus acutifrons Sars 1862	North America, Europe, Asia, Africa.
[*Echinisca* Liéven 1848]	May be endemic to the Western Cape Province. Species names uncertain.
Macrothrix propinqua Sars 1909	Western Cape Province; also South Georgia (South Atlantic), the Falklands and Australia.
Macrothrix spinosa King 1852	Australia, South America, Southern Africa.

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GLOSSARY

abdomen	the third and most posterior tagma or division of the body of some animals (the first being the head and the second the thorax); in branchiopod crustaceans, usually without appendages except for a pair of caudal rami (qv)
acute	at a sharp angle (less than 90°)
adaptation	the accumulation of inherited modifications that suit an organism to its environment or to its way of life
adductor muscle	in bivalved crustaceans a muscle, or one of a series of muscles, that closes the valves
antenna	(= antenna 2, second antenna): the jointed, sensory second appendage on the head of most crustaceans (see *antennule*)
antennal process	prominent, most obvious part of the antenna in streptocephalid anostracans, leading from the basal joint and with the terminal joint lying parallel to it.
antennal ramus	branch-like structure on the antenna (Cladocera)
antennule	(= antenna 1, first antenna): the small, sensory first appendage on the head of most crustaceans (much reduced in some branchiopods, especially the notostracans) (see *antenna*)
anterior	the 'front end'
anus	the posterior opening of the digestive tract (*adj*. anal)
apex	tip
apical	referring to the tip
apodal	without limbs
appendage	in crustaceans, any of the paired, articulated structures attached to each somite (e.g. antennae, maxillipeds, pereiopods) (qv)
articulated	jointed
athalassic	non-marine; of aquatic systems, those having no contact with the sea
atrium oris	the pre-oral cavity, bounded laterally by mouthparts
bacteria	primitive micro-organisms with no nucleus
basal joint	proximal part of the antenna of anostracans that is attached to the head
basal process	one or two processes or structures attached medially / anteriorly to the fused basal joints of the antennae of branchipodid anostracans
basal spine	in cladocerans, a spine near the base of the postabdominal claw (qv)
benthic	pertaining to, or living on, the bottom
bifid	forked into two 'prongs'
biramous	having two branches (the archetypal crustacean appendage is said to be biramous, consisting of outer exites and inner endites - qv.)

bivalved	having a carapace divided into two 'shells' or valves
body ring	in notostracans, posterior somites that fuse and are covered by a single band of exoskeleton
brood chamber	intermal cavity in which eggs are brooded (Cladocera)
brood pouch	external pouch in which fertilized eggs are maintained until deposition (Anostraca)
caecum	an internal, finger-like sac
carapace	a shield-like or bivalved cuticular extension covering most or all of an animal
carina	a crest (= keel)
caudal	pertaining to the `tail' or posterior end
caudal furca	tail fork
caudal ramus	tail filament: in *Triops* (Notostraca) one of a pair of long, segmented structures projecting posteriorly from the telson
cephalon	in crustaceans, the fused anterior-most somites that together make up the head tagma (qv)
cephalothorax	the body region formed by the fusion of the head and thorax
cercopod	(Cladocera): a jointed appendage at the end of the abdomen; (Anostraca): (= caudal furcae) tail forks attached to the last abdominal segment
cervical notch	groove across dorsal surface of cephalothorax in the 'neck' region of certain crustaceans
cheliform	pincer or nipper-like
chitinous	made of chitin - the tough, usually brownish, material that forms the major portion of the exoskeletons of most arthropods
clasper	an appendage in the male modified for holding the female during copulation (in conchostracans, the modified first (or first and second) thoracopods (qv)
class	a taxon below phylum and above order
claw (terminal)	one of a pair of stout spines on the tips of the postabdomen (qv) of cladocerans
clone	one of a group of genetically identical individuals
clypeus	the part of the head carrying the labrum (qv) (but in anostracans, the anterior head plate formed by fusion of the basal segments of the second antennae)
cohort	a group of conspecifics (qv) of roughly the same age
compound eye	an eye consisting of separate light receptors, showing several to many facets
conspecific	of the same species
cosmopolitan	of world-wide distribution
coxal lobe	in conchostracans, the proximal endite of a thoracopod (qv)
crest	a mid-dorsal ridge on the head
cyclomorphosis	cyclical, recurrent morphological changes, particularly in the

	shape of the helmet, in cladocerans
cyst	a thin-walled, usually hardened, protective capsule containing a dormant egg or larva (cf *resting egg*)

dentate	toothed
denticle	a small tooth
denticulate	bearing small teeth
detritus	organic remains (e.g. dead leaves, bark, particulate organic matter, animal bodies or parts thereof)
diapause	period of suspended development or growth, accompanied by greatly decreased metabolism
digitate	divided into fingers
digitiform	finger-like
dilated	expanded
direct development	development from egg to adult with no intervening larval stages (qv)
distal	the part of a structure furthest from the mid-line of the body or the point of its attachment (opposite = proximal)
dorsal	referring to the upper surface (the `back') of an organism
dorsal appendage	(= frontal organ - qv)
dorsal filament	in female conchostracans, filamentous extensions of some thoracopods to which eggs are attached

egg sac	an external sac containing eggs
elongate	long
endemic	referring to organisms found only in a particular area
endite	medially-directed expansion of the protopodite (coxa or basis) of a crustacean limb: in phyllopodous limbs up to six in number, of which the distal is the endopod (qv)
endopod	(= endopodite): see endite (qv): in phyllopodous limbs the endopod is usually short and unsegmented but in stenopodous biramous limbs forms the 'walking leg'
entire	complete, without breaks or notches
ephippium	a hardened, resistant dorsal part of the carapace of female cladocerans into which resting eggs are deposited
epiphytic	of crustacenas, living on the surfaces of plants
epipod(ite)	:a laterally directed, unsegmented exite (qv), often respiratory in function
epipodal lamella	(also spelt 'epipodal lamina'): a flattened epipodite in conchostracans
exite	a flattened, laterally directed, expansion of the protopodite (coxa or basis) of a crustacean limb; includes exopod and epipod (qv)
exopod	(= exopodite): see exite (qv): in phyllopodous limbs the endopod is usually unsegmented but in stenopodous

	biramous limbs it may be segmented and used for swimming
exoskeleton	(= cuticle, integument) the external chitinous covering of crustaceans and other arthropods, often hardened in places with calcium carbonate or by tanning
exuvium	the moulted exoskeleton of an arthropod
family	a taxonomic category below order and above genus
fascicle	a bundle or group (of setae)
fecundity	fertility, usually expressed as numbers of offspring produced by an individual span
feeding current	in filter feeders, the current that brings food particles to the mouthparts
filamentous	thread-like
filter chamber	a chamber, usually formed between body wall and appendages, in which filter-feeding takes place
filter feeder	an animal that feeds by filtering small particles out of the water
finger	lower or ventral, tapered and terminal part of the hand region of the antenna of streptocephalid anostracans.
flagellum	(pl. flagella): a long, multi-articulated part of an appendage
foliaceous	leaf-like
food groove	in some filter feeders, the midventral groove along which food is passed to the mouth
fornix	a ridge on the lateral part of the head above the insertion of the antennal muscles in cladocerans and conchostracans.
frontal	referring to the anterior surface of the head (the 'face')
frontal organ	(= dorsal appendage): a small articulated knob between or behind the eyes in some conchsotracans
frontal appendage	an appendage anteriorly between the bases of the second antennae in some male anostracans
frontal process	= frontal appendage
furca	a fork, usually referring to the caudal furca or tail fork
gametogenesis	the process of formation of gametes (eggs and sperm)
geniculate	bent like a knee
genital	reproductive
genital segment	abdominal segment bearing the reproductive and genital structures
genus	a taxonomic category below family and above species
gill	a flattened or finger-like structure used in gaseous exchange
globose	rounded, inflated
gnathobases	paired endites, the jaw-like bases of the trunk limbs of some crustaceans, usually with opposed teeth or crushing surfaces, used to manipulate or triturate food, and the forerunners of the mandibles

growth line	a line indicating a growth interval
head	the first tagma (see cephalon)
head capsule	the exoskeleton of the head
head pores	tiny pores on the posterior median aspect of the head in chydorid cladocerans
head shield	dorsal cover over the head
helmet	a large, flattened expansion of the head of cladocerans
hepatic caeca	lobes of the liver
hermaphrodite	bearing both male and female organs in a single individual
hinge line	the line of fusion or articulation between the two valves of a bivalved carapace
hyaline	clear and translucent
in copula	male and female in copulatory position
inflated	enlarged, swollen
instar	a stage of development between moults (often a larval stage)
joint	a) the point of articulation between skeletal elements b) more commonly, the individual elements of a segmented (jointed) appendage
juvenile	an immature individual: one that has not reached reproductive age
keel	a ridge or crest (= carina)
labrum	upper 'lip', above and in front of the mouth (not a true appendage)
lamelliform	flattened, sheet-like
lamina	a flattened sheet
large branchipods	a descriptive term that distinguishes the fairy shrimps (Anostraca), clam shrimps (Conchostraca) and tadpole shrimps (Notostraca) from the cladocerans (i.e. the 'small branchipods')
larva	any juvenile instar of different form from that of the adult
lateral	pertaining to the side or flank of an animal
limb	an appendage, usually one used in locomotion
leg	a limb
limnetic	relating to open water
littoral	relating to the shore of a lake or the sea
lobate	consisting of a number of lobes
mandibles	the first pair of mouthparts: hardened jaws used for crushing or biting food
marginal denticles	small tooth-like processes at or near the margin (edge)
marginal teeth	pointed tooth-like outgrowths at or near the margin

maxilla	(= maxilla 2): either of the second pair of mouthparts behind the mandibles (crustaceans normally have two pairs, the first often called the maxillules - qv)
maxillule	(= maxilla 1): either of the first pair of mouthparts behind the mandibles (crustaceans normally have two pairs, the second often called the maxillae - qv)
median	in the mid-line
medial	towards the mid-line
medial process	a process attached anteriorly and in the mid-region of the of the fused basal joints of the antennae (Anostraca)
medial ventral process	a process at the junction of the basal joints of the second antennae of male anostracans
metachronal	of a series of limbs, each pair beating slightly out of phase with the ones in front and behind, resulting in an apparent wave of motion passing down the length of the body
metanauplius	(pl. metanauplii): a crustacean larval stage with at least four pairs of appendages (antennules, antennae, mandibles and maxillules), the stage at which cysts ('eggs') of branchiopods hatch (see nauplius)
molar process	the grinding (occasionally piercing) portion of the mandible
monotypic	of a genus, having a single species
morphological	(n. = *morphology*): pertaining to form and structure
moult	the action of shedding the exoskeleton
mouthparts	appendages modified for feeding
nauplius	(pl. nauplii): the diagnostic first larval stage of crustaceans in which the only appendages are the antennules, antennae and mandibles
nuchal organ	(= dorsal organ): in notostracans, a small oval structure, of unknown function and located between the eyes
obscure	not evident
occipital angle	the angle at the 'back' of the head of some conchostracans
ocellus	a single simple eye or eyespot (see *compund eye*)
order	taxonomic category below class and above family
organic matter	material produced by, or part of, living (or once-living) organisms
ovate	oval or egg-shaped
ovisac	an external bag in which eggs are housed
ovoviviparous	producing eggs that are retained within the maternal body throughout development
palm	the medial surface of the hand region of the streptocephalid antenna (Anostraca)

pan	a large, flat depression in the landscape, holding water at times
papilla	a small lobe or nipple
papillate	covered with papillae (qv) or papilla-shaped
parthenogenesis	asexual reproduction in which an egg develops without fertilization
pecten	a comb-like structure
penes	structures that together form a penis (also the plural of *penis*)
phyletic	pertaining to evolutionary relationships
phylum	the highest taxon used to classify animals
phyllopod	a flattened and leaf-like trunk limb (cf *stenopod*)
plankton	a collective term for the small organisms living suspended in the water column and at the mercy of currents
plumose	feathery
polyphyletic	in evolutionary terms, derived from more than one ancestral group
post-abdomen	the terminal part of the body of a cladoceran
	posterior at the tail end
posterior sinus	a deep notch on the posterior border of the carapace (in *Triops* – Notostraca)
pre-epipodite	basal, lateral lobe of the thoracic appendages of the anostracans
process (*n.*)	a projection
protopodite	the proximal part of any crustacean limb, consisting of the coxa and basis
proximal	towards the point of attachment (cf *distal*)
ramus branch	one of the two branches making up the stenopodous (qv) crustacean limb
rami	plural of *ramus* (qv)
resting egg	an egg undergoing diapause (cf 'cyst')
reticulate	net-like
rhomboidal	having the form of an equilateral parallelogram
robust	stout, sturdy
rostrum	a pointed anterior protrusion between the eyes
sclerotized	hardened by deposition of proteins that tan chitin
scraper	an animal that feeds by scraping organic matter off hard substrata
second antenna	see *antenna*
second maxilla	see *maxilla*
segment	a single element or article in a jointed appendage, or one of the individual units making up the body of a 'segmented' animal (in these volumes, usually the former) (see *joint*, *somite*)

segmented	consisting of segments
serrate(d)	with a saw-like edge
serration	a saw-like edge or ridge
sessile	without a stalk (more commonly, animals permanently fixed in one spot)
seta	(pl. setae) a chitinous hair or bristle
setiferous	bearing setae
setose	bearing setae (usually implies dense covering of setae)
sexual dimorphism	difference in form between male and female of the same species
shell	in branchiopods, a) the carapace and b) the wall of a cyst (qv)
shell gland	organ in which material for forming the shell is secreted (Cladocera)
somite	the more correct term for a body segment
spatulate	flattened and splayed
spermatophore	a capsule containing sperm
spine	a long, tough, pointed seta
spiniform	spine-like
spinose	in the form of a spine, or covered with spines
spinule	a small spine
stenopodous	literally, with narrow legs: the subcylindrical walking legs of many non-branchiopod crustaceans (cf *phyllopodous*)
sub-	a prefix indicating 'almost' or 'not quite'
subitaneous	of cladoceran eggs, those that have no resting stage
supernumerary	above the normal number
supra-anal plate	a dorsal spatulate extension of the telson (in species of *Lepidurus* – Notostraca)
supra-ocular	depression a depression above the eyes in some cladocerans
suspensoids	fine particles suspended in water
synonym	in taxonomy, another name for the same species
synonymy	in taxonomy, the list of names given previously to a particular taxon
systematist	a biologist interested in the classification of particular taxa, and the evolutionary relationships between them
taxon	any taxonomic category (e.g. species, class, phylum)
telson	the terminal part of the body of a crustacean, behind the last abdominal somite and usually bearing the anus
telsonal filament	(= telsonic filament): one of the filaments attached antero-dorsally to the telson of conchostracan
terminal	at the tip
terminal joint	distal part of the antenna of anostracans, usually tubular in shape
thorax	the middle of the three tagmata of most crustaceans

thoracic legs	legs on the thorax
thoracopod	(= thoracic leg): any of the paired appendages of the thorax
thumb	the upper or dorsal part of the antennal hand region of the streptocephalid anostracans; often a long, tapering terminal structure opposite the finger, and with a ventral spur.
thumb spur	ventral, shorter, digitiform section of the thumb region of the hand in streptocephalid anostracans.
tooth	any pointed, fang-like seta or projection
trifid	divided into three points at the tip
trophic	referring to food and feeding
truncate	bluntly ending
trunk	the tagma forming the posterior part of the body, behind the head the combined thorax and abdomen
tubercle	a small rounded protuberance
umbo	the apical (oldest) portion of the valve of a bivalved crustacean
uniramous	consisting of a single ramus or branch
valve	the lateral part of a divided carapace: one of the two 'shells' of conchostracans and cladocerans
vas deferens	(pl. *vasa deferentia*): the tubes carrying sperm from the testis
ventral	referring to the underside of the body
ventral ramus	referring to the ventral branch of the antenna (in Cladocera)
vlei	a wetland (Cape) or a riverine reed-bed (rest of Southern Africa)

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'.

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.
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.
Makatini Flats	Pongola River floodplain, north-east of Jozini, Maputaland (qv)
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.
Orange Free State	One of the four former provinces of South Africa, now known as the Free State.
Owamboland (Ovamboland)	Northern region of Namibia.
Southern Cape	The southern coastal strip from Cape Agulhas in the west to Cape St Francis in the east.
Transkei	The region coloquially 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.

INDEX OF SCIENTIFIC AND COMMON NAMES