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Taxonomy and geographical distribution of freshwater Cyclopidae (Crustacea:Copepoda) of the Sudan.

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Abstract

In this study, twenty genera and species of Cyclopoid Copepods from Sudan were identified; the specimens were collected from different areas: fromKhartoum State, Central, Northern, Western and Eastern Sudan. The specimens were collected from The River Nile, White Nile, Rain pools, water jars and from irrigation Canals. The genera and species foundwere: Mesocyclopsaspercornis, M. major, M. isabellae, M. ogunnus, Mesocyclops sp. (new species), Thermocyclops sp. (new species), T. decipiens, T. rylovi, Microcyclopsdavidi, M. pachyspina, M.rubelloides, Eucyclopsroseus, Eu. ohtakai, Cryptocyclopslinjanticu, Cryptocyclops sp1, Cryptocyclopssp 2, Afrocyclopsgibsoni, Trpocyclopsconfinis,Metacyclops sp. 1 (minutus-group) andMetacyclops sp. 2 (minutus-group). The morphological identification was done in the Museum & Institute of Zoology, Polish Academy of Science, Warsaw- Poland, during the period October 2012- March 2013.

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Keywords: Copepoda, Cyclopidae, Taxonomy, Morphology, Sudan.

Introduction

Cyclopoids are the most abundant and successful Copepoda in freshwater and they inhabit all kinds of fresh¬water environments such as rivers, streams, pools, lakes, reservoirs, wetlands and temporary pools. The Cyclopoida group commonly represents the main component of the zooplanktonic biomass in tropical water bodies (Rocha, et al., 1995; Santos-Wisniewski and Rocha, 2007).

Sudanese waters are rich in Cyclopoid Copepods. But work on these organisms or Crustacea in general is very scanty.AbuGideiri (1969) working on the development and distribution of planktons in the northern part of the White Nile reported 14 species of planktonic crustaceans among which were ThermocyclopsneglectusSars and Mesocyclopsleuckarti Claus. The same species were reported by Abu Gideiri and Yousif (1974) in their work concerning the influence of Eichhorniacrassipes on planktonic development in the White Nile. Abu Gideiri and Ali (1975) making a preliminary biological survey of Lake

Nubia again mentioned the presence of these two species.

More recently, Van de Velde (1984) revised the African species of the genus MesocyclopsSars and mentioned that Dumont et. al. (1981) found M. aspericornis at Khartoum and Kaboushia in the North. The same author reported the presence of Mesocyclopsmajor at Kaboushia and Roseiris (South-east), he also found Mesocyclopsogunnus at Roseiris and Atbara (in the North). Gautier(1981) reported the same species from Khartoum and El-Gaily northwards. However, Monod (1981) recorded the same species from El-Fasher at the far West of Sudan. Apparently these findings were just communicated to the author Van de Velde.

Materials and Methods

Research Objective

The aim of this research is to determine the genera and species of Cyclopoid Copepods of the Sudan.

Collection Sites

In this survey, Cyclopoid Copepods have been collected from nine different localities: River Nile State, Kassala State, North Kordofan State, Dinder National Park, Gezira State, White Nile state, Khartoum State, Northern State and Gadarif State, during the period October, 2012-July, 2013 (Plate1).

Samples were collected from different areas, from large water bodies created by Nile flood during the rainy season (Plate 2), from irrigation canals (Plate 3); samples were also collected from water jars "Zeers" in different regions of Khartoum (Plate 4) and from pools (Plate 5).

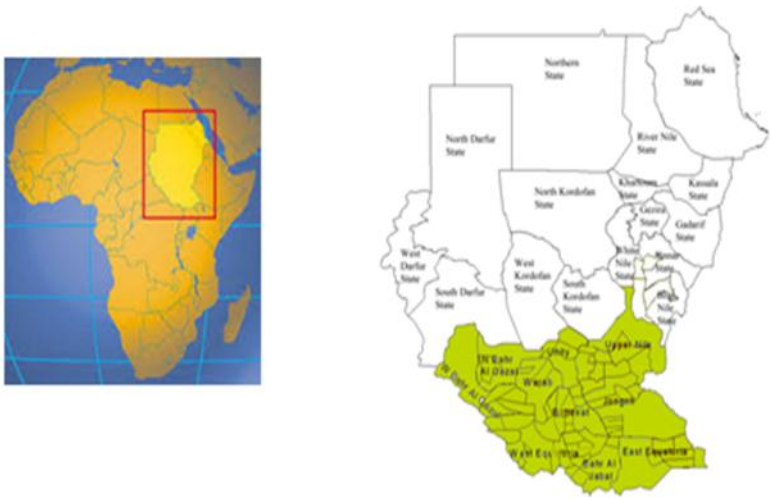

Plate (1): Map showing the location of Sudan in Africa, and the Sudan States. Green color is the States of Southern Sudan.

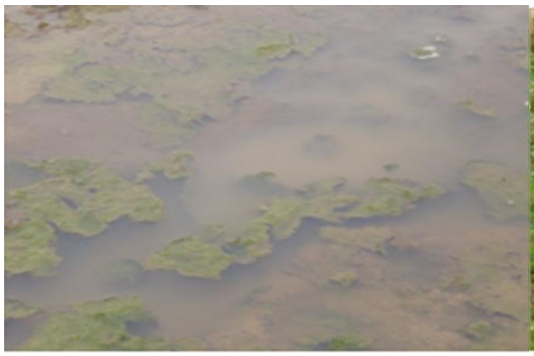

Plate (2): Rain water

Plate (3) Irrigation canal

Plate (4): Water Jars (zeers)

Plate (5): A small isolated pool

Morphological identification Methodology:
Only female specimens were selected for identification.Each specimen was mounted on two slides: the first containing A1- P4, the second P5- abdomen.Slides prepared were drawn by drawing tube, attached to an Olympus BX 50 compound microscope, on white papers and ultimately traced on tracing paper.The dissection, identification and the drawings were done at the laboratory of The Museum and Institute of Zoology, Polish Academy of Science, Warsaw-Poland.The identification was done mainly by using "The Guides of the Identification of the Microinvertebrates of the Continental waters of the World" (Hoły´nskaet al, 2003), beside other publications.

Results

Species recorded in Sudan were- Mesocyclopsaspericornis,Daday, 1906 (Fig. 1), M. major,Sars, 1927(Fig. 2), M. isabellae,Dussart& Fernando, 1988 (Fig. 3), Mesocyclops. sp (new) (Fig. 4 & 5) and M. ogunnusOnabamiro, 1957(Fig. 6).

- Thermocyclopssp(new) (Fig. 7 & 8), T. ryloviSmirnov, 1928(Fig. 9)and T. decipiensKiefer, 1929 (Fig. 10).

- MicrocyclopsdavidiKiefer, 1952(Fig. 11), M. pachyspinaLindberg, 1937(Fig. 12) and M. rubelloidesKiefer, 1952(Fig. 13).
- EucyclopsroseusIshida, 1997 (Fig. 14 & 15)andEu. ohtakaiIshida, 2000(Fig. 16).

- AfrocyclopsgibsoniBrady, 1904(Fig. 17 & 18).

- TropocyclopsconfinisKiefer, 1930(Fig. 19).

- CryptocyclopslinjanticusKiefer, 1928(Fig. 20), Cryptocyclops. sp 2 (new)(Fig. 21) andCryptocyclops. sp 1 (new)(Fig. 22).

- Metacyclops sp. 1 (minutus-group)(Fig. 23) andMetacyclops sp. 2 (minutus-group)(Fig. 24).
The distribution of the genera and species of Cyclopoid Copepods in Sudan was shown in (Fig. 25).

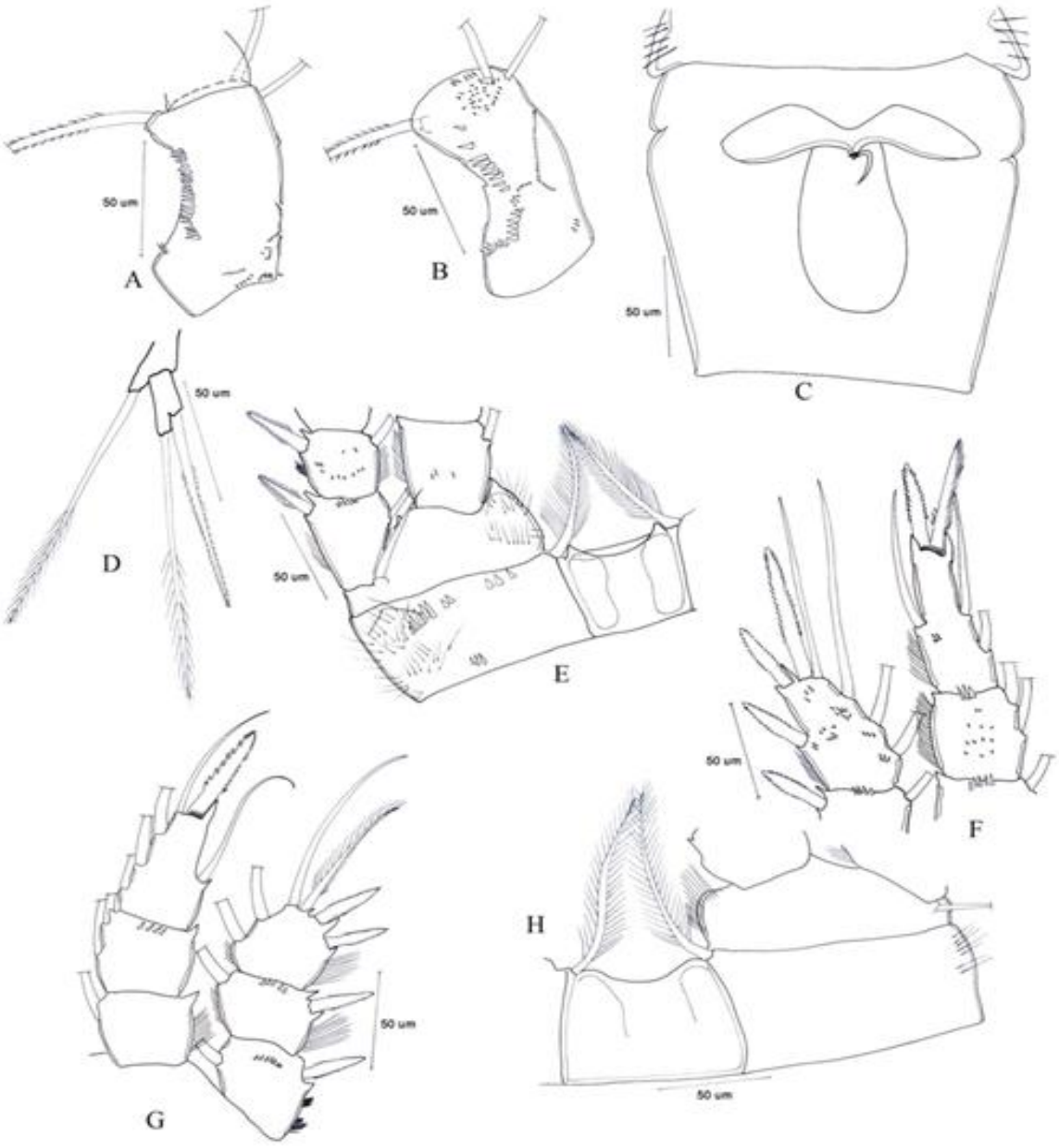

Fig (1): *Mesocyclops aspericornis* (Daday, 1906). **Female**; **A**. anntenary basipodite, frontal, **B**. antennary basipodite, caudal; **C**. pediger 5 and genital double-somite, ventral; **D**. P5; **E**. P4 coupler, protopodite, enp1, and exp1 & 2; **F**. P4 exp3, enp2 & 3; caudal; **G**. P1 rami, frontal; **H**. P1coupler and protopodite, frontal.

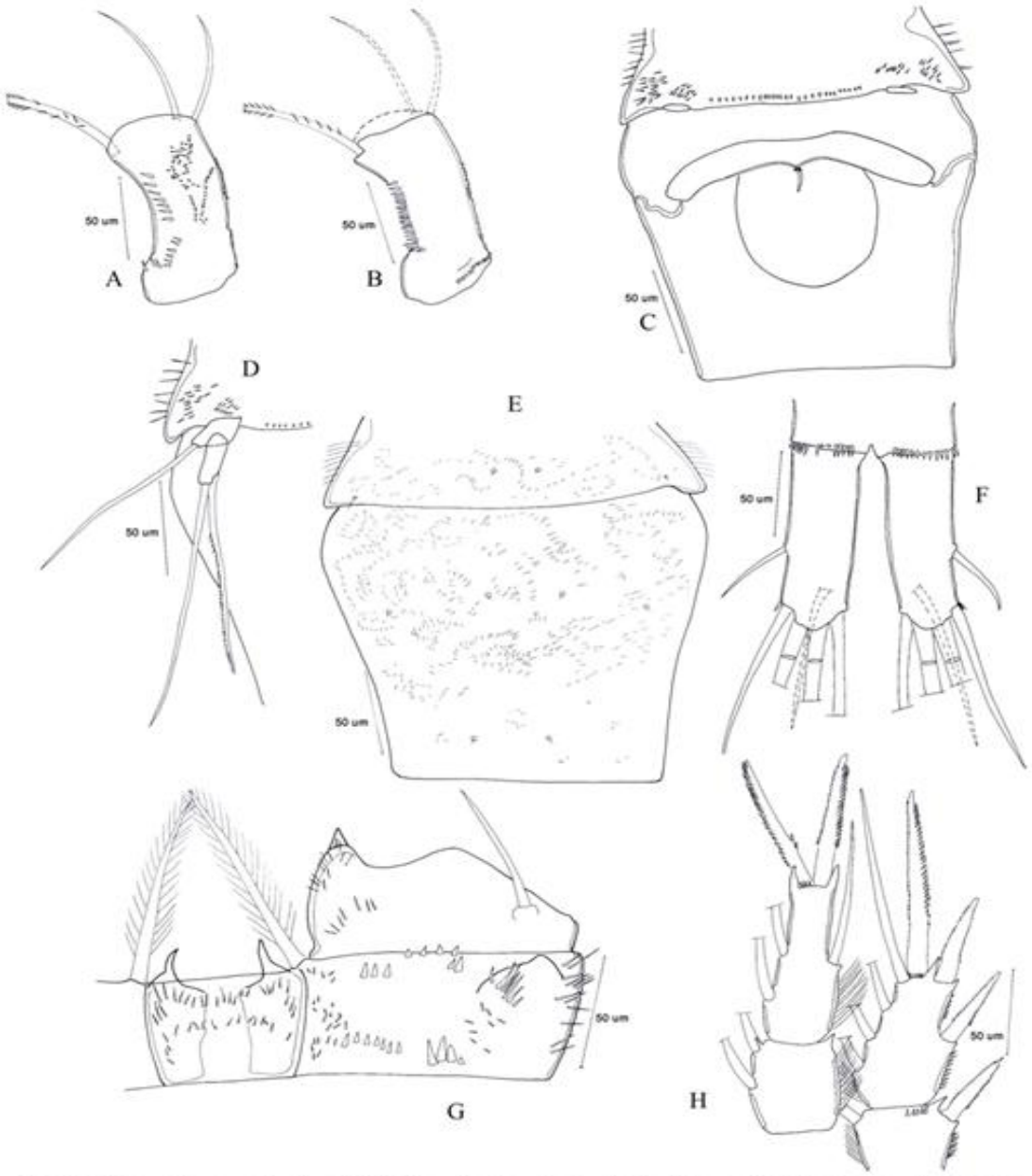

Fig (2). *Mesocyclops major* Sars, 1927. **Female; A.** antennary basipodite, caudal; **B.** antennary basipodite. frontal; **C.** pediger 5 and genital double-somite, ventral; **D.** P5; **E.** pediger 5 and genital double-somite, dorsal; **F.** caudal rami, ventral; **G.** P4 coupler and protopodite, caudal; **H.** P4 rami without enp1 and exp1, caudal.

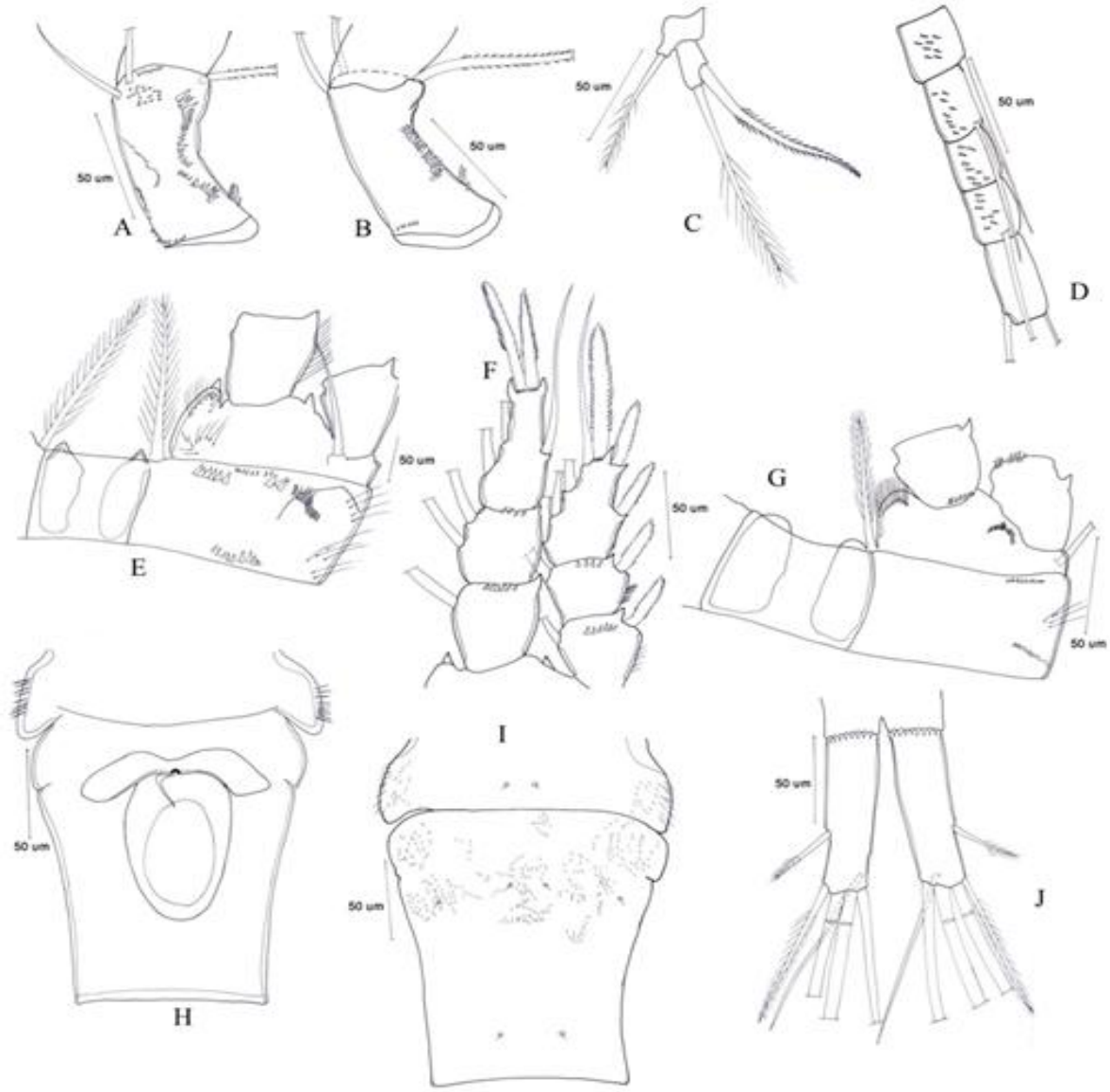

Fig (3). *Mesocyclops isabellae*, Dussart & Fernando, 1988. **Female, A**. antennary basipodite, caudal; **B.** antennary basipodite, frontal; **C.** P5. **D.** antennule, segments 11- 14; **E.** P4 coupler and protopodite, caudal; **F.** P4 rami, caudal; **G.** P1 coupler, protopodie, enp1 and exp1, frontal ; **H.** Pediger 5 and genital double-somite, ventral; **I.** Pediger 5 and genital double-somite, dorsal; **J.** caudal rami, ventral.

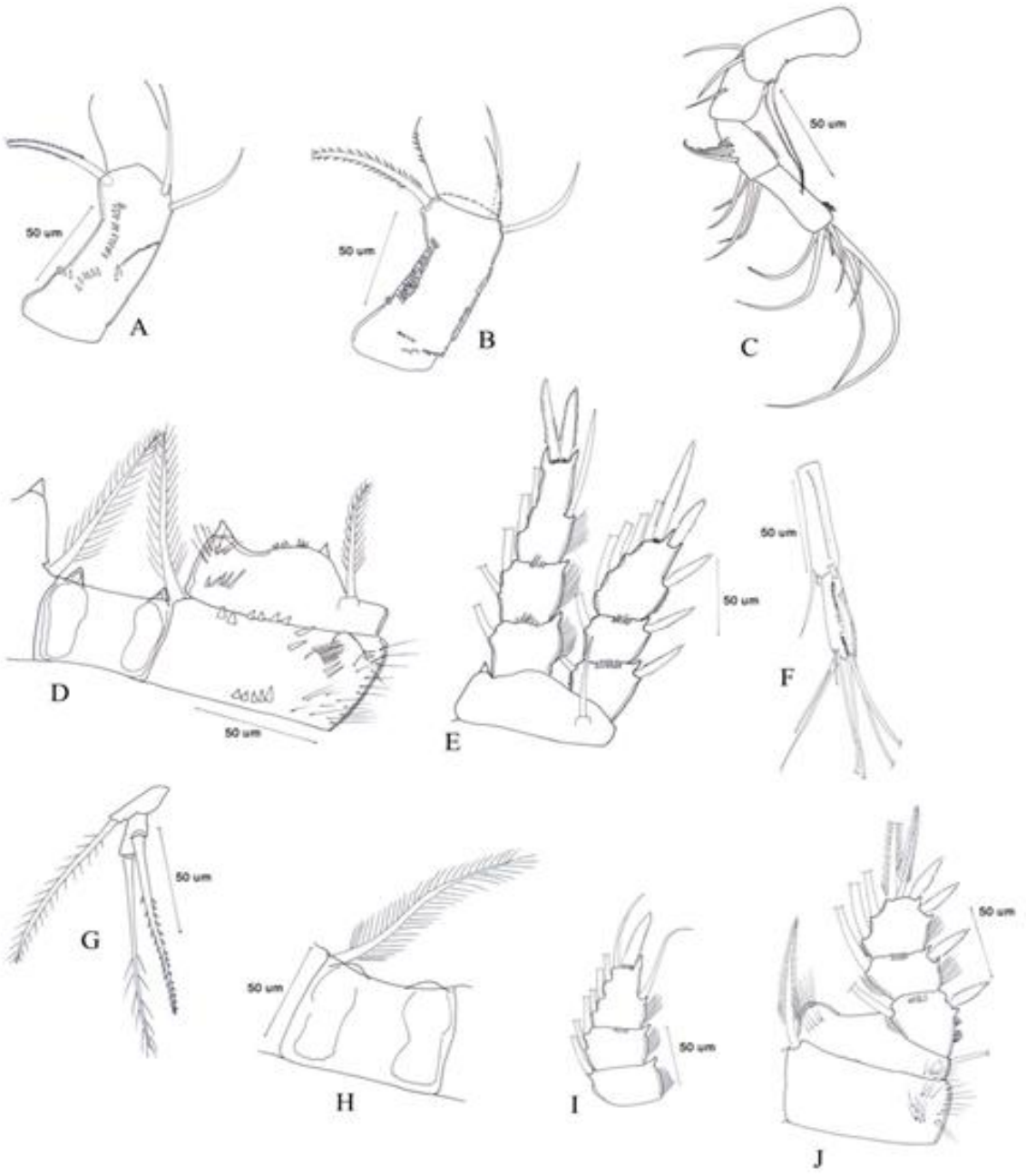

Fig (4): *Mesocyclops sp. (new).* **Female, A.** antennary basipodite, caudal; **B.** antennary basipodite, frontal; **C.** antenna; **D.** P4 coupler and protopodite, caudal; **E.** P4 basipodite and rami, caudal; **F.** antennule, last two segments; **G.** P5; **H.** P1 coupler, frontal; **I.** P1 endopodite, frontal; **J.** P1 protopodite and exopodite, frontal.

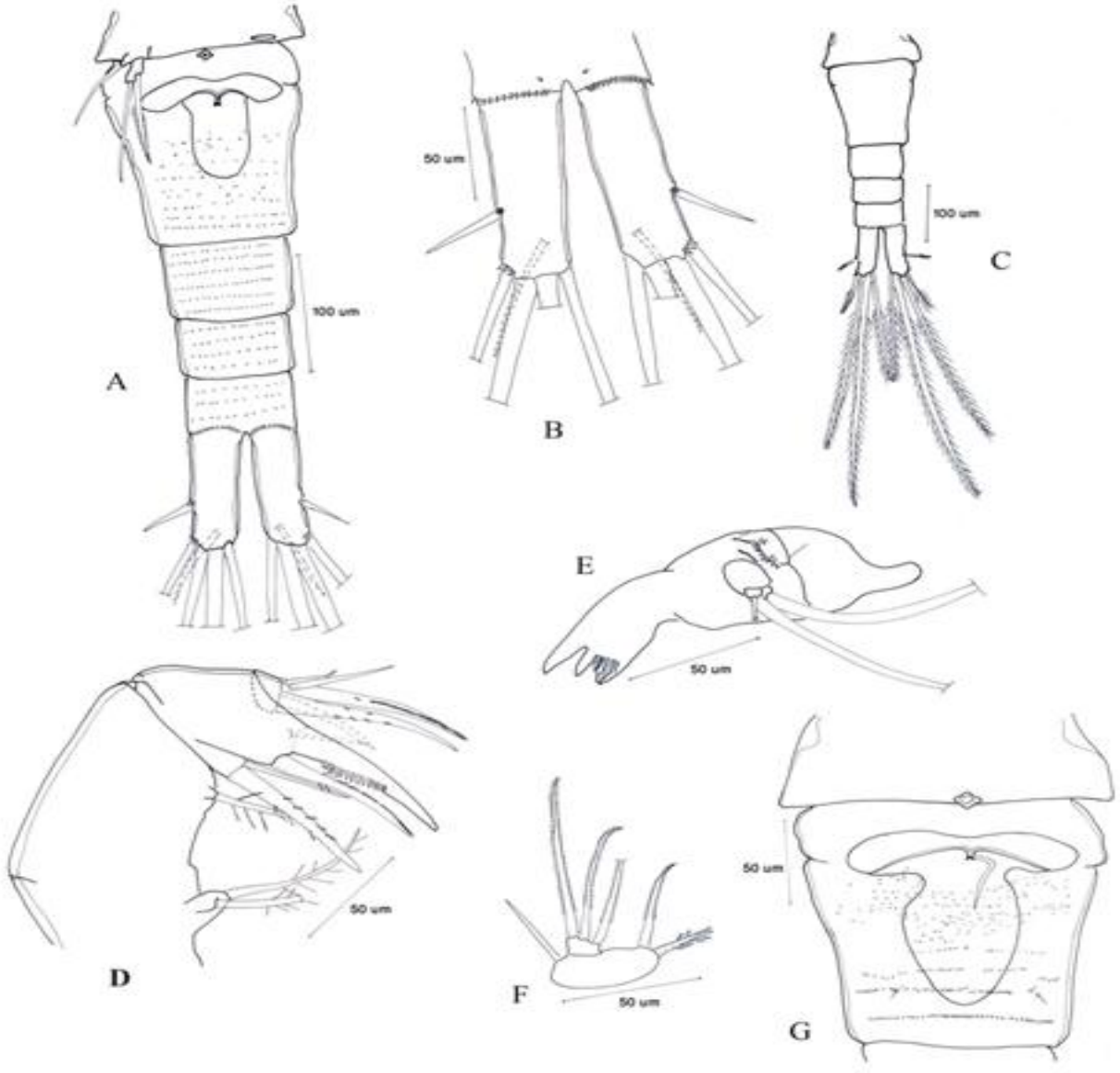

Fig (5): *Mesocyclops sp. (new)*. **Female, A.** urosome, ventral; **B.** caudal rami, ventral; **C.** urosome with lateral setae, ventral; **D.** maxilla; **E.** mandible; **F.** maxillulary palp; **G.** pediger 5 and genital double-somite, ventral.

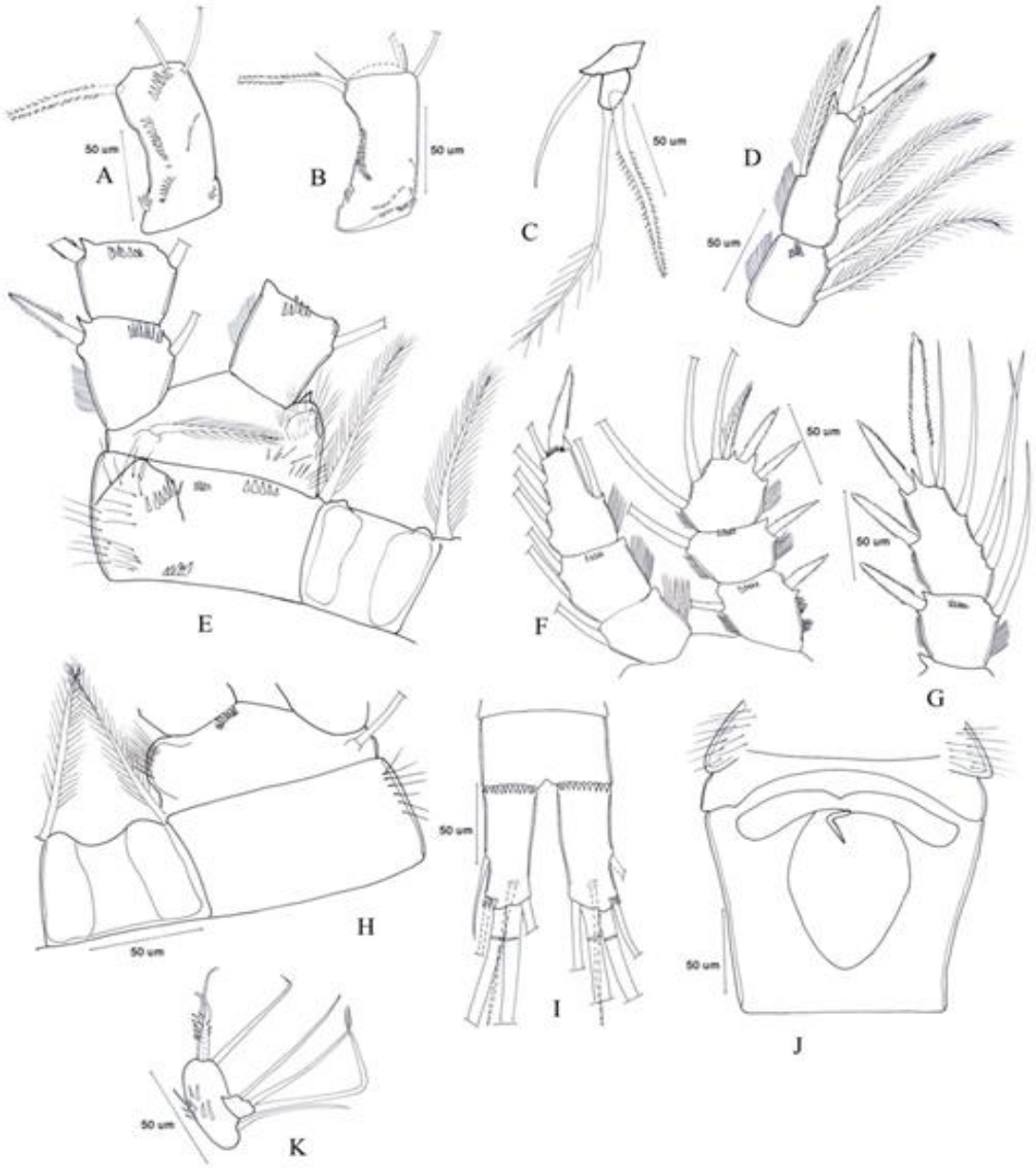

Fig (6): *Mesocyclops ogunnus* Onabamiro, 1957. **Female, A.** antennary basipodite, caudal; **B.** antennary basipodite, frontal; **C.** P5; **D.** P4 enp2 and enp3, caudal; **E.** P4 coupler, protopodite, enp1, exp2 &3, caudal; **F.** P1 rami, frontal; **G.** P4 exp2 &3, caudal; **H.** P1 coupler and protopodite, frontal; **I.** caudal rami, ventral; **J.** pediger 5 and genital double-somite, ventral; **K.** maxillulary palp.

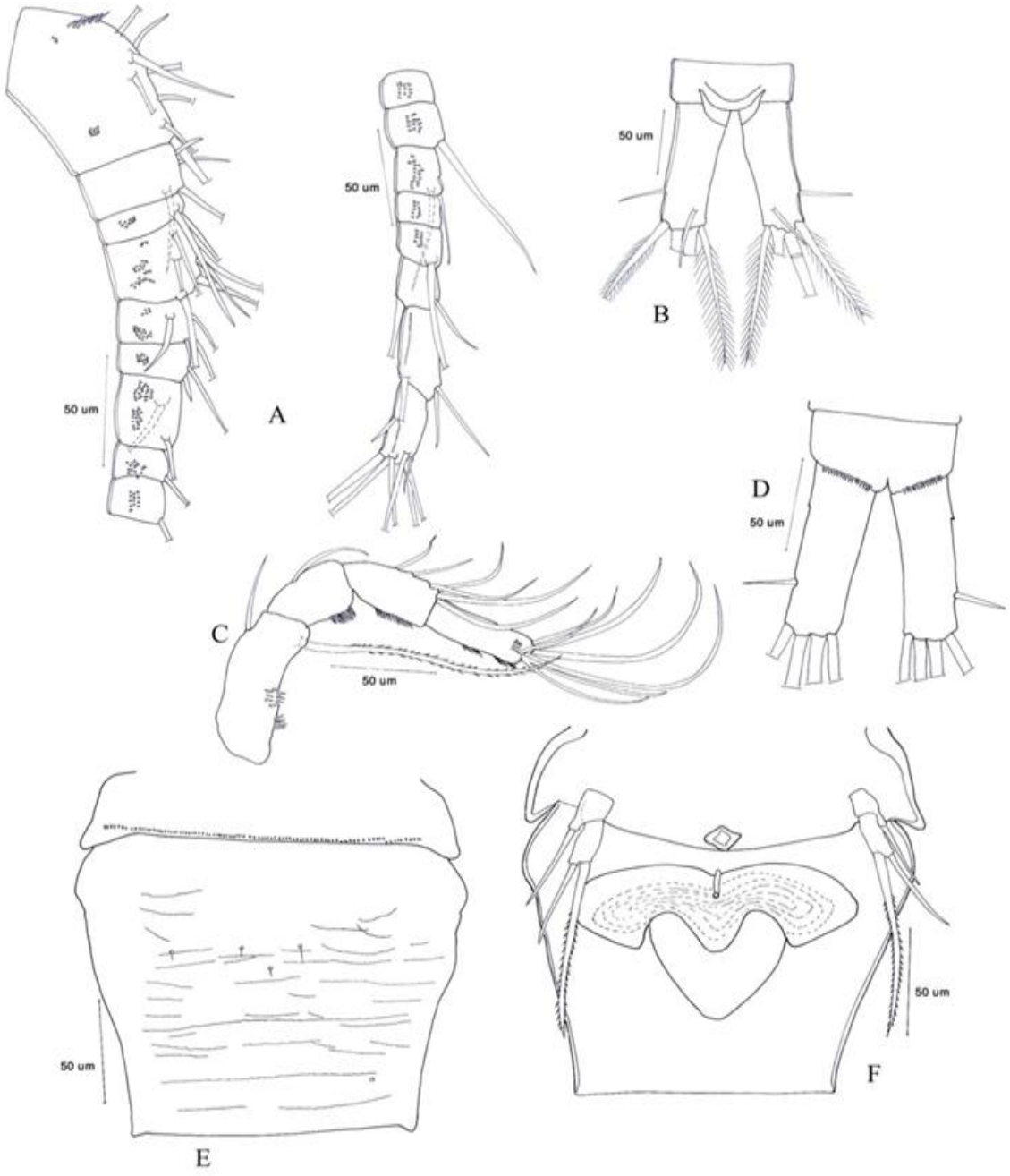

Fig (7): *Thermocyclops sp. (new)*, **Female, A.** antennule ; **B.** caudal rami, dorsal; **C.** antenna; **D.** caudal rami, ventral; **E.** pediger 5 and genital double-somite, dorsal; **F.** P5**,** pediger 5 and genital double-somite, ventral.

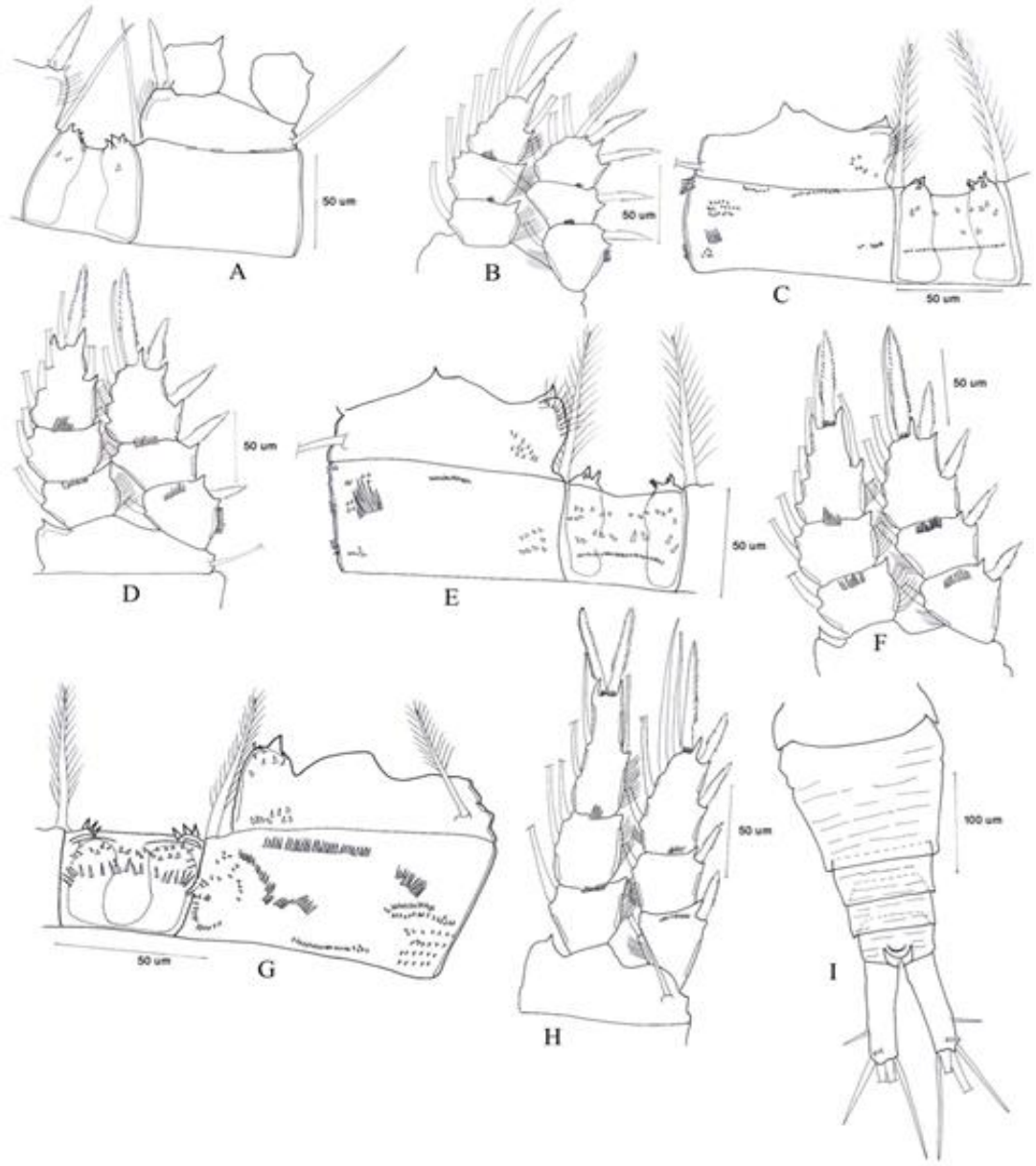

Fig (8): *Thermocyclops sp. (new).* **Female, A.** P1 protopodite, enp1 and exp1, frontal; **B.** P1 rami, frontal; **C.** P2 coupler and protopodite, caudal; **D.** P2 rami and basipodite, caudal; **E.** P3 coupler and protopodite, caudal; **F.** P3 rami, caudal; **G.** P4 coupler and protopodite, caudal; **H.** P4 rami and basipodite, caudal; **I.** urosome, dorsal.

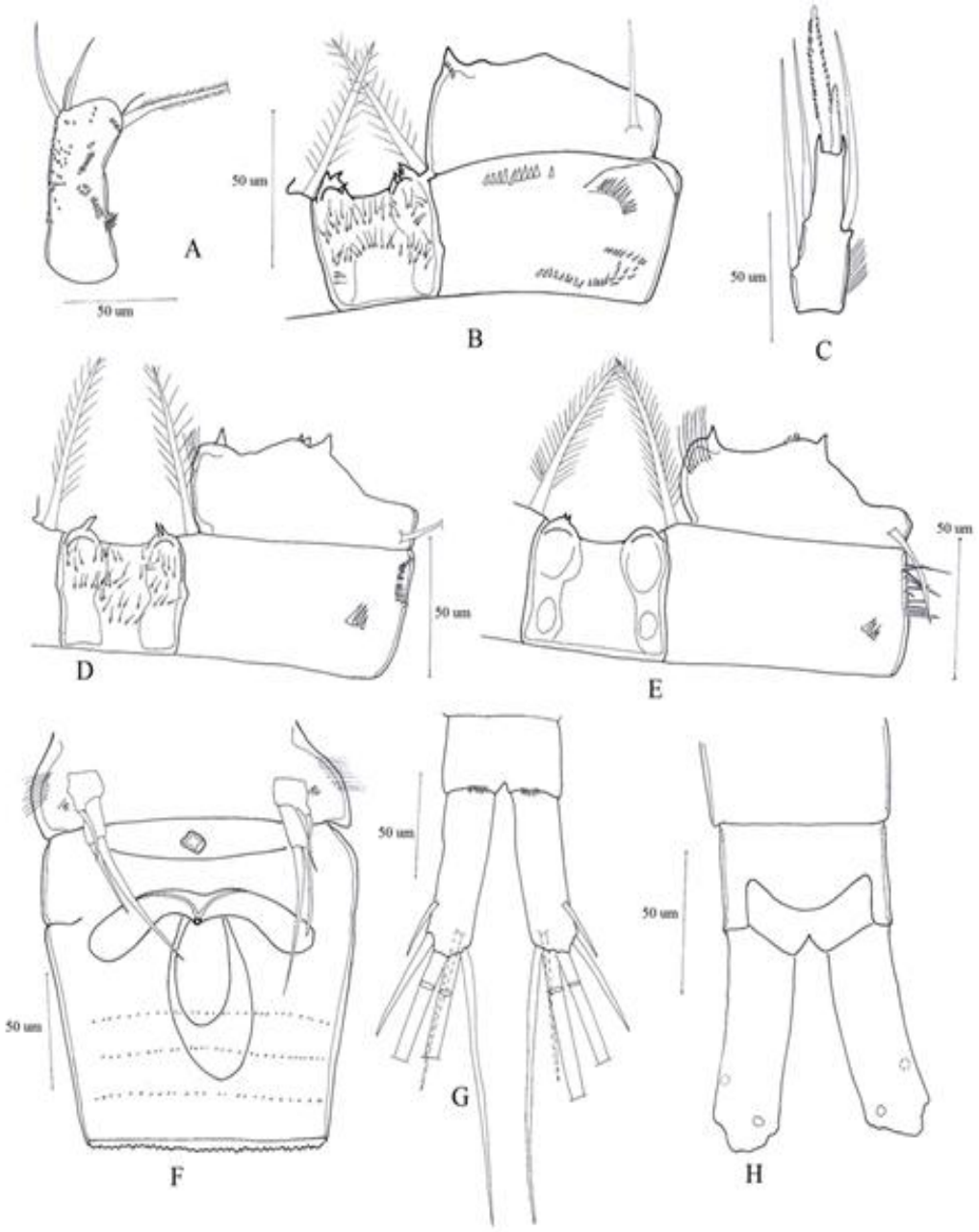

Fig (9): *Thermocyclops rylovi* Smirnov, 1928. **Female. A.** antennary basipodite, caudal; **B.** P4 coupler and protopodite, caudal; **C.** P4 enp3, caudal; **D.** P3 coupler and protopodite, caudal; **E.** P2 coupler and protopodite, caudal; **F.** Pediger 5, P5 and genital double-somite; ventral; **G.** anal somite and caudal rami, ventral; **H.** anal somite and caudal rami, dorsal.

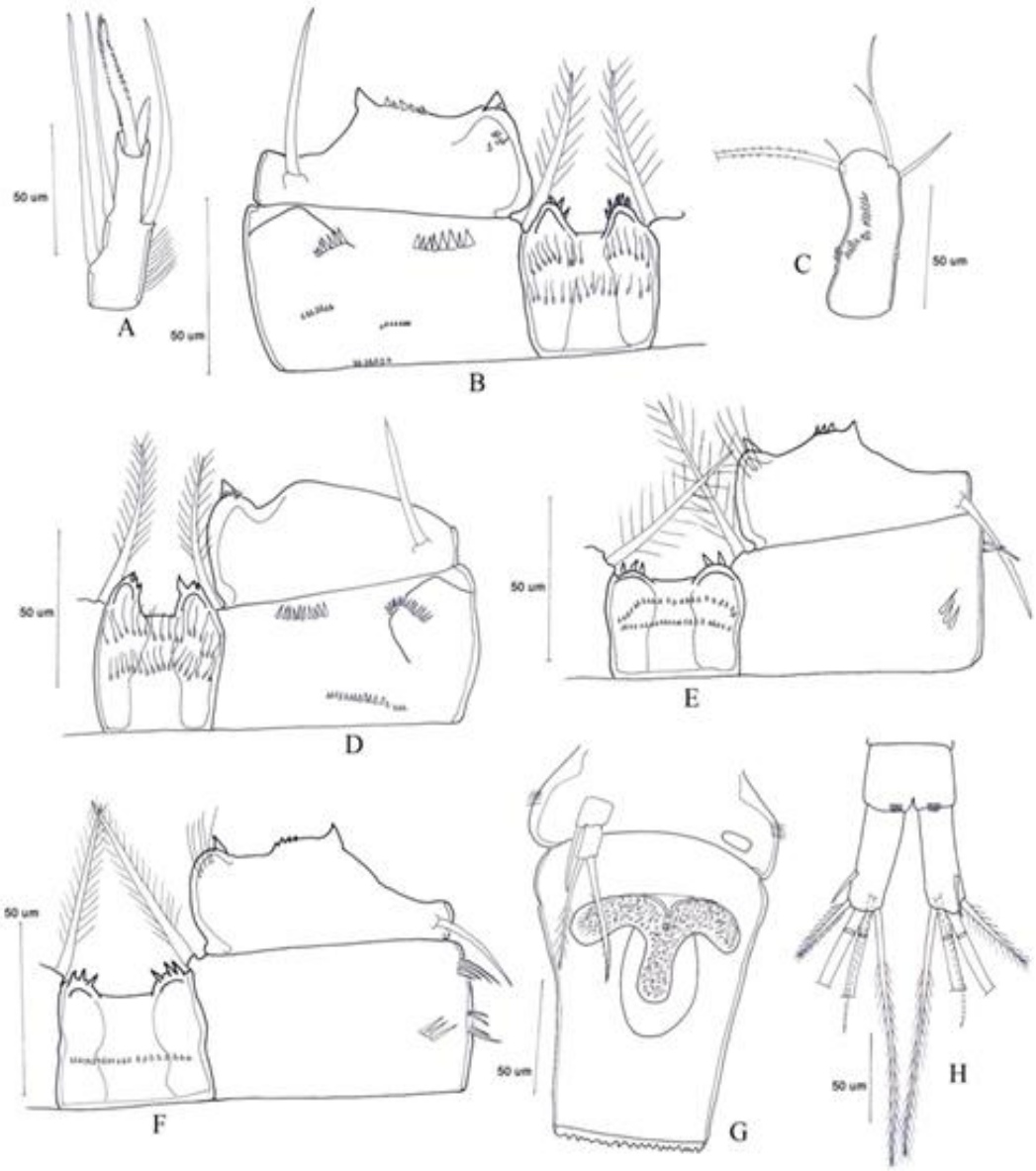

Fig (10): *Thermocyclops decipiens* Kiefer, 1929. **Female, A.** P4 enp3; **B.** P4 coupler and protopodite, caudal; **C.** antennary basipodite, caudal; **D.** P4 coupler and protopodite, caudal (from other speciemen); **E.** P3 coupler and protopodite, caudal; **F.** P2 coupler and protopodite, caudal; **G.** P5, pediger 5 and genital double-somite, ventral; **H.** anal somite and caudal rami, ventral.

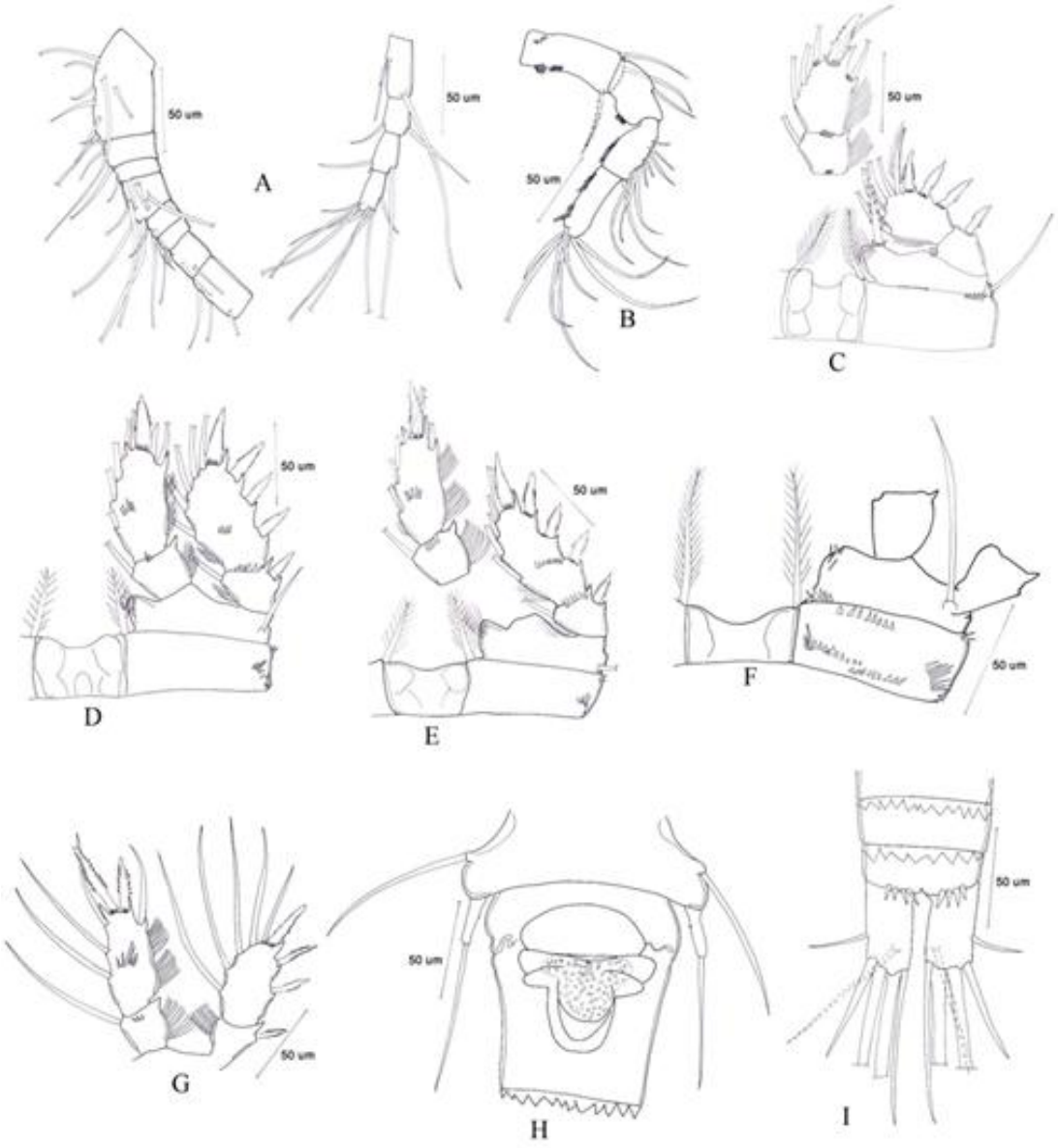

Fig (11): *Microcyclops davidi*, Kiefer, 1952. **Female. A.** antennule; **B.** antenna; **C.** P1, frontal; **D.** P2, caudal; **E.** P3, caudal;**F.** P4 coupler, protopodite, enp1 and exp1, caudal; **G.** P4 rami, caudal; **H.** P5, pediger 5 and genital double-somite, ventral; **I.** caudal rami, ventral.

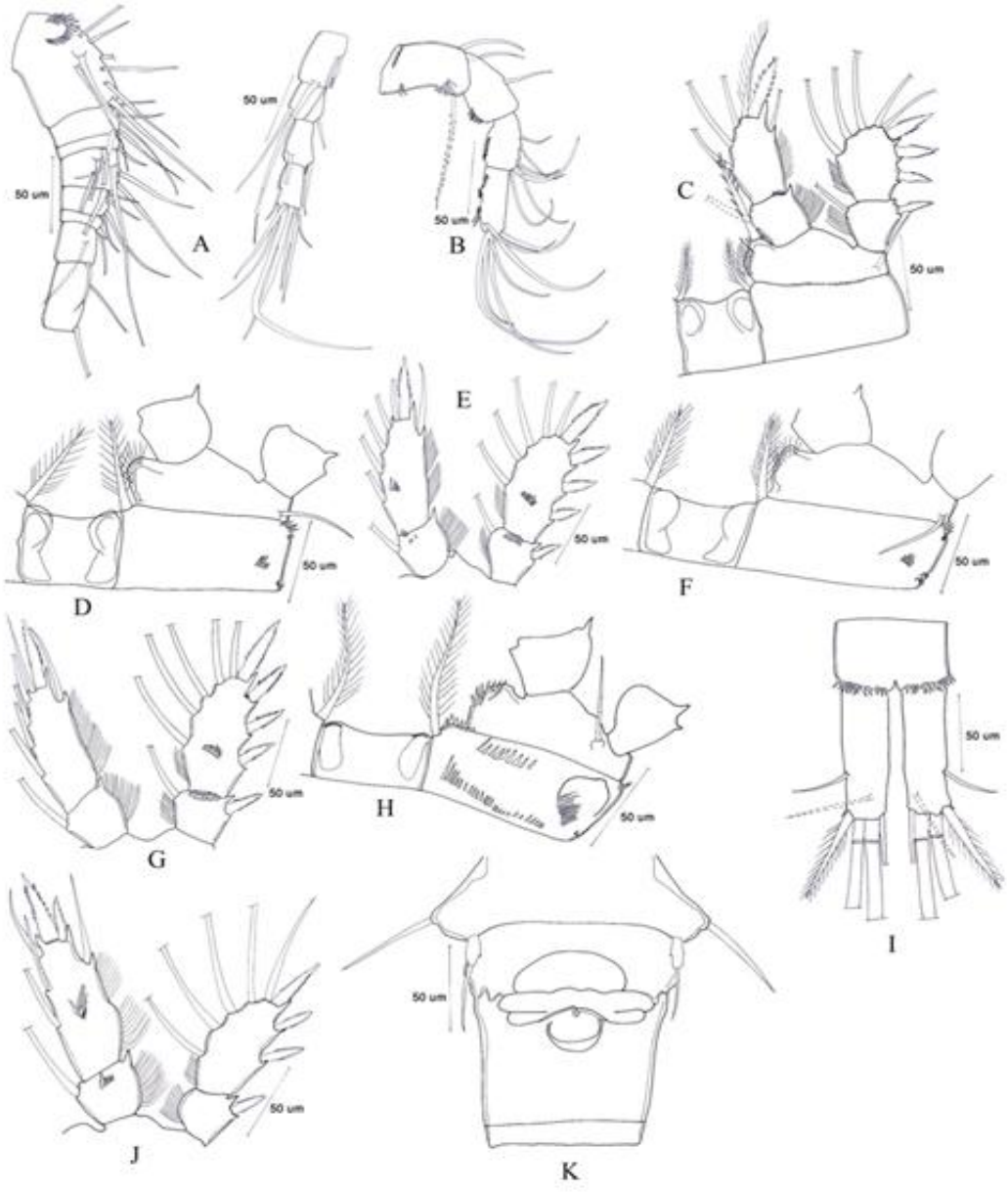

Fig (12): *Microcyclops pachyspina*, Lindberg, 1937. **A.** antennule, **B.** antenna; **C.** P1, frontal; **D.** P2 coupler, protopodite, enp1 and exp1, caudal; **E.** P2 rami, caudal; **F.** P3 coupler and protopodite, caudal; **G.** P4 rami, caudal; **H.** P4 coupler, protopodite , enp1 and exp1, caudal; **I.** anal somite and caudal rami, ventral; **J.** P4 rami, caudal; **K.** P5, pediger 5 and genital double-somite, ventral.

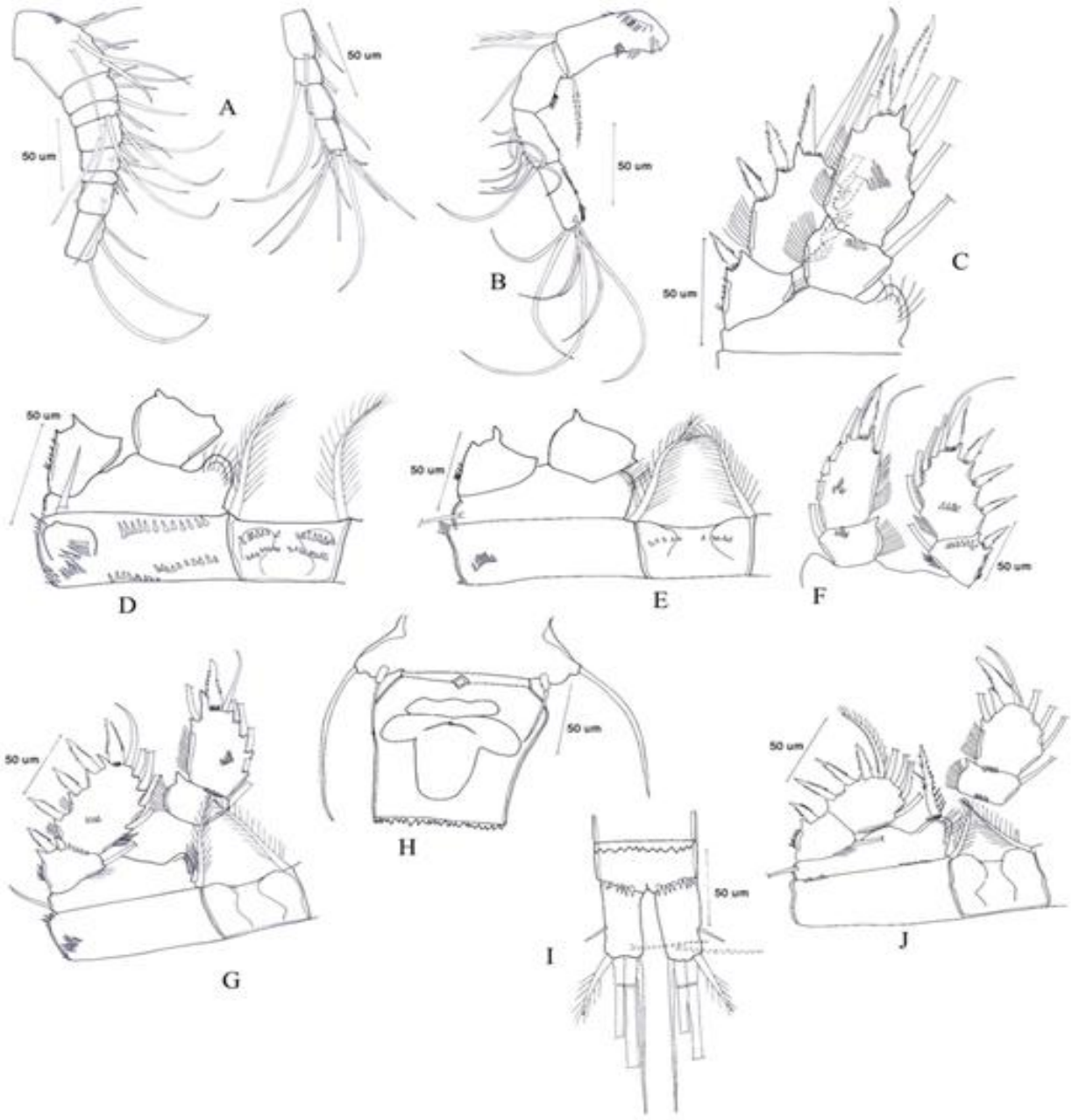

Fig (13): *Microcyclops rubelloides,* Kiefer, 1952. **Female. A.** antennule; **B.** antenna; **C.** P4 basipodite and rami, caudal; **D.** P4 coupler, protopodite, enp1 and exp1, caudal; **E.** P3 coupler, protopodite, enp1 and exp1, caudal; **F.** P3 rami, caudal; **G.** P2, caudal; **H.** P5, pediger 5 and genital double-somite, ventral; **I.** anal somite and caudal rami, ventral; **J.** P1, frontal.

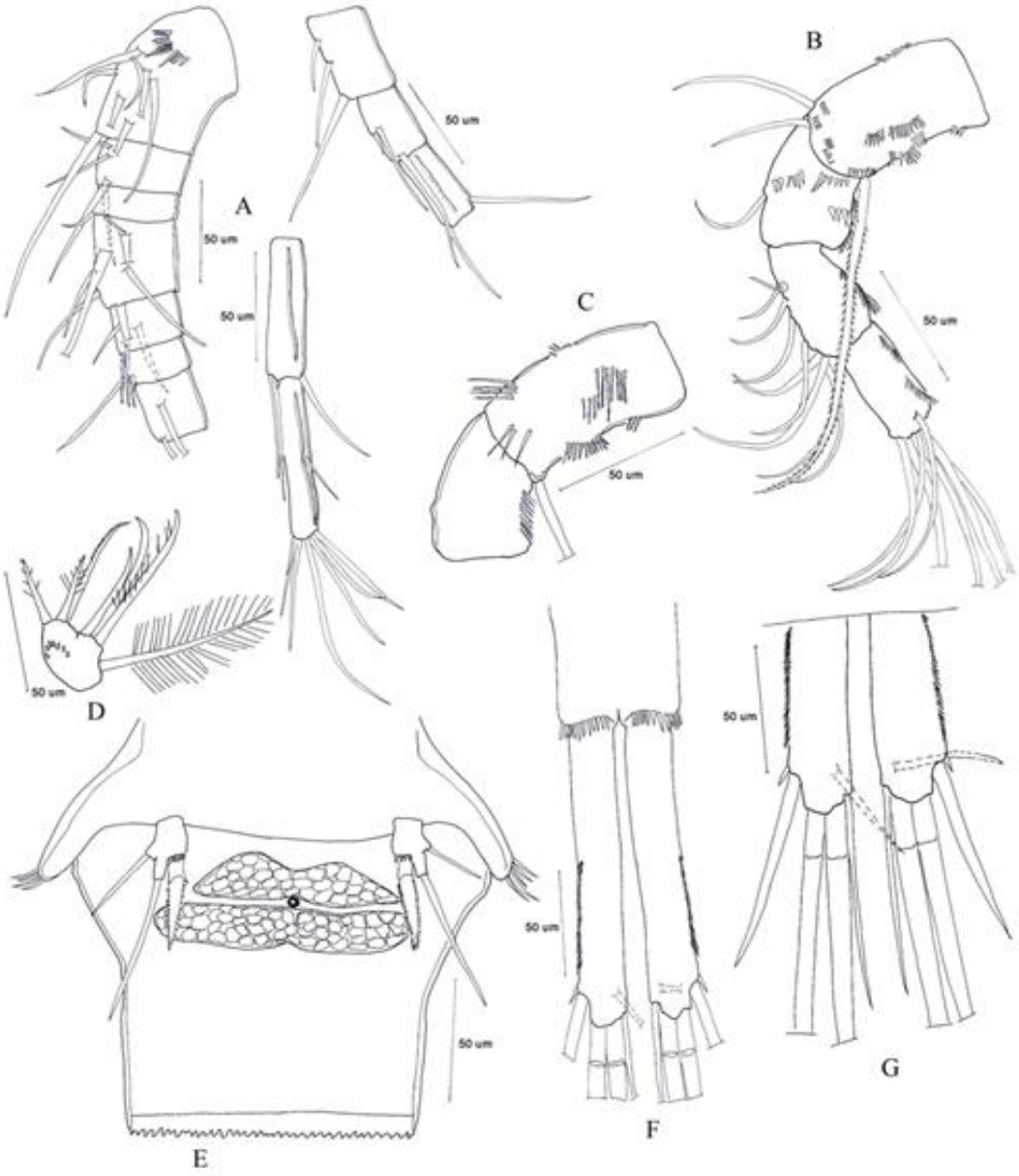

Fig (14): *Eucyclops roseus,* Ishida, 1997. **Female. A.** antennule; **B.** antenna, caudal; **C.** antenna, frontal; **D.** maxilullary palp; **E.** P5, pediger 5 and genital double -somite, ventral; **F.** caudal rami, ventral; **G.** caudal rami with caudal setae.

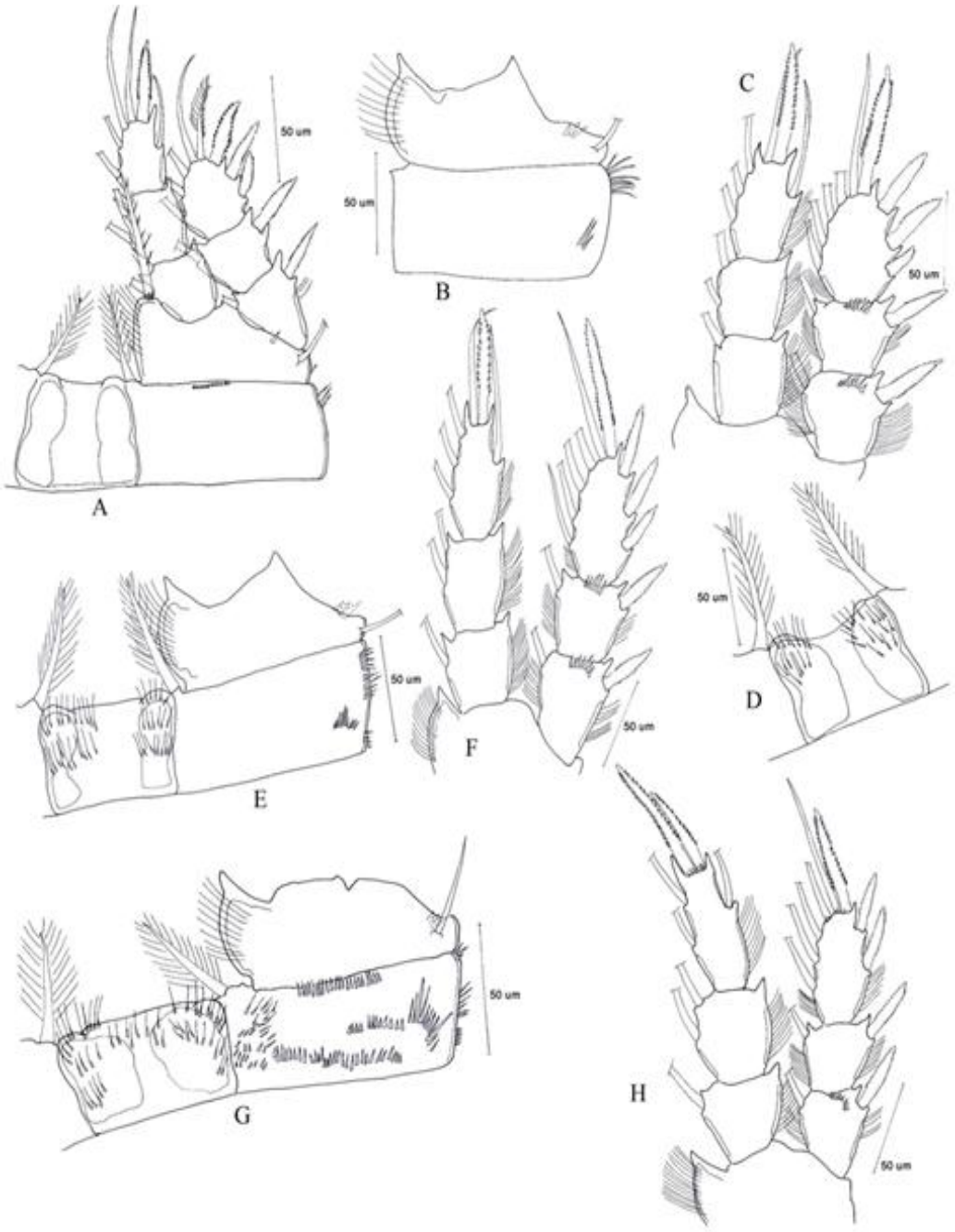

Fig (15): *Eucyclops roseus,* Ishida, 1997. **Female. A.** P1, frontal; **B.** P2 protopodite, caudal; **C.** P2 rami, caudal; **D.** P2 coupler, caudal; **E.** P3 coupler and protopodite, caual; **F.** P3 rami, caudal; **G.** P4 coupler and protopodite, caudal; **H.** P4 rami, caudal.

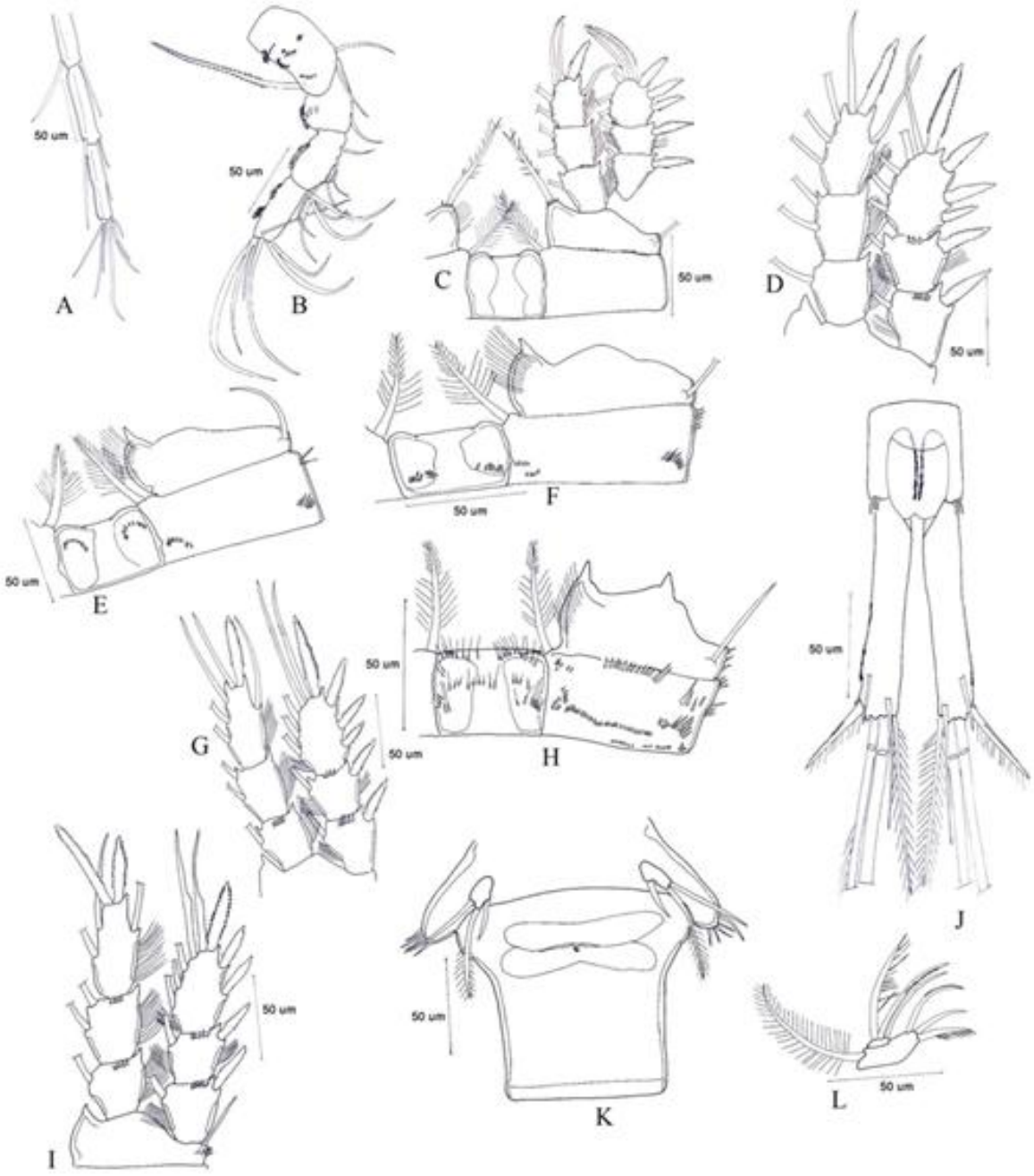

Fig (16): *Eucyclops ohtakai*, Ishida, 2000. **Female. A.** antennule, last two segments; **B.** antenna; **C.** P1, frontal; **D.** P2 rami, caudal; **E.** P2 coupler and protopodite, caudal; **F.** P3 coupler and protopodite, caudal; **G.** P3 rami, caudal; **H.** P4 coupler and protopodite, caudal; **I.** P4 basipodite and rami, caudal; **J.** anal somite and caudal rami, dorsal; **K.** P5, pediger 5 and genital double-somite, ventral; **L.** maxilullary palp.

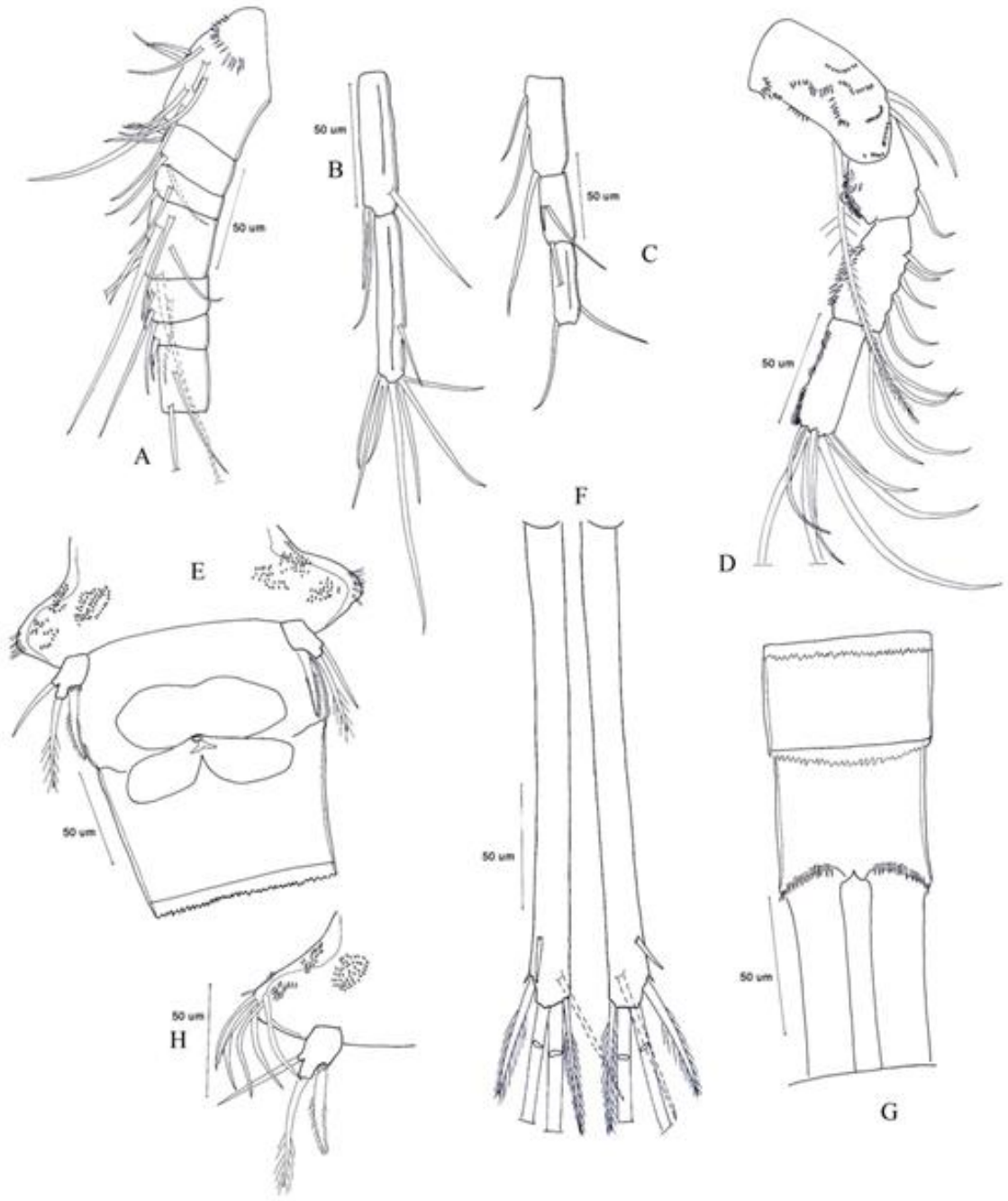

Fig (17): *Afrocyclops gibsoni,* Brady, 1904. **Female, A- C.** antennule; **D.** antenna; **E.** P5, pediger 5 and genital double-somite, ventral; **F.** caudal rami, ventral; **G.** urosomite 3 and anal somite, ventral; **H.** P5.

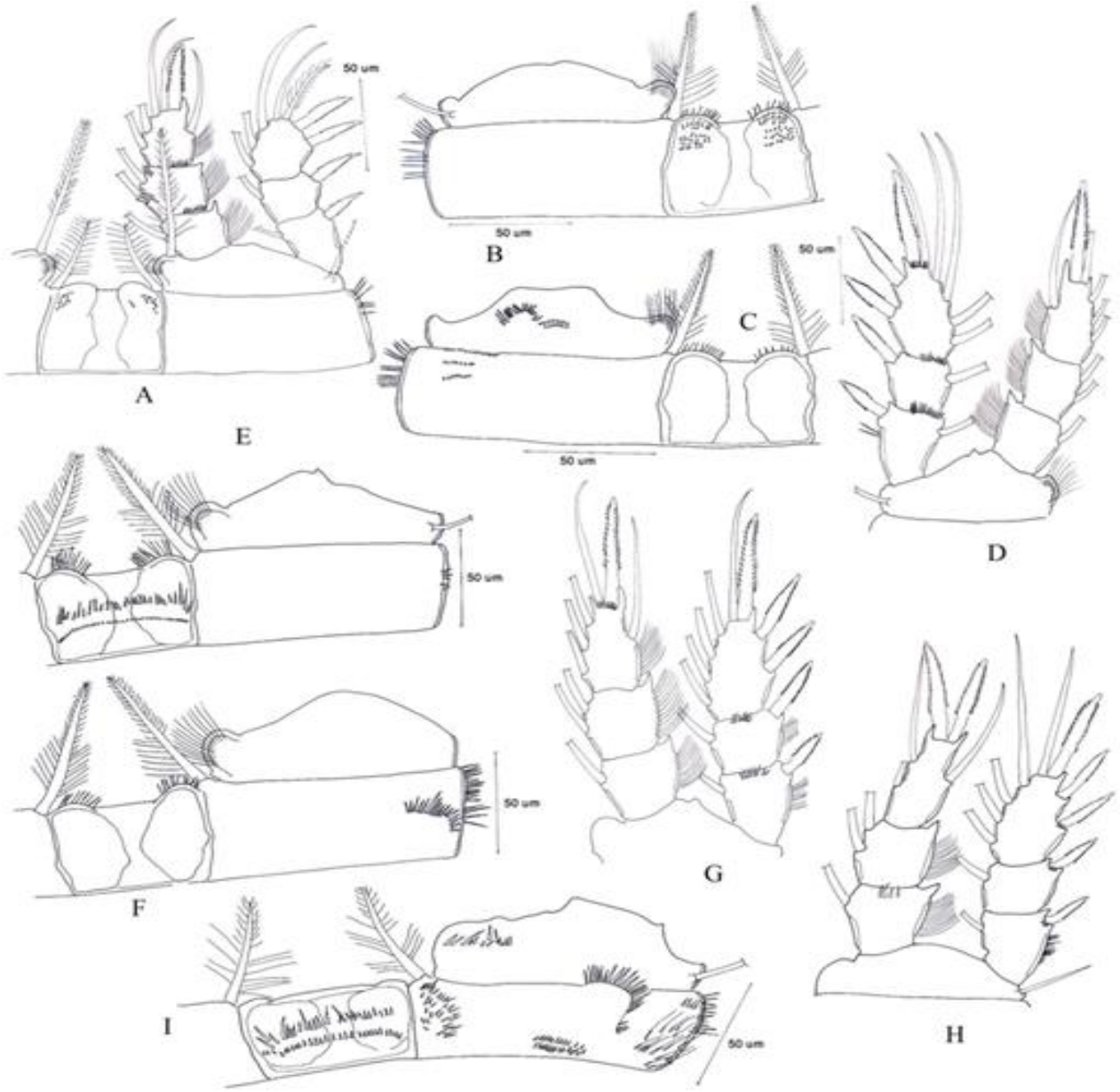

Fig (18): *Afrocyclops gibsoni*, Brady, 1904. **Female, A.** P1, frontal, **B.** P2 coupler and protopodite, caudal; **C.** P2 coupler and protopodite, frontal; **D.** P2 rami and basipodite, caudal; **E.** P3 coupler and protopodite, caudal; **F.** P3 coupler and protopodite, frontal; **G.** P3 rami, caudal; **H.** P4 rami and basipodite, caudal; **I.** P4 coupler and protopodite, caudal.

Fig (19): *Tropocyclops confinis*. Kiefer, 1930. **Female. A.** antennule; **B.** antenna; **C.** P5, pediger 5 and genital double-somite, ventral; **D.** P1 frontal; **E.** P2, caudal; **F.** P3, caudal; **G.** P4, caudal; **H.** P4, frontal; **I.** maxillulary palp; **J.** anal somite and caudal rami, ventral.

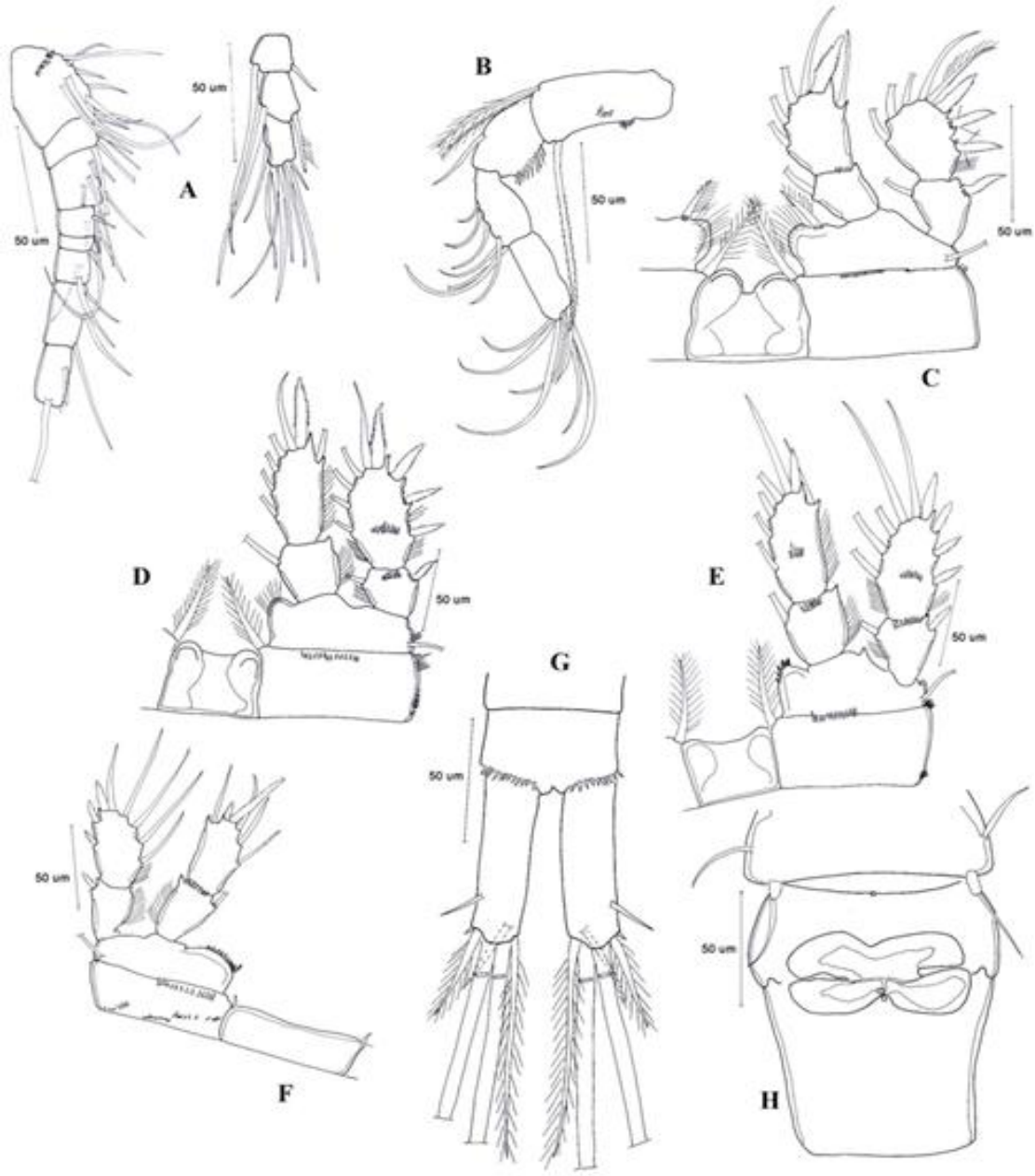

Fig (20): *Cryptocyclops linjanticus*. Kiefer, 1928. **Female. A.** antennule; **B.** antenna; **C.** P1, frontal; **D.** P2, caudal; **E.** P3, caudal;**F.** P4, caudal; **G.** anal somite and caudal rami, ventral; **H.** P5, pediger 5 and genital double-somite, ventral.

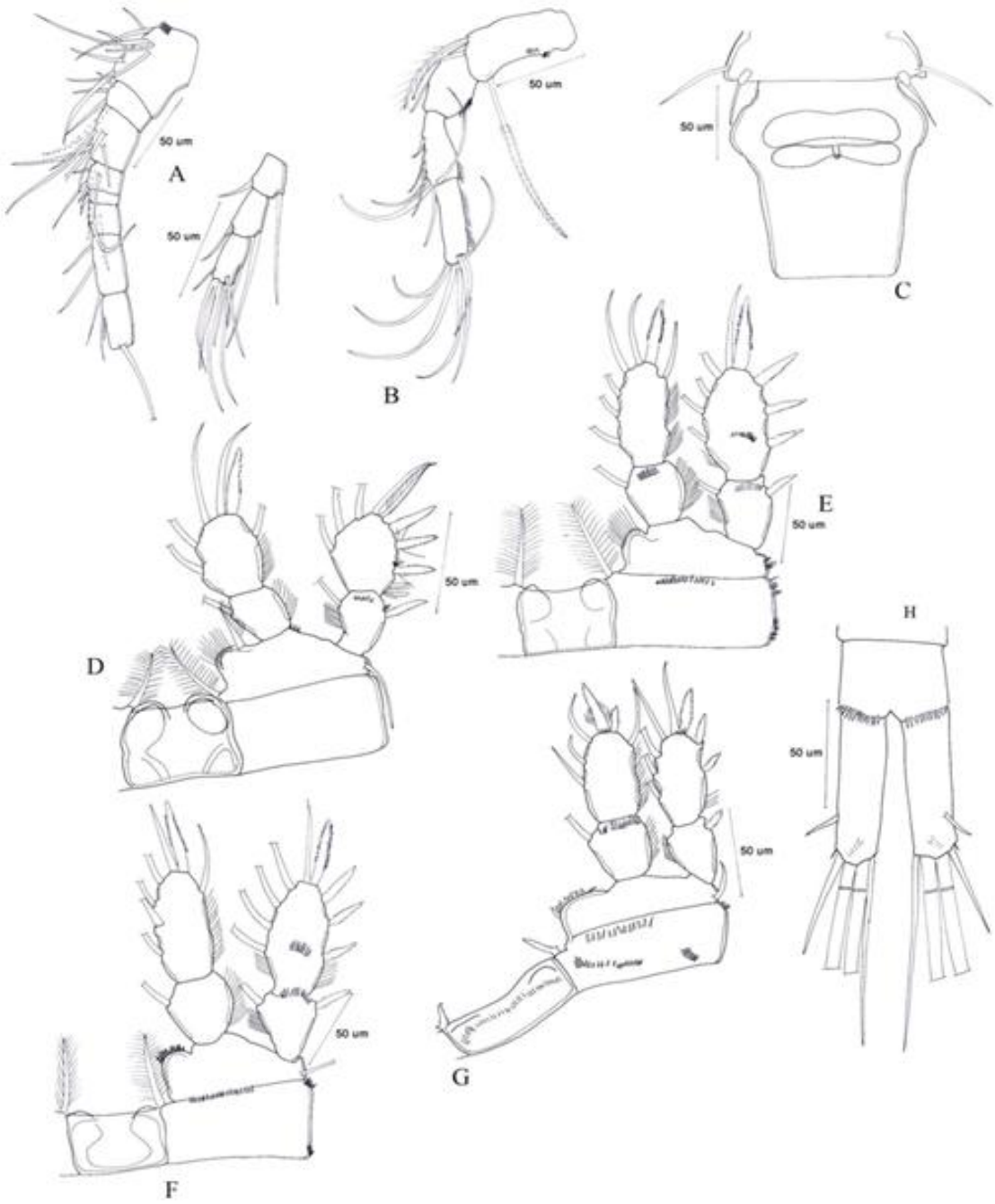

Fig (21): *Cryptocyclops new 2.* **Female. A.** antennule; **B.** antenna; **C.** P5, pediger 5 and genital double-somite; **D.** P1, fontal; **E.** P2, caudal; **F.** P3, caudal; **G.** P4, caudal; **G.** anal somite and caudal rami, ventral.

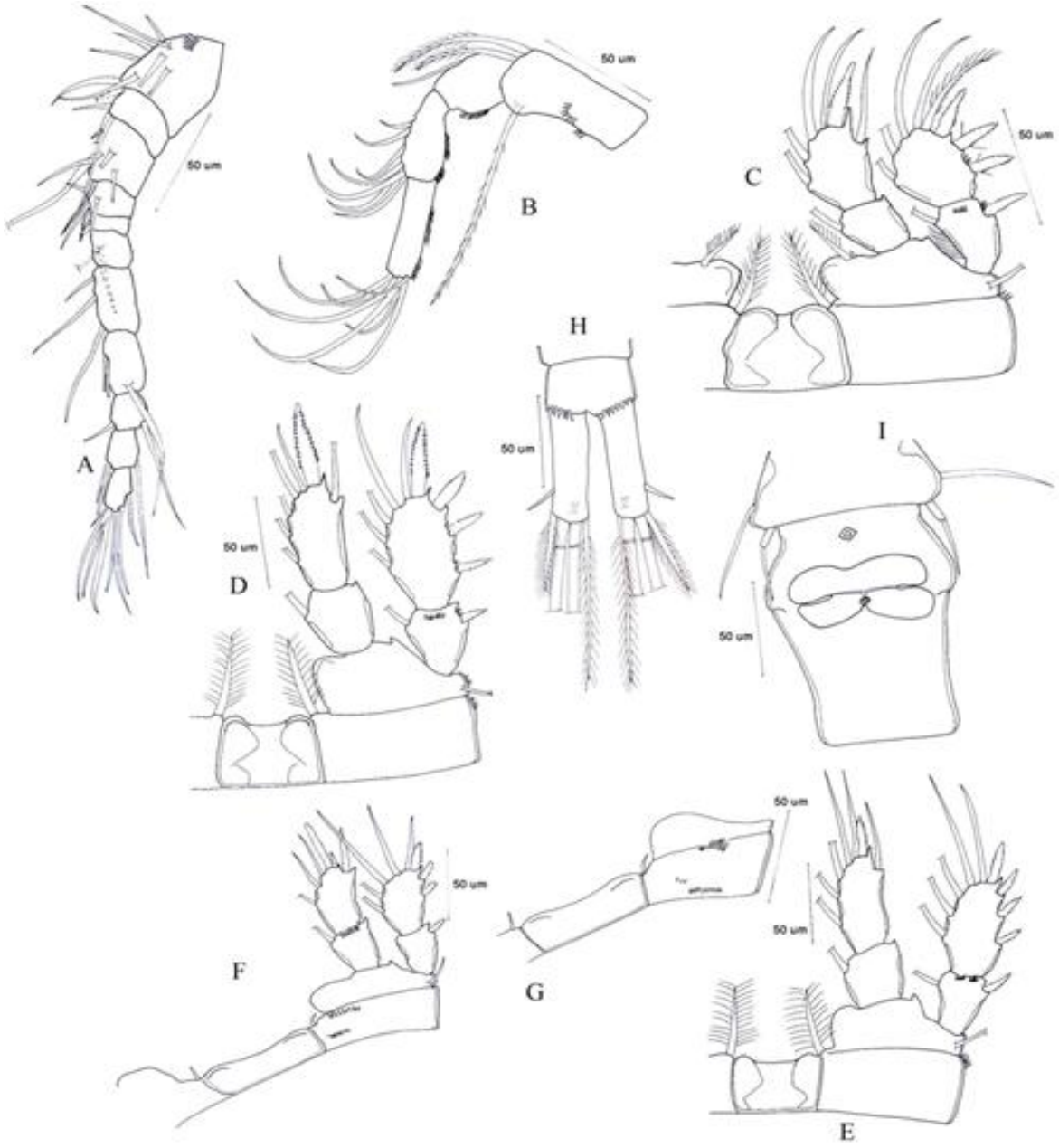

Fig (22): *Cryptocyclops new 1*, **Female. A.** antennule; **B.** antenna; **C.** P1, frontal; **D.** P2, caudal; **E.** P3, caudal; **F.** P4, caudal; **G.** P4, frontal; **H.** anal somite and caudal rami, ventral; **I.** P5, pediger 5 and genital double-somite, ventral.

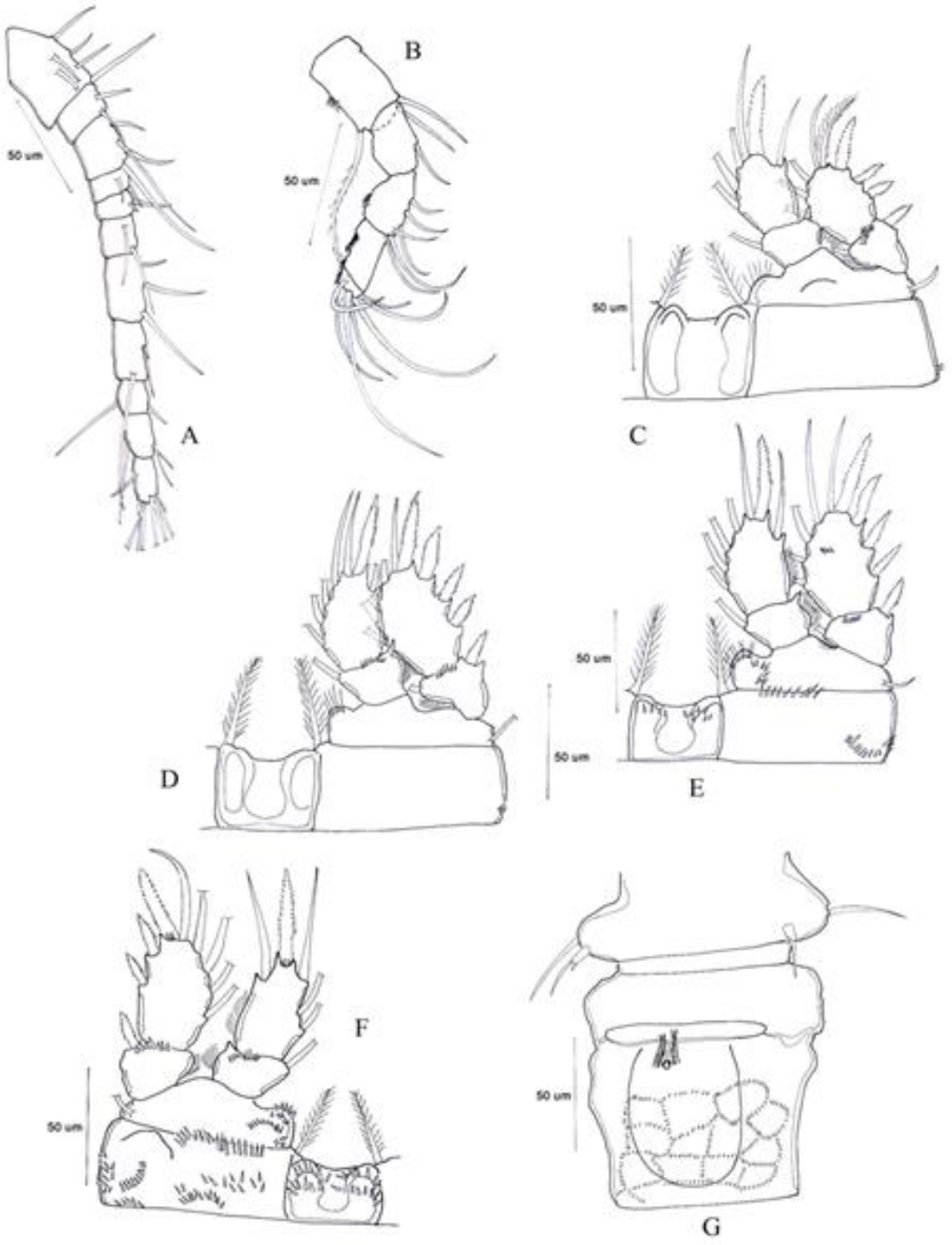

Fig (23): *Metacyclops sp.* 1 **(minutus-group). Female. A.** antennule; **B.** antenna; **C.** P1, caudal; **D.** P2, caudal; **E. P3,** caudal; **F.** P4, caudal; **G.** P5, pediger 5 and genital double-somite, ventral.

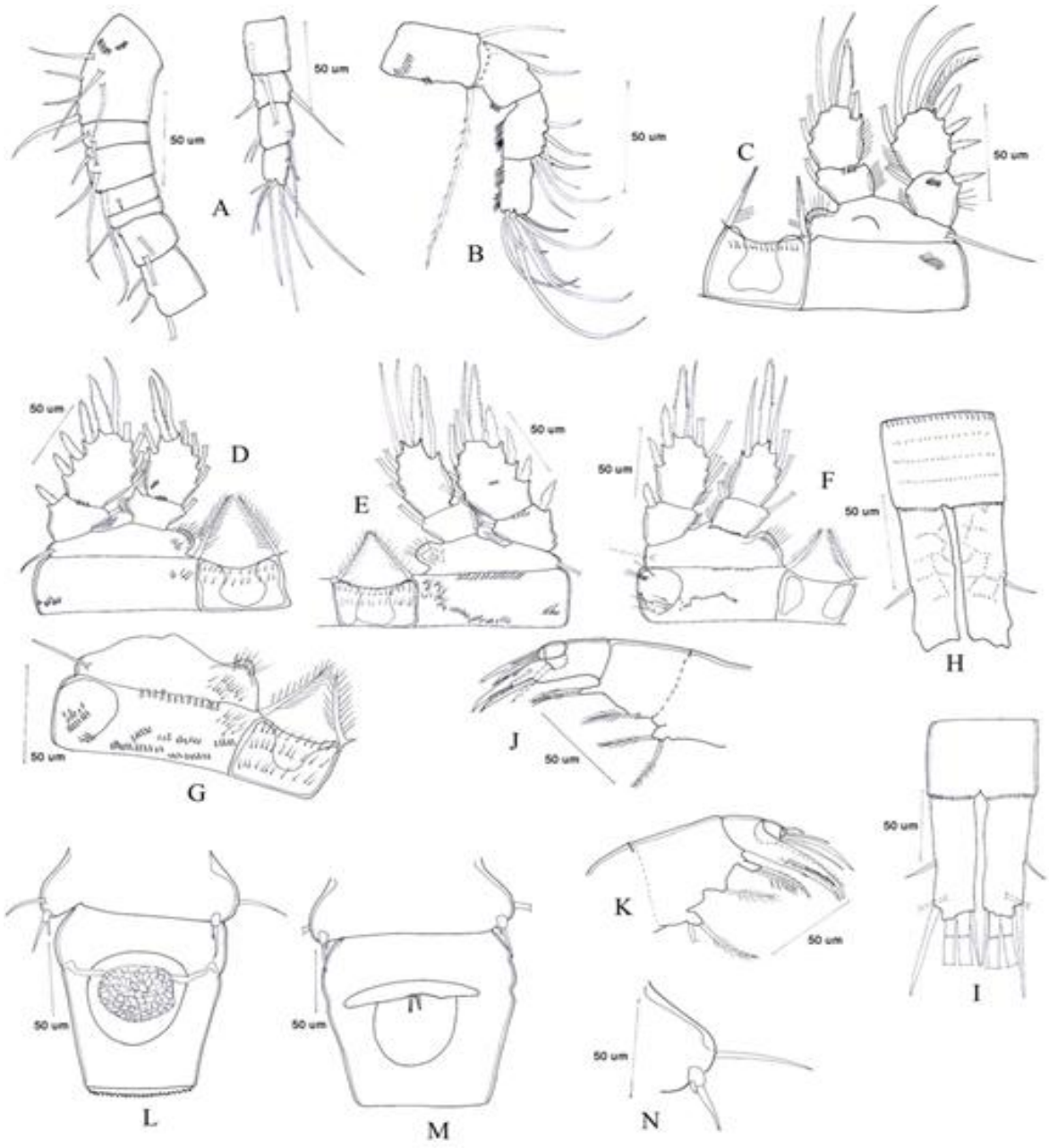

Fig (24): *Metacyclops sp. 2* **(minutus-group)** . **Female. A.** antennule; **B.** antenna; **C.** P1, caudal; **D.** P2, caudal; **E.** P3, caudal; **F.** P4, frontal; **G.** P4, caudal; **H.** anal somite and caudal rami, ventral; **I.** anal somite and caudal rami, ventral (from another specimen); **J.** maxilla; **K.** maxilla (from another specimen); **L.** P5, pediger 5 and genital double-somite, ventral; **M.** P5, pediger 5, genital double somite, ventral (from another specimen); N. P5, (from another specimen).

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Fig (25): Map showing the Cyclopidae distribution of the Sudan.

Discussion

Many workers worldwide have been interested in identification of cyclopoid Copepods, particularly those of the African continent. Van de Velde (1984) made a revision of the African species of the Genus *Mesocyclops*Sars, 1914. Moreover, in 1991, Boxshall&Braide made a review of almost all records of freshwater Cyclopoid Copepods from Nigeria with an illustrated key to all identified species. Olsen (1993) made a similar key to the species of *Thermocyclops* and *Mesocyclops* in tropical Africa.

In this study, a total of 20 species of freshwater CyclopoidCopepods is recognized from Sudan. All the materials were examined and figured during this study.

Cyclopoid Copepods, which collected from the Sudanese waters, belong to the two subfamilies: Cyclopinae (16 species) and Eucyclopinae (4 species). They include some of the well known African Cyclops e.g. *Mesocyclopsaspericornis*, *M. major*and*M. ogunnus*; that is besides *Thermocyclopsdeciepins*, *Afrocyclopsgibsoni.*and*Tropocyclopsconfinis.*

Abu Gideiri and Abu Gideiri*et. al.* (1969, 1974, 1975) surveying the planktonic fauna of the Nile recorded two important species of Cyclops namely *Mesocyclopsleuckarti* and *Thermocyclopsneglectus*. Later Van de Velde (1984) reported that *Mesocyclopsleuckarti* does not occur in Africa; its presence is restricted to Europe and Asia. However, *Mesocyclopsleuckarti* and *Thermocyclopsneglectus* were not found in the present study.

Rzoska (1976) in his work on the zooplankton of the Nile system also reported the presence of *M. leuckarti* and *Thermocyclopsneglectus* with its varieties from the White and Blue Niles. *Tropocyclopsprasinus* was recorded from the White Nile only. However, Boxshall and Braide (1991) mentioned that *M. aspericornis*had been reported by Lindberg (1951) as *M. leuckarti*.

It worth mentioning that *M. aspericornis*is the only *Mesocyclops*species found in Africa that also has a wide distribution in the oriental region (Van de Velde, 1984). It is reported from Democratic Republic of Congo, Ethiopia, Ghana, Niger, Nigeria, Sudan, Argentina, Brazil, Colombia, Venezuela, Mexico, Burma, India, China, Iran Jaya, Java, Kalimantan, Malay Peninsula, Papua new Guinea, Philippines, Sabah and Sarawak, Singapore, Sulawesi, Sumatra, Taiwan, Thailand, Uzbekistan, Vietnam, Yemen (Socotra), Aruba, Bonaire, Curacao, Grand Cayman, Guadeloupe, Haiti, Inagua, Jamaica, Martinique, Puerto Rico, Turks & Caicos, US Virgin Island. Pacific Islands (Hawaii, Marshall, Marianas, Polynesia (Tahiti)) (Dussart and Defaye, 2006).

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