

Redescription of the fairy shrimp *Streptocephalus proboscideus* (FRAUENFELD, 1873) (Crustacea, Anostraca)

by Luc BRENDONCK

Abstract

The freshwater anostracan *S. proboscideus* has been reported from temporary ponds in the environment of Khartoum and from several localities in southern Africa. The first descriptions were inadequate or restricted to the most distinguishing characters, such as the morphology of the male antennae and of the frontal appendage. The external morphologies of adults and cysts are here described in full, using light and scanning electron microscopy. The distribution of this species is discussed.

Key-words : Crustacea, Anostraca, *Streptocephalus proboscideus*, redescription, distribution.

Résumé

L'Anostracé d'eau douce *Streptocephalus proboscideus* a été rapporté des mares temporaires aux environs de Khartoum et de quelques localités du sud de l'Afrique. Les premières descriptions étaient incomplètes et limitées aux caractères les plus spécifiques tel que la morphologie des antennes et l'appendice frontale des mâles. La morphologie des adultes et des oeufs sont ici présentées intégralement. Un bref rappel de la distribution est présenté.

Mots-clefs : Crustacea, Anostraca, *Streptocephalus proboscideus*, redescription, distribution.

Introduction

The anostracan genus *Streptocephalus* BAIRD, 1852, the only one in the family of the Streptocephalidae, is known from northern and southern temperate zones and from the tropics in between (MATHIAS, 1937). The genus composes at present 47 species (BELK, 1982). Representatives have been collected from temporary ponds on all continents except South America, Antarctica, and possibly also Australia (BARNARD, 1929 ; MATHIAS, 1937 ; LINDER, 1941 ; MOORE, 1966 ; BRTEK, 1974 ; BELK, 1982). Its center of greatest species richness is found in Africa (BRTEK, 1974). In southern Africa, for example, at least eighteen species occur (HARTLAND-ROWE, in prep.). *Streptocephalus* species are mainly distinguished by the morphology of the male antennae and of the frontal appendage (process). *Streptocephalus proboscideus* was first reported by FRAUENFELD (1873). This record, however, only presents a brief description of the frontal appendage, though not accompanied by illustrations. Some years

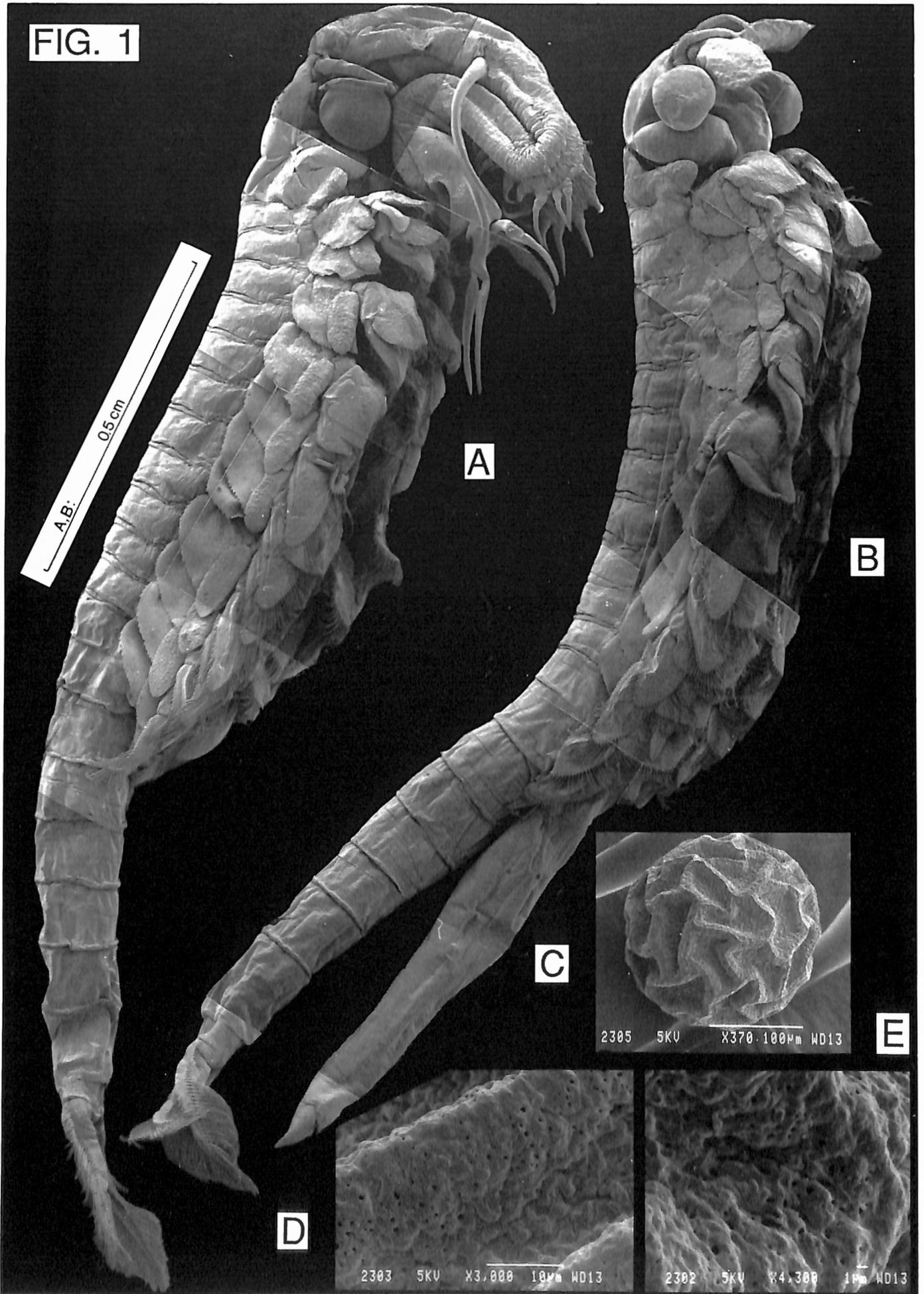
later, BRAUER (1877), using specimens from Khartoum (Sudan), offered drawings of the male and female heads together with general figures of the external genital structures of both sexes. DADAY'S (1910) description of this species is based on the latter work, though restricted to the male antennae and frontal appendage. BARNARD (1929), also restricted illustrations and descriptions of the majority of southern african anostracans in general and of *S. proboscideus* in particular to these structures. Although the morphology of male antennae and frontal process indeed presents the major key characters for species identification, it should be stressed that the morphology of male and female genital structures, of the eleven pairs of thoracopods, of the mouthparts, and of the external sculpturing of the cysts are also important when tracing phylogenetic relationships on the different taxonomical levels in the Branchiopoda.

The present contribution aims to review the diagnostic characters of *S. proboscideus*, to supply descriptions of mouth-parts, thoracopods, cercopods, male and female genital structures, cyst-morphology, and to offer a brief account of its present day distribution.

Material and methods

Cysts of *S. proboscideus* were collected from dry temporary pools in Al Gedid, a flat Sahelian region with some shallow depressions near Khartoum (Sudan) (RZOSKA, 1961). The top layer of mud with resting stages of former pool inhabitants was removed and transported to the laboratory. One day after inundation of the mud with distilled water, nauplius larvae could be detected and sampled. This method was already used by BRAUER (1872) and regularly applied by SARS in various publications. These nauplii were then reared in standard reference water following the formula of FREEMAN (1953) at 25°C. Animals were fed with micro-algae (*Selenastrum* and *Chlamydomonas*) until they reached the adult stage. Living adult males were then identified down to species level and couples were formed with females in order to observe fertilization, cyst deposition, and successional hatching of the cysts, as a control that only one species was involved.

FIG. 1



Prior to preservation in 4% formalin, animals were first narcotized with soda water to avoid violent muscle contractions and consequently unnatural positions. All illustrations were made with a Wild M-5 stereoscope and M-11 compound microscope, both equipped with a camera lucida. Specimens used for scanning electron microscopy (SEM) were first cleaned and dehydrated in a graded ethanol series. Specimens were then critical-point dried, mounted on stubs, and coated with 200 Å of gold for observation in a JEOL JSM-840 at accelerating voltage of 10 kV.

The material is deposited in the collections of the "Koninklijk Belgisch Instituut voor Natuurwetenschappen", Brussels.

Taxonomic descriptions

Class : Branchiopoda LATREILLE, 1817.
Subclass : Sarsostraca TASCH, 1969.
Order : Anostraca SARS, 1867.
Family : Streptocephalidae DADAY, 1910.
GENUS : *Streptocephalus* BAIRD, 1852.

Type species : *Branchipus torvicornis* WAGA, 1842.

Abbreviated diagnosis : Male antennes with medial outgrowth from basal joint terminating in a chelaform structure. Vas deferens with dorsal loop and without distinct seminal vesicle. Female brood pouch cylindrical and elongate.

Remarks : The male antennes consist in the Streptocephalidae of a basal segment, from which distally both a slender, smooth, lateral process, and a recurved medial process terminating in a chelaform structure originate. These structures are referred to as "scissors", "pincers", "clasper", or "hand" (MOORE, 1966) (Fig. 2A, B, C). WAGA (1842), who described the first streptocephalid, and BAIRD (1852) who introduced the taxonomic name *Streptocephalus*, interpreted the second antenna as a 3-jointed or triarticulate structure, an opinion followed by many authors as THIELE (1900, 1904), GURNEY (1906), and others. This interpretation was already questioned by FRAUENFELD (1873), BARNARD (1929), and was also disputed by LINDER (1941) who, based on studies of larval development (CLAUS, 1873 & 1886; GISLLER, 1883; cited in LINDER, 1941), maintained that the lateral process is actually the apical joint of a 2-segmented appendage, as in most other anostracans. This opinion was later shared by BRTEK (1974), who proposed a standardized terminology for the male *Streptocephalus* antennes. The medial process, including the hand is than regarded by these authors as a distal outgrowth of the basal joint, with superficial folds instead of a true segmentation. Following MOORE

(1966), the internal and ventral branch of the hand is called the finger, while the external and dorsal branch is called the thumb (see Fig. 2 A, B, C).

Streptocephalus proboscideus (FRAUENF., 1873).

Synonyms : *Branchipus* (*Streptocephalus*) *proboscideus* FRAUENFELD, 1873.

Branchipus (*Streptocephalus*) *proboscideus* BRAUER, 1877.

Streptocephalus proboscideus DADAY, 1910.

Type material : In the original descriptions, FRAUENFELD (1873) does not specify the number of specimens investigated, nor the museum where they have been deposited. PESTA (1921) reported one male and one female from Khartoum, deposited as type material in the museum of Natural History in Vienna (code : BRAUER don. Acqu.-Nr. 1879.I.19.-E. WOLF (Frankfurt) determ. 1911). There is, however, no way to check its validity as type material. One male and four females collected by MARNO in 1870 from the environment of Khartoum are stored in the same museum and were probably used by BRAUER for his descriptions.

Material investigated :

IG 27.574a : 5 males + 5 females in toto in ethanol ; 1 male + 1 female with limbs dissected and mounted in glycerine in a sealed slide.

All specimens reared from dried mud, collected on 23.10.1985 from a dried pool near Khartoum, Sudan (see material and methods). (All illustrations based on these specimens)

IG 27.574b : 2 males + 2 females in toto in ethanol, raised from dried mud, collected from Fisherspan in the Etosha National Park (South West Africa/Namibia) on 9.10.1987 by K. MARTENS and B. CURTIS (loc. 87/48).

IG 27.574c : 2 males + 2 females in toto in ethanol, raised from dried mud, collected from a dried vlei along the road between Ruacana and Oshakati, c. 125 km from Ruacana (South West Africa/Namibia) on 6.10.1987 by K. MARTENS and B. CURTIS (loc. 87/33).

Abbreviated diagnosis : Male frontal appendage very long, rolled up ventrally between antennes and with bifid apex. Truncal and abdominal segments smooth. Brood pouch reaching last abdominal segment in full grown females. Cercopods setiferous up to the tips.

Measurements :

Mean length measured from front to tips of cercopods of 5-month old specimens :

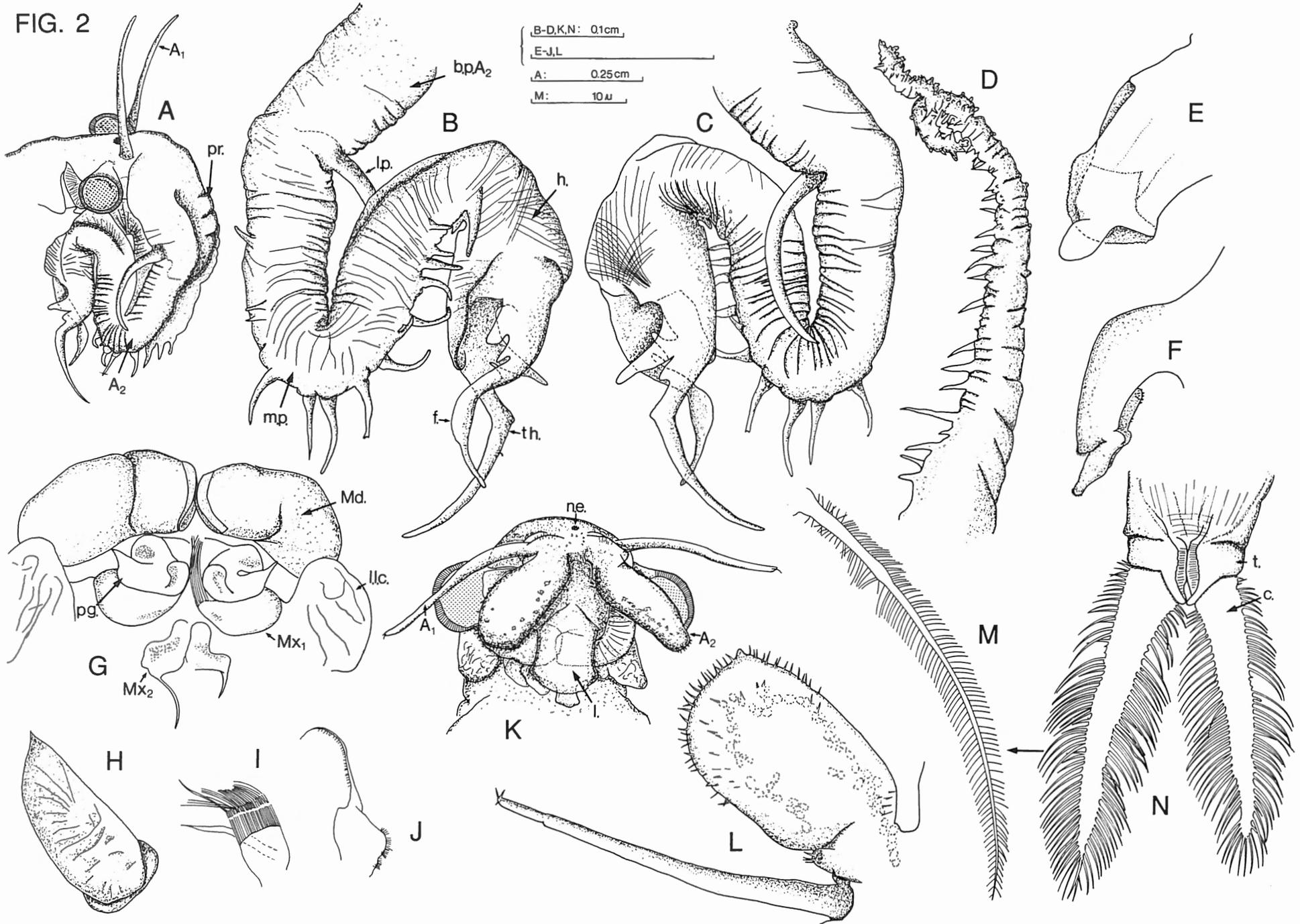
Males : $L=2.09 \pm 0.16$ cm (n=20)

Females : $L=1.88 \pm 0.12$ cm (n=20)

Fig. 1. *Streptocephalus proboscideus* (FRAUENFELD)

A. Adult male, right lateral view. B. Adult female, right lateral view. C. Cyst. D. Detail of cyst-surface with ridges and pores. E. Detail of cyst-surface with ridge, depression, and pores.

FIG. 2



Thorax + head + cervical segment in both sexes about 50% of total length, abdomen and telson 38% and 12% respectively.

Description of adult male :

Labrum considerably long and rectangular, with a convex, slightly serrated distal border and ending in a small lamella (Fig. 2 E, F).

Maxillules with many rigid setae and curved around the paragnaths (Fig. 2 G, I).

Maxilles with one distal seta placed on a digitiform processus (Fig. 2 G, J).

Lateral lobes of cervical segment behind the head very distinct and pouch-like (Fig. 2 G).

Antennules (Fig. 2 A, K, L) simple and slender, without clear segmentation and with a restricted number of setae on the apex.

Lateral process of antennae (second or apical joint, see above), smooth, slender, strongly curved and pointed, and inserted at the postero-lateral margin of distal end of basal segment (Fig. 2 A, B, C).

Medial process (medial outgrowth of antennae, see above), placed at the distal end of the basal segment and consisting of a stout, wrinkled and recurved middle part and terminal hand (Fig. 2 A, B, C).

Middle part, superficially annulated and set with a row of generally nine to ten digitiform processes on the internal surface at and beyond the bend. Big triangular lobe located on the inner side, proximal to the origin of the hand. Also one or more spine-like processes near the junction with the hand (Fig. 2 B).

Thumb, spoon-shaped at the base and distally bifurcate, with a long, curved and apically acute anterior part and a shorter posteriorly projecting spur ; a triangular, smooth blade, broad at the base, tapering distally. A short, rounded and triangular tooth located between the two parts (Fig. 2 B, C).

Finger with two unequal teeth along the proximal anterior margin. Proximal tooth broad at the base, almost rectangular in shape. Distal tooth slender, curved and slightly pointed. Distal part of the finger curving down- and backwards, showing a conspicuous inflation at the bend, though tapering to a slightly pointed tip. Finger about 2/3 of the length of the thumb (Fig. 2 B, C).

Frontal appendage very long, though not extending beyond the tip of the hand and, in rest, deflected and coiled backwards between the two antennae. Ventral

margin set with a single row of spiniform processes, pointing ventrally and diminishing in size towards the apex which is bifid and set with short, tuberculiform knobs (Fig. 2 A, D).

Five endites of thoracopods with long posterior setae (Fig. 3 A, D), arising from the caudal part of the edge, and shorter anterior setae, less in number and arising from the cranial part. Endite 1 bearing three anterior setae. The most proximal seta arising singly, somewhat basal to the middle of the edge, the other two positioned close together above the middle of the edge of first endite, the basal one being a short spine without any setules (Fig. 3 B). A similar set of short spine and longer seta occurring at the base of second endite (Fig. 3 C). Arrangement of setae on endites as presented in Table 1. Endites 3 and 4, further characterized by long hairs on the sides and tip, different from the smooth 5th endite (Fig. 3 I).

Table 1.

first leg					2nd-10th leg					eleventh leg				
1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3+m	2+m	2+32	2+24	2	3+m	2+m	2+32	2+21	2	3+f	2+f	2+2	2+2	2+1

Arrangement of setae on the five endites of the thoracal appendages. First figure indicating the number of cranial setae, the second figure giving number of posterior setae.

m = many (>10)

f = few (<5)

Endopodites squarely truncated and terminally notched in some of the thoracopods with a variability between the parts of both sides. Endopodite and exopodite only bearing one type of plumose setae, those on the endopodites, however, shorter than the exopodite setae. (Fig. 3 E, F).

Each leg with one lamelliform, irregular oval-rectangular pre-epipodite, serrate along the entire outer margin, with the greatest extension in the longitudinal direction of the leg (Fig. 3 A, G).

A small incision, not constant in its occurrence, sometimes found in the middle of the edge (Fig. 3 H), with a variability between legs of the two sides.

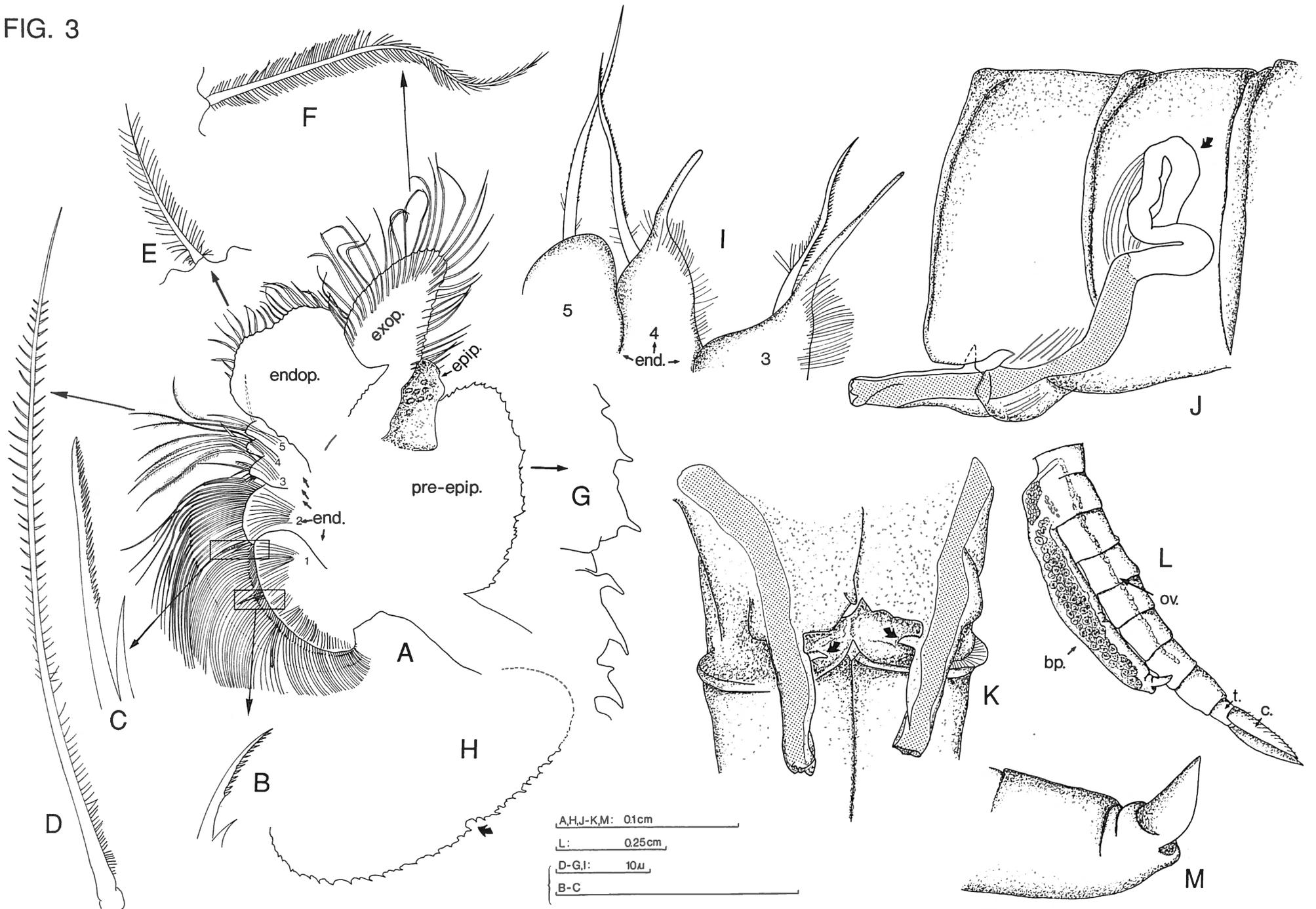
Eleventh pair of thoracopods less developed and with less prominent endites, endopodites, and exopodites, and bearing less and shorter setae than anterior legs.

Fig. 2. *Streptocephalus proboscideus* (FRAUENFELD)

A. Male, lateral view of head. B. Male antennae, medial view. C. Male antennae, lateral view. D. Male, frontal appendage (process). E. Male, medial view of labrum. F. Male, lateral view of labrum. G. Male, mouthparts with labrum removed. H. Male, lateral view of mandible. I. Male, maxille. J. male, maxillule. K. Female, ventral view of head. L. Female, dorsal view of antennule and antennae. M. Male, detail of seta on telson. N. Male, telson.

Abbreviations used : A1 = antennule ; A2 = antennae ; b.p. = basal part of antennae ; b.p. = broodpouch ; c = cercopod ; end. = endite ; endop. = endopodite ; epip. = epipodite ; exop. = exopodite ; f. = finger, h = hand ; l. = labrum ; l.l.c. = lateral lobes of cervical segment ; l.p. = lateral process ; Md. = mandible ; m.p. = medial process ; Mx1 = maxillule ; Mx2 = maxille ; n.e. = naupliar eye ; o. = ovarium ; pg. = paragnath ; pr. = frontal process ; pre-epip. = pre-epipodite ; t. = telson ; th. = thumb.

FIG. 3



Epipodite flat and blade-like with the typical appearance of a pre-epipodite. Anterior setae of endites 1 and 2 reduced to small hooks.

Genital region consisting of two partly coalescent segments. Vas deferens with dorsal loop and without distinct seminal vesicle (Fig. 3J), with some variation in height and general configuration of the loop, linked with state of contraction of the muscles attached to the vasa deferentia.

Basal and non-retractile parts of the hemipenes each bearing a median spine-like outgrowth, projecting at right angles on the inner side, with a dentated proximal surface (Fig. 3K). Basal parts of hemipenes almost as long as individual abdominal segments.

Cercopods lanceolate, setiferous to the tips with rather short subequal plumose setae and separately attached to postero-lateral margin of short telson (Fig. 2N, M). Truncal segments of living males usually pale greenish or gray-green. Distal part of cercopods and evertible part of vas deferens orange. Coloration of thoracopods, mandibular region, and 'hand' generally pale orange.

Differentiating female characters :

Antennae pseudo-rectangular, broad and flat, measuring about 2/3 of the length of antennules and bearing short setae along the edge on each side of the pointed apex (Fig. 2K, L). Frontal appendage absent.

Brood pouch cylindrical, elongate, and, in full-grown specimens extending to the middle of last abdominal segment (Fig. 3L). Conical tip consisting of two unequal lips surrounding the opening, the dorsal lip being the more prominent (Fig. 3M).

Post genital abdominal segments usually orange on ventral, but sometimes also on dorsal side. Proximal part of telson, ovisac, and complete cercopods clear orange. Legs and mandibular region pale orange.

Description of the cysts :

Cysts spherical, measuring about $250 + 11 \mu\text{m}$ ($n=20$) in diameter, with ornamented surface characterized by a considerable number of ribs delineating many polygonal cells (Fig. 1C, D, E). Pores occurring on the ridges.

Remark : The original work of FRAUENFELD (1873) presents a classification and brief diagnose of subgenera and species within the genus *Branchipus*. *B. (S.) proboscideus* is distinguished only by the morphology of the frontal appendage: 'Stirnfortsatz ein langer an der Spitze zweilappiger gezählter Rüssel'. In a short

foot-note, the author reports it as a new species and promises to describe it in a next paper. This, however, has never been published. Based on the code, there can consequently be some doubt about the taxonomical validity of this original description. To maintain the stability of the nomenclature, however, it seemed preferable to keep the current name of this wide-spread species in use.

Distribution

S. proboscideus was originally described from Khartoum (FRAUENFELD, 1873 ; BRAUER, 1877). Also RZOSKA (1961) reported its occurrence in the environment of Khartoum. It has for a long time been considered as being restricted to this area, e.g. in some papers of DADAY (1910, 1913), and sometimes even in recent literature (DE RIDDER et al., 1988). BARNARD (1924, 1929), however, already clearly reported several southern African localities for this species. DE RIDDER et al. (1988) reported a northern range expansion to the confines of Egypt.

Discussion

Body size in Anostraca is not a useful taxonomic criterion, because the animals become sexually mature long before the maximum size is attained. Growth also seemed to be influenced by various aspects of water quality, which in turn was determined by the density of animals in the culture tank. In all situations, however, males were constantly and significantly longer than females.

Also coloration must be approached cautiously because color seemed to be determined by food. The color of the living specimens described in the diagnosis presented above, is only valid for animals fed with living micro algae. When *S. proboscideus* specimens were cultured on yeast, the dominating colour was blue-greenish, while in the females only the proximal part of the telson and of the cercopods were constant in their orange color. In males, only the tips of the cercopods, the distal part of the vas deferens, and finger and thumb of the 'hand' were colored orange.

The male antennae and frontal appendage are the best described parts in the Streptocephalidae. Consequently, they are the only structures allowing a detailed morphological discussion and comparison with those of our studied specimens. Both BRAUER (1877) and BAR-

Fig. 3. *Streptocephalus proboscideus* (FRAUENFELD)

A. Male, first thoracic appendage. B. Male, detail of second and third anterior setae of first endite. C. Male, detail of first and second anterior setae of second endite. D. Male, detail of posterior seta of third endite. E. Male, detail of seta of endopodite. F. Male, detail of seta of exopodite. G. Male, detail of the edge of the pre-epipodite. H. Male, detail of the edge of pre-epipodite with small incision. I. Endites 3-5, showing anterior setae. J. Lateral view of male genital region. K. Ventral view of male genital region. L. Lateral view of female abdomen with brood-pouch. M. Detail of tip of brood-pouch.

Abbreviations used : see Fig. 2.

NARD (1929) illustrated the two teeth on the proximal margin of the finger as equal and similar structures, although they are much bigger in BARNARD'S specimen. This is different from our animals, which are characterized by the constant occurrence of a bigger rectangular and smaller pointed tooth, as mentioned above.

In the genus *Streptocephalus*, the lateral process of the antennae varies only in proportions and smaller morphological details and is always positioned at the tip of the basal segment (LINDER, 1941). The relative length and curvature, however, have thus far been ignored by many authors or were inadequately illustrated (BRTEK, 1974). Also, the digitiform processes on the internal surface of the middle part of the male antennae were frequently ignored in older literature.

The male frontal appendage constitutes in *S. proboscideus* the major specific character (DADAY, 1910). In the original, restricted description of FRAUENFELD (1873), it is the only character considered. Only four other *Streptocephalus* species (*S. cladophorus* BARNARD, *S. bouvieri* DADAY, *S. neumanni* THIELE and *S. spinifer* GURNEY) have equally or even more conspicuous, branched frontal appendages (THIELE, 1904; GURNEY, 1906; DADAY, 1910, BRTEK, 1974). BARNARD (1929) only observed a single row of processes on the ventral side of the frontal appendage in southern African specimens. This differs from the Sudan specimen drawn by BRAUER (1877), who distinguished two rows, but it is in agreement with our observations.

The male genital segments of *S. proboscideus* are not significantly broader and higher than the other segments, as has been observed by LINDER (1941) in 6 other *Streptocephalus* species. A dorsal loop on the vas deferens is furthermore also characteristic for the genera *Branchinella*, *Dendrocephalus*, and *Thamnocephalus* (LINDER, 1941). In *Streptocephalus*, however,

the dorsal loop seems to be shorter and often placed deeper than in the other genera. All *Streptocephalus* species examined by LINDER (1941) have two linguiform outgrowths lateral to the bases of the hemipenes. These parts couldn't be observed by MOORE (1966) for the North-american *Streptocephalus* species, nor were they observed in our specimens.

The external morphology of phyllopod cysts recently became an important tool for species identification (oötaxonomy), even in the absence of adults, or when the adult habitat has dried out (MURA et al. 1978; MUNUSWAMY et al. 1985; ALONSO and ALCARAZ, 1984; MURA, 1986; MURA and THIERY, 1986; MARTIN, 1989; BELK, 1989). The general cyst morphology resembles that described for *S. dichotomus*, *S. simplex echinus*, and *S. simplex longimanus* from India (MUNUSWAMY and SUBRAMONIAM, 1984; MUNUSWAMY et al., 1985) and *S. torvicornis* collected from Spain and Morocco (ALONSO and ALCARAZ, 1984; MURA and THIERY, 1986). The occurrence of pores on the cyst surface was already reported for several species (GILCHRIST, 1978; MURA et al. 1978; MUNUSWAMY and SUBRAMONIAM, 1983, 1984; MURA and THIERY, 1986; MURA, 1986).

Acknowledgements

I am very grateful to prof. Dr. G. PERSOONE for his incessant interest and for providing me with all facilities, as well as to Dr. K. MARTENS and Dr. A. THIERY for critical reading and correcting the manuscript. Special thanks are due to S. WELLEKENS for expert assistance with S.E.M. The author is research assistant with the National Fund for Scientific Research (Belgium) and research associate with the 'Koninklijk Belgisch Instituut voor Natuurwetenschappen, K.B.I.N.'.

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