or records are not traceable. Tribute must be paid also to Frederich Kiefer, one of the greatest of all freshwater copepod taxonomists, who, together with Sars, laid the foundation of the taxonomy of freshwater micro-crustaceans in southern Africa. Kiefer (1934) reviewed the South African freshwater Copepoda and so provided a firm basis for current taxonomic research on copepods in southern Africa. In addition, the world list of calanoid copepods compiled by Dussart & Defaye (1983) is an important reference work.

The four closely related *Lovenula* species are among the largest of the freshwater diaptomids and it is surprising that there has been so much confusion about the identity of these distinctive predatory copepods. However, the constant changes to the generic name, as well as the large number of synonyms, testify to the lack of any in-depth study, and Kiefer (1934) was largely dis-

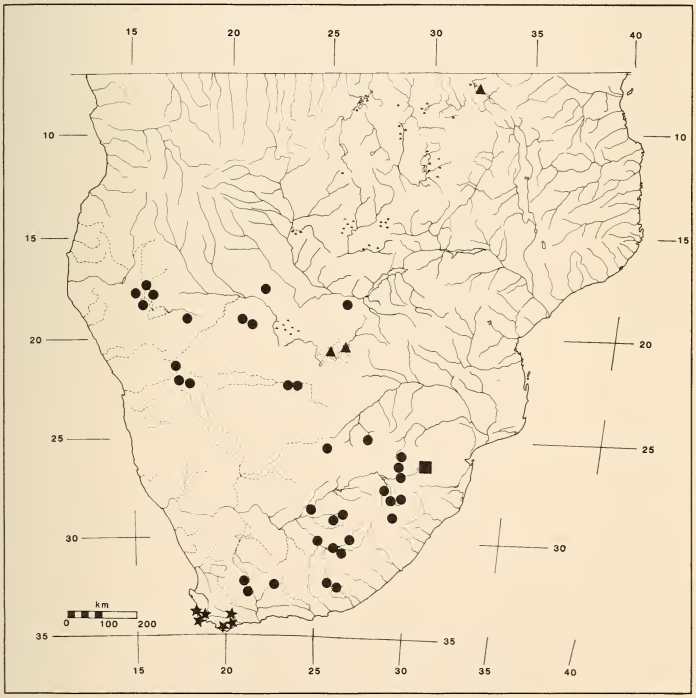

Fig. 2. Map showing river systems and distribution of *Lovenula falcifera* (●), *L. africana* (▲), *L. excellens* (■) and *L. simplex* (★).

regarded in his attempt to create stability. Sars (1899) redescribed '*L. falcifera*' from material that had been sent to him from the Cape Flats by W. F. Purcell, but the specimens used by Sars were *L. simplex* (yet to be recognized as a new species by Kiefer in 1929). Rühe (1914) also did not recognize *L. simplex* as a new species when he identified it as *Paradiaptomus falcifer*. Although these two species are closely related taxonomically, the geographical separation of *L. falcifera* and *L. simplex*, which is so obvious today (Fig. 2), would surely have been questioned by early taxonomists if more material had been available for study. Communication was also a problem as shown by Lovén (1845) giving the type locality of *L. falcifera* as the Magaliesberg (Transvaal) on the road to Port Natal. Van Douwe (1912*a*) suggested that Sars' (1899) redescription was not that of *L. falcifera* but related to a new species. However, despite Van Douwe's misgivings, Sars (1927) again recorded *L. simplex* as *L. falcifera*. In his collecting expeditions in Ovamboland in the 1920s, K. H. Barnard had collected a species of *Lovenula* from temporary pools in this arid area of Namibia. Sars (1927), realizing that this was a different species from his *L. falcifera* (i.e. *L. simplex*), named the new species *L. barnardi*. From this time onwards, *L. simplex* was known as *L. falcifera* and *L. falcifera* as *L. barnardi*, an error perpetuated by Harding & Smith (1967). In addition to the confusion over *L. falcifera* and *L. simplex*, there was a lack of authentic information on *L. excellens*, a Lake Chrissie species described by Kiefer (1929). Methuen (1910) failed to recognize it as a new species, identifying it as 'a local variety' of *Broteas falcifer*. It is hoped that this revision will create stability in the genus *Lovenula* and lead to a reassessment of the Paradiaptominae of Africa. Dussart (1980) stressed the importance of revising, genus by genus, the African copepod fauna.

SYSTEMATIC DISCUSSION

TERMINOLOGY AND ABBREVIATIONS

Names of collectors

KHB—K. H. Barnard (S. A. Museum, 1911–1956); FMC—F. M. Chutter; JAD—J. A. Day; AJCG—A. J. C. Gardiner; RCH—R. C. Hart; JMK—J. M. King; WFP—W. F. Purcell (S. A. Museum, 1896–1905); MTS—M. T. Seaman.

Repositories

AM—Albany Museum, Grahamstown; NM—Natal Museum, Pietermaritzburg; SAM—South African Museum, Cape Town; TM—Transvaal Museum, Pretoria; SMN—State Museum, Windhoek, Namibia; BMNH—British Museum (Natural History); ZMUH—Zoological Museum, University of Hamburg; HMNH—Hungarian Natural History Museum.

Terminology (see Fig. 3)

Some of the terms are well known to copepodologists but have been included for non-specialists who may be unfamiliar with copepod terminology. All measurements are in millimetres. Measurements and coloration are affected by age and period of time of preservation of the specimen. Curvature of female antennae affects measurements relative to body length. Thoracic 'wings' and shape of the tip of last segment of male right A1 may be affected by orientation on the microscope slide. Antennule segment numbers refer to existing segments and do not necessarily relate to homologous ancestral numbers. Material examined consisted of a number of adult males and females, unless otherwise stated. Details are presented in the following order: museum catalogue number (if relevant), locality, collector's name, date.

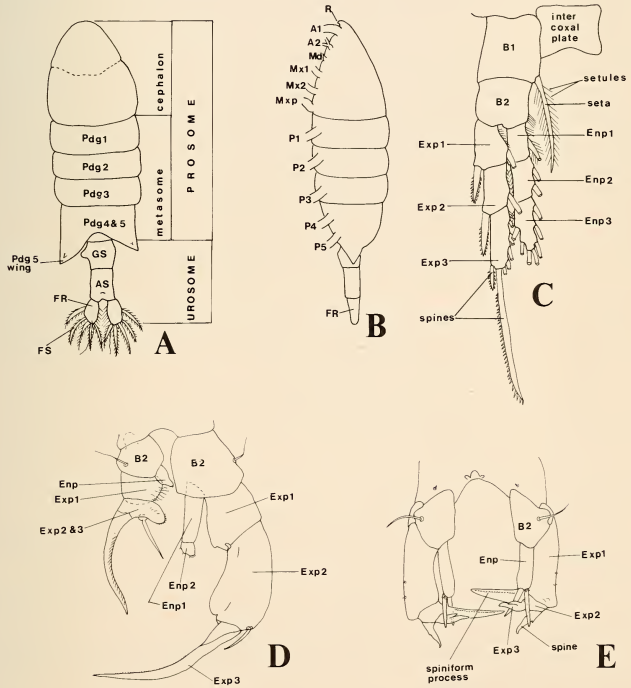

Fig. 3. Terminology and abbreviations (see p. 302 for glossary). A. Somites and body divisions. B. Position of appendages. C. P2. D. Male P5. E. Female P5.

C. V.—coefficient of variation (%); $\bar{x}$ = mean.
aesthetask—small, rod-shaped sense organ on A1
anal somite (AS)—somite proximal to furca (Ur2 or 3 in female; Ur5 in male)
antenna 1 (A1)—antennule, the first prosomal limb
antenna 2 (A2)—antenna, the second prosomal limb
basis (B2)—basal stem segment of endopodite and exopodite
body length (TL)—total length excluding furcal setae
cephalon (cephalosome)—head, including maxilliped somite
coxa (B1)—the middle stem segment of a biramous limb
egg sac, brood sac—receptacle for eggs, forming part of genital complex
endopodite (Enp)—inner ramus of biramous appendage beginning with segment Enp1
exopodite (Exp)—outer ramus of biramous appendage beginning with segment Exp1
furca (FR)—caudal rami
furcal setae (FS)—five spiny terminal setae and one slender 'dorsal' seta arising from each furcal ramus
genital somite (GS)—first urosomal double somite in female
length:breadth (L:B)—ratio maximum length to breadth of a structure
mandible (Md)—the third prosomal limb
maxilla 1 (Mx1)—maxillule, the fourth prosomal limb
maxilla 2 (Mx2)—maxilla, the fifth prosomal limb
maxilliped (Mxp)—the sixth prosomal and first thoracic limb
metasome—pedigerous somites between cephalon and major articulation of the body
natatory legs (P1–P4)—swimming legs, relating to pedigerous somites (Pdg1–4)
non-natatory legs (P5)—modified legs, used in male for spermatophore transference, in female for egg protection
pedigerous somites (Pdg1–5)—leg-bearing somites
precoxa (PCX)—the proximal stem segment of a biramous limb
prosome (Pr)—complete body section anteriad to the major articulation (Cephalon + Pdg1–5)
rostrum (R)—a beak-like projection on anterior of the prosome
segment (Seg)—fundamental division of a limb
seta—relatively long, flexible process, tapering to a point, generally with a double row of fine hairs (setules), giving the appearance of a feather
somite—fundamental body division
spine—short, strong, more or less inflexible, usually armed on each side with a row of small denticles giving it a saw-like edge
spiniform process—an extension of a segment having the appearance of a spine
spinule—very small spine
thoracic somites (Pdg1–5)—pedigerous thoracic somites
thoracic 'wings' (Pdg5 wings)—expansion of last prosomal somite in female to form wing-like processes

thorn—a hollow, usually pointed, extension of a limb segment

urosome (Ur)—complete body section posteriad to the major articulation, the first somite being the non-pedigerous genital double somite

Limnological terms of local origin (Fig. 1)

dam—a man-made impoundment. This term has become common usage in South Africa, although in the Northern Hemisphere it relates to a wall that impounds a river.

pan—as defined by King (1951: 81) 'Pans, in the South African usage of the term, are shallow depressions varying from a few square feet up to several square miles in area which occur typically along a belt stretching north–north-east from Calvinia, through the northern Cape and the western Orange Free State to the Transvaal. This belt is about 600 miles long and 100 miles wide, with a branch into South-West Africa and an outlying patch about Lake Chrissie in the Eastern Transvaal. After rain they may contain water; but often they are dry, broad floors of muddy and salty accumulation'.

vlei—as defined by King (1951: 92) 'The beds of intermittent rivers have in many cases been so choked by wind-drifted sand or silt that the original gradients have been lost, and a series of shallow lakes or "vleis" now appears after rains instead of a flowing river'.

KEY TO THE FAMILIES OF FRESHWATER CALANOIDA

Adapted from Gurney (1931), Dussart (1967), and Kiefer (1978*a*).

1. P1 endopodite with 3 segments; P2–P4 endopodite with three segments. . 2
— P1 endopodite with fewer than three segments; P2–P4 endopodite with 1–3 segments 3
2. P5 in both sexes identical to P1–P4, with three-segmented endopodite ..... Family **Centropagidae**
— P5 modified in both sexes, female without endopodite*, male with one-segmented endopodite* ..... Family **Pseudodiaptomidae**
3. P1 endopodite two-segmented; P2–P4 endopodite with 2–3 segments 4
— P1 endopodite one-segmented; P2–P4 endopodite one- or two-segmented .. .. Family **Temoridae**
4. P2–P4 endopodite three-segmented; P5 with endopodite in both sexes..... ..... Family **Diaptomidae**
— P2–P4 endopodite two-segmented; P5 without endopodite in both sexes .... Family **Acartiidae**

* Some exceptions (Dr T. C. Walter, Smithsonian Institute, Washington, D.C., U. S. A., pers. comm.).

Family **Diaptomidae** G. O. Sars, 1903

Centropagidae (*part.*): Giesbrecht, 1892: 58. Schmeil, 1896: 5–6. Giesbrecht & Schmeil, 1898: 52. Van Douwe, 1909: 4. Thiebaud, 1915: 8.
Diaptomidae Sars, 1903: 83. Pesta, 1928: 27–28. Rylov, 1930: 78; 1935: 169. Gurney, 1931: 108. Kiefer, 1932*a*: 460; 1960: 23–24; 1978*a*: 70. Damian-Georgescu, 1966: 40. Dussart, 1967: 88.

General description of the Diaptomidae

The cephalon is distinct from Pdg1. Pdg4 and Pdg5 are fused and often expanded in female to form 'wings'. Female urosome with two or three somites; urosome of male with five somites and may be asymmetrical. Genital somite of female is expanded laterally, sometimes with prominent asymmetrical lobes. Furcal rami are usually longer than broad, typically symmetrical in female, sometimes asymmetrical in male, with lateral setae on right furcal ramus sometimes modified in male. Female A1 and male left A1 are 25-segmented (for details of individual segments with setae, aesthetasks and sensory spines see Kiefer 1978*a*). Male right A1 has 21 or 22 segments, enlarged and modified between segments 13 and 18, with geniculation between segments 18 and 19. The 21-segmented A1 has three terminal, post-geniculate segments; the 22-segmented A1 has four. A2 has a seven-segmented exopodite that is longer than endopodite. P1 has a two-segmented endopodite and three-segmented exopodite, Exp2 lacks spine, Exp3 with one or two spines; P2–P4, endopodite and exopodite with three segments, Exp3 with one spine. P5 is non-natatory and biramous in both sexes. Female P5 has Exp2 produced mediad into a large, inner, spiniform process; Exp3 is reduced or absent or represented by one or two movable spines. Male P5, as well as basal segments of limb, highly asymmetrical, right leg much longer than left. Right leg has a lateral spine on Exp2; Exp3 is represented by a long, hinged, terminal blade-like claw. Male left P5 with Exp2 and Exp3 fused and variously modified, with sensory pads, spinelike outgrowths and setae. A single egg-sac in female, rod-shaped spermatophore in male.

Kiefer (1932*a*, 1932*b*) divided the Diaptomidae into two subfamilies, Paradiaptominae and Diaptominae.

Subfamily Paradiaptominae Kiefer, 1932*a*

P1, Exp3 with two outer spines; male right A1 with three post-geniculate segments, terminal segment may have beak-like extension; male left P5, Exp2 with strong, well-developed lateral or medial spiniform process. There are three genera in the subfamily Paradiaptominae: *Lovenula* Schmeil, *Paradiaptomus* Sars, and *Metadiaptomus* Methuen. They include some large predatory species that occur in temporary waters in drier regions and also in permanent waters. The majority of species are endemic to Africa.

Subfamily Diaptominae Kiefer, 1932*a*

P1, Exp3 with one outer spine; male right A1 with four post-geniculate segments, terminal segment without extension; male left P5 often with circular,

serrated Exp2 and spine, if present, short and broad-based. The Diaptominae are cosmopolitan and include all the rest of the diaptomids, some 45 genera (Dussart & Defaye 1983).

KEYS TO THE AFRICAN GENERA OF THE FAMILY DIAPTOMIDAE

KEY TO FEMALES

1. Urosome with two somites* 2
— Urosome with three somites ..... *Metadiaptomus*
2. Body length usually >2,0 mm, robust build. Maxillipeds raptorial, with Enp with <5 segments 3
— Body length seldom >2,0 mm, small build. Maxillipeds not modified, with Enp with five segments 4
3. Body length 3,0–4,0 mm. Maxillipeds scythe-shaped (Fig. 5I). P5, Exp3 represented by two closely-applied spines, outer longer than inner, which project across large spiniform process of Exp2. Furcal rami twice as long as broad, setae without bulbous bases ..... *Lovenula*
— Body length 2,0–3,5 mm. Maxillipeds not as above. P5, Exp3 represented by two small spines, outer shorter than inner, spines not projected across Exp2 spiniform process. Furcal rami sometimes lamelliform, expanded distally, setae may have bulbous bases ..... *Paradiaptomus*
4. P5 endopodite with two terminal setae ..... *Tropodiaptomus*
— P5 endopodite without terminal setae ..... *Thermodiaptomus*

KEY TO MALES

1. Right A1, 21-segmented, geniculate between segments 18 and 19, no articulation between segments 20 and 21, diagnostic spiniform processes on segments 8, 10, 11, 13. Left P5, Exp2 with spiniform process well developed, lateral or medial 2
— Right A1, 22-segmented, geniculate between segments 18 and 19, articulation between segments 20 and 21, diagnostic spiniform processes on segments 10, 11, 13, 15. P5, Exp2 without spiniform process 3
2. Maxillipeds not raptorial, with endopodite of five segments. Right P5, B2 expanded on inner margin and fringed with small knobs, spines or setae ..... *Metadiaptomus*
— Maxillipeds raptorial with endopodite of <5 segments. Right P5, B2 not expanded and without knobs, spines or setae 4
3. P5, Exp2 parallel to long axis of body with lateral spine adjacent to Exp3 blade-like claw ..... *Tropodiaptomus*
— P5, Exp2 at right angles to long axis of body, with lateral spine separated from Exp3 blade-like claw ..... *Thermodiaptomus*

* The North African species *Paradiaptomus alluaudi* has three somites.

4. Body length 2,5–4,0 mm. Maxillipeds scythe-shaped (Fig. 5I). Left P5, Exp2 with strong, terminal spiniform process. Setae of right furcal ramus modified with three lateral setae separated from two medial setae..... ..... *Lovenula*

— Body length 2,0–3,5 mm. Maxillipeds not as above. Left P5, Exp2 with short, lateral spiniform process. No separation of setae on right furcal ramus but outermost seta may be enlarged ..... *Paradiaptomus*

Genus *Lovenula* Schmeil, *in* Giesbrecht & Schmeil, 1898

Broteas Lovén, 1845: 436 (*non* C. L. Koch, 1839). Sars, 1899: 6–24.
Lovenula Schmeil, 1898 (*in* Giesbrecht & Schmeil, 1898: 105). Grochmalicki, 1913: 524. Kiefer, 1932*a*: 461; 1934: 108–110; 1978*a*: 74. Damian-Georgescu, 1966: 43. Dussart, 1967: 88. Dussart & Defaye, 1983: 54.
Paradiaptomus Sars, 1907: 3. Stebbing, 1910: 531. Van Douwe, 1912*b*: 25; 1914: 96. Brady, 1913: 467. Gurney, 1929: 581; 1931: 109. Lowndes, 1930: 164. Barnard, 1935: 490.
Paradiaptomus (Lovenula) Dussart, 1989: 32.

Type species. *Lovenula falcifera* (Lovén, 1845).

Remarks

The generic name of this taxon was originally *Broteas*, assigned by Lovén (1845) when he described *Broteas falcifer*. Schmeil (*in* Giesbrecht & Schmeil, 1898) changed the name to *Lovenula* because *Broteas* was preoccupied by an arachnid genus. Sars (1895) described *Paradiaptomus lamellatus*, the type species of the genus *Paradiaptomus*. Sars (1907) gave the generic name *Paradiaptomus* to both *B. falcifer* and *P. lamellatus* as he considered them to be congeneric and also the name *Paradiaptomus* was older than Schmeil's *Lovenula*. Sars (1927) conceded that *Lovenula* and *Paradiaptomus* were two distinct genera but it was still a few years before the name *Lovenula* Schmeil gained full acceptance.

Characteristics of the genus (Figs 4–6)

Length 2,5–4,0 mm, females more robust than males, prosome approximately two-thirds total length in both sexes (Table 1).

Prosome, urosome and furca. Female with two urosomal somites; last thoracic double somite (Pdg4–5) of female expanded as 'wings' (Fig. 4A). Female genital somite expanded laterally, usually more pronounced on left (Fig. 4C). Male urosome of five somites, slender and cylindrical, often curving to the right or directed ventrally (Fig. 4I). Furcal rami in both sexes asymmetrical, right slightly longer than left, each furcal ramus with five strong apical setae and a slender 'dorsal' seta; a very small dorsolateral seta on each furcal ramus (Fig. 4D); three outer setae on male right furcal ramus are spine-like, lack setules on outer margin and separate from two inner setae (Fig. 4J).

Antennae. Female A1 (Fig. 5A) and left A1 of male, 25-segmented with notably two very short spines on segments 8 and 12. Male right A1 (Fig. 5B–D) 21-segmented, geniculate between segments 18 and 19, with terminal segment

TABLE 1
Measurements (in mm) of four species of *Lovenula*.

Locality	Catalogue number	Date	Sex	n	Total length (TL)			Prosome (Pr)			Pr	Ratio
					x̄	Range	C.V.	x̄	Range	C.V.	L : B	Pr : TL
L. falcifera												
Spioenkop Dam	—	9 Sept. 1987	♀	5	3,6	3,2–4,0	8,8	2,6	2,2–2,7	8,8	2,4	0,7
Spioenkop Dam	—	9 Sept. 1987	♂	6	3,3	3,1–3,5	5,2	2,3	2,2–2,5	5,0	2,7	0,7
Sterkfontein Dam	—	13 Mar. 1985	♀	10	3,1	2,6–3,4	7,7	2,2	2,1–2,4	6,2	2,1	0,7
Ovamboland	SAM-A11573	Mar. 1923	♀	58	3,6	3,2–4,0	5,0	2,7	2,4–2,9	4,6	2,7	0,7
Ovamboland	SAM-A11573	Mar. 1923	♂	21	3,5	3,1–4,0	5,3	2,5	2,2–2,7	5,2	2,8	0,7
L. africana												
Lake Rukwa	BMNH 1958.10.2.29 (Daday material)	1908	♀	11	2,4	2,1–2,6	5,3	1,8	1,7–1,9	5,0	3,0	0,7
Lake Rukwa	BMNH 1958.10.2.29 (Daday material)	1908	♂	13	2,4	2,2–2,9	7,6	1,6	1,4–2,0	8,2	2,8	0,7
Makgadikgadi Pan	—	4 May 1957	♀	7	3,0	2,9–3,2	3,7	2,2	2,0–2,3	4,0	2,5	0,7
Makgadikgadi Pan	—	4 May 1957	♂	4	3,0	2,8–3,0	3,9	2,1	2,0–2,1	2,2	2,4	0,7
(Syn. *Paradiaptomus biramata* Lowndes)												
Hora Keloli	BMNH 1932.4.23.6-15	1926	♀	4	3,0	3,0–3,1	0,8	2,2	2,2–2,3	1,1	2,4	0,7
Hora Keloli	BMNH 1932.4.23.6-15	1926	♂	4	2,6	2,4–2,9	8,3	1,8	1,7–2,0	7,2	2,4	0,7
L. excellens												
Lake Chrissie	VAL1179D	1 June 1960	♀	6	3,1	3,1–3,2	1,5	2,3	2,2–2,3	2,8	2,3	0,7
Lake Chrissie	VAL1179D	1 June 1960	♂	10	3,2	3,1–3,4	4,2	2,1	2,0–2,2	3,6	2,4	0,7
L. simplex												
Groot Rondevlei	—	1981	♀	4	3,7	3,5–3,9	4,2	2,6	2,5–2,6	1,6	2,3	0,7
Groot Rondevlei	—	1981	♂	20	3,4	3,0–3,7	4,7	2,3	2,0–2,4	3,8	2,5	0,7
Sirkelsvlei	—	1981	♀	3	3,1	3,0–3,2	4,6	2,1	1,9–2,2	6,0	2,3	0,7
Sirkelsvlei	—	1981	♂	14	2,8	2,5–3,0	6,0	1,8	1,6–2,0	7,0	2,5	0,6

with a beak-like extension; longest diagnostic spiniform process on segment 11, with spiniform process on segment 10 shorter and curved in towards it; a strong, broad-based spiniform process on segment 13; the smallest process on segment 8. A2 biramous (Fig. 5E), with two-segmented endopodite and seven-segmented exopodite; basis with 1–2 setae; Enp1, two setae, lateral border denticulate distally; Enp2 with two distal lobes with approximately 16 setae (not all shown in figure); Exp2 and Exp7 long, Exp3–6 compacted; a single, strong seta arises from Exp3, Exp5, Exp6, and proximal end of Exp7; reduced Exp4 lacks a seta and Exp7 has three long, terminal setae.

Mouthparts. Mandible (Fig. 5F) consists of a large gnathobasal coxa with a single tooth and 5–6 smaller teeth separated by a V-shaped cutting edge; mandibular palp with four inner setae on basis, two-segmented endopodite with four setae on Enp1, six setae on Enp2; five-segmented exopodite with one inner seta on each of Exp1–4, two setae on Exp5. Maxilla 1 (Fig. 6) with precoxa with 13 spine-like setae with bristle-like setules; coxa with two lobes on inner border, one lobe with three strong setae, the other with two long and two short setae; basis with one proximal seta and four distal setae of different lengths; one-segmented endopodite with two lobes, with three short, one long, and four very long setae, one-segmented exopodite with seven long setae; nine very long setae on outer border of coxa. Maxilla 2 (Fig. 5G) with precoxa with two lobes with 5 + 3 setae, coxa with 3 + 3 setae, basis with three long and one very small setae, Enp 1–3 each with spine-like seta; one seta on precoxa, two on coxa and one on basis are claw-like with fine bristles (Fig. 5H). Maxilliped (Fig. 5I) consists of precoxa, coxa, basis and four-segmented endopodite; groups of 1, 2, 3 and 3 setae on coxa and a spiny process at articulation with basis; basis with fringe of small denticles on inner border with two and one strong setae; Enp1 with two long and two shorter setae; three terminal segments (Enp2–4) produced distally to form spiniform processes, smooth on outer margin, denticulate on inner.

Natatory legs. First natatory leg (P1) (Fig. 4E) with two-segmented endopodite and three-segmented exopodite (spine formula: 1, 0, 2); second, third and fourth natatory legs (P2–P4) (Fig. 4F) with endopodite and exopodite three-segmented, spine formula of exopodite: 1, 1, 2; endopodites of P2–P4 same length; exopodites of P3 and P4 longer and sturdier than P2, length being achieved by extension of Exp1.

Non-natatory P5. Female P5 (Fig. 4G, H), endopodite one-segmented with two terminal setae, 5–6 sub-apical spinules at base of outer seta; Exp2 and Exp3 fused, Exp2 with an inner spiniform process and an outer broad-based spine; Exp3 represented by two closely applied spines, outer spine longer than inner, both projecting across Exp2 spiniform process. Male P5 (Fig. 4K–M), right leg, Exp1 with an inner rounded process, Exp2 with an outer distal spine and Exp3 represented by a terminal, medially denticulate, blade-like claw; endopodite two-segmented, the last segment ball-shaped with a semi-circular fringe of 6–8 spinules; left leg with one-segmented endopodite, Exp2 produced laterally into a

strong, medially denticulate spiniform process; on medial margin of Exp2, a triangular pad fringed with knobs or setae, and between outer spine and inner pad, a slender apical spine extending diagonally between the two structures.

Kiefer (1932*a*) divided the genus *Lovenula* into two subgenera, *Lovenula* s.s. and *Neolovenula* for *Diaptomus alluaudi* Guerne & Richard, 1890 (see p. 324).

Lovenula falcifera (Lovén, 1845)

Figs 4–6

Broteas falcifer Lovén, 1845: 436, pl. 6 (figs 1–16). Guerne & Richard, 1889: 118–121, figs 41–43.
Lovenula falcifera Giesbrecht & Schmeil, 1898: 105, fig. 25. Daday, 1910*b*: 118. Kiefer, 1932*a*: 481, 484 (figs 6–8), 486; 1932*b*: 214–215, fig. 1; 1934: 110–115, figs 1–8; 1939: 324, figs 1–3. Hutchinson *et al.*, 1932: 17–150. Brehm, 1958: 34. Löffler, 1961: 356; 1964: 187; 1968. Kok, 1974: 153–183. Dussart & Defaye, 1983: 54.
non *Broteas falcifer* Sars, 1899: 6–24, pl. 1 (figs 1–15).
Lovenula mea Gurney, 1904: 300–301, pl. 18 (figs 7–13) (*part.*).
Diaptomus bouvieri Daday, 1910*a*: 187, 188, 195, pl. 5 (figs 1–11), text-fig. 1a–b.
Paradiaptomus falcifer Stebbing, 1910: 532. Tollinger, 1911: 189. Van Douwe, 1912*a*: 2, pl. 1 (figs 1–5); 1912*b*: 29, 31; 1914: 95–96. Brady, 1913: 468, pl. 35 (figs 7–10). Gurney, 1929: 582.
Paradiaptomus meus Stebbing, 1910: 533 (*part.*).
Paradiaptomus gurneyi Tollinger, 1911: 188 (*part.*). [*syn. nov.*]
Lovenula barnardi Sars, 1927: 92, pl. 6 (figs 6–9). Kiefer, 1928: 8. Harding & Smith, 1967: 518.
Paradiaptomus barnardi Lowndes, 1931: 1291; 1933: 308. Barnard, 1935: 490.
Lovenula furcata Brehm, 1958: 34, fig. 29. [*syn. nov.*]
Lovenula excellens Brehm, 1958: 35–37 (figs 34–37). Hart, 1984: 1602–1607; 1985*a*: 151–178; 1985*b*: 17–26; 1986: 351–371; 1987: 287–318 (misidentification).
Paradiaptomus (*Lovenula*) *falcifera* Defaye, 1988: 115, table 1, figs 13–16. Dussart, 1989: 33–34, 126, figs 20, 71.
Paradiaptomus (Lovenula) furcata Dussart, 1989: 39–40, 130, fig. 24C.

Material examined (Figs 1–2, Gazetteer)

BMNH 1904.9.21.23–24, BMNH 1951.8.10.68–69, wet specimens labelled *Lovenula mea* Gurney, 1904. Identity of male: *Lovenula falcifera*, female: *Paradiaptomus schultzei* van Douwe, 1912*b*; *L. mea* placed into synonymy with *L. falcifera* (see above). SAM–1501, Port Elizabeth, no details. NM, pond, Harrismith, E. Warren, February 1908. SAM–A3787, Kimberley, no details. HMNH–K8896, Farm Frauenstein, near Neudamm, 50 km east-north-east Windhoek, Namibia, W. Michaelsen, 13 May 1911. HMNH–K8895, Farm Otjituezu, near Neudamm, 66 km north-east of Windhoek, Namibia, W. Michaelsen, 13 May 1911. SAM–A4791, Grootfontein, S. H. Haughton, August 1917. SAM–A11573, Ukualonkathi, Ovamboland, KHB, March 1923. SAM–A11574, Ongka, Ondangua, Ovamboland, KHB, February 1923. SAM–A11575, Onambeke, Ovamboland, KHB, April 1923. SAM–A11576, Ukualuthi, Ovamboland, KHB, April 1923. SAM–A5915, Junction Marico and Crocodile rivers, R. W. Tucker, 1918. SAM–A5943, Beaufort West, S. H. Haughton, August 1917. SAM–A11581, Aliwal North, S. H. Haughton, 24 July

1921. SAM–A11582, Cornets Kop, Molteno, Beaufort West, S. H. Haughton, June 1921. SAM–A11584, west of Gouritzrivier bridge, G. E. Hutchinson, 1927. SAM–A11590, Lobatsi, Bophuthatswana, J. H. Power, 1927. SAM–A11537, SAM–A11538, SAM–A11539, SAM–A12446, SAM–A12448, SAM–A12449, SAM–A12450, SAM–A12451—all these vials contain material from Ovamboland, identified in G. O. Sars' handwriting as '*L. barnardi*' and relate to SAM–A11573–6. Barnard sent this material for identification to Sars in 1925 (correspondence files, S. A. Museum). TM–1225, 1 mile north-east of Tsotsoroga Pan, 23 June 1930, Vernay-Lang Kalahari Expedition. TM–1260, 1 mile north-east of Tsotsoroga Pan, 3 July 1930, VLKE. TM–1508, N'Kate Pan, 7 August 1930, VLKE. BMNH 1959.3.2.3–4, Dodoma, Tanganyika, H. J. de S. Disney, undated. AM–VAL 907A, Vaal River catchment, Stn 3, stones-in-current, FMC, 11 November 1959. AM–VAL 912A, Vaal River catchment, Stn VD 17, stones-in-current, FMC, 10 November 1959. AM–GEN 591D, pan between Middleburg and Belfast, J. Agnew, 23 June 1960. AM–GEN 595B, Dewetsdorp, J. Agnew, 29 March 1961. AM–VAL 1379F, Vaal River catchment, Stn SV 9, stones-in-current, FMC, 14 April 1964. AM–VAL 1390B, Vaal River catchment, Stn SV 9, marginal vegetation, FMC, 14 April 1964. Witbank Dam, MTS, 2 March 1978. Welbedacht Dam, MTS, July 1980. Mazelspoort Dam, MTS, August 1981. P. K. le Roux Dam, MTS, 4 July 1981. P. K. le Roux Dam, RCH, 12 January 1982. SMN–50727, waterhole, eastern Caprivi, Namibia, S. Bethune, 8 December 1982. SMN–50772, 65 km east of Windhoek, Namibia, C. Meyer, 23 January 1984. Greyvenstein Dam, MTS, 11 May 1984 and 15 June 1984. Omatako Dam, Namibia, W. A. Smit, 20 September 1984. AM–GFR, Witmos, J. O'Keefe and F. de Moor, 19 February 1985. Sterkfontein Dam, W. Dorgelöh, 13 March 1985. White Hill Pan, 42 km from Hwange, Zimbabwe, A. J. C. Gardiner, July 1985. Elandsdrift, Great Fish River, R. W. Palmer, 20 January 1986. Spioenkop Dam, RCH, 9 September 1987. SMN–51328, Gautscha Pan, Boesmanland, Namibia, B. A. Curtis, 17 March 1988. SMN–51330, Tjokwe Pool, Boesmanland, Namibia, B. A. Curtis, 17 March 1988. Quaggaplaat, Sutherland, temporary pool under snow, JMK, 31 August 1988. D510/02, Brak River airfield, JMK, 31 August 1988. Nuweleeurivierdam, RCH, 18 January 1989. D560/02, Quaggaplaat, JMK, 2 August 1989.

Description

Measurements are given in Table 1 and abbreviations on p. 302.

Female (Figs 4–6). Large, robust build (Fig. 4A); A1 extends to posterior border of GS; antennae and mouthparts (Figs 5A, E–I, 6); thoracic 'wings' markedly expanded and backwardly directed, left longer than right, two points on left 'wing', one on right with a small additional spine on each 'wing'; GS expanded more on left than right, slightly shorter than AS (Fig. 4C); furca (Fig. 4D); P1 (Fig. 4E); P2 (Fig. 4F); P5 strongly developed, spiniform process of Exp2 often carried at right angles to Exp1; endopodite same length as Exp1, with two strong terminal setae, more than half length of endopodite; small

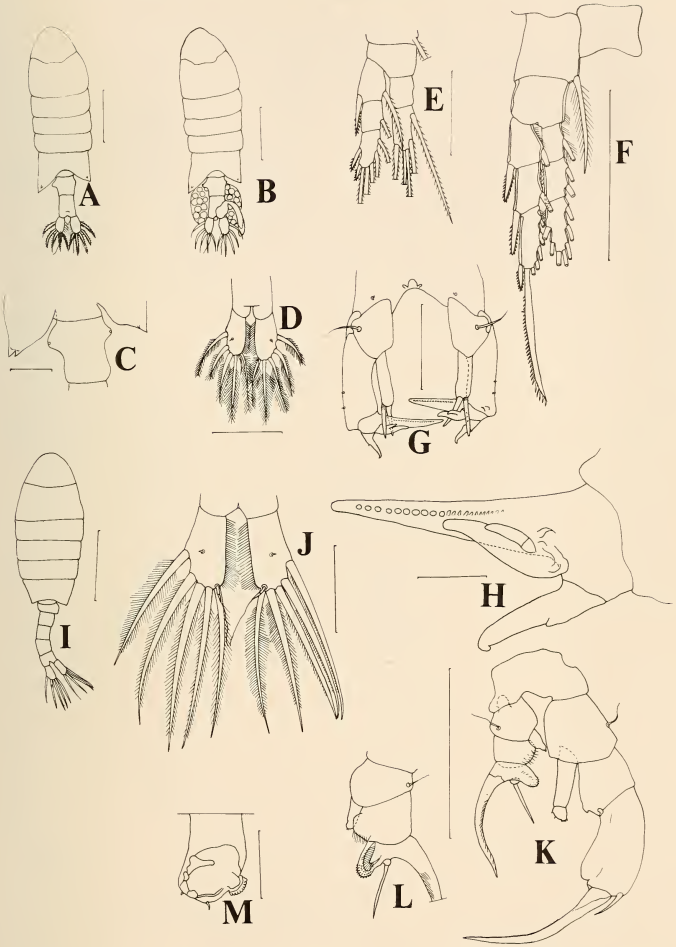

Fig. 4. *Lovenula falcifera*. A–H. Adult female. A. Dorsal view. B. With egg sac and spermatophore. C. Thoracic 'wings' and GS, dorsal view. D. Furca, dorsal view. E. Left P1, posterior view. F. Left P2, posterior view. G. P5, posterior view. H. P5, Exp2 and Exp3, posterior view. I–M. Adult male. I. Dorsal view. J. Furca, dorsal view. K. P5, posterior view. L. P5, left leg, Exp2, anterior view. M. P5, right leg, Enp2, ventral view. Bar scales in mm. A, B, I = 1. D, F, K, L = 0,5. C, E, G, J = 0,25. H, M = 0,05.

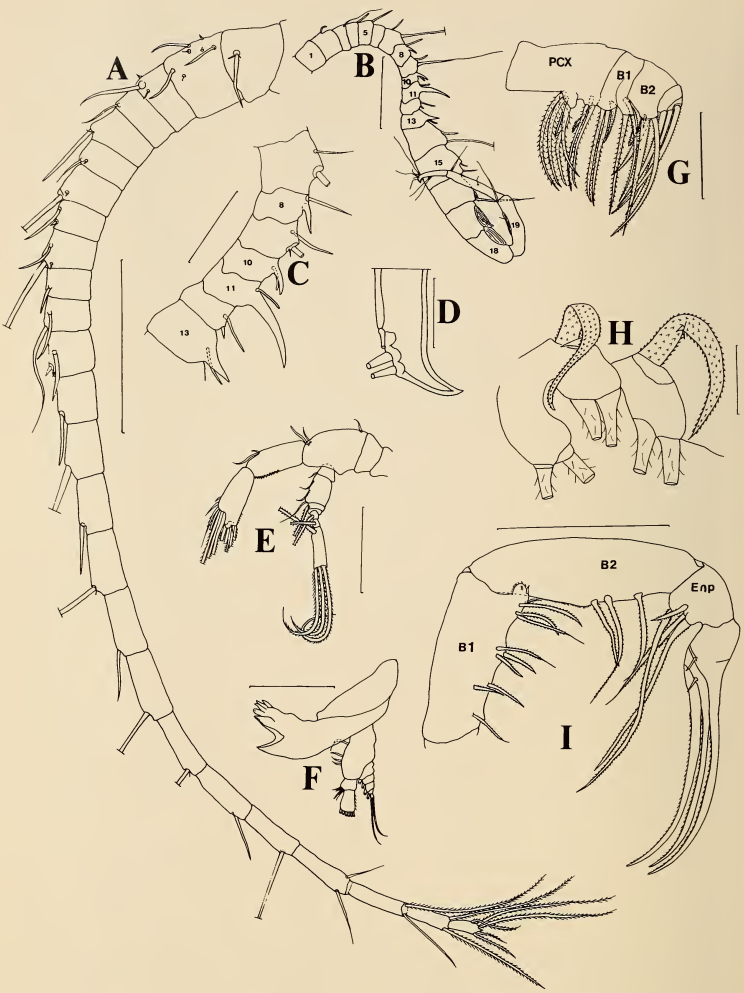

Fig. 5. *Lovenula falcifera*. Antennae and mouthparts. A. Female left A1. B. Male right A1. C. Male A1, segments 8–13. D. Male A1, end of terminal segment. E. Antenna 2. F. Mandible. G. Maxilla 2. H. Maxilla 2, claw-like setae of coxa and basis, ventral view. I. Maxilliped. Bar scales in mm. A, B, I = 0,5. C, E, F, G = 0,25. D, H = 0,05.

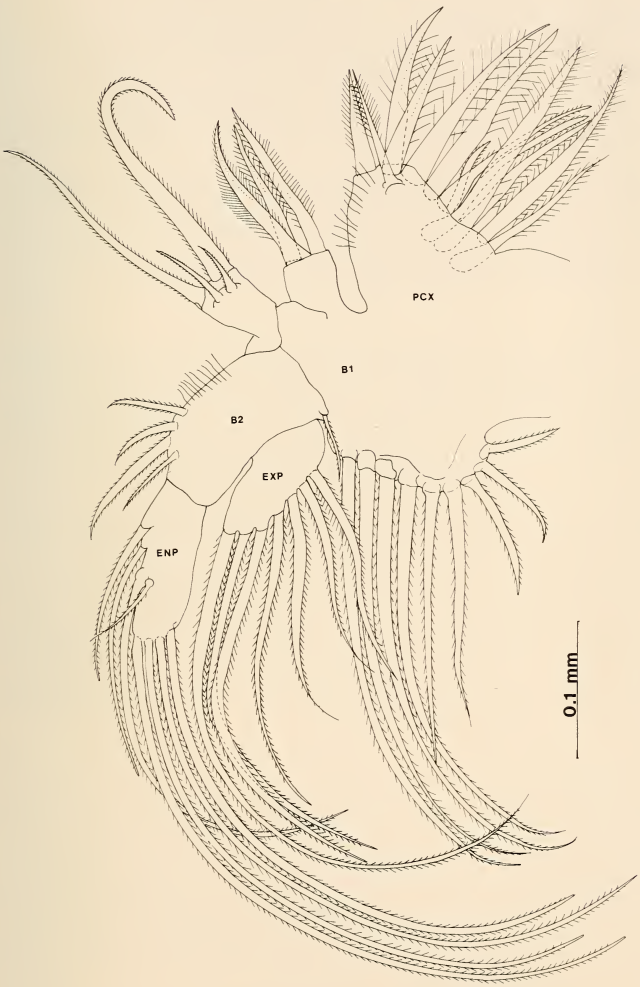

Fig. 6. *Lovenula falcifera*. Maxilla 1.

process on outer margin of Exp2 lateral spine (Fig. 4G–H). Egg sac (Fig. 4B), details from three localities:

1. One female, *c.* 258 eggs, bilobed sac, L. 0,8 × B. 1,2 mm (SAM–A4791, temporary pool, Grootfontein, 1917).
2. Range 9–43 eggs, $\bar{x}$ = 21,6, P. K. le Roux Dam (Hart 1987).
3. One female, *c.* 116 eggs, sac L. 0,85 × B. 1,0 mm (D560/02, Quaggaplaat, 1989).

Male (Figs 4–5). Slender build (Fig. 4I); right A1 strongly developed, segments 13–18 expanded and flattened (Fig. 5B–D); furca (Fig. 4J); P5, right leg, Enp2 spinules short and rounded; left leg endopodite well developed, with 2–3 apical spinules; Exp2 with strong, semi-circular spiniform process (Fig. 4K–M). Spermatophore length, range 0,75–0,95 mm.

Coloration

In freshly collected specimens, there may be indigo pigment deposited internally in appendages and furca. J. M. King, University of Cape Town (pers. comm.), noted that *L. falcifera* collected from a snow-bound pond at Quaggaplaat, near Sutherland, was blue-green. Barnard (1935) recorded *L. falcifera* from near Tsotsoroga Pan, Kalahari, as having a sky-blue body and anterior and posterior appendages bright red. Specimens collected by Warren in 1908 from a pond near Harrismith, were described as follows: '. . . the body milky white, the antennae purple, the furca bright red round the base and purple terminally, the setae purple' (Brady 1913).

Historical

Lovenula falcifera was collected by J. Wahlberg, from a salt pan in the Magaliesberg, between the Crocodile and Apies rivers, Transvaal. Lovén gave the specific name 'falcifer'—bearing a scythe or sickle—referring to the sickle-shaped, large raptorial maxillipeds. Swedish museum authorities declined to supply any information regarding types.

Distribution (Fig. 2)

In South Africa, *Lovenula falcifera* occurs in temporary, often saline, waters on the highveld, major impoundments on the Orange and Vaal rivers; Ovamboland and other areas of Namibia; and Kalahari (Barnard 1935). Hutchinson *et al.* (1932) collected the species in 1928 from Transvaal pans: Bothasrust, Brakpan 1 and 2, Eliazar, Florida Grass, Leeuwkraal, Rietfontein 1 and 2, Weltevreden East and West; from O. F. S.: Morgenson farm dam; from Eastern Cape: Stormberg Dam. Also recorded from Kenya (Van Douwe 1912*a*), Uganda (Lowndes 1931), East African high mountain lakes (Löffler 1964, 1968), and Ethiopia (Defaye 1988).

Lovenula falcifera is widely distributed, especially in drier areas in temporary pools but it also has the ability to colonize major man-made water bodies (Hart 1984, 1985*a*, 1985*b*, 1986, 1987; Defaye 1988). Despite its wide

distribution, it has not been recorded from low-lying areas, vleis, coastal lakes or coastal plains (Fig. 2). It appears to be confined to the high plateau of Africa above 1 000 m, much of which lies in the pan belt (see p. 303), as well as high mountain lakes in East Africa. It is obviously well adapted to the extreme temperature ranges of these regions.

Lovenula falcifera often co-occurs with a species of *Metadiaptomus* as prey species. It has been recorded as co-existing with *M. meridianus* (Witmos, Sterkfontein Dam, P. K. le Roux Dam, Greyvenstein Dam, Mazelspoort Dam, Quaggaplaat Pan, Nuweleeurivier Dam), *M. colonialis* (Spioenkop Dam, White Hill Pan in Zimbabwe, Omatako Dam and Neudamm in Namibia) and *M. transvaalensis* (a pan between Middleburg and Belfast, Tvl.). In Witbank Dam in the eastern Transvaal, *L. falcifera* co-exists with *Thermodiaptomus syngenes*.

Remarks

In southern Africa, the confusion of *L. falcifera* with *L. simplex* and *L. excellens* has detracted from correct interpretation of the biology of this important diaptomid.

Lovenula africana (Daday, 1908)

Fig. 7

Diaptomus africanus Daday, 1908: 45, 46 (figs 25a–e); 1910*a*: 111, pl. 5 (figs 1–13). Tollinger, 1911: 55. Cunnington, 1920: 559. Gurney, 1929: 579–580.
Paradiaptomus biramata Lowndes, 1930: 163, pl. 1 (figs 1–7), pl. 3 (figs 1–8); 1933: 308–309.
Lovenula africana Daday, 1910*b*: 118. Kiefer, 1932*a*: 461, 486, 489 (figs 15–17); 1934: 119–122, figs 19–23; 1939: 324. Brehm, 1958: 37. Löffler, 1961: 356 (table 2), 363. Dussart & Defaye, 1983: 55. Green, 1986: 496–498.
Paradiaptomus africanus Lowndes, 1936: 6, figs 1A–H, 2A–B. LaBarbera & Kilham, 1974: 461–464.
Paradiaptomus (Lovenula) africanus Harding, 1942: 180.
Paradiaptomus (Lovenula) africana Defaye, 1988: 112, table 1, figs 8–12. Dussart, 1989: 37, 129, figs 23A, 70.

Material examined (Figs 1–2, Gazetteer)

HMNH–1908 (Daday's material), Lake Rukwa. BMNH 1932.4.23.6–15, syntypes of *Paradiaptomus biramata* Lowndes, Hora Keloli, Ethiopia, J. Omer Cooper, 1926. BMNH 1941.5.16.50–60, Lake Rukwa, East Africa, C. K. Ricardo and R. J. Owen, undated. BMNH 1958.10.2.29, Makgadikgadi main pan, Botswana, D. H. Eccles, 4 May 1957. Sowa Pool, north-eastern tip of Sowa Pan, Makgadikgadi, Botswana, R. C. Hart, 10 July 1990; males and females with egg sacs and spermatophores.

Description

Measurements are given in Table 1 and abbreviations on p. 302.

Female (Fig. 7A–E). Moderate size (Fig. 7A); A1 extends to posterior border of GS; thoracic 'wings' asymmetrical with three dissimilar processes on

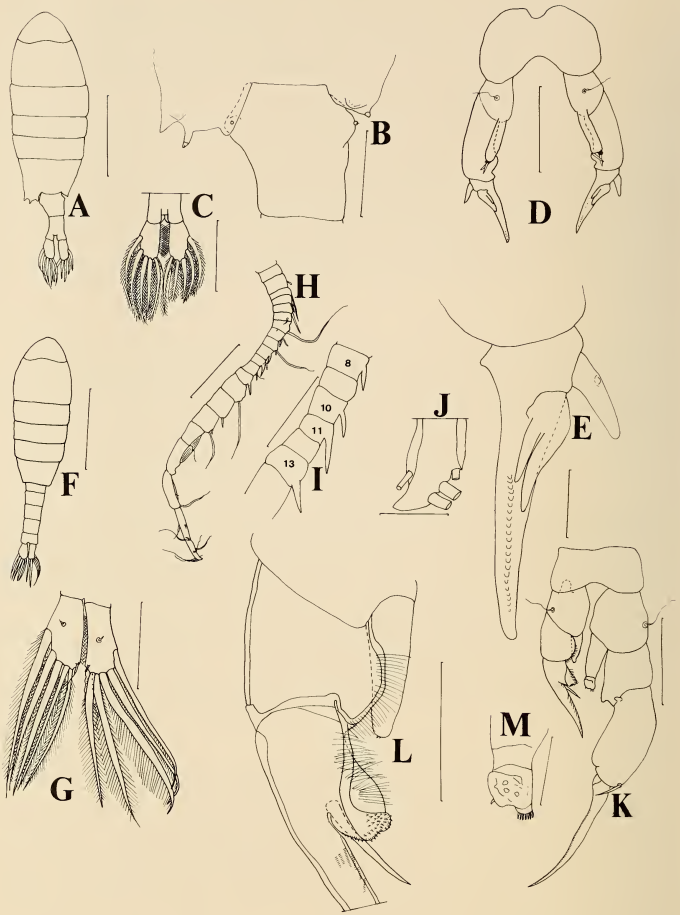

Fig. 7. *Lovenula africana*. A–E. Adult female. A. Dorsal view. B. Thoracic 'wings' and GS, dorsal view. C. Furca, dorsal view. D. P5, posterior view. E. P5, Exp2 and Exp3, posterior view. F–M. Adult male. F. Dorsal view. G. Furca, dorsal view. H. Right A1. I. A1, segments 8–13. J. A1, end of terminal segment. K. P5, posterior view. L. P5, left leg, Exp2, posterior view. M. P5, right leg, Enp2, posterior view. Bar scales in mm. A, F = 1. B, H = 0,5. C, D, G, I, K = 0,25. L = 0,1. E, J, M = 0,05.

left side, outer process pointed, medial finger-like, inner rounded; GS slightly expanded, same length as AS (Fig. 7B); furca (Fig. 7C); P5, endopodite weakly developed, distinctly shorter than Exp1, setae small, one-quarter length of endopodite; spiniform process of Exp2 directed backwards; Exp2 lateral spine shorter than in other species and with barely discernible process (Fig. 7D–E); egg sac, 13–14 eggs (Daday 1908; paralectotype).

Male (Fig. 7F–M). Moderate size (Fig. 7F); A1 moderately developed (Fig. 7H–J); furca (Fig. 7G); P5, right leg, Enp2 spinules slender and pointed; left leg endopodite well developed, with 2–3 apical spinules; Exp2 produced to form a straight, backwardly-directed spiniform process (Fig. 7K–M).

Type material

Daday (1908) did not designate type material (Dr László Forró, HMNH, pers. comm.). Type locality, Lake Rukwa, Tanzania. Lectotype and paralectotypes designated from Daday's original material, deposited by author in 1989, with the Hungarian Natural History Museum, Budapest. Catalogue numbers: lectotype III/P–382; paralectotypes, male III/P–383, female III/P–384. Examination of syntypes of *Paradiaptomus biramata* Lowndes (BMNH 1932.4.23.6–15) confirmed its synonymy with *L. africana* (Kiefer 1934).

Distribution (Fig. 2)

Only one southern African record, Makgadikgadi Pan, Botswana; other African records: in Ethiopia: Hora Keloli, Hora Horeso (Lowndes 1930); in Kenya: Lake Elementeita, Rift Valley (Lowndes 1933); crater lake, 2 miles west of Lake Naivasha (Lowndes 1936); Lake Rukwa (Harding 1942); in Kenya, Uganda, Tanzania, Rwanda: Lakes Big Momela, El Kekhotoito, Embagai, Eyasi, Kusare, Magad, Manyara, Mikuyu, Nakuru, Reshitani, and Tulusia (LaBarbera & Kilham 1974); in Ethiopia: Lakes Paulo, Bishoftu, Arenguade, Kilotes, Abijata, Langano, and Arenguade (Green 1986; Defaye 1988).

Lovenula africana occurs in waters with high conductivity from Ethiopia through East Africa, with the southernmost record being Makgadikgadi Pan, Botswana. The conductivity range of 11 East African lakes was 3 350–15 000 μmhos cm^{-1} ($\bar{x}$ = 11 439 ± 5 528), the highest conductivity range recorded for any of 11 common species of copepods (LaBarbera & Kilham 1974). This suggests that *L. africana* has an affinity for saline waters, confirmed by its occurrence in Makgadikgadi salt pan. The salt concentration in this pan may reach proportions such that flamingos' legs are encrusted with salt deposits (R. Kennard, pers. comm.). *Metadiaptomus transvaalensis* has been recorded as the prey species of *Lovenula falcifera* in Makgadikgadi Pan. In Lake Bunyonyi, *Metadiaptomus aethiopicus* co-occurs with *L. africana* (Lowndes 1936). Cunnington's (1920) record of *L. africana* from Lake Malawi is doubtful, because of the low conductivity of the lake (210 μmhos cm^{-1}).

Lovenula excellens Kiefer, 1929

Fig. 8

Lovenula excellens Kiefer, 1929: 309–310, figs 1–3.
Broteas falcifer Methuen, 1910: 159, pl. 16 (fig. 45a–b). [*syn. nov.*]
Lovenula excellens Kiefer, 1932*a*: 461, 487–488, figs 12–14; 1934: 102, 106–107, 116–119, figs 15–18. Hutchinson *et al.*, 1932: 1–150, pl. 8 (fig. 2). Löffler, 1961: 356 (table 2), 363. Dussart & Defaye, 1983: 56.
Paradiaptomus excellens Gurney, 1929: 582.
Paradiaptomus (Lovenula) excellens Dussart, 1989: 38–39, 130, figs 24A, 70.

Material examined (Figs 1–2, Gazetteer)

AM–VAL 676B, Lake Chrissie, bottom sediment, FMC, 10 December 1958. AM–VAL 720D, Vaal River catchment, Stn VD 2, Eckman grab, FMC, 10 December 1958. AM–VAL 1179D, Lake Chrissie, bottom sediment, FMC, 1 June 1960.

Description

Measurements are given in Table 1 and abbreviations on p. 302.

Female (Fig. 8A–E). Moderate size, robust build (Fig. 8A); A1 extends to posterior border of AS; thoracic 'wings' not markedly expanded, left slightly longer than right; GS with cone-shaped expansion on left side; AS slightly longer than GS (Fig. 8B); bases of FS widely separated, setae fine, long and tapering (Fig. 8C); P5, small, setae on endopodite one-quarter length of endopodite, inner seta shorter; Exp2 lateral spine with well-developed process on outer margin (Fig. 8D–E); egg sac, unknown.

Male (Fig. 8F–M). Slender build (Fig. 8F); right A1 slender (Fig. 8H–J); right FR, three outer FS shorter than inner two (Fig. 8G); P5, left leg, endopodite reduced, Exp2 spiniform process curved distally; right leg, Enp2 spinules sturdy and pointed; Exp2 lateral spine short, blunt; Exp3 claw not strongly developed (Fig. 8K–M); spermatophore length 0,62.

Historical

Type material was not designated. Kiefer's microscope slide numbers: 01154*, 01155*, 01156, 01165* (Dr Ulrich Franke, Landessammlungen für Naturkunde, Karlsruhe, Germany, pers. comm.).

Material for description was obtained from alkaline pans (Avenue, Banagher 3, Blaauwater 1–5, Eilandspan, Liefgekosen, Magdalenasmeer North, Rietkuil) in Lake Chrissie area, Eastern Transvaal, South Africa, collected May 1928, by Hutchinson *et al.* (1932).

Distribution (Fig. 2)

Lovenula excellens has been recorded only from pans in the Lake Chrissie area and the upper Vaal River catchment. The Lake Chrissie pans are peculiar in that they are relics of an ancient drainage system belonging to the Umpilusi

* with diagram.

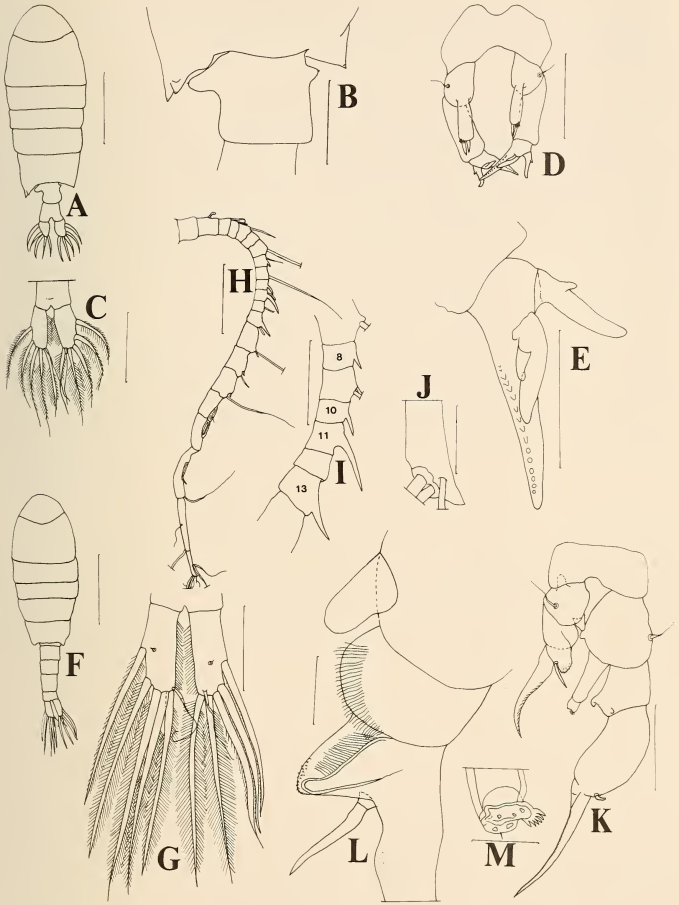

Fig. 8. *Lovenula excellens*. A–E. Adult female. A. Dorsal view. B. Thoracic 'wings' and GS, dorsal view. C. Furca, dorsal view. D. P5, posterior view. E. P5, Exp2 and Exp3, posterior view. F–M. Adult male. F. Dorsal view. G. Furca, dorsal view. H. Right A1. I. A1, segments 8–13. J. A1, end of terminal segment. K. P5, posterior view. L. P5, left leg, Exp2, anterior view. M. P5, right leg, Enp2, posterior view. Bar scales in mm. A, F = 1. C, H = 0,5. B, D, G, I, K = 0,25. E = 0,1. J, L, M = 0,05.

River, from which the Vaal River has captured the headwaters (King 1951). *Lovenula excellens* and *Metadiaptomus transvaalensis* were recorded as co-existing in Lake Chrissie (Methuen 1910).

Remarks

This species posed a major problem in the resolving of the taxonomy of the *Lovenula* species. It was described by Kiefer (1929) from material collected by Hutchinson *et al.* (1932) in the Lake Chrissie area in the Eastern Transvaal and was not mentioned again until its identity was queried by Kok (1974). Kiefer (1929, 1934) did not emphasize the main taxonomic differences between *L. excellens* and *L. falcifera*, although Hutchinson *et al.* (1932) stated clearly that *L. excellens* was different enough from *L. falcifera* to be a good species. More recently, a misidentification of *L. falcifera* as *L. excellens* from the Orange River impoundments (Hart 1984) almost entrenched the supposition that *L. falcifera* was a temporary pool-dweller and *L. excellens* a permanent-water species, although the recent origin of man-made water bodies rules out this possibility. The identity of *L. excellens* was confirmed by examination of material collected by Chutter (1963) in his 1958–1960 survey of Lake Chrissie and the Vaal River catchment.

Lovenula simplex Kiefer, 1929

Fig. 9

Broteas falcifer Sars, 1899: 6–24, pl. 1 (figs 1–15) (*non* Lovén, 1845).
Paradiaptomus falcifer Rühe, 1914: 8–9, 29–32, fig. 10a–f.
Lovenula falcifera Sars, 1927: 86, pl. 5 (figs 1–12). Harding & Smith, 1967: 518.
Lovenula simplex Kiefer, 1929: 309–310, figs 1–3; 1932*a*: 461, 487, figs 9–11; 1934: 105, 116–117, 123, figs 9–14. Gurney, 1929: 582. Brehm, 1958: 37. Dussart & Defaye, 1983: 56. Gardiner, 1988: 181–229.
Paradiaptomus (Lovenula) simplex Dussart, 1989: 38, 129, figs 23B, 69.

Material examined (Figs 1–2, Gazetteer)

SAM–A12440, ponds, Green Point Common, Cape Town, WFP, 1898, labelled *Lovenula falcifer*. SAM–A3788, Cape Flats, KHB, 1916. SAM–A11534, Sars' writing, *Broteas falcifer*. SAM–A11535, Sars' writing *Broteas falcifer*. SAM–A11549, Green Point Common, *Paradiaptomus falcifer*. SAM–A11551, Touwsrivier, *Paradiaptomus falcifer*. SAM–A11015, Diep River Quarry, Milnerton, E. G. H. Oliver, undated. SAM–1503, Faure, near Zeekoevlei, ?1920. SAM–A12468, SAM–A12469, SAM–A12470, very old, no details, ?late 1800s. 5 Si 1T, 9 Si 1T, 9 Si 2T, 10 Si 2T, four different samples from Sirkelsvlei, AJCG, August 1981. 14 GR 2T, 16 GR 2T, 17 GR 2T, three different samples from Groot Rondevlei, AJCG, August 1981. Gi 1T, Gillidam, AJCG, November 1981. SWT–19A, Sirkelsvlei, JAD, 1 September 1983. SWT–27A, temporary pool, Noordhoek, JAD, August 1983. SWT–17H, 10 km south-east of D. F. Malan Airport, Cape Town, JAD, 12 August 1983. De

Hoop Vlei, sites 1, 3, 4, 5, JMK, 1 November 1986. G501/18, Wiesdrift, JMK, 11 May 1989. G501/18, Soetendalsvlei ditch, JMK, 12 May 1989.

Description

Measurements are given in Table 1 and abbreviations on p. 302.

Female (Fig. 9A–E). Large, robust build (Fig. 9A); A1 extends to posterior border of GS; thoracic 'wings' slightly expanded, left longer than right, an additional small spine on each 'wing'; GS slightly expanded; AS twice length of GS (Fig. 9B); furca (Fig. 9C); P5, setae on endopodite strong, about one-third length of endopodite; Exp2 spiniform process well developed, directed backwards (Fig. 9D–E); egg sac, *c.* 87 eggs, L. 0,83 × B. 1,25 mm (SAM–A11534); *c.* 113 eggs (SAM–1503).

Male (Fig. 9F–N). Large (Fig. 9F); right A1 strongly developed, segments 8–13 expanded and flattened (Fig. 9H–J); urosome sturdy, right FR with three outer FS tapering distally (Fig. 9G); P5 long, right leg extending to posterior border of furca; left leg, endopodite reduced to a rounded process; Exp2 spiniform process straight and backwardly directed (Fig. 9L); right leg, Enp2 spinules sturdy and pointed (Fig. 9N); Exp2, outer spine slender, one-quarter length of claw; Exp3 claw with slight S-shape (Fig. 9K, M); spermatophore length 0,65 mm.

Historical

Type material was not designated. Kiefer's microscope slide numbers: 01183, 01192*, 01193*, 01194* (Dr Ulrich Franke, Landessammlungen für Naturkunde, Karlsruhe, Germany, pers. comm.). Kiefer's (1929) description related to material collected from Simon's Town, Cape Peninsula, by Rühe (1914) and housed in the Berlin Museum.

Distribution (Fig. 2)

Lovenula simplex is restricted to the coast of the Cape Province where it has been recorded only from humic vleis (e.g. Gillidam, Sirkelsvlei and Groot Rondevlei), pools on the Cape Peninsula and environs, and De Hoop Vlei on the southern Cape coast. Gillidam is a small closed basin (35 m × 10 m) with dark-brown water and large water-level changes, with pH 3,8–4,1, maximum depth 1,4 m, temperature range 10,5–29,0 °C. Sirkelsvlei is a closed basin (475 m × 90 m), with dark-brown water and large water-level changes, with pH 6,3–6,7, maximum depth 1,4 m, temperature range 10,5–26,0 °C. Groot Rondevlei is an open basin (420 m × 360 m), with brown water and moderate water-level changes, with pH 5,7–6,4, maximum depth 1,6 m, temperature range 11,0–26,0 °C (Gardiner 1988). In the Cape Province, *Lovenula simplex* co-occurs with *Metadiaptomus capensis* (Green Point Common, De Hoop Vlei, Sirkelsvlei, Varkensvlei, and Vermont Pan) and with *Metadiaptomus purcelli* (Cape Flats, Gillidam, Groot Rondevlei, and Soetendalsvlei).

* with diagram.

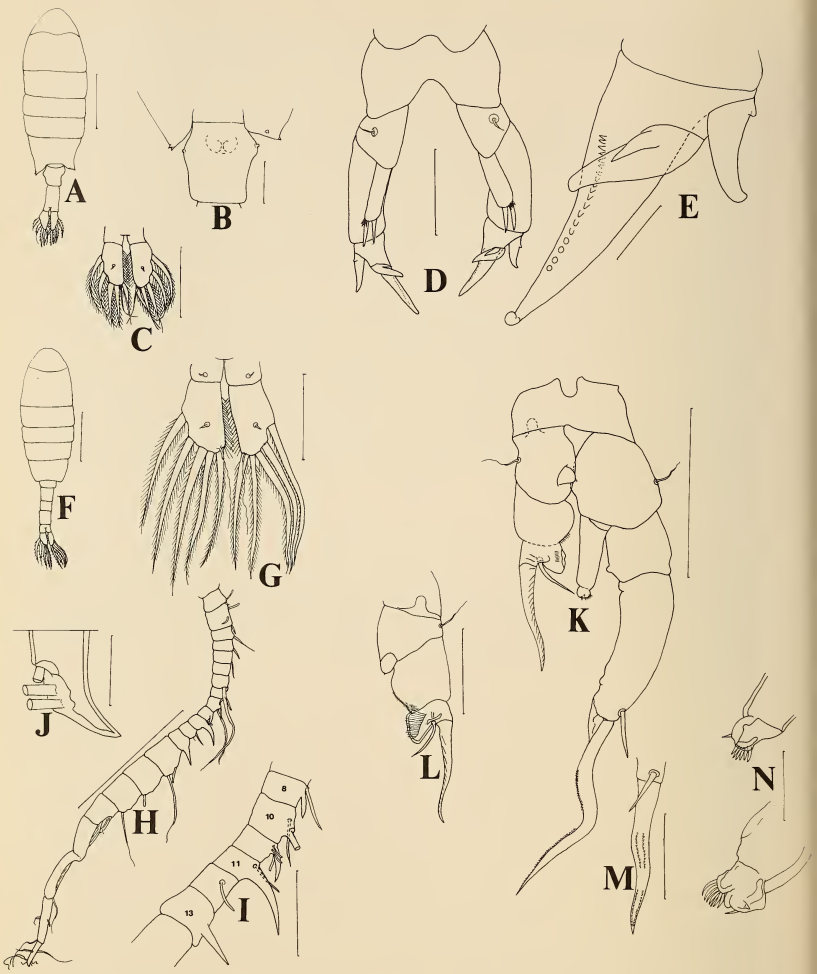

Fig. 9. *Lovenula simplex*. A–E. Adult female. A. Dorsal view. B. Thoracic 'wings' and GS, dorsal view. C. Furca, dorsal view. D. P5, posterior view. E. P5, Exp2 and Exp3, posterior view. F–O. Adult male. F. Dorsal view. G. Furca, dorsal view. H. Right A1. I. A1, segments 8–13. J. A1, end of terminal segment. K. P5, posterior view. L. P5, left leg, Exp2, anterior view. M. P5, right leg, Exp3 claw, medial view. N. P5, right leg, Enp2, posterior and anterior views. Bar scales in mm. A, F, H = 1. C, K = 0,5. B, D, G, I, L, M = 0,25. E, N, J = 0,05.

Remarks

Lovenula simplex has a very restricted distribution (Fig. 2), a fact that has been overlooked because of the confusion of this species with *L. falcifera* by Sars (1899, 1927), Rühe (1914), and Harding & Smith (1967). Kiefer (1929, 1934) pointed out that it was not the same species as *L. falcifera* but his opinion was disregarded. Gurney (1929) noted that *L. falcifera* was 'one variable species', not realizing in fact that there were two species involved.

KEY TO THE SPECIES OF *LOVENULA*

Figs 4–9

KEY TO FEMALES

1. Genital somite strongly expanded on left side. P5, Exp2 lateral spine with well-defined process on outer margin 2
— Genital somite slightly expanded on left side. P5, Exp2 lateral spine with very small process on outer margin 3
2. Body length 3,0–3,2 mm. Genital somite with cone-shaped expansion on left side, P5 endopodite with paired terminal setae one-quarter of its length, inner seta shorter than outer. P5, Exp2 lateral spine with pronounced process on outer margin ..... *Lovenula excellens*
— Body length 3,2–4,0 mm. Genital somite with rounded expansion on left side. P5 endopodite with paired terminal setae more than half its length, setae of equal length. P5, Exp2 lateral spine with small process on outer margin ..... *Lovenula falcifera*
3. Anal somite twice length of genital somite. Left thoracic 'wing' with two pointed processes ..... *Lovenula simplex*
— Anal somite and genital somite of equal length. Left thoracic 'wing' with three dissimilar processes ..... *Lovenula africana*

KEY TO MALES

1. Body length 3,0–4,0 mm. Geniculate (right) A1, combined length of last two segments twice length of ante-penultimate segment. Left P5, Exp2 spiniform process curved; right P5, Exp2 lateral spine short 2
— Body length 3,2–4,0 mm. Geniculate (right) A1, combined length of last two segments slightly exceeds length of ante-penultimate segment. Left P5, Exp2 spiniform process straight; right P5, Exp2 lateral spine long 3
2. Geniculate (right) A1 strongly developed with segments 13–18 flattened and expanded. Left P5, Exp2 spiniform process semi-circular; right P5, lateral spine slender and pointed ..... *Lovenula falcifera*
— Geniculate (right) A1 less strongly developed with segments 13–18 slightly expanded. Left P5, Exp2 spiniform process curved distally; right P5, Exp2 lateral spine very short and blunt ..... *Lovenula excellens*

3. Right P5, Exp3 with blade-like claw with slight S-shape, Exp2 lateral spine one-quarter length of claw. Left P5 endopodite reduced to rounded process ..... *Lovenula simplex*

— Right P5 Exp3 with blade-like claw slightly curved, Exp2 lateral spine one-sixth length of claw. Left P5 endopodite well developed with 2–3 terminal spinules ..... *Lovenula africana*

SPECIES REMOVED FROM THE GENUS *LOVENULA*

Two species, *Paradiaptomus alluaudi* and *P. natalensis*, have been removed from the genus *Lovenula*.

Paradiaptomus alluaudi (Guerne & Richard, 1890)

Diaptomus alluaudi Guerne & Richard, 1890: 198–201; 1891: 213–217. Richard, 1893: 465–466, figs 32–33. Poppe & Mrázek, 1895: 131. Schmeil, 1896: 177, pl. 14 (figs 7–9). Giesbrecht & Schmeil, 1898: 67, 93. Daday, 1910*b*: 118. Tollinger, 1911: 52, fig. P1. Gurney, 1929: 576, 581. Gauthier, 1931.

Diaptomus ungviculatus Daday, 1891: 48, pl. 4 (figs 4–9).

Diaptomus lorteti Barrois, 1891: 277, figs 6–11.

Lovenula (Neolovenula) alluaudi Kiefer, 1932*a*: 461, 486, figs 18–20. Gauthier, 1933*b*: 128. Kiefer, 1934: 123; 1958: 158–160; 1978*a*: 74, 231, pl. 13; 1978*b*: 494. Damian-Georgescu, 1966: 44. Dussart, 1967: 89, fig. 23. Dumont & Decraemer, 1977: 258. Dussart & Defaye, 1983: 56.

Paradiaptomus lorteti Gauthier, 1933*a*: 64.

Neolovenula alluaudi Gauthier, 1938: 116. Löffler, 1961: 356, table 2. Dumont & Verheye, 1984: 319.

Paradiaptomus (Lovenula) alluaudi Dussart, 1989: 40–41, 130, fig. 24B.

Material examined

TM—uncatalogued slide of 2 males, labelled *Neolovenula alluaudi*, Ostrovan-See, Mazedonien, H. W. Schäfer, 9 December 1941.

BMNH 1961.6.28.1, wet specimens labelled *Diaptomus alluaudi*, Galatui Lake, near Calarasi, Romania, A. D. Georgescu, undated.

Remarks

Kiefer (1932*a*) created the subgenus *Neolovenula* for *Diaptomus alluaudi* and included it in the genus *Lovenula* as *Lovenula (Neolovenula) alluaudi*. Characters that this species has in common with other *Lovenula* species are two external spines on last segment of P1, asymmetrical thoracic 'wings' of female, beak-like extension on last segment of male right A1 and shape of exopodite of male left P5. Characters not typical of *Lovenula* species are the small adult size and the maxillipeds that do not have the very characteristic scythe-shape. Also, in the female, the urosome has three somites, expansion of female genital somite is dorso-ventral not lateral, endopodite of female P5 is reduced and without terminal setae, outer Exp3 spine is shorter than inner, and the spines do not project across Exp2. In the male, the right furcal setae are not modified, spine on segment 11 of male A1 is shorter than spine on segment 13, whereas in

all other *Lovenula* species it is longer, male P5 has no endopodite on left leg, and right P5 is atypical.

Paradiaptomus alluaudi is included in the subfamily Paradiaptominae on the possession of two external spines on the last segment of the exopodite of the first swimming leg, although the proximal spine is reduced. It cannot, however, be included in the genus *Lovenula* even as a subgenus, as it lacks four of the most highly weighted characters of the genus, namely, the massive raptorial maxillipeds, the modification of the right furcal setae in the male and, in the female, a urosome with two somites and the arrangement and projection of spines on the P5. *Paradiaptomus alluaudi* is as tenuously related to the genus *Paradiaptomus* as it is to the genus *Lovenula*. A solution to the problem would be to raise *Neolovenula* to full generic status in the Paradiaptominae, and to include *'Paradiaptomus' alluaudi* as a species in the monotypic genus *Neolovenula*.

Paradiaptomus natalensis (Cooper, 1906)

Adiaptomus natalensis Cooper, 1906: 97–103, pl. 12 (figs 1–14). Tollinger, 1911: 190, fig. Y5. Van Douwe, 1912*b*: 29, 31.
Diaptomus pictus Brady, 1913: 464, pl. 34 (figs 1–6).
Paradiaptomus natalensis Gurney, 1929: 582.
Lovenula natalensis Kiefer, 1932*a*: 461; 1934: 122–123. Dussart & Defaye, 1983: 55.
Paradiaptomus (Lovenula) natalensis Dussart, 1989: 36.
Metadiaptomus natalensis Dussart, 1989: 128, fig. 22.

Material examined (Fig. 1, Gazetteer)

AM–VAL 372F, males and females, ground pool, near Lindeque's drift, 8 km below Vaal River barrage, F. M. Chutter, 29 April 1958.

Remarks

Kiefer (1932), recognizing this species as a paradiaptomid, placed it in the genus *Lovenula* although it is of small size and lacks both the large raptorial maxillipeds and the three spinous setae on the male right furcal ramus—two highly weighted *Lovenula* characters. Also, the female has a dorsal keel on the last thoracic somite. The shape of the endopodite of the male right P5 is a good *Paradiaptomus* character and the absence of important *Lovenula* characters justify placing this species in the genus *Paradiaptomus*. The shape and arrangement of spines on the male geniculate A1 is almost identical to that of *P. alluaudi*, a fact that may indicate a relationship between these two species. Gurney (1929) stated that *A. natalensis* was a typical *Paradiaptomus* and should be included in that genus. Kiefer (1934) noted that the status of this species could be decided only if the poor descriptions of Cooper (1906) and Brady (1913) could be checked against new material, as no types were designated. It was 45 years before this rare species was collected again by Chutter in 1958 (Chutter 1963), and its examination confirmed that it ranks as a species of *Paradiaptomus*.

SYSTEMATIC STATUS OF *LOVENULA* AND *PARADIAPTOMUS*

Gurney (1929) assessed the status of South African diaptomids, but his attempt to form two series, one for *Lovenula* and one for *Paradiaptomus*, was flawed by poor descriptions and misidentifications. Gauthier (1951), in describing *Paradiaptomus rex*, discussed the affinities of the two genera. He stated incorrectly that the only character that distinguishes the two genera is the massive raptorial maxillipeds of *Lovenula*. More recently, Dussart & Defaye (1983) indicated that *Lovenula* should be made a subgenus of *Paradiaptomus*, so Defaye (1988) and Dussart (1989) established *Paradiaptomus* as the genus, with subgenera *Paradiaptomus* s.s. and *Lovenula*. However, the four *Lovenula* species have been shown to be closely related and current research leaves no doubt that they have enough characters in common with one another, and different from *Paradiaptomus*, to retain generic status. These characters are the large size of the adult, the massive raptorial maxillipeds, arrangement of spiniform processes and shape of the terminal segment of geniculate A1, exopodite of male left P5, the three outer spiny setae on the male right furcal ramus, and the relative sizes and arrangement of Exp2 spines of female P5. A comparison of the morphology of the mandible, maxillae 1 and 2 and maxilliped of the two genera gives a good indication that *Paradiaptomus* has retained more of the characters of their most recent common ancestor than has *Lovenula*. Feeding appendage morphology is important in diaptomid systematics.

Many of the early taxonomists interchanged the generic names *Lovenula* and *Paradiaptomus*, but Kiefer (1932*a*, 1934) never had any doubts as to which species he placed in the genus *Lovenula*. He was the only taxonomist to study all four *Lovenula* species and he described two of them. Confusion arose because species of uncertain affinities such as *L. mea*, *L. furcata* and *L. natalensis* were included in the genus. A major factor also has been the lack of any in-depth study on the freshwater copepods of southern Africa and the tendency to think of southern Africa in isolation from the rest of the continent. Ongoing studies on the Diaptomidae have shown that the wealth and diversity of freshwater diaptomids in southern Africa is such that their further study will have a major impact on both the biogeography and systematics of the diaptomids in Africa. Therefore, it seems pointless at this stage, to reduce a now known stable genus (*Lovenula*) to subgeneric status in a genus (*Paradiaptomus*) that has as its type *Paradiaptomus lamellatus* Sars, 1895, a species that lacks most of the important *Lovenula* characters. Also, with the recent discovery of at least four new, as yet undescribed, species of *Paradiaptomus* in southern Africa, that genus will need to be reassessed.

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GAZETTEER

Fig. 1

Cape Province: CP; Natal: NTL; Orange Free State: OFS; Transvaal: TVL.

Aliwal North, CP	30°40′S	26°40′E
Apies and Crocodile rivers, TVL	25°50′S	28°10′E
Beaufort West, CP	32°20′S	22°35′E
Belfast, TVL	25°40′S	30°03′E
Brak River airfield	32°30′S	20°43′E
Bunyonyi, lake	1°20′S	29°50′E
Cape Flats, CP	34°04′S	18°38′E
Caprivi, Namibia	18°05′S	21°45′E
Chrissie, lake, TVL	26°20′S	30°12′E
De Hoop Vlei, CP	34°27′S	20°23′E
Dewetsdorp, OFS	29°35′S	26°40′E
D. F. Malan Airport, CP	33°58′S	18°37′E
Diep River, Milnerton, CP	33°52′S	18°30′E
Dodoma, Tanganyika	6°00′S	35°40′E
Faure, CP	34°02′S	18°45′E
Gautscha Pan, Boesmanland, Namibia	19°00′S	20°00′E
Gillidam, CP	34°18′S	18°26′E
Gouritzrivier, CP	33°40′S	21°40′E
Great Fish River, Elandsdrift, CP	32°31′S	25°45′E
Green Point Common, CP	33°54′S	18°25′E
Greyvenstein Dam, TVL	29°04′S	26°09′E
Grootfontein, CP	31°28′S	25°05′E
Groot Rondevlei, CP	34°14′S	18°23′E
Harrismith, OFS	29°20′S	29°08′E
Hora Keloli, Ethiopia	7°30′N	38°30′E
Kimberley, CP	28°45′S	24°45′E
Lobatsi, Bophuthatswana	25°30′S	25°35′E
Makgadikgadi Pan, Botswana	21°00′S	26°00′E
Marico River, TVL	25°10′S	26°25′E
Mazelspoort Dam, OFS	29°02′S	26°25′E
Middleburg, TVL	25°48′S	29°27′E
Molteno, near Beaufort West, CP	31°23′S	26°20′E
Neudamm, east of Windhoek, Namibia	22°30′S	17°20′E
Noordhoek, CP	34°07′S	18°23′E
Nuweleeurivierdam, OFS	29°20′S	27°08′E
Omatako Dam, Namibia	21°11′S	17°12′E
Ombika (Onambeke), Namibia	19°20′S	15°55′E
Ondangua, Namibia	17°55′S	16°00′E
Ongka, Namibia	17°35′S	15°50′E
P. K. le Roux Dam, CP	30°35′S	24°50′E
Quaggaplaat, CP	32°32′S	20°57′E
Richmond, NTL	29°53′S	30°17′E
Rukwa, lake, Tanzania	7°30′S	32°30′E
Sirkelsvlei, CP	34°16′S	18°25′E
Soetendalsvlei, CP	34°44′S	19°58′E
Sowa Pan, Makgadikgadi, Botswana	20°10′S	26°10′E
Spioenkop Dam, NTL	28°40′S	29°30′E
Sterkfontein, TVL	28°35′S	29°04′E
Stormberg, CP	31°25′S	26°40′E
Tamsu (Tamansu), Namibia	18°35′S	20°36′E
Tjokwe Pool, Boesmanland, Namibia	19°00′S	20°00′E
Touwsrivier, CP	33°20′S	20°03′E

Ukualonkathi, Ovamboland, Namibia	17°45′S	15°40′E
Ukualuthi, Ovamboland, Namibia	17°40′S	15°30′E
Vaal River catchment, TVL	26°45′S	27°30′E
Welbedacht Dam, OFS	29°54′S	26°52′E
White Hill Pan, Hwange, Zimbabwe	18°20′S	26°35′E
Wiesdrift, CP	34°40′S	19°55′E
Windhoek, Namibia	22°35′S	17°05′E
Witbank Dam, TVL	25°53′S	29°18′E
Witmos, CP	32°33′S	25°45′E