An ultrastructural investigation of Argulus personatus Cunningham, 1913 (Crustacea: Branchiura) from Lake Tanganyika, northern Zambia

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Sixteen male and one female specimen of Argulus personatus Cunningham, 1913, were collected from Bathybates ferox Boulenger, 1898, from Lake Tanganyika in northern Zambia. Light and scanning electron microscopy (SEM) examinations documented a thickening of cuticle located on the dorsal surface between last thoracic segment and abdomen, which was rectangular in shape; a basal section of the pre-oral spine and proboscis ornamented with simple scales; three large simple setae present on the distal end of the basal plate; the dorsal distal end of second podomere of maxillae ornamented with scales resembling those of a fish; second and third podomeres of maxillae ornamented with two types of pectinate scales (with fine bristle-like ends and scales with large pointed ends); the ventral distal end of third and fourth maxillary podomeres bearing large teardrop-shaped scales; a pair of tubular structures present adjacent to the anterior projection; a peg on the fourth pairs of legs of males bearing shallow grooves running irregularly across surface; and an accessory cushion bearing minute projections. These characters differed from the original description of A. personatus and are addressed in a redescription.

Key words: Crustacea, Argulus personatus, external morphology, SEM, light microscopy.

INTRODUCTION
Lake Tanganyika harbours eight Argulus species of which seven are endemic to the lake (Cunnington 1913). These species were originally discovered during the third expedition to Lake Tanganyika conducted by W.A. Cunnington in 1904 and 1905. The seven species endemic to Lake Tanganyika are A. angusticeps, A. exiguis, A. incisus, A. personatus, A. rubescens, A. rubropunctatus, and A. striatus. The non-endemic species Argulus africanus was also present in Lake Tanganyika (Cunnington 1913). However, it was later discovered by Fryer (1960) that many of the A. africanus specimens collected in the Great African lakes region were in fact A. rhipidiophorus. He mentioned Lake Albert in particular, the same lake in which Cunnington sampled his specimens. There is no specific mention of Lake Tanganyika in Fryer’s paper. Cunnington reiterated his findings in his subsequent publication of 1920 without mentioning anything new. Since Cunnington’s publications on Lake Tanganyika (Cunnington 1913, 1920), there has been no updated information regarding the argulids of this lake. Therefore there is no existing confirmation as to whether A. africanus truly exists there. Cunnington’s (1913) first descriptions of these seven endemic Argulus also lacked much morphological detail and due to this, a subsequent redescription of these species was conducted by Rushton-Mellor (1994a,b). She examined Cunnington’s type-material and gave detailed redescriptions of these endemic species in Lake Tanganyika. A detailed key for identification was also created for most of the African Argulus species. Specimens of A. personatus collected in Zambia were compared to the literature (Rushton-Mellor 1994a,b; Cunnington 1913) and the British Museum of Natural History type specimens (cotypes 46–49). Previous research on A. personatus was conducted with light microscopy only. Therefore SEM was conducted on the specimens to add characteristics previously undescribed. Morphological examinations with light and scanning electron microscopy documented differences from Rushton-Mellor (1994a,b), which were incorporated into a redescription of the species. It must also be noted that the objective of this paper is not to rearrange the taxonomy of African argulids but merely to provide additional

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MATERIALS & METHODS

Seventeen specimens of *Argulus personatus* were sampled from the buccal cavities of 35 specimens of *Bathybates ferox* Boulenger, 1898 (Perciformes: Cichlidae) on 4 July 2000, near the city of Mpulunga in northern Zambia and were collected from Lake Tanganyika. The fishes were sampled by four persons, one of whom (J.R. Sullivan) is a fish specialist (see acknowledgements). This pelagic fish is endemic to this lake and has some commercial importance as a food and aquarium fish. Sixteen specimens of males and one female of *Argulus* were immediately preserved in vodka (40% ethanol) and subsequently transferred to 10% formalin. The specimens were donated to E.H.W. who subsequently donated them to A.A-O. They were rinsed under running tap water prior to examination, dehydrated in an ascending ethanol series to 70%, cleared in 90% lactic acid containing Dimethylamino azo-benzene sodium sulphonate for light microscopy with a Wild M5 dissection microscope and Zeiss Lab 18 compound microscope, both with drawing tubes. Eight male specimens were mounted on slides and examined with light microscopy. The single female along with other eight male specimens was used for scanning electron microscopy. Specimens for scanning microscopy, following hydration, were freeze-dried and sputter-coated with gold prior to examination with a JEOL JSM-5600. Micro-dissection was performed to reveal the internal structure of the mouthparts. The specimens from the Natural History Museum (London) were examined with a dissection and a compound microscope. Measurements of specimens were taken as indicated in Fig. 1. The length of the carapace was measured from the right side only.

The remaining specimens were deposited in the collection of the Albany Museum, Grahamstown, South Africa (*Argulus personatus. RAU 10 A-H*).

Locality. Off the south coast near Mpulunga, Lake Tanganyika, Zambia.

RESULTS

Description of adult male. Measurements based on eight specimens. Body shape elongated; average length 5.5 mm, range 4.68–7.20 mm. Anterolateral depressions pronounced, carapace almost as broad as long; average length of carapace 3.03 mm, range 2.42–4.05 mm, percentage range 48–57% (53% of overall body length). No variation in the length of the carapace lobes was visible. Average width of carapace 2.9 mm, range 2.37–3.95 mm, carapace lobes extend to anterior midline of third pair of swimming legs. Compound eyes large, nauplius eye visible, and distance between compound eyes and nauplius eye form an equilateral triangle. Nauplius eye composed of three ocelli, one ocellus facing anteriorly and two facing...
Antennal spines present ventrally on carapace. Anterior and lateral surfaces of carapace are thickening rectangular in shape (Fig. 26). Abdomen elongated, average length of abdomen 2.1 mm, range 2.00–2.47 mm, percentage range 37–41% (39% of total length). Posterior part of abdomen separated into two tapering lobes, ending in sharp points. Abdominal sinus comprises 41% of abdomen length, range of sinus length 0.84–1 mm, percentage range 40–48%. Average abdomen width 0.93 mm, range 0.84–1.26 mm. Furcal rami very small and located at junction of abdominal sinus, adjacent to anus. Each bulbous ramus carries four simple setae. Length of testes comprises 61% abdomen length, range 0.8–1.9 mm, percentage range 45–77% average width of one testis 0.39 mm (42% of abdomen width of one abdominal lobe), and range 0.32–0.58 mm, 38–46%.

Antennules and antennae. Antennules divided into four podomeres (Fig. 2). First basal podomere consists of large posterior spine, second podomere large and stout, positioned horizontally, composed of a straight anterior spine, minute medial spine pointing towards posterior. Second podomere ends in slender, tapering terminal hook. Third podomere located ventral to terminal hook, elongated and slender with large, single seta located on distal end. Fourth podomere minute and short, ending in four apical setae positioned on distal end of podomere. Antennae separated into four podomeres. First podomere larger and stouter than the three other podomeres, minute posterior spine positioned on proximal end of first podomere (Fig. 4). A series of five, minute, closely arranged, simple setae present adjacent to posterior spine, two setae extending medially from podomere above posterior spine. A group of four setae positioned on ventral distal end of podomere. Large, elongated seta present on distal end of first podomere, with two smaller setae present directly above larger seta, single smaller seta present directly ventral to larger seta (Fig. 3). Second podomere elongated and slender, series of four setae found on distal end. Third podomere shorter than second, series of four simple setae present on distal end. Fourth podomere shortest, bears four apical setae on distal end. Two large pointed post-antennal spines present ventrally on carapace.

Scales on ventral carapace surface. Scales on ventral anterolateral and lateral surfaces of carapace are simple in shape and pointed. Scales on ventral anterolateral surface dented on one side, broad at their bases and curve towards tapered end (Fig. 5).

Respiratory areas. Consist of two large areas located on each lateral lobe of carapace. Outer area larger and located near to edge of carapace lobes, area is slightly C-shaped. Smaller respiratory area encompassed within larger outer area. Male respiratory areas similar to illustrations of respiratory areas of female cotype in Rushton-Mellor (1994a).

Maxillules/suckers. Suckers relatively large, outermost circumference bordered by closely arranged single layer of setae. Number of rods in sucker 49 with no variation observed. No variations regarding the shape or number of sclerites were found in the anterior and posterior supporting rods. Anterior and posterior supporting rods regularly arranged, composed of crucible-shaped sclerites fitting into one another, diminishing in size towards periphery. Basal sclerites elongated and vase-shaped. Variation was observed where some rods became fused with one another (Fig. 6) other rods possessed five or six deformed sclerites that deviated from the normal crucible shape. Only the sclerites in the normal rods were counted. Number of sclerites in normal rods ranges from eight to ten; adjacent rods parallel.

Pre-oral spine and proboscis. Retractable pre-oral spine elongated, located midway between maxillules and ornamented with simple scales (Fig. 8). Proboscis present posterior to pre-oral spine and surface covered by simple scales (Fig. 9).

This is in contrast to the finding of Rushton-Mellor (1994a) that the proboscis is ornamented with pectinate scales. Labrum square-shaped, lateral walls of labrum arch bears pair of minute sharp projections, which originate from a shallow circular depression, and a row of pectinate outgrowths extend from each wall of labrum arch (Fig. 10). Two labial tubules present within mouth tube (Fig. 11). Labium unadorned with scales but bears fine rows of serrations on surface. Two mandibles present within mouth tube, each consists of two sections. Basal section stout and second section stout and bulbous, tapers towards a flat plate-like tip, bearing row of conspicuous, curved denticles. Series of denticles extend all around tip to proximal edge where three larger, recurved denticles are present on a small projection situated at a 90° angle to former (Figs 12 & 13).

Maxillae. Consist of five podomeres (Fig. 14) with first basal podomere bearing three spines. Spines elongated and sharp, basal plate large and
ornamented with simple slender scales, three elongated simple setae present at posterior end of basal plate (Fig. 15). It was previously stated by Rushton-Mellor (1994a) that the basal plate lacked any setae. Dorsal surface of second podomere adorned with minute scales resembling those of fish arranged in patches, scales positioned at distal end of podomere (Fig. 16). Ventral surface of second podomere bears two types of pectinate scales (with fine, bristle-like ends; or with large, thick ends) (Fig. 17). Third podomere bears both types of pectinate scales, distal end of podomere bears patches of teardrop shaped scales. Fourth podomere bears teardrop-shaped scales at distal end of podomere (Fig. 18). Fifth podomere ends in a blunt, terminal extension, conspicuously separated into two sections, distal part with a pair of claws situated ventrally to terminal extension (Fig. 19). Pair of accessory solid and curved thoracic spines situated on either side of midline, and pair of post maxillary spines situated on anterior end of first thoracic segment.

Figs 2–8. Scanning electron micrographs of Argulus personatus; 2, antennule and antennae (AS, anterior spine; MS, medial spine; PS, posterior spine; TH, terminal hook); 3–4, first podomere of antenna (arrows showing position of various groups of setae); 5, simple scales on ventral anterolateral surface of carapace; 6, maxillule of male showing damaged rods; 7, maxillule of female; 8, pre-oral spine. Scale bars: 2 = 100 µm, 3 & 4 = 20 µm, 5 = 10 µm, 6 & 7 = 20 µm, 8 = 100 µm.
Swimming legs. Ventral surface of thorax and swimming legs covered by simple elongated scales. Four pairs of biramous legs present. First and second pair of legs divided into three podomeres, third and fourth pairs divided into two podomeres. First and second pairs each bear flagellum on basipodite, flagella positioned on dorsal surface of basipodite, extending medially across podomere. Second pair of legs bears a conical projection on posterior midline of precoxae, projection ornamented with elongated, simple scales (Fig. 20). Third and fourth pair of legs bears accessory copulatory structures (Fig. 21). On third leg, a rounded extension is present on anterior midline of basipodite adjacent to exopodite, covered all over by narrow bristle-shaped scales (Fig. 23). Adjacent to projection two tubular structures are present (Fig. 22). On posterior side of third leg, socket present on proximal end. Socket consists of deep cavity surrounded by folds.
Fourth pair of legs slightly shorter than third pair; large peg present on distal end of basipodite, originating from proximal end, extending medially across basipodite. Peg bears minute indentation patterns and minute scales on surface (Fig. 24). Accessory cushion originates medially from ventral surface of basipodite. Cushion also ornamented with minute scales (Fig. 25).

**Description of female** (measurements based on one specimen). Length 5.6 mm, carapace length 3.7 mm (66% of total length), carapace width 3.4 mm. Carapace lobes extend to anterior midline of third pair of legs. Abdomen shorter and broader than male abdomen, lobes rounded terminally, abdomen length 1.5 mm (comprises 27% of total body length), abdomen width 0.9 mm, and abdominal sinus 0.57 mm (comprises approximately 38% of total length of abdomen). Spermathecae small and oval in shape, positioned on anterior end of abdomen, length of spermathecae 0.3 mm and width 0.18 mm.

**Maxillules/suckers.** Very similar to male maxillule,
with rods composed of crucible shaped sclerites. Sclerites numbering from 8–10 in each rod (Fig. 7). No variation in number or shape of sclerites observed. (Only one specimen collected).

Swimming legs. No accessory copulatory structures on third and fourth pair of legs. Large natatory lobe present, positioned between fourth segment of thorax and coxapodite of fourth pair of legs. Outgrowth present on proximal edge of natatory lobes and edge of natatory lobes carries a single layer of setules.

DISCUSSION & CONCLUSION
This redescription adds numerous characters that had not been previously recognized; possibly because this was the first examination done on A. personatus by SEM. The study also helped to verify morphological characters from previous descriptions. Cunnington’s original description (1913) is generally concurrent with this one; specifically with regards to the different body measurements and the various descriptions of the appendages such as the antennae and suckers. His description of the male accessory copulatory structures is also the same. He mentioned that the males possess a large conical projection on the anterior face of the leg. The specimens that were examined in this study also have this conical projection. He also mentioned a projection on the proximal end of the posterior midline of the second pair of legs. This projection was also observed in the SEM study. Rushton-Mellor’s description of this species is also generally concurrent, but with very few minor differences. Rushton-Mellor (1994a) found that the basal plate lacks setae and the proboscis is adorned with pectinate scales. In the present study it was observed that these specimens do indeed have setae (three elongated simple setae) at the base of the plate, and that the proboscis was adorned with simple scales in these specimens. During the SEM study it was common to observe the setae detaching from their basal plates when being handled. It was also found that the shape of the respiratory areas of the male specimens were similar in shape to the respiratory areas of the female specimens illustrated in Rushton-Mellor (1994a,b). The ‘anteriorly directed processes located on dor-
sal surface of fourth thoracic segment' mentioned in Rushton-Mellor (1994a) were also present in the male specimens studied. However, they were not as pronounced as they were in her illustration or in the museum specimens examined. It was also noted that the number and arrangement of setae on the first podomere of the antennae were also different to Rushton-Mellor’s illustrations. In Rushton-Mellor (1994a), she illustrated the first podomere with setae extending medially from the podomere, with a large single setae on the distal end of the podomere. In the present study, it was observed that there were various groups of setae situated on different areas of the first antennal podomere. It was observed that in some instances two or three (of 49) of the supporting rods in the suckers were fused with one another, possibly resulting from natural damage while the parasites were still alive. Fused rods were still counted as two separate ones but they were not used to determine the variation in the number of sclerites. The sclerites in these rods deviated from the normal crucible shape and it was common to see five or six in a rod. Some rods were not fused with their adjacent counterparts but did possess deformed sclerites. The rods with deformed sclerites were not included in the sclerite count because the shape of these sclerites is not accepted as part of A. personatus, whereas Rushton-Mellor (1994a) found 12–13 sclerites. There were also no fused rods observed, nor were there any rods with sclerites with deformed shapes. It was also not possible to count the number of rods for the female as sections of the maxillules were heavily damaged. However, there was only a single female specimen to examine and therefore variations on morphology cannot be commented on. With regards to the additional information gleaned, the detailed morphology of various types of scales on the maxillae is described. Additional information regarding the ultrastructure of the male copulatory structures is also provided. The structure of the labrum, labium and mandibles are described for the first time and the rectangular thickening found between the fourth thoracic segment and abdomen. This thickening was also found in the museum specimens.

Owing to the very detailed illustrations done by Rushton-Mellor (1994a,b), it is possible to identify the seven endemic Argulus species from each other, by using superficial differences such as the shape of the carapace and the shape and length of the abdomen. There is one species, however, that is similar in shape and in body proportions to Argulus personatus, namely A. rubropunctatus. The shape and proportions of their carapaces are only slightly different, and both species have long abdomens with long, tapering lobes and elongated testes. The eyes of both species offer an important difference in identification. The eyes of A. rubropunctatus are far smaller than those of A. personatus. Another difference is that the antennules of A. personatus consist of four podomeres while the antennule of A. rubropunctatus consists of three only. Also, both species have similarly structured accessory copulatory structures, i.e. paired tubular structures on the anterior midline of each third pair of legs. However, the males of A. personatus possess a large projection on the distal anterior midline of the third pair of legs, whereas A. rubropunctatus does not.

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REFERENCES


