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# Expanded description of *Lamproglena cleopatra* Humes, 1957 (Lernaeidae: Copepoda) from *Labeo* spp. (Cyprinidae) with a key to species of *Lamproglena* von Nordmann, 1832

**Katlego D. Kunutu · Sareh Tavakol · Ali Halajian · Chantelle Baker · Michela Paoletti · Richard A. Heckmann · Wilmien J. Luus-Powell**

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**Abstract** The occurrence of the copepod *Lamproglena cleopatra* Humes, 1957, parasitising freshwater fishes in the Limpopo River System is presented, along with new morphological data. This crustacean was originally described parasitising a cyprinid (*Labeo forskalii* Rüppell) from the River Nile, Egypt. During 2014–2015 crustacean samples were collected from the gills of three cyprinid fish species, *Labeo rosae* Steindachner from Flag Boshielo Dam, *Labeo molybdinus* Du Plessis from Nwanedi-Luphephe Dam in South Africa, and *Labeo ruddi* Boulenger from the River Bubye in Zimbabwe. The specimens from the present study were morphologically similar regardless of the host, but exhibited some morphometric intraspecific differences in comparison with the type-specimen from Egypt. A description of *L. cleopatra* copepodid III stage and a taxonomic key to *Lamproglena* spp. is provided.

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K. D. Kunutu · S. Tavakol · A. Halajian · W. J. Luus-Powell (✉)
Department of Biodiversity, University of Limpopo, Private Bag X1106, Sovenga 0727, South Africa
e-mail: wilmien.powell@ul.ac.za

C. Baker
Electron Microscope Unit, Sefako Makgatho Health Sciences University, Ga-Rankuwa, P.O. Box 60, Medunsa 0204, South Africa

M. Paoletti
Department of Ecology and Sustainable Economic Development, Tuscia University, Viale dell'Università, 01100 Viterbo, Italy

R. A. Heckmann
Department of Biology, Brigham Young University, 401 WIDB, Provo, UT 84602, USA

## Introduction

The genus *Lamproglena* von Nordmann, 1832 is the second largest and oldest member of the family Lernaeidae Cobbold, 1879 which consists of parasitic freshwater copepods (Jirsa et al., 2006). There are currently 38 nominal species of *Lamproglena.* This list excludes the subspecies *Lamproglena chinesis sprostoni* Kirtisinghe, 1965 and species which were either synonymised or transferred to other lernaeid genera. These include *Lamproglena ophiocephali* Yamaguti, 1939 synonymised with *Lamproglena chinensis* Yu, 1937 (see Sproston et al., 1950); *Lamproglena nyasae* Fryer, 1956 synonymised with *Lamproglena monodi*

Capart, 1944 (see Fryer, 1959); *Lamproglena aubentoni* Dollfus, 1960 synonymised with *Lamproglena hemprichii* von Nordmann, 1832 (see Fryer, 1964); *Lamproglena seenghalae* Kumari, Khera & Gupta, 1989 transferred to *Indolernaea* (see Ho, 1998); *Lamproglena gurayai* Battish & Brar, 1989 transferred to *Indolernaea* Kabata 1983 (see Ho, 1998); *Lamproglena intercedens* Fryer, 1964 transferred to *Catlaphilla* Tripathi, 1960 (see Ho, 1998). The list of valid species presented hereafter also excludes the species *Lamproglena notopterai* Jafri & Mahar, 2006 due to the inadequate description, scanty illustrations and inaccuracies in the article in which the species was presented by Jafri & Mahar (2006). Twelve of the 38 nominal species of *Lamproglena* occur in Africa: *Lamproglena angusta* Wilson, 1929; *Lamproglena barbicola* Fryer, 1961; *Lamproglena clariae* Fryer, 1956; *Lamproglena cleopatra* Humes, 1957; *Lamproglena cornuta* Fryer, 1965; *Lamproglena elongata* Capart, 1956; *Lamproglena hemprichii* von Nordmann, 1832; *Lamproglena hepseti* Van As & Van As, 2007; *Lamproglena hoi* Dippenaar, Luus-Powell & Roux, 2001; *Lamproglena monodi* Capart, 1944; *Lamproglena werneri* Zimmermann, 1922; and *Lamproglena wilsoni* Capart, 1956. Six of the African lamproglenid species are known from southern Africa, namely *L. barbicola*, *L. clariae*, *L. cornuta*, *L. hepseti*, *L. hoi* and *L. monodi* (see Austin & Avenant-Oldewage, 2009). During parasitological surveys of freshwater fish parasites in South Africa, specimens of species of *Lamproglena* were collected in the Limpopo and Olifants River systems from Flag Boshielo Dam on *Labeo rosae* Steindachner; Nwanedi-Luphephe Dam on *Labeo molybdinus* du Plessis; River Bubi on *L. rosae* and *Labeo ruddi* Boulenger and were identified as *Lamproglena cleopatra.* This species was last reported and described by Humes (1957) parasitising the gills of *Labeo forskalii* Rüppell and has not been reported since. The fish host was obtained from the Giza Fish Market, Cairo, Egypt; and were thus presumed by Humes (1957) to be from the River Nile. The description of *L. cleopatra* lacks some morphological and morphometric details which are now presented in this paper. In addition, scanning electron microscopy images are added to illustrate some of the fine diagnostic features which are otherwise not visible using light microscopy. Although some *Lamproglena* spp. have been studied extensively, redrawn and re-described, the majority of illustrations and descriptions appear to be inadequate. As such a taxonomic key is also included in the present paper to facilitate the identification of species of *Lamproglena* without having to sieve through numerous literature sources, and to resolve the taxonomic uncertainties within this genus.

The first key to species of *Lamproglena* was presented by Markewitsch (1936) which included only six species, i.e. *L. hemprichii*, *Lamproglena pulchella* von Nordmann, 1832, *L. angusta*, *L. werneri*, *Lamproglena compacta* Markewitsch, 1936 and *Lamproglena orientalis* Markewitsch, 1936. These were the only nominal species described at the time, hence the key was based on only a few diagnostic features such as overall body shape, size of abdomen compared to cephalothorax, segmentation of fifth thoracic segment, and armament of caudal rami. Although these were valid diagnostic features, the addition of new species meant that some of these features were common among numerous species. Yu (1937) provided a key, and addition to the description of *Lamproglena chinensis* Yu, 1937, which did not include *Lamproglena lichiae* von Nordmann, 1832 as it was then doubted to be a valid species; and also did not include *L. compacta* and *L. orientalis*. Sproston et al. (1950) published two keys: one included 12 species of *Lamproglena* based on adult females; and the other included five species based on adult males. The latter was the first keys which distinguished among *Lamproglena* spp. based on the morphological characteristics of adult males. However, the use of adult males presented difficulties, majority of which included the unavailability of descriptions of male specimens in other species. Another problem with using male diagnostic features is that male specimens do not undergo extensive metamorphosis as females, as such, there are only a few diagnostic features to distinguish among males. Fryer (1964) published a key consisting of ten species of *Lamproglena* in Africa. Fryer's key was comprehensive and also included characters such as the family to which the host fish species belong. This was based on the notion that *Lamproglena* spp. exhibit a level of host specificity, either on a specific genus or family. The key presented by Kumari et al. (1989) was also comprehensive but included only 29 species. Kumari et al. (1989) divided the species into two groups: the first group (group I) consisting of species that have an elongated, cylindrical body, while the second group

(group II) includes species that have a short and compact body. The taxonomic key presented here is based on similar groupings and includes 38 species of *Lamproglena*. Thus the present paper not only entails additional morphological features of *L. cleopatra*, but also includes a taxonomic key which is based on the morphological descriptions, re-descriptions and illustrations of 38 species (and 1 subspecies) from original descriptions in literature.

## Materials and methods

Fish were collected from various sampling localities in the River Limpopo and its tributary, the River Olifants: the Nwanedi-Luphephe Dam (in the Nwanedi Nature Reserve, Limpopo Province, South Africa); Flag Boshielo Dam (in the middle River Olifants catchment, Limpopo Province, South Africa); and the River Bubye (in the Bubiana Conservancy, Zimbabwe). Fishes were collected using gill-nets and kept in aerated tanks until examined in a field laboratory. The fish were euthanised by severing the spine, after which the gills were removed and examined using a Leica™ EZA stereo-microscope for the presence of *Lamproglena* spp. specimens. The copepods were stored in 70% ethanol. Some of the specimens were cleared and stained in lactic acid into which a small amount of lignin pink was dissolved (Humes & Gooding, 1964). These were dissected using a stereo-microscope after which the various parts of the copepods were drawn and measured with the aid of an ocular micrometer and a drawing tube using an Olympus™ BX50F compound-microscope. The measurements are given in micrometres unless otherwise indicated as the range followed by the mean ± standard deviation and the number of measurements taken (n) in parentheses. For scanning electron microscopy, the selected specimens were cleaned ultrasonically for 10–12 s to remove mucus and debris. The specimens were then dehydrated through graded ethanol series (70%, 80%, 95% and 100%), after which they were immersed in hexamethyldisilazane solution to about 24 h to remove the ethanol. The specimens were then left to dry and were mounted on aluminium stubs, sputter-coated with carbon using a Quorum™ Q150T ES sputter coater, viewed and studied with a Carl Zeiss™ Suppra 55VP Scanning Electron Microscope. The drawings and SEM images were edited using Microsoft Paint (Version 10.0) and IrfanView for Windows (Version 4.37).

## Results

A total of 137 fish hosts (*L. rosae*, n = 79; *L. molybdinus*, n = 34; *L. ruddi*, n = 24) were collected from various sampling localities in the Limpopo and Olifants River Systems. *Lamproglena cleopatra* was found parasitising the three *Labeo* species from three localities. Of the 137 *Labeo* spp. collected, 27% were infested with adult females of *L. cleopatra*, which were isolated from the gill filaments. No significant difference ($P > 0.05$) was found in seasonal occurrence of *L. cleopatra* between host species and localities. No distinct correlation were found between the total length of *L. cleopatra* and that of *L. rosae* (Pearson correlation coefficiant, $R^2 = 0.028$, $P = 0.896$), *L. molybdinus* ($R^2 = 0.24$, $P = 0.258$), and *L. ruddi* ($R^2 = 0.36$, $P = 0.084$).

### Family Lernaeidae Cobbold, 1879
### Genus *Lamproglena* von Nordmann, 1832

### *Lamproglena cleopatra* Humes, 1957

*Type-host*: *Labeo forskalii* Rüppell (family Cyprinidae) (see Humes, 1957).
*Type-locality*: River Nile, Egypt (see Humes, 1957).
*Other hosts*: Present study: *Labeo rosae* Steindachner, *Labeo ruddi* Boulenger, and *Labeo molybdinus* du Plessis (family Cyprinidae).
*Other localities*: Present study: Flag Boshielo Dam, River Bubye and Nwanedi-Luphephe Dam (see Table 1 for details).
*Voucher material*: Voucher specimens are deposited in Museum für Naturkunde, Berlin, Germany, collection Crustacea: one female from Flag Boshielo Dam (ZMB 29947) and one female from Nwanedi-Luphephe Dam (ZMB 29948).

Description (Figs. 1–4)

*Female* [Based on 58 specimens; 8 used for SEM.] Body elongated, cylindrical, distinctly segmented (Figs. 1M, 2E), 1.66–3.38 (2.79 ± 0.39) mm (n = 40) in length. Cephalothorax (Fig. 1A)

**Table 1** Hosts, localities, coordinates, prevalence (P in %) and mean intensity (MI) of *Lamproglena cleopatra* from *Labeo* spp. from Limpopo River system

| Host species | Locality | Coordinates | n[a] | P (%) | MI |
|---|---|---|---|---|---|
| *Labeo rosae* Steindachner | Flag Boshielo Dam | 24°46′47.3″S; 29°25′42.5″E | 45 | 31.1 | 1.1 |
| | River Bubye | 21°45′20.8″S; 30°35′30.8″E | 34 | 23.5 | 2.3 |
| *Labeo ruddi* Boulenger | River Bubye | 21°45′20.8″S; 30°35′30.8″E | 24 | 8.3 | 3.0 |
| *Labeo molybdinus* du Plessis | Nwanedi-Luphephe Dam | 22°38′09.4″S 30°24′07.4″E | 34 | 38.2 | 1.6 |

[a]Number of fish examined

410–710 (580 ± 70; n = 40) in width, representing 20.8% of entire body length; characterised by lateral indentations visible posteriorly and ventrally (Fig. 2A); dorsal surface with medial U-shaped ridge. Thorax with three pedigerous segments, demarcated by depressions visible laterally (Fig. 1M): first segment 190–400 (320 ± 50; n = 40) wide, 160–410 (280 ± 70; n = 40) long; second segment 200–590 (430 ± 80; n = 40) wide, 150–480 (380 ± 60; n = 40) long; third segment 200–590 (430 ± 80; n = 40) wide, 160–510 (410 ± 70; n = 40) long; second and third segments sub-equal in diameter. Fifth leg-bearing segment narrower and shorter than preceding segments, 160–300 (220 ± 30; n = 40) wide, 60–140 (90 ± 20; n = 40) long, forming deep constriction separating genital segment from rest of thorax. Genital segment wider than fifth thoracic segment, 160–430 (350 ± 60; n = 40) wide, 130–220 (170 ± 30; n = 40) long, bears egg-sacs attached dorso-laterally. Each egg-sac unseriate, 0.92–1.46 (1.22 ± 0.23) mm (n = 9) long, contains 13–21 (16 ± 3.33; n = 9) eggs per sac (Fig. 2E). Some specimens had 2 chitinous and reniform spermatophores attached ventrally.

Abdomen overall width 140–250 (190 ± 20; n = 40), length 0.56–1.22 (0.96 ± 0.16) mm (n = 40) comprising 34% of total body length, tapering posteriorly, consisting of 3 sub-equal, distinctly demarcated segments. Caudal rami minute, 30–60 (40 ± 10; n = 40) long, fused with abdomen (Fig. 2B). Each ramus (Figs. 1L, 2B) with single seta on outer and inner margins, and 5 terminal setae. Antennule indistinctly 2-segmented, uniramous (Fig. 1D), with long, swollen basal podomere and significantly shorter and narrower distal podomere, both bearing naked setae (Fig. 2C). Distal podomere bearing 1 long seta and 6 smaller setae, basal podomere bears 22 setae varying in length and width. Circular pores present on antennule surface. Antenna uniramous, indistinctly 4-segmented, distal segment with 4 small terminal setae and 4 on lateral margin (Fig. 1C). Oral region surrounded by projecting, lobed, sucker-like process characterised by 2 lateral lobes and 2 finger-like posterior lobes (Fig. 1B). Mandible not observed. Maxilla uniramous, rigid, covered with thin layer through which conspicuous terminal spine projects (Fig. 1F). Maxilliped 2-segmented, armed with 3 sub-equal, curved claws (Fig. 1E): 2 long and 1 short with small spine-like protrusion on proximal region (Fig. 2D).

Leg pairs 1–3 biramous, with indistinctly 2-jointed rami, and endopodites terminating in 2 blunt seta. Protopodite of leg pairs 1–4 with 1 lateral seta at base prior to exopodite (Fig. 1G–J). Exopodite of first leg with 2 long terminal setae and 2 smaller setae on second podomere, and 1 lateral seta on first podomere. Second exopodite podomere of leg pairs 2–4 with 3 small terminal setae. Fifth leg forms small lobe with 3 setae, 1 short and 2 long (Fig. 1K); long setae positioned distally and laterally; short seta often not clearly visible under light microscopy but easily observed under SEM (Fig. 2F).

*Larval forms* [Only copepodid III stage specimens (n = 10) where found on *L. rosae* and *L. molybdinus*; these were identified based on copepodid III features described by Madanire-Moyo & Avenant-Oldewage (2013).] Body cyclopiform, total body length 0.43 mm (0.14–0.48; n = 10) (Fig. 3A, B). Body comprises of 3 segments: cephalothorax (with first pedigerous segment incorporated) (Figs. 3C, 4B), free thorax (with second to sixth pedigerous segment) and abdomen (comprising 3 abdominal segments). Leg-bearing thoracic and abdominal segments delimited from cephalothorax (Fig. 4A), and progressively decreasing in size towards posterior region. Genital structures

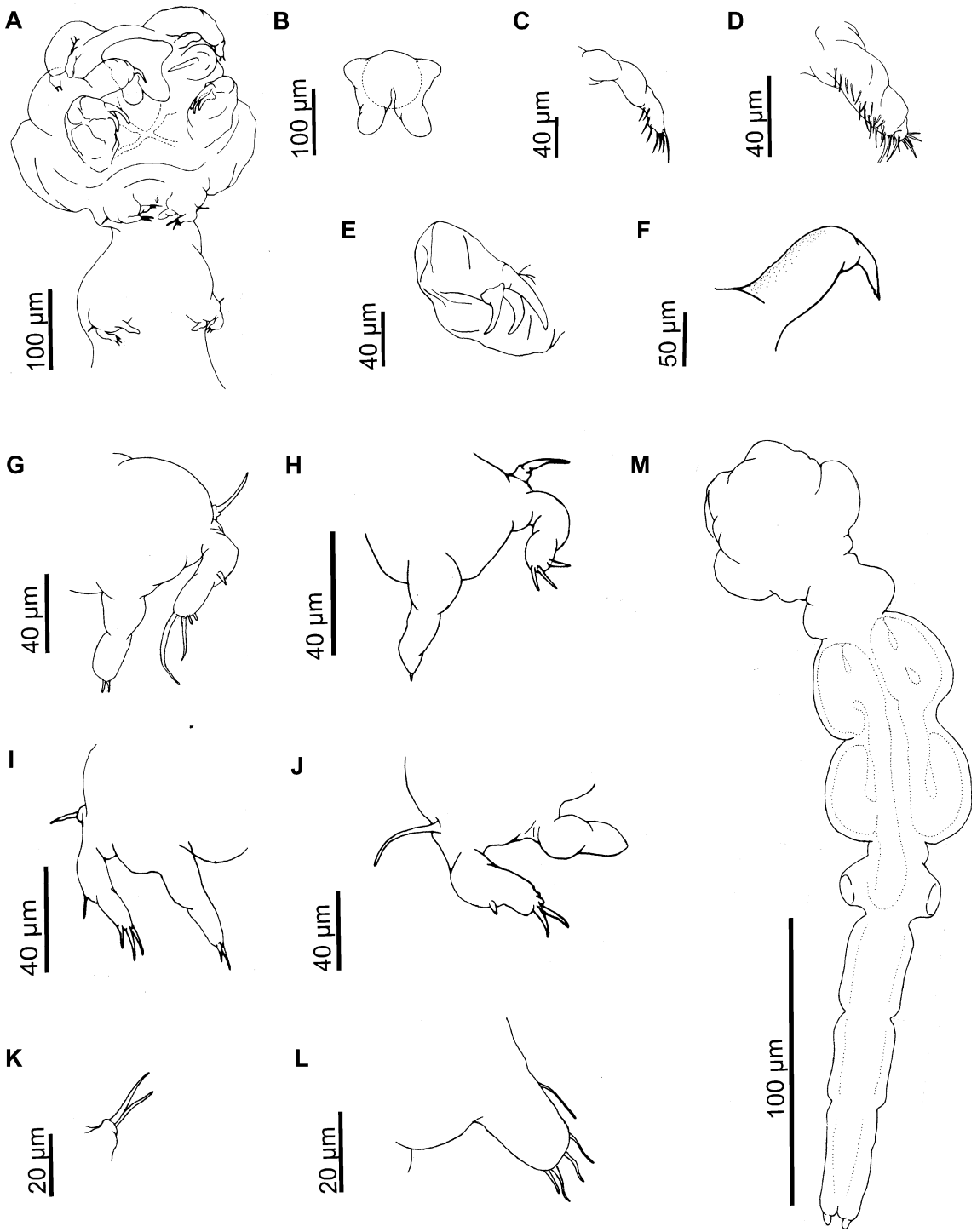


**Fig. 1** Adult female *Lamproglena cleopatra*. A, Cephalothorax, ventral view; B, Sucker-like process; C, Antenna; D, Antennule; E, Maxilliped; F, Maxilla; G, Leg 1; H, Leg 2; I, Leg 3; J, Leg 4; K, Leg 5; L, Caudal ramus; M, Body, dorsal view

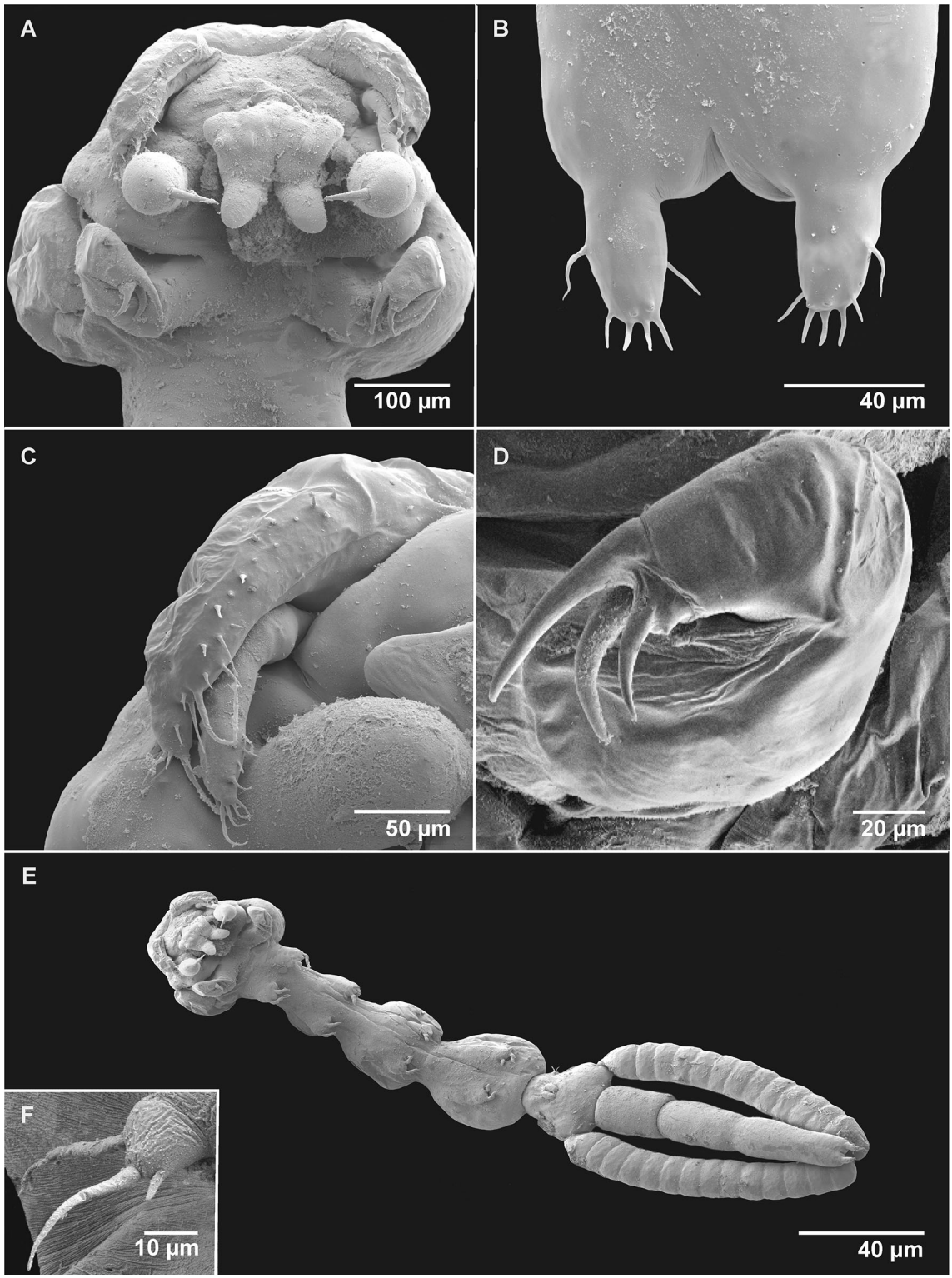


**Fig. 2** Scanning electron micrographs of *Lamproglena cleopatra*. A, Cephalothorax; B, Caudal rami; C, Antennule and antenna; D, Maxilliped; E, Body, ventral view; F, Leg 5

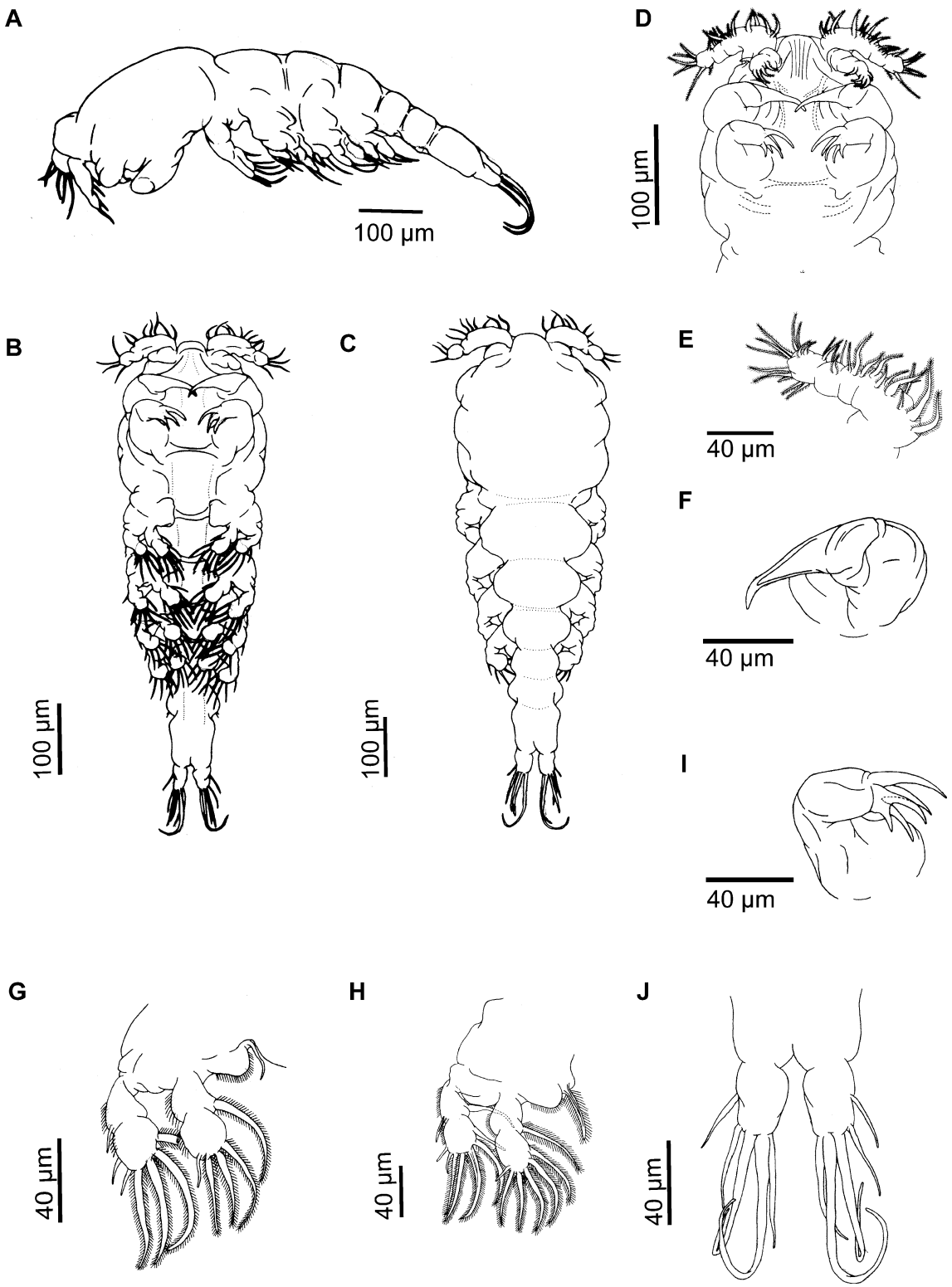


**Fig. 3** *Lamproglena cleopatra* copepodid III. A, Body, lateral view; B, Body, ventral view; C, Body, dorsal view; D, Cephalothorax, ventral view; E, Antennule; F, Maxilla; G, Legs 1 and 2; H, Legs 3 and 4; I, Maxilliped; J, Caudal rami

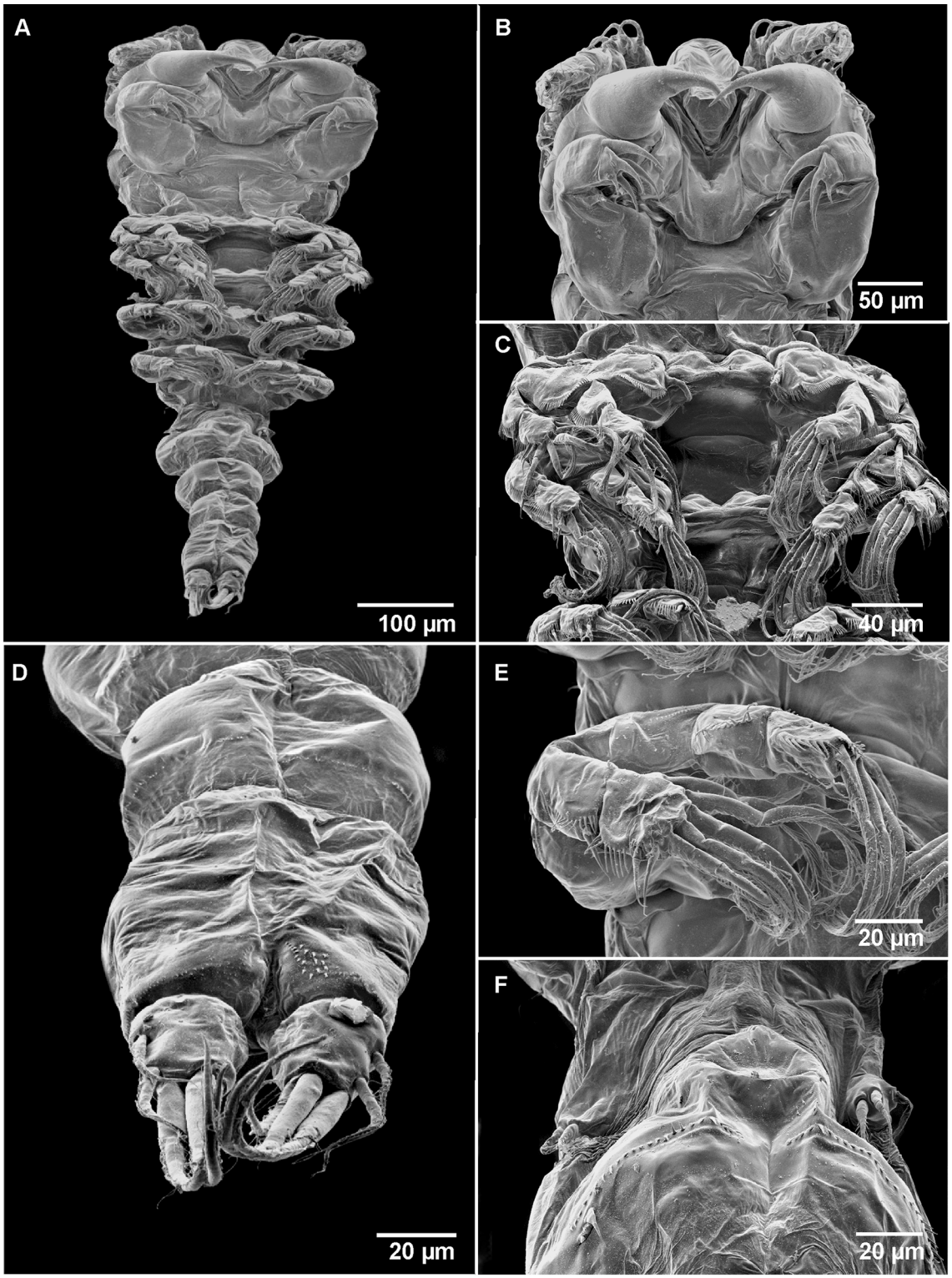


**Fig. 4** Scanning electron micrographs of *Lamproglena cleopatra* copepodid III. A, Body, ventral view; B, Cephalothorax, ventral view; C, First and second pairs of legs; D, Abdomen and caudal rami; E, Leg 4; F, Fifth pair of legs

**Table 2** Formula of setae on first to fourth pair of swimming legs of *Lamproglena cleopatra* copepodid III stage

| | Exopod | | Endopod | |
|---|---|---|---|---|
| | 1 | 2 | 1 | 2 |
| Leg 1 | I-1 | II, 5 | 0-1 | II, 5 |
| Leg 2 | I-1 | II, 5 | 0-1 | II, 5 |
| Leg 3 | I-0 | II, 4 | 0-1 | I, 3 |
| Leg 4 | I-0 | II, 4 | 0-1 | I, 3 |

not visible in the copepodid III stage. Maxilla anterodorsal to maxilliped, with 2 podomeres (Fig. 3F); proximal podomere forming broad base; distal podomere with terminal sickle-shaped claw. Maxillipeds robust, 2-segmented (Fig. 3I); distal segment unsegmented, articulating with subchela. Subchela consisting of shaft and 5 sickle-shaped terminal claws of varying size; terminal claws well delimited from shaft. Antennule 4-segmented; first segment with 7 setae; second segment with 3 setae; third segment with 2 setae; fourth segment with 4 setae; fifth segment with 12 setae (Fig. 3E). Antenna 3-segmented; first and second segment unarmed; third segment elongate, armed with 3 lateral setae along inner margin, with 1 claw-like seta on inner distal angle and 4 setae at outer distal angle (Fig. 3D). Swimming leg pairs 1–4 biramous, with 2-segmented rami on each leg (Figs. 3G, H, 4C, E), with spine and setae formula included in Table 2. Fifth swimming leg unsegmented with 2 lateral setae (1 small and 1 large) and 1 distal seta (Fig. 4F). Abdomen 3-segmented, with pair of furcal rami bearing 5 smooth setae of varying lengths (Figs. 3J, 4D); third and fourth setae on furcal rami the longest (Fig. 3B, C).

## Identification key

The following key to adult females (as the males in most cases are unknown) is adapted from Kumari et al. (1989), but has been expanded and now includes 38 *Lamproglena* spp. and one subspecies (*Lamproglena chinesis sprostoni* Kirtisinghe, 1965).

1a Body long and cylindrical ……..…. 2
1b Body short and compact …… 21
2a Cephalothorax less broad than neck …… 3
2b Cephalothorax broader than neck …… 4
3a Exo- and endopodites of all thoracic legs 3-segmented ……..…… ……..…… *Lamproglena forficata* Kuang, 1977
3b Exo- and endopodites of all thoracic legs 2-segmented …… 8
4a Maxillipeds armed with less than 5 claws ..… 5
4b Maxillipeds armed with 5 claws …… ……..….. *Lamproglena elongata* Capart, 1956
5a Maxillipeds armed with 4 claws …… 6
5b Maxillipeds armed with less than 4 claws ….. 7
6a Maxillipeds armed with 4 claws, exo- and endopodites of all thoracic legs 2-segmented …… … *Lamproglena hepseti* Van As & Van As, 2007
6b Maxillipeds armed with 4 claws, exo- and endopodites of all thoracic legs 3-segmented …. *Lamproglena krishnai* Thomas & Hameed, 1984
7a Maxillipeds armed with 3 claws …… 9
7b Maxillipeds armed with single claw only ……..… *Lamproglena cornuta* Fryer, 1965
8a All caudal rami armed with 5 setae …….. ……. *Lamproglena chinensis* Yu, 1937
8b All caudal rami armed with 6 setae … *Lamproglena chinensis sprostoni* Kirtisinghe, 1964
9a Abdomen shows no traces of external segmentation ……..… 10
9b Abdomen 2- or 3-segmented …… 13
10a Second to fourth thoracic segments delimited by lateral indentations ……... 11
10b Second to fourth thoracic segments fused together …….. … *Lamproglena cirrhinae* Kuang & Qian, 1985
11a Caudal rami simple ……... 12
11b Caudal rami bifid; lateral processes long, slim, longer than main ramus; 3 terminal setae on main ramus; a single long spine on inner margin of main ramus …… *Lamproglena hemprichii* von Nordmann, 1832
12a Caudal rami conical and surmounted with sclerotised prominent denticle …….. ….. *Lamproglena lichiae* von Nordmann, 1832
12b Caudal rami round-tipped, with single minute terminal seta pointed medially ……. ... *Lamproglena pulchella* von Nordmann, 1832
13a Abdomen 3-segmented …… 14
13b Abdomen 2-segmented ……. ……..… *Lamproglena jordani* Paperna, 1964
14a Fifth thoracic segment fused or absent ……. 15
14b Fifth thoracic segment distinct ……..… 18
15a Fifth pair of thoracic legs absent …… 16

15b Fifth pair of thoracic legs present ……..… 17
16a Leg 5 absent; caudal rami in the form of 2 widely separated spines ……. ……..… *Lamproglena angusta* Wilson, 1929
16b Leg 5 absent; caudal rami bifid with a rounded distal cone and a sharp branch of subequal length on the outer margin …… …… *Lamproglena wilsoni* Capart, 1956
17a Leg 5 lacking setae or spines …… ……... *Lamproglena monodi* Capart, 1944
17b Leg 5 with setae, spines or both …… 36
18a First antenna (antennule) 2-segmented ……. 19
18b First antenna (antennule) 5-segmented; armed with 14–17 setae unevenly distributed among the five segments (1:2:5:3:6) ……. …… *Lamproglena hospetensis* Manohar, Seenappa & Venkateshappa, 1992
19a Basal segment of antennule with anterior fringe of setae …….. 20
19b Basal segment of antennule lacks anterior fringe of setae …. *Lamproglena barbicola* Fryer, 1961
20a Distal segment of antennule armed with more than 4 setae …… 37
20b Distal segment of antennule armed with 4 setae, basal segment armed with 16 setae on anterior margin ……..… ……... *Lamproglena hoi* Dippenaar, Luus-Powell & Roux, 2001
21a First to fourth thoracic segments do not form rectangular trunk ……... 22
21b First to fourth thoracic segments fused to form rectangular trunk; cephalon as wide as the thorax ……..… *Lamproglena markewitschi* Suchenko & Allamuratov, 1966
22a Maxillipeds armed with 4 claws …… 23
22b Maxillipeds armed with 3 claws …… 24
23a Exo- and endopodites of thoracic legs 1–4 3-segmented ……..… ..… *Lamproglena compacta* Markewitsch, 1936
23b Exo- and endopodites of thoracic legs 1–4 2-segmented …… *Lamproglena cavasii* Kumari, Khera & Gupta, 1989
24a Abdomen indistinctly or distinctly 3-segmented ……... 25
24b Abdomen shows no traces of external segmentation …… 29
25a All abdominal segments of the same size …… *Lamproglena minuta* Capart, 1943
25b All abdominal segments not of same size (third shorter than first and second abdominal segments) ……... 26
26a Abdomen very small, about 0.133–0.155 mm long ……..*Lamproglena curta* Gussev, 1950
26b Abdomen longer than 0.4 mm …….. 27
27a Caudal rami simple ……... 28
27b Caudal rami bifid; the inner limb of each caudal ramus armed with 2 long and 1 short terminal setae, and 1 spine on the inner margin of each ramus ……. *Lamproglena meridiona* Kuang & Qian, 1985
28a Each caudal ramus armed with 2 terminal setae or spines …… 38
28b Each caudal ramus armed with a long spine in the medial region of the outer margin and a single seta on the inner margin ……. …… *Lamproglena werneri* Zimmermann, 1922
29a Fifth thoracic segment distinct ……. 30
29b Fifth thoracic segment absent or fused ……. 31
30a Fifth segment small, fifth pair of legs biramous, endopodite exceptionally long …….. ……..…… *Lamproglena brevis* Kuang, 1977
30b Fifth segment large and equally boarder to fourth thoracic segment, fifth pair of legs uniramous, simple outgrowth, tipped with 2 apical bristles …… …. *Lamproglena orientalis* Markewitsch, 1936
31a Caudal rami simple ……... 32
31b Caudal rami bifid …….. 34
32a Caudal rami armed with setae only; second to fifth pair of legs absent ……. ……... *Lamproglena inermis* Capart, 1943
32b Caudal rami armed with tubercles and 4 lateral spines …… 33
33a Each caudal ramus with an unarmed broad terminal papilla surrounded by 3 unequal setae (2 on the outer margin) ……..… *Lamproglena carassii* Sproston, Yin & Hu, 1950
33b Each ramus bears a single seta on the outer and inner margin, 2 terminal papillae and a single seta on either side of the papillae ……. *Lamproglena semilabecola* Liu & Wang, 1991
34a Second antenna unsegmented ……... 35
34b Second antenna indistinctly 4-segmented, terminal segment with 6 setae (4 terminal and 2 lateral) ……... …..… *Lamproglena mongtinensis* Kuang, 1977

35a Second antenna armed terminally with 5 unequal spines ……... …… *Lamproglena yunnanensis* Kuang, 1977

35b Second antenna armed terminally with 3 setae; with a small depression towards the basal region, followed by a micro-barbed outer margin with pedipalps …… ……..… *Lamproglena dibara* Kuang, 1991

36a Leg 5 with one terminal spine and one long spine on the base …… *Lamproglena indica* Kumari, Khera & Gupta, 1989

36b Leg 5 in the form of minute swellings bearing 3 setae …… *Lamproglena clariae* Fryer, 1956

37a Distal segment of antennule armed with 7 setae, basal segment armed with 22 setae on anterior margin ……...… ……... *Lamproglena cleopatra* Humes, 1957

37b Distal segment of antennule armed with 10 setae, basal segment armed with anterior fringe of 15 setae …….. ……... *Lamproglena cylindrata* Kuang, 1977

38a Each caudal ramus armed with 2 terminal setae and 4 lateral spines …… ……... *Lamproglena robusta* Capart, 1943

38c Each caudal ramus armed with 2 terminal spines, 2 short setae on the outer margin, a single seta on the inner margin …….. *Lamproglena heterognatha* Kuang & Qian, 1985

## Discussion

The species described in the present paper was identified as *L. cleopatra* as it displayed similar characteristics to those presented by Humes (1957) in the original description. The prevalence of the parasite accounted for 31.1% of the examined *L. rosae* in the Flag Boshielo Dam and 38.2% of the examined *L. molybdinus* in the Nwanedi-Luphephe Dam. This was significantly ($P < 0.05$) higher than on *L. rosae* and *L. ruddi* from River Bubye, in which the parasite made up 23.5% and 8.3%, respectively. However, the parasite had relatively higher mean intensities on the hosts examined from River Bubye compared to those from Flag Boshielo and Nwanedi-Luphephe dams (see Table 1). The recorded prevalence values for *L. cleopatra* on *Labeo* spp. were relatively low compared to those of *L. hoi* on *Labeobarbus polylepis* (Boulenger) recorded by Austin & Avenant-Oldewage (2009), in which the prevalence ranged between 21–95% depending on the locality. Hassan et al. (2013) recorded a prevalence of 36.7% of *L. monodi* on *Oreochromis niloticus* (Linnaeus) which is higher than the 27% prevalence recorded in this study for *L. cleopatra* on *Labeo* spp. Soylu (2012) also recorded a higher prevalence (68.8%) of *L. pulchella* on the gills of *Scardinius erythrophthalmus* (Linnaeus), with a mean intensity of 2.85 individuals per infected fish. The mean intensity of *L. cleopatra* on *Labeo* spp. was 1.85 which is lower than those reported by Austin & Avenant-Oldewage (2009), Soylu (2012) and Hassan et al. (2013) of the different *Lamproglena* spp. on their respective hosts. The specimens collected from the different localities and hosts exhibited similar morphometric characteristics. Comparisons with the original description by Humes (1957) revealed minor differences in relation to the specimens collected in South Africa and Zimbabwe. Humes (1957) described the antennule as having naked setae on both the basal and distal podomere. However, there is no mention of the number of setae on each podomere. The antennule of the specimens observed in the present study bears one long seta and six smaller setae on the distal podomere, and 22 setae varying in length and width on the basal podomere. Humes (1957) described the antenna with five small setae, whereas in the present study the antenna was observed with four setae on the lateral margin and five terminal setae. The endopodites of the first to fourth pair of legs were described by Humes (1957) to be similar and terminating in a minute blunt seta. Upon close examination, these endopodites were observed not to be similar, with the second and fourth pair of legs terminating in one blunt seta, whereas the first and third pair of legs terminate in two blunt setae. Humes (1957) also described the fifth pair of legs having one lateral and one distal seta; however, there is another small lateral seta which was observed with scanning electron microscopy.

Neither the male larvae nor the female larvae of *L. cleopatra* have been described before. Although no male specimens where found in the present study, the copepodid III larvae representing the last copepodid stage were recorded from the gills of *L. rosae*, *L. molybdinus* and *L. ruddi*, and described in this paper. The taxonomic key includes 38 (with one subspecies included) species of *Lamproglena* excluding

*Lamproglena notopterai* Jafri & Mahar, 2006. *Lamproglena notopterai* is considered as an invalid species in the present study and is not included in the taxonomic key due to its inadequate description, the scanty illustrations and inaccuracies in the article in which it was presented by Jafri & Mahar (2006). In their description, Jafri & Mahar (2006) presented the species based on one specimen, which they considered to be male. The species therefore cannot be valid as all species of the family Lernaeidae and Ergasilidae Burmeister, 1835 are described based on mature females which are the only sex that develops into parasitic stages. The illustration given in the article by Jafri & Mahar (2006) is actually of a female; however, due to the poor quality of the illustration and its description the species cannot be considered valid based on such limited information.

The original description of *L. cleopatra* lacked some morphological and morphometric details which are now presented in this paper. The before mentioned differences and omissions in the original description of *L. cleopatra* can be attributed to the level and accuracy in microscopy used at the time, and thus do not warrant the specimens collected from the rivers Limpopo and Olifants being identified as a separate species or sub-species. However, herein we report new geographical and host records of *L. cleopatra* on *L. rosae*, *L. molybdinus* and *L. ruddi* from the rivers Olifants and Limpopo.

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**Compliance with ethical standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving animals were in accordance with the ethical standards of the University of Limpopo. Permit for catching and/or collecting fish species was issued by the Department of Economic Development, Environment and Tourism (permit no. ZA/LP/HO/3370).

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