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Description of the adult female and male of *Naobranchia kabatana* n. sp. (Copepoda: Lernaeopodidae) from *Muraenesox bagio* (Hamilton) (Muraenesocidae) caught in the Indian Ocean off South Africa

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Abstract *Naobranchia* Hesse, 1863 is a genus of the family Lernaeopodidae. This report presents an illustrated description of the adult female and male of a new species of this genus collected from the gill filaments of *Muraenesox bagio* (Hamilton) (pike conger) caught off the coast of Richards Bay, KwaZulu-Natal, South Africa. Its morphological features were examined using light and scanning electron microscopy. Characteristic features of the female *Naobranchia kabatana* n. sp. include egg-sacs situated along most the length of the trunk, cephalothorax and trunk of about equal lengths, and egg-sacs, lacking distinct sclerotised bands, which meet at the posterior end of the body and usually obscure the abdomen and caudal rami in ovigerous specimens. The male has no division into the cephalothorax and trunk, resulting in an unsegmented body with a prominent genito-abdominal papilla in a subterminal position.

Introduction

Naobranchia Hesse, 1863 is a genus with a chequered taxonomic past. Wilson (1915) attempted a revision of the family Lernaeopodidae Milne Edwards, 1840 (Siphonostomatoida) and divided it into four subfamilies (Lernaeopodinae Wilson, 1915, Tracheliastinae Wilson, 1915, Brianellinae Wilson, 1915 and Clavellinae Wilson, 1915) based on various combinations of two morphological characteristics of adult females (location of the maxillipeds and structure of the cephalothorax) with *Naobranchia* considered to be a member of the Clavellinae. Yamaguti (1939) placed *Naobranchia* in a separate family, Naobranchiidae Yamaguti, 1939. Markevich (1956) added two more subfamilies (Naobranchiinae and Nectobrachiinae Markevich, 1946) to Wilson's (1915) concept of the Lernaeopodidae in order to accommodate *Naobranchia* and *Nectobrachia* Fraser, 1920, respectively. However, Yamaguti (1963) did not approve of Markevich's (1956) changes and retained the four subfamily structure, placing *Nectobranchia* within the subfamily Lernaeopodinae and retaining *Naobranchia* as the type-genus of the Naobranchiidae. Kabata (1979) agreed with Yamaguti (1963), since the structural plan of *Naobranchia* only superficially resembles that of the other lernaeopodids, but differs from it in the absence of a bulla (it holds on to its host by means of an annulus formed by flat maxillae), the incorporation of the egg-sacs into the trunk and differences in the structure of the appendages. *Naobranchia* was therefore removed from the Lernaeopodidae to the Naobranchiidae (see Kabata, 1979). However, on the basis of similarities in the morphology of the males, Kabata (1981) considered the Naobranchiidae as a sister group of the *Clavella*

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species-group within the Lernaeopodidae. With this relationship in mind and because *Naobranchia* does not exhibit any derived characteristics that warrant independent familial status (Benz, 1994), it was returned to the Lernaeopodidae (see Boxshall & Montu, 1997). The Naobranchiidae was again considered as a separate family by Kazatchenko in Boxshall & Halsey, (2004), but this view was not accepted due to the absence of phylogenetic support (Boxshall & Halsey, 2004). Therefore, *Naobranchia* was returned to the Lernaeopodidae, as proposed by Kabata (1981) (see Boxshall & Halsey, 2004).

Naobranchia currently consists of 22 members. The adult females of the different species can be divided into two groups according to the position of the egg-sacs, which may be situated laterally along most, or all, of the trunk or posterolaterally, in which case they do not extend all the way up to the anterior end of the trunk (Kabata, 1992). Thirteen species (*N. cygniformis* Hesse, 1863; *N. amplectens* (Kurz, 1877); *N. occidentalis* Wilson, 1915; *N. aulopi* Yamaguti, 1939; *N. pagelli* Nunes-Ruivo, 1963; *N. hemiconiati* Nunes-Ruivo, 1963; *N. sargi* Nunes-Ruivo, 1963; *N. smaridis* Nunes-Ruivo, 1963; *N. auriculata* Shiino, 1958; *N. maxima* Ho, 1975; *N. microsoma* Dojiri, 1981; *N. scorpaenae* Dojiri, 1981; and *N. alta* Kabata, 1992) belong to the group with posterolateral egg-sacs, while nine (*N. lizae* (Krøyer, 1863); *N. pomolobi* Fowler, 1913; *N. variabilis* Brian, 1924; *N. wilsoni* Nigrelli, 1935; *N. spinosa* Pearse, 1952; *N. vermiformis* Rangnekar, 1956; *N. polynemi* Tripathi, 1962; *N. prichardae* Kensley & Grindley, 1973; and *Naobranchia* sp. of Lewis (1967) (*N. stibara* Leigh-Sharpe, 1926 synonomised with *N. lizae* (see Boxshall & Montú, 1997)) belong to the group with lateral egg-sacs. Known males belong to three different types depending on the position of their genito-abdominal complex (Kabata, 1992).

Materials and methods

Copepods were collected from the gill-filaments of *Muraenesox bagio* (Hamilton), caught by fishermen of the Meer-en-See Boat club off the coast of Richards Bay, KwaZulu-Natal, South Africa. Collected copepods were fixed and preserved in 70% ethanol. Before being dissected, they were cleared and stained in lactic acid with a pinch of dissolved lignin pink. Copepods were studied using stereo- and light microscopy and the wooden slide technique of Humes & Gooding (1964), and drawn with the aid of drawing tubes. Measurements were made using an ocular micrometer. Several specimens were studied using scanning electron microscopy. These specimens were dehydrated through a graded ethanol series (70, 80, 90, 100, 100%, immersed in each for 30 min.) followed by immersion in a small volume of hexamethyldisilazane (30 min.). Before mounting, drying was achieved by placing specimens under a slight vacuum to remove the hexamethyldisilazane. Specimens were sputter-coated with gold-palladium. The anatomical terminology used conforms mostly with that of Huys & Boxshall (1991) and Kabata (1979).

Naobranchia kabatana n. sp.

Type-host: *Muraenesox bagio* (Hamilton) (pike conger) (Muraenesocidae).
Type-locality: Off Richards Bay (28°48′S, 32°06′E), KwaZulu-Natal, South Africa.
Site: Gill-filaments.
Material studied: 10 adult females (2 with a male attached), i.e. 2 ♀♀ from each of 2 infected hosts, caught on the 14th October, 2000; 3 ♀♀ on 1 one host and 3 ♀♀ and 2 ♂♂ from another host caught on 9th November, 2002.
Type-material: One adult female (holotype) with male attached (SAM A45531) deposited in the Iziko South African Museum. The remaining females and dissected male have been retained in the personal collection of the first author.
Etymology: The species epithet, *kabatana*, is for Dr Zbigniew Kabata in recognition of his major contribution to our knowledge and understanding of symbiotic Copepoda.

Description (Figs. 1–5)

Adult female (Figs. 1–4)
Overall length in ventral view 9.1 mm; cephalothorax 4.6 mm; trunk 4.5 mm. Cephalothorax (Fig. 1A–C) cylindrical, elongate, about same length as trunk, anteriorly with slightly enlarged head, somewhat

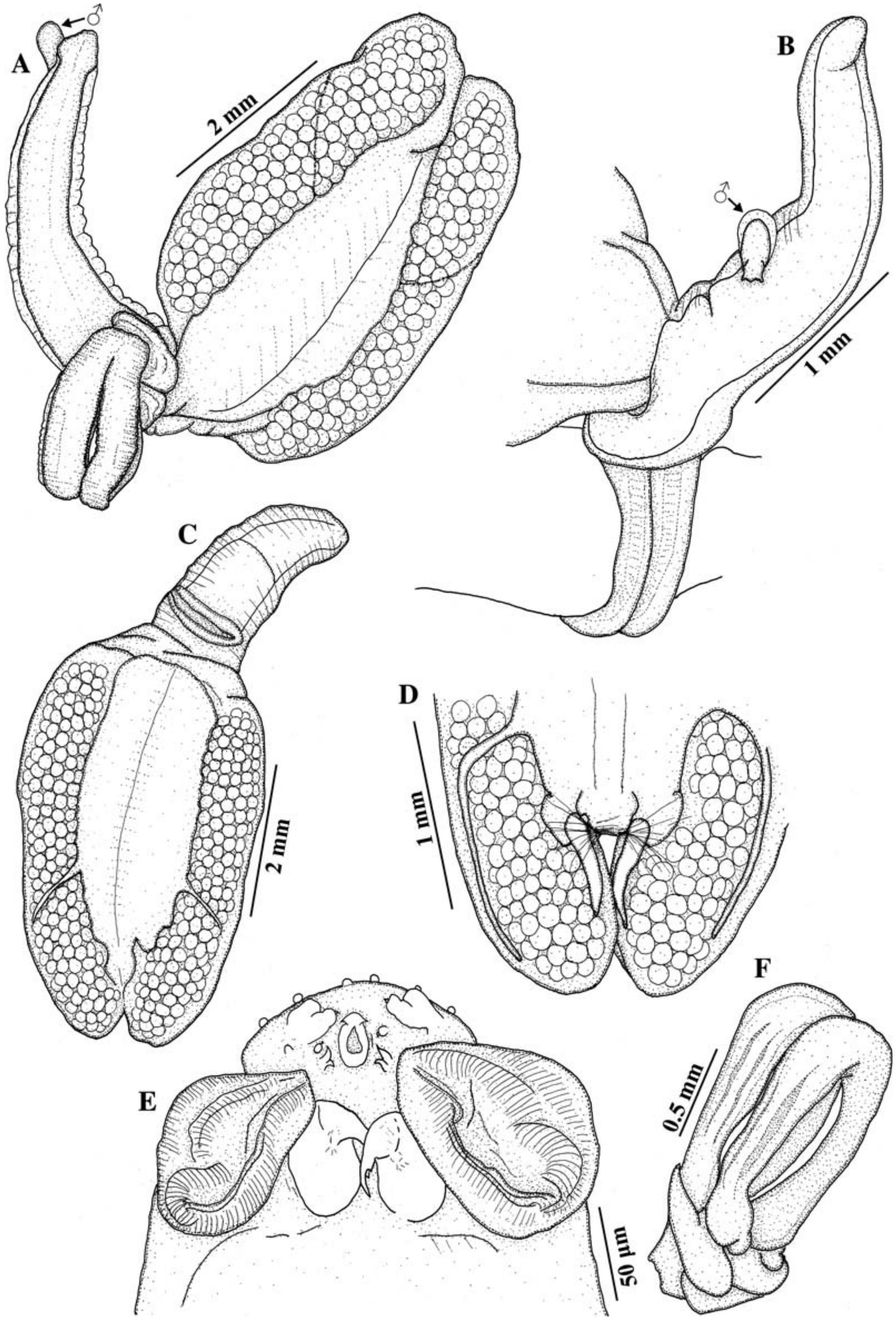

Fig. 1 *Naobranchia kabatana* n. sp., adult female: A. general habitus (with male attached), ventral view; B. cephalothorax (with male attached) attached to host's gill filament, lateral view; C. general habitus, dorsal view; D. posterior of trunk and abdomen, ventral view; E. tip of cephalothorax (head), ventral view; F. maxillae. *Scale-bars*: A, C, 2 mm; B, D, 1 mm; E, 50 μm; F, 0.5 mm

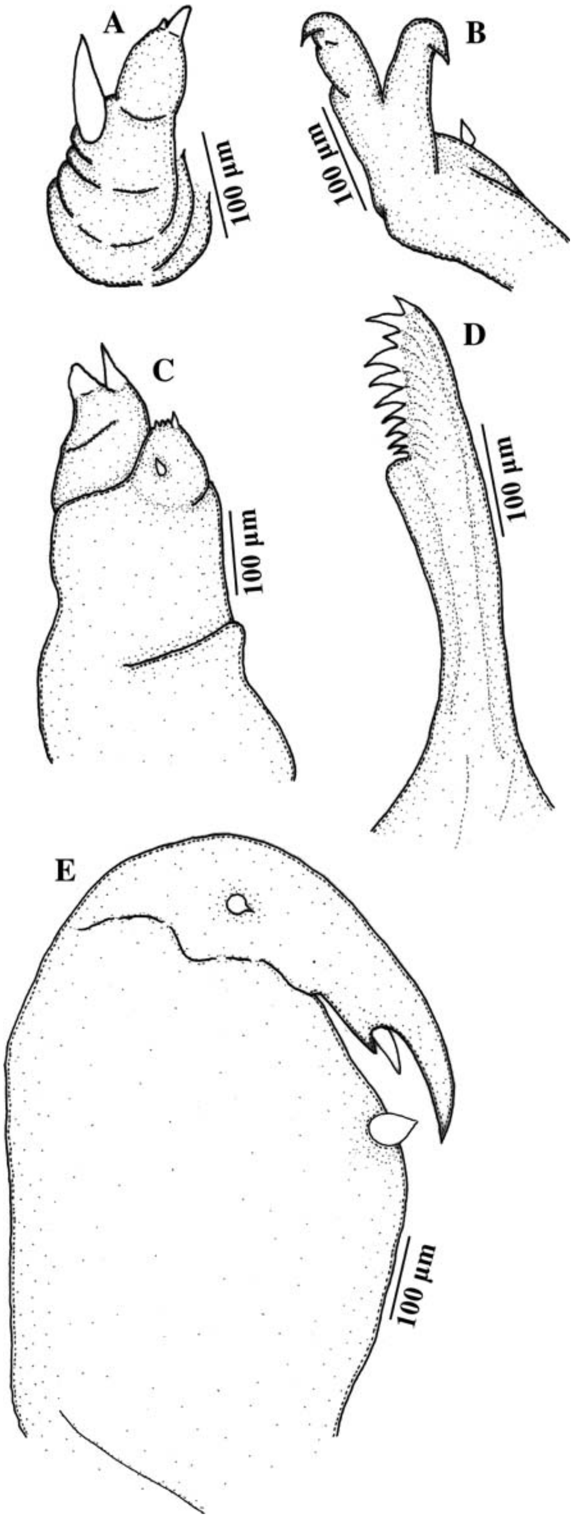

Fig. 2 *Naobranchia kabatana* n. sp., adult female: A. antennule; B. maxillule; C. antenna; D. mandible; E. maxilliped. *Scale-bars*: 100 μm

increasing in diameter posteriorly, almost as wide as trunk and about 1/3 width of trunk and egg-sacs, dorsally covered by transversely wrinkled membrane, with deep dorsal groove anterior to attachment of maxillae (Fig. 1C); head conical (Fig. 1A); anterior margin bears 6 spherical hyaline papillae symmetrically arranged on both sides (Figs. 1E, 3A); adhesive lobes lateral to maxillipeds, protrude beyond margins of cephalothorax (Fig. 1E). Trunk (Fig. 1A,C) oblong to almost elliptical, width 3.18 mm, laterally with egg-sacs meeting posterior to abdomen and caudal rami; abdomen (only slightly visible in some specimens) subquadrangular, distolaterally bearing unarmed, short, digitiform caudal rami (only visible in some specimens) (Fig. 1D). Egg-sacs (Fig. 1A,C) cylindrical, extend laterally along most of length of trunk meeting at posterior extremity; egg-sac membranes in posterior half re-enforced by thin extension from trunk (Fig. 1D) (not always visible); eggs multiseriate.

Antennule (Figs. 2A, 3B) lateral to mouth tube (Figs. 3A,E), 4-segmented; first 2 segments stout, unarmed; third segment with medial digitiform process extending beyond distal margin of terminal segment; latter with apical digitiform process and small tubercle-like process. Antenna (Fig. 2C) lateral to antennule (Fig. 3A), biramous, indistinctly segmented; exopod (Figs. 2C, 3C) smaller than endopod, distally with two short setae and three flat-lying lateral projections each ending in 2 spine-like outgrowths on apex (Fig. 3C); endopod (Figs. 2C, 3D) indistinctly 2-segmented; basal segment with posterior comb-like outgrowth rimmed by fringe of setules; distal segment with strongly flexed hook-like seta; stout seta with 5 terminal digitiform papillae, inflated area bearing conical seta, comb-like outgrowth similar to that on basal segment covering medial and posterior surfaces of inflated area and accompanying seta. Mandible (Figs. 2D, 3E) with teeth extending posteriorly in mouth tube; dental formula S1, P1, S1, P1, B6. Maxillule (Figs. 2B, 3E, F) posterolateral to mouth tube, biramous; exopod small with terminal dentiform seta; endopod with 2 long truncate setae on elongate papillae. Maxillae (Fig. 1A,B,F) at base of cephalothorax, ribbon-like, slightly wrinkled transversely, equal-sized, with 3 strands of muscles (visible laterally); distal ends attached to base of cephalothorax (Fig. 1B,F). Maxilliped (Fig. 2E) corpus robust, 1-segmented; myxa

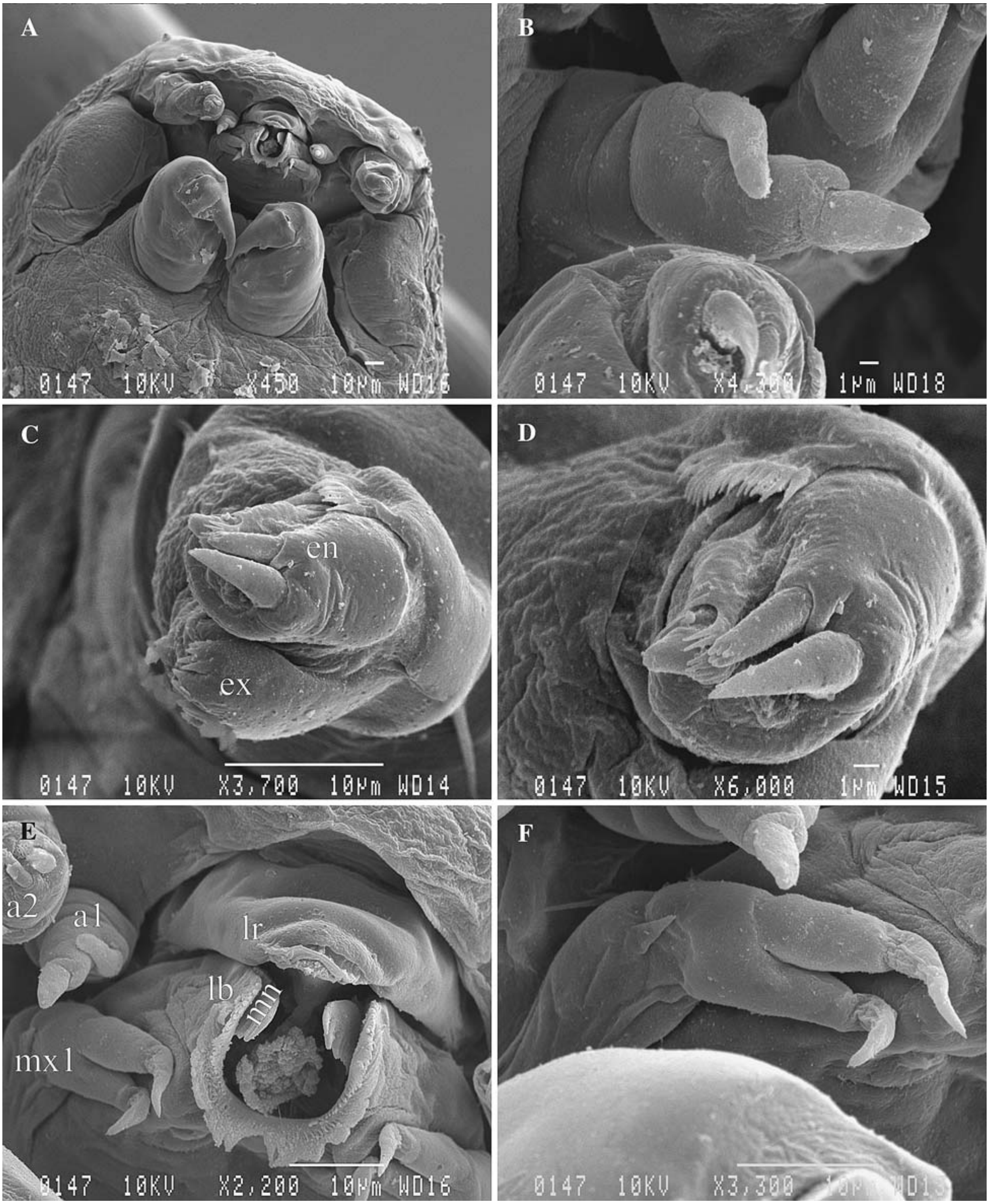

Fig. 3 *Naobranchia kabatana* n. sp., adult female: A. tip of cephalothorax, ventral view; B. antennule; C. antenna with exopod (ex) and endopod (en); D. antenna endopod; E. mouth cone (lr = labrum, lb = labium) with mandibles (mn) facing posteriorly, antennule (a1), antenna (a2) and maxillule (mx1); F. maxillule

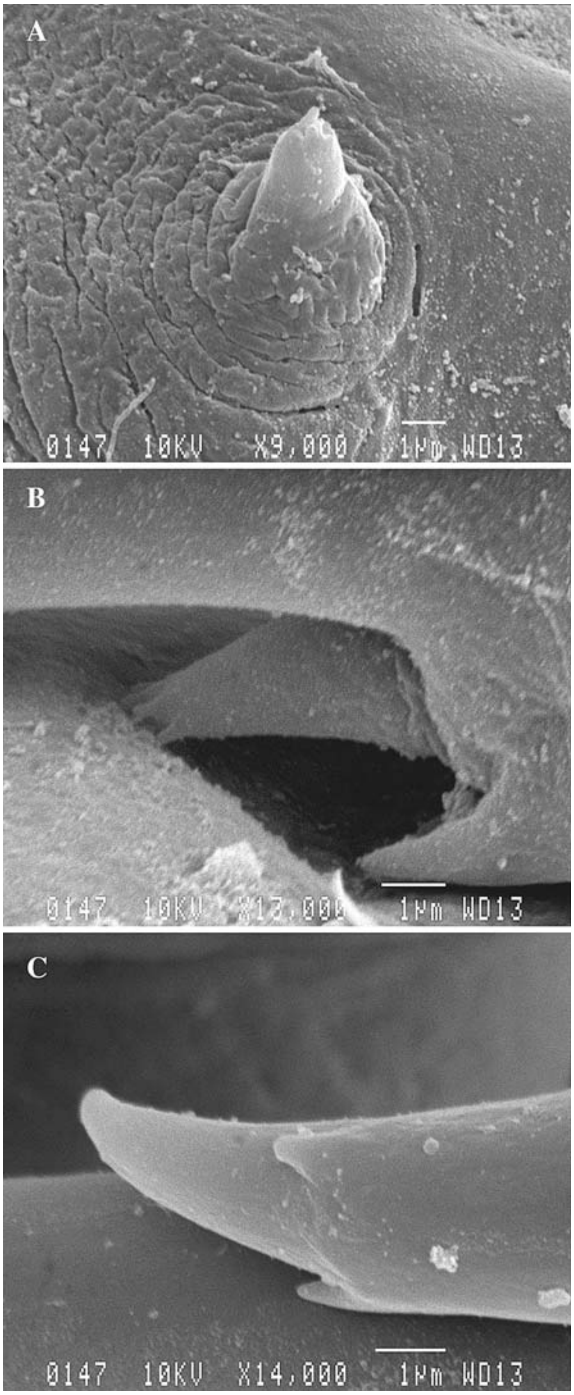

Fig. 4 *Naobranchia kabatana* n. sp., adult female maxilliped: A. myxa with small conical seta; B. subchela with protruding inner margin and distal seta with small papillae on apex; C. tip of claw with small papillae

with small conical seta with 2–3 very small papillae on apex (Fig. 4A); subchela slightly tapered towards claw, with distal end of inner margin slightly protruding, bears papilliform seta halfway along length of posterior margin and distal seta [with couple of very small papillae on apex (Fig. 4B)] between protruding inner margin and base of claw; claw slender, gently curved, with 2 small papillae short distance from tip (Fig. 4C).

Male (Fig. 5)
Dorsally attached to cephalothorax of female (Fig. 1A,B). No division into cephalothorax and trunk; oval, unsegmented body with genito-abdominal papilla prominent, subterminal in position (Fig. 5A). Anterior margin of head bears spherical hyaline papillae symmetrically arranged on both sides (Fig. 5 A). Antennule (Fig. 5D) similar to that of female but with small tubercle-like process not observed. Antenna (Fig. 5E) also similar to that of female but lacking some detail observed using the scanning electron microscope. Mandible (Fig. 5F) very small, with dental formula S1, P1, S1, P1, B5 (?). Maxillule (Fig. 5B) similar to that of female. Maxilla (Fig. 5C) broad, stout, linked to its opposite by tympanum, subchelate; corpus with slightly raised denticulated myxal area; subchela broader than claw; tip of claw tapered and curved, meets myxal area. Maxillipeds (Fig. 5G) robust, situated on mediative process, smaller than maxillae; myxa unarmed, elevated to receive tip of claw; subchela, broad, unarmed, with tip indistinctly tapering into claw; claw opposed to tip of myxa. Caudal ramus (Fig. 5H) small, digitiform, on distal margin of genito-abdominal papilla.

Discussion

Naobranchia kabatana n. sp. belongs to the group of species with egg-sacs situated laterally along most, or all, of the trunk (*N. lizae*, *N. pomolobi*, *N. variabilis*, *N. wilsoni*, *N. spinosa*, *N. vermiformis*, *N. polynemi*, *N. prichardae* and *Naobranchia* sp.). Due to most of the descriptions of the different species being somewhat scanty, it is difficult to compare the current species with its congeners. However, the current

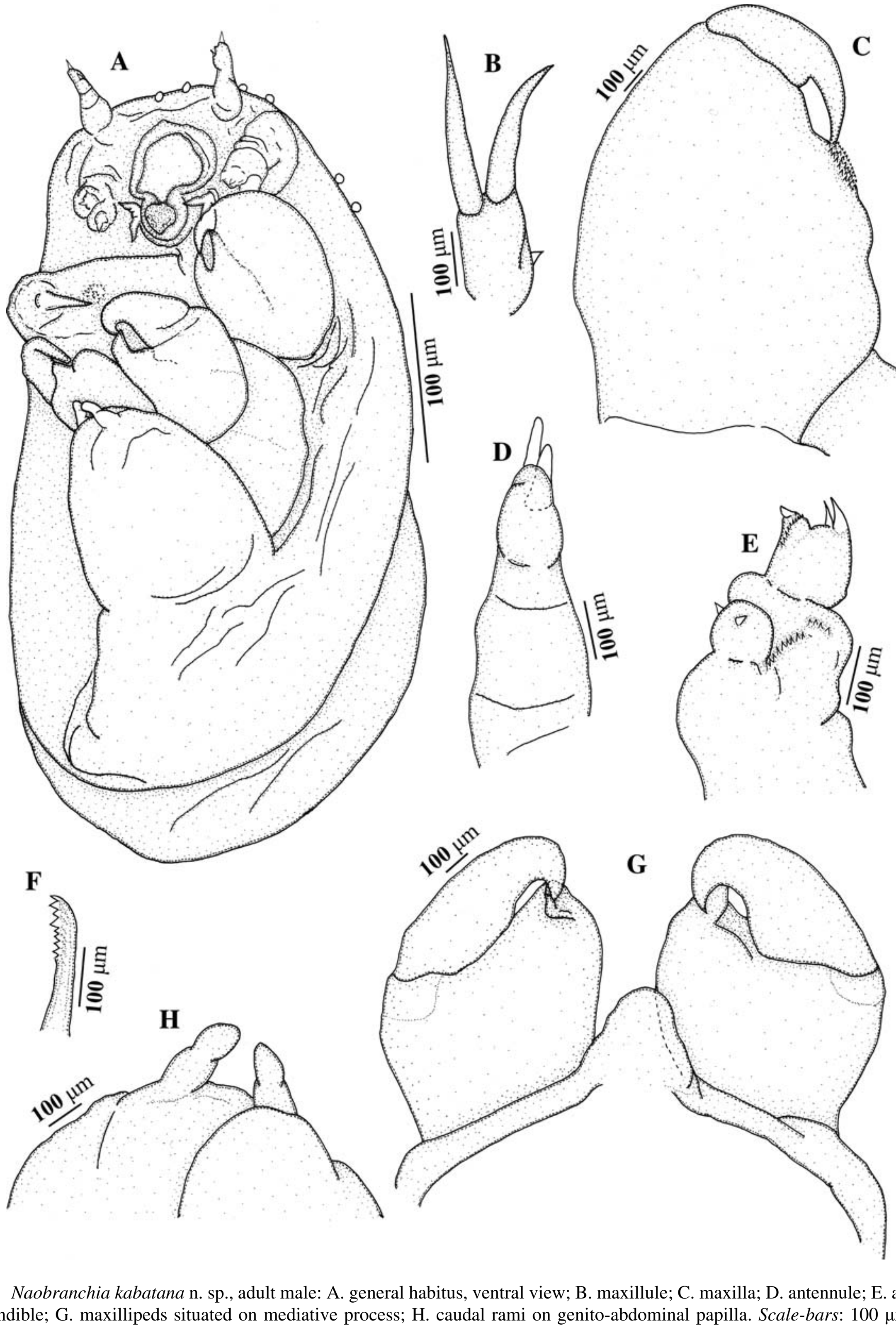

Fig. 5 *Naobranchia kabatana* n. sp., adult male: A. general habitus, ventral view; B. maxillule; C. maxilla; D. antennule; E. antenna; F. mandible; G. maxillipeds situated on mediative process; H. caudal rami on genito-abdominal papilla. *Scale-bars*: 100 µm

species is most similar to *N. wilsoni* and *Naobranchia* sp. of Lewis (1967), firstly in the membrane of the egg-sacs that covers the posterior end of the trunk and secondly in the almost equal lengths of the cephalothorax and trunk (Nigrelli, 1933; Lewis 1967). However, it differs from *N. wilsoni* in the structure of the egg-sacs, with those of *N. wilsoni* being divided into a smaller anterior and a larger posterior part by an annular muscular septum (Nigrelli, 1933), whereas no such division is visible in the current specimens. Furthermore, it differs in the number of muscle bands present in the maxillae, with those of *N. wilsoni* having only one muscle band (Nigrelli, 1933) and the current specimens three muscle bands in each maxilla. Additionally, *N. wilsoni* was collected from a host belonging to the Diodontidae (Tetraodontiformes) caught off Bermuda in the Gulf of Mexico (Nigrelli, 1933), whereas the current specimens were collected from a muraenesocid (Anguilliformes) off South Africa in the western Indian Ocean. The current material differs from *Naobranchia* sp. of Lewis, firstly in terms of body proportions, with *Naobranchia* sp. consisting of a short body with a short, broad trunk, while the current species has a more slender, elongate appearance; secondly by the position of the maxillae, which are included in the anterior part of the trunk in *Naobranchia* sp. (Lewis, 1967) but at the base of the cephalothorax in the present specimens; and thirdly by the maxillae, which lack distinct muscle bands in *Naobranchia* sp. but have three bands each in the new species. More differences are present in the structure of the appendages, but, according to Lewis (1967), his descriptions should be used with caution. *Naobranchia* sp. was collected from a muraenid host in the Honolulu Aquarium (Lewis, 1967) and is the only previous record of any species of *Naobranchia* from Anguilliformes.

This is the first report of a *Naobranchia* species from a host of the family Muraenesocidae and the second report from South African waters. The first report was of *N. pritchardae* from *Pomadasys commersonni* (Lacépède) caught off Durban (Kensley & Grindley, 1973). Other *Naobranchia* species have been reported from 19 different families of hosts, representing 11 different orders (excluding *N. wilsoni* and *Naobranchia* sp.). Therefore, members of *Naobranchia* appear to be cosmopolitan parasites of Osteichthyes.

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