

Two New Species of *Ochridacyclops* (Kiefer, 1937) (Copepoda, Cyclopoida) from Kenya and Nepal

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ABSTRACT—Two species of cyclopoid copepods, *Ochridacyclops kenyaensis* sp. nov. and *O. nepalensis* sp. nov. are described as the first records of this genus from Kenya and Nepal, respectively. *Ochridacyclops kenyaensis* can easily be distinguished from its congeners by having a rounded and blunt distal end of the outer terminal seta (IV) on the caudal rami, and by the inner terminal spine being about equal in length to the outer terminal spine on the endopod of leg 4. *Ochridacyclops nepalensis* can easily be distinguished from other members of the genus by having two spines on exopodal segment 3 of leg 1, and by the proportions of the caudal rami, which are 3.4 times longer than wide.

Key words: taxonomy, Copepoda, *Ochridacyclops*, Kenya, Nepal

INTRODUCTION

The genus *Ochridacyclops* was established by Kiefer (1937) to accommodate *O. arndti* found in the body of a freshwater sponge endemic to Lake Ohrid, Macedonia. Subsequently, three other species and one subspecies of this genus have been described: *O. arndti prespensis* Petkovski, 1954 from another sponge species in freshwater habitats near Lake Ohrid, *O. brevicaudatus* Shen and Tai, 1964 from streams in Guangdong, China, *O. nipponensis* Karaytug *et al.*, 1996 from small streams in Kochi, Japan, and *O. iriomotensis* Ishida, 2002 from a puddle in Iriomote Island, Okinawa, Japan.

Karaytug *et al.* (1996) pointed out that *Ochridacyclops* and *Paracyclops* Claus, 1893 are closely related. However, the absence of a detailed description of the male antennule of *Ochridacyclops* prevented them from addressing this problem, since the male antennule provides a number of significant taxonomic characters in *Paracyclops* (Karaytug and Boxshall, 1996).

An undescribed species of the genus *Ochridacyclops* was found in copepod samples collected from Kenya by two of the authors (T. Ito and N. Minakawa), and another species from Nepal by Dr. A. Ohtaka. We have found male specimens of the genus from Nepal, which gives us the opportunity to look at the characters separating the genera.

The present paper describes these new species of *Ochridacyclops*, the first known from Kenya and the first from Nepal, and discusses the generic characteristics of *Ochridacyclops*.

MATERIAL AND METHODS

Both in Kenya and Nepal, materials were collected by scraping the stream bottom with a fine mesh hand net and fixed in about 5% formalin at the site. Copepods were dissected and mounted on glass slides in gum-chloral medium. The specimens were examined using Nomarski differential interference contrast on an Olympus BH-2 microscope and illustrated with the aid of a camera lucida. The terminology proposed by Huys and Boxshall (1991) is adapted. The type material is deposited in the National Science Museum, Tokyo (NSMT).

TAXONOMY

***Ochridacyclops kenyaensis* sp. nov.**
(Figs. 1–4)

Type locality. Kakamega Forest (ca 0°16'N, 34°44'E), Kenya; 2 May 2002, coll. by N. Minakawa and T. Ito.

Type material. Holotype: female, length 0.71 mm, dissected on one slide (NSMT-Cr 16042). Paratypes: two females (length 0.69 mm, 0.67 mm), dissected on one slide each (NSMT-Cr16043, 16044). One male, length 0.59 mm, dissected on one slide (NSMT-Cr 16045). Two females and two males, undissected in 70% ethanol (NSMT-Cr 16046).

Description of adult female (NSMT-Cr 16042)

Body length: 0.71 mm, body width: 0.21 mm. Body cyclopid form (Fig. 1A); prosome with cephalothorax narrowing ante-

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riorly and free pedigerous somites decreasing in width from anterior to posterior. Genital double-somite (Fig. 1E, F) length $1.2 \times$ width. Seminal receptacles divided into broad anterior and posterior lobes. Fifth pedigerous somite with fringe-like array of elongate setules along posterolateral margins. Anal somite with spinular row ventrally along posterior margin (Fig. 1B). Anal operculum (Fig. 1C) weakly developed, barely convex, smooth.

Caudal rami length about $2.5 \times$ width. Caudal rami with 6 setae (Fig. 1C, D); seta (I) absent; posterolateral seta (III) length $1.7 \times$ terminal accessory seta (VI); outer terminal seta (IV) length $0.8 \times$ inner terminal seta (V), distal end blunt (Fig. 1D); small seta (II) on dorsolateral surface.

Antennule 12-segmented (Fig. 2B). First segment with spinular row ventrally. Apical segment lacking marginal membrane. Segment nine with short aesthetasc. Another aesthetasc present on each of segments 11 and 12. Setal formula 8, 4, 2, 6, 4, 1, 2, 3, 2 + 1 aesthetasc, 2, 2 + 1 aesthetasc, 7 + 1 aesthetasc; seta on segment 6 spiniform.

Antenna 4-segmented (Fig. 1G), comprising coxobasis and 3-segmented endopod. Coxobasis ornamented with rows of spinules laterally (Fig. 1G) and armed with 1 inner seta; outer spinulose seta representing exopod. First endopodal segment with inner distal seta and midsurface row of spinules. Second endopodal segment with 9 setae; segment ornamented with spinules along outer margin. Third endopodal segment armed with 7 setae around apex; segment ornamented with spinular row along outer margin.

Labrum (Fig. 2A) comprising slender anterior part and broad posterior part. Posterior margin forming strong teeth; ventral surface ornamented with rows of long spinules.

Mandible (Fig. 2C) with coxal gnathobasic blades mostly simple, dorsal seta with spinules along inner rim. Palp represented by 3 setae, two of which long and plumose, third short and naked.

Maxillule (Fig. 2D) comprising elongate praecoxa and 2-segmented palp; praecoxa, with 2 apical spines, inner margin with 3 spines, short seta, and spinulose seta.

Maxilla 5-segmented (Fig. 2E). Praecoxal endite with 2 spinulose setae. Coxa with proximal endite represented by single spinulose seta, distal endite with well developed process carrying 2 spinulose setae apically. Basis armed with strong claw with spinular row along convex margin and naked seta. First endopodal segment carrying 2 spinulose setae, second carrying 3 setae.

Maxilliped 4-segmented (Fig. 2F), syncoxa armed with 3 spinulose setae representing endites. Basis armed with 1 spinulose and 1 naked inner seta; ornamented with 2 transverse rows of spinules near outer distal angle. First endopodal segment bearing spinulose seta. Second endopodal segment with 3 seta, one of which naked.

Leg 1 (Fig. 3A) with 3-segmented protopod. Coxa with inner spinulose seta. Basis with outer angle seta, slightly longer than exopodal segment 1, and spinulose seta on inner margin. Terminal spine of exopodal segment 3 length $1.3 \times$ segment.

Leg 2 (Fig. 3B) with 3-segmented protopod. Praecoxa represented by triangular sclerite at outer proximal angle. Coxa with inner spinulose seta. Basis with outer angle seta as long as exopodal segment 1. Terminal spine of exopodal segment 3 length $1.3 \times$ segment. Terminal spine of endopodal segment 3 length $1.6 \times$ segment.

Leg 3 (Fig. 3C) with 3-segmented protopod. Praecoxa represented by triangular sclerite at outer proximal angle. Coxa with inner spinulose seta. Basis with outer angle seta length $0.8 \times$ exopodal segment 1. Terminal spine of exopodal segment 3 length $1.5 \times$ segment. Terminal spine of endopodal segment 3 length $1.4 \times$ segment.

Leg 4 (Fig. 3D) with 3-segmented protopod. Praecoxa represented by triangular sclerite at outer proximal angle. Coxa with inner spinulose seta. Basis with outer angle seta. Terminal spine of exopodal segment 3 length $1.3 \times$ segment. Inner terminal spine length $1.1 \times$ outer terminal spine.

Seta and spine formula of legs 1–4 as shown in Table 1.

Table 1. Armature of legs 1–4 of *Ochridacyclops kenyaensis* sp. nov. Roman numerals indicate number of spines, and Arabic numerals indicate number of setae.

	Coxa	Basis	Exopod	Endopod
Leg 1	0–1	1–1	I–1; I–1; II, I, 4	0–1; 0–2; 1, I, 4
Leg 2	0–1	1–0	I–1; I–1; II, I, 5	0–1; 0–2; 1, I, 4
Leg 3	0–1	1–0	I–1; I–1; II, I, 5	0–1; 0–2; 1, I, 4
Leg 4	0–1	1–0	I–1; I–1; II, I, 5	0–1; 0–2; 1, II, 2

Leg 5 (Fig. 1F) comprising single free segment, armed with 2 naked and 1 plumose setae, middle seta length $0.6 \times$ plumose seta. Minute spinules present on segment at base of plumose seta.

Leg 6 (Fig. 1E) represented by 1 naked seta and 2 tiny spinules dorsolaterally.

Description of adult male (NSMT-Cr 16045)

Body length: 0.59 mm. Genital somite separate (Fig. 4A).

Antennule 16-segmented (Fig. 4E). First segment with slender club seta and spinular row ventrally, seta A simple. Segments 2 and 3 each with club seta, respectively. Segment 4 with 2 club setae and aesthetasc. Segment 10 bearing curved seta ornamented with row of denticles. Segment 12 armed with stiff seta ornamented with row of denticles and short seta. Segment 13 with spinulose seta. Segments 14 and 15 with 2 modified setae, respectively. Setal formula 8, 4, 2, 4 + aesthetasc, 1, 2, 1, 2, 2, 1, 2, 2, 1, 2, 3, 13.

Leg 5 (Fig. 4A) comprising single free segment, armed with 2 naked and 1 plumose setae, middle seta length $1.2 \times$ plumose seta. Minute spinules present on segment at base of plumose seta.

Leg 6 (Fig. 4E) represented by 1 stiff seta ornamented with row of denticles and 2 naked setae dorsolaterally.

Condition of material

Female with all appendages. One inner seta on the right

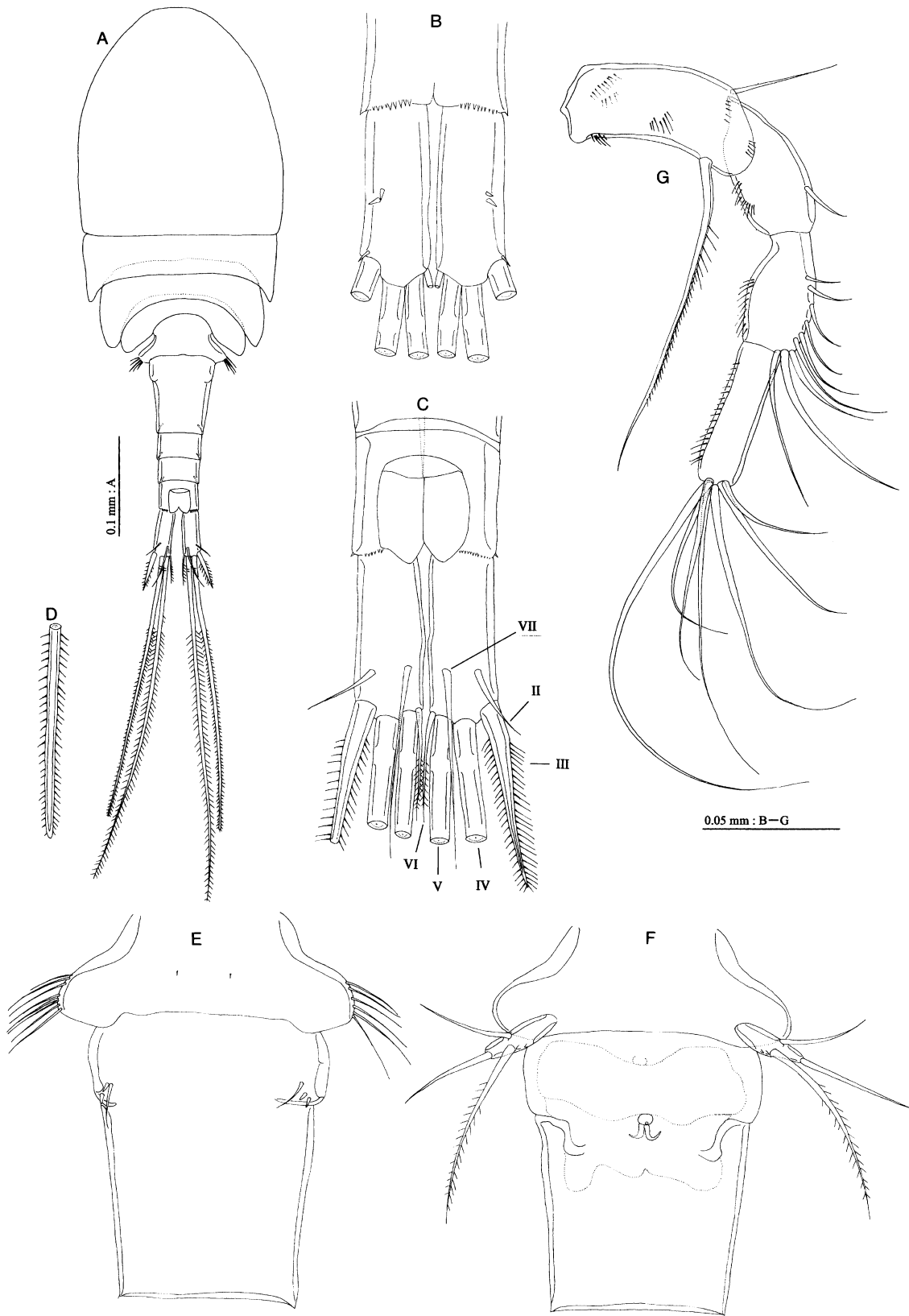


Fig. 1. *Ochridacyclops kenyaensis* sp. nov. Adult female, holotype (NSMT-Cr 16042). A, dorsal view; B, anal somite and caudal rami, ventral view; C, anal somite and caudal rami, dorsal view; D, distal end of outer terminal seta (IV) on caudal rami; E, genital double-somite, dorsal view; F, genital double-somite, ventral view; G, antenna, anterior view.

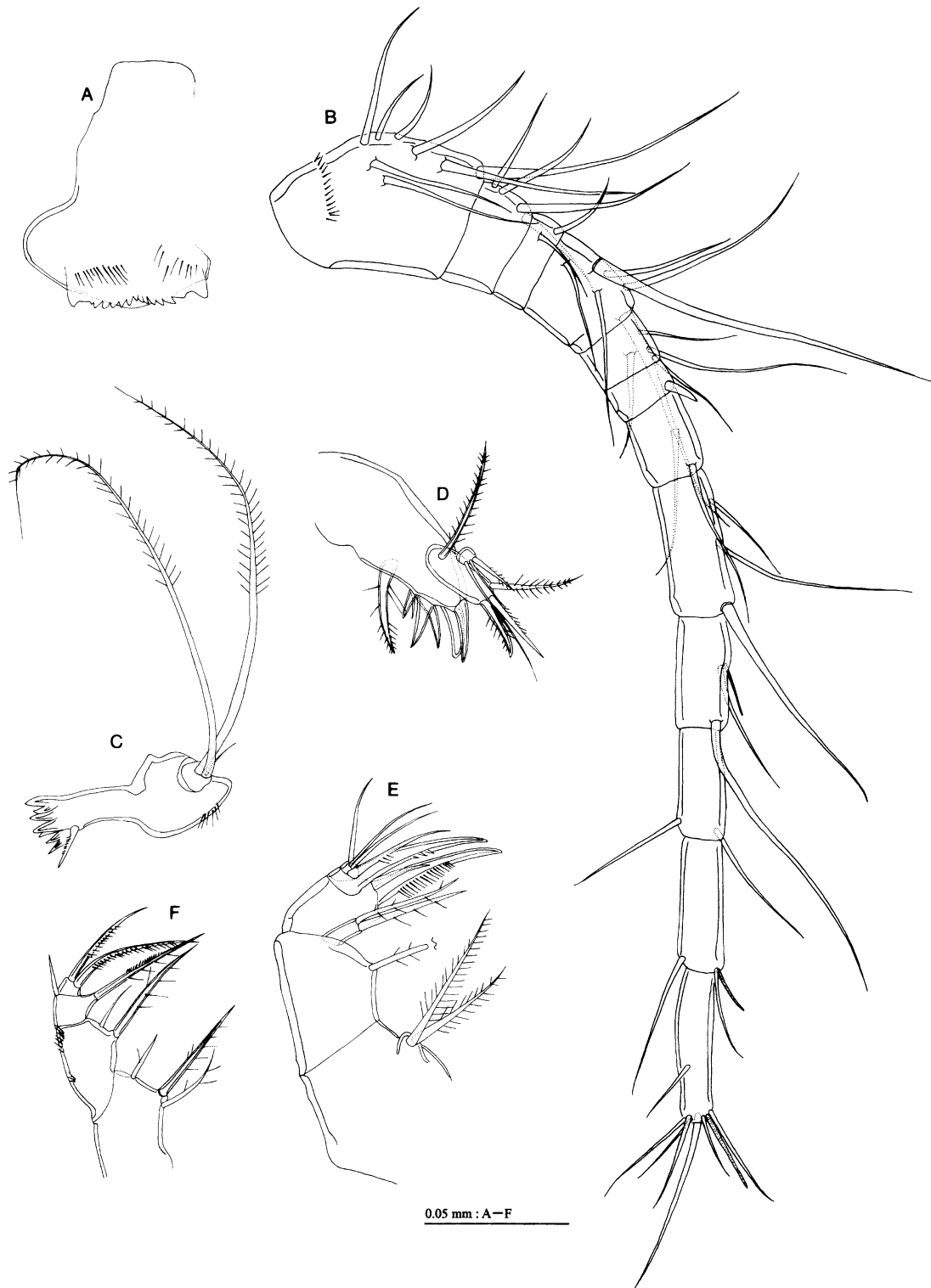


Fig. 2. *Ochridacyclops kenyaensis* sp. nov. Adult female, holotype (NSMT-Cr 16042). A, labrum, ventral view; B, antennule, ventral view; C, mandible, posteroventral view; D, maxillule, dorsal view; E, maxilla, posterior view; F, maxilliped, anterior view.

antenna is missing. Male with all appendages.

Etymology

The specific name is derived from the type locality.

Remarks

Ochridacyclops kenyaensis can easily be distinguished from other members of genus by the following characters: distal end of outer terminal seta (IV) on caudal rami rounded, not tapering sharply and in endopod of leg 4 inner terminal

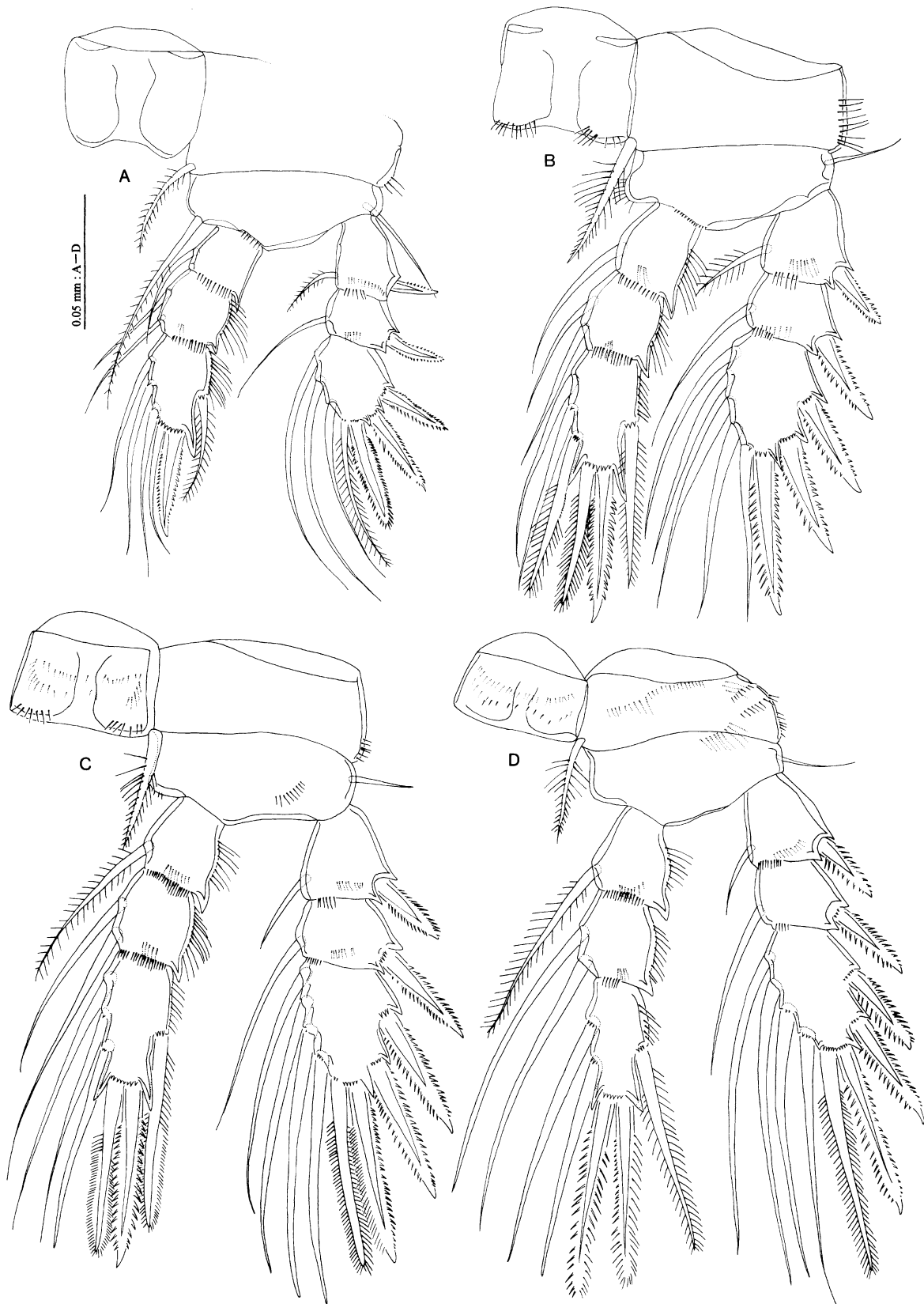


Fig. 3. *Ochridacyclops kenyaensis* sp. nov. Adult female, holotype (NSMT-Cr 16042). A, leg 1, anterior view; B, leg 2, anterior view; C, leg 3, anterior view; D, leg 4, anterior view.

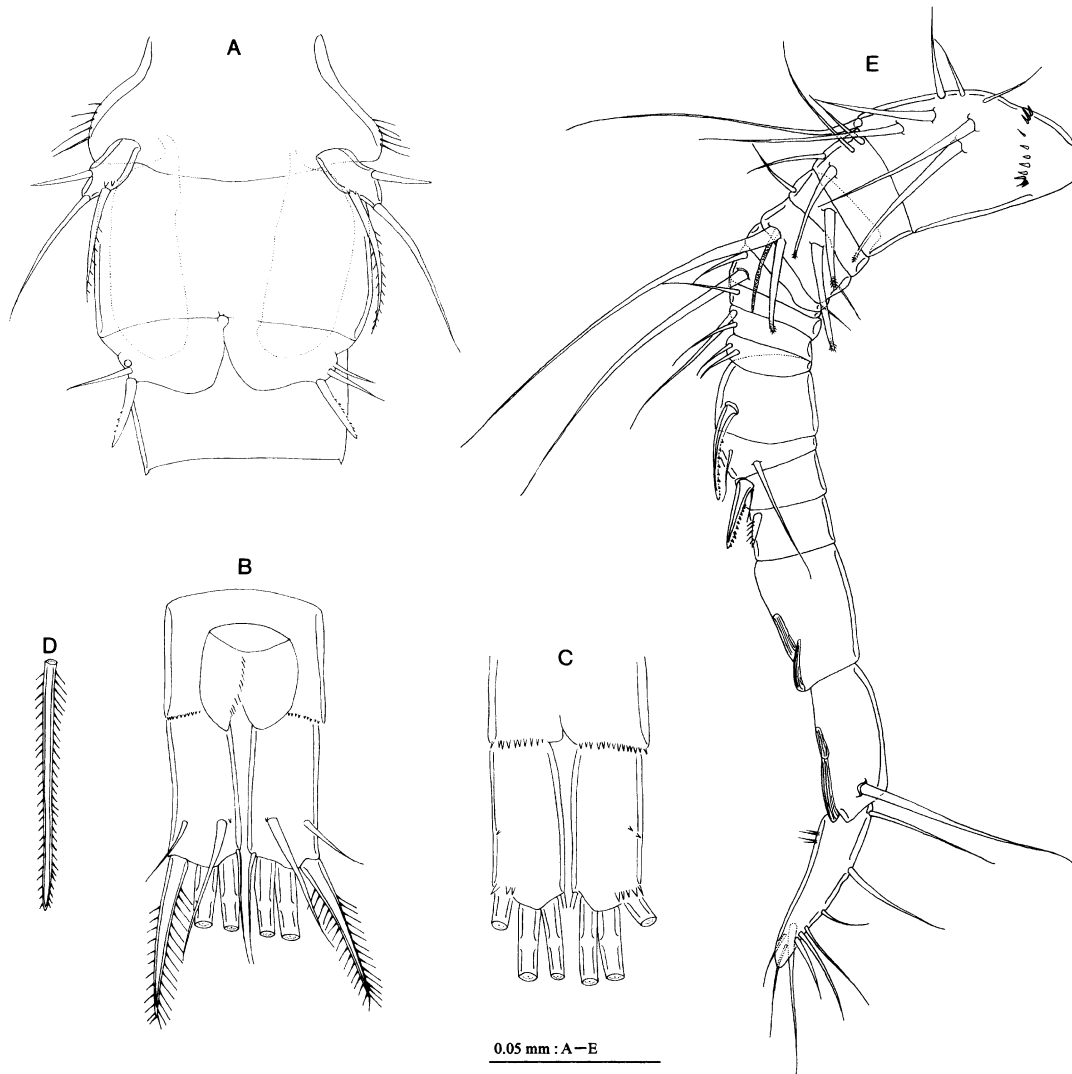


Fig. 4. *Ochridacyclops kenyaensis* sp. nov. Adult male, paratype (NSMT-Cr 16045). A, genital somite, ventral view; B, anal somite and caudal rami, dorsal view; C, anal somite and caudal rami, ventral view; D, distal end of outer terminal seta (IV) on caudal rami; E, antennule, ventral view.

spine about equal in length to outer terminal spine. *Ochridacyclops kenyaensis* is most similar to *O. nepalensis* sp. nov. The affinity of this species with *O. nepalensis* is discussed in the remarks on the latter species. The present new species is also similar to *O. nipponensis* Karaytug *et al.*, 1996 and *O. iriomotensis* Ishida, 2002 in having a 12-segmented antennule in the female. Distinguishing characters from *O. nipponensis* and *O. iriomotensis* are as follows: from *O. nipponensis* (the character states of which are shown in parentheses), posterolateral seta (III) length $1.7 \times$ terminal accessory seta (VI) (about equal), outer terminal seta (IV) length $0.8 \times$ inner terminal seta (V) ($0.6 \times$), exopodal segment 3 of leg 1 with four setae (five), spine formula of exopodal segment 3 of legs 1–4 3, 3, 3, 3 (3, 4, 4, 3), terminal spine of exopodal segment 3 of leg 2 length $1.3 \times$ segment ($0.7 \times$), terminal spine of exopodal segment 3 of leg 3 length $1.5 \times$ segment ($0.5 \times$), terminal spine of endopodal segment 3 of leg 3 length $1.4 \times$ segment ($0.6 \times$), terminal spine of exopo-

dal segment 3 of leg 4 length $1.3 \times$ segment ($0.5 \times$) and inner seta of leg 5 slender, length $2.7 \times$ free segment (spiniform, $0.6 \times$); from *O. iriomotensis* (states of *O. iriomotensis* are in parentheses), posterolateral seta (III) length $1.7 \times$ terminal accessory seta (VI) ($0.4 \times$), outer terminal seta (IV) length $0.8 \times$ inner terminal seta (V) ($0.6 \times$), exopodal segment 3 of leg 1 with four setae (five), spine formula of exopodal segment 3 of legs 1–4 3, 3, 3, 3 (3, 4, 4, 3), terminal spine of exopodal segment 3 of leg 3 length $1.5 \times$ segment ($0.6 \times$), terminal spine of endopodal segment 3 of leg 3 length $1.4 \times$ segment ($0.7 \times$), terminal spine of exopodal segment 3 of leg 4 length $1.3 \times$ segment ($0.5 \times$), inner seta of leg 5 slender, length $2.7 \times$ free segment (stout, about equal) and leg 5 with minute spinules at base of inner seta (absent).

Habitat

Kakamega Forest (1500–1700 m above sea level) is a small

patch of tropical rainforest in western Kenya. This African equatorial forest is known for the rich fauna and flora including several endemic species (Kenya Indigenous Forest Con-

servation Program, 1994). This species was collected from the bottom of a small stream in the forest. The width of the stream was about 1–2 m and the depth, 5 cm at the sam-

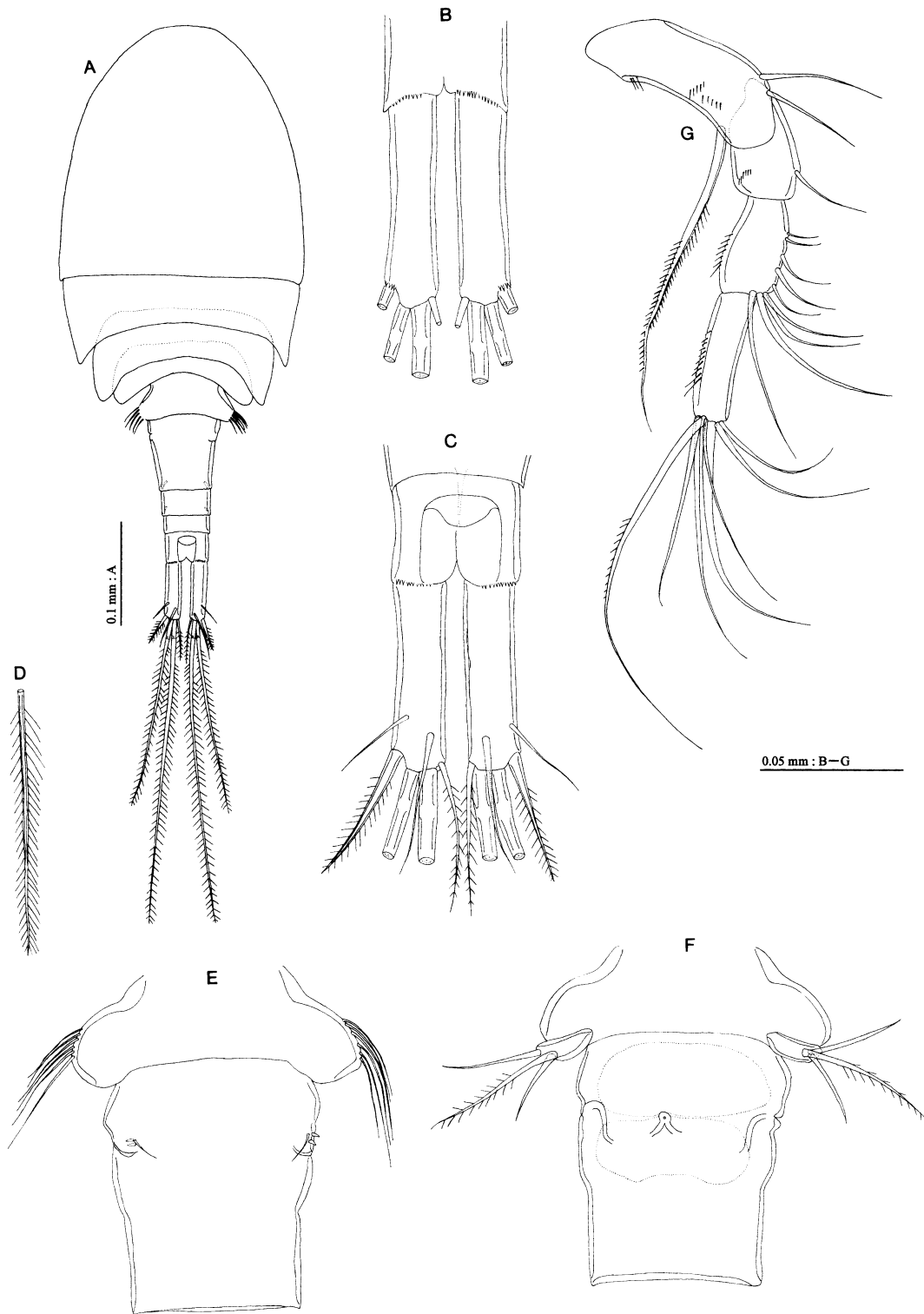


Fig. 5. *Ochridacyclops nepalensis* sp. nov. Adult female, holotype (NSMT-Cr 16047). A, dorsal view; B, anal somite and caudal rami, ventral view; C, anal somite and caudal rami, dorsal view; D, distal end of outer terminal seta (IV) on caudal rami; E, genital double-somite, dorsal view; F, genital double-somite, ventral view; G, antenna, anterior view.

pling location. The stream substrate consisted of pebbles, sand and silt. Plant litter was also present on the stream bottom.

***Ochridacyclops nepalensis* sp. nov.**

(Figs. 5–7)

Type locality. Pokhara (ca 28°13'N, 83°59'E), Nepal; 15 Dec. 1999, coll. by Dr. A. Ohtaka.

Type material. Holotype: female, length 0.62 mm, dissected on one slide (NSMT-Cr 16047). Paratype: female, length 0.61 mm, dissected on one slide (NSMT-Cr 16048).

Description of adult female (NSMT-Cr 16047)

Body length: 0.62 mm, body width: 0.24 mm. Anal operculum (Fig. 5C) well developed.

Caudal rami length about $3.4 \times$ width. Caudal rami with 6 setae (Fig. 5C, D); posterolateral seta (III) length $0.8 \times$ terminal accessory seta (VI); outer terminal seta (IV) length $0.7 \times$ inner terminal seta (V), distal end tapering sharply (Fig. 5D).

Antennule 12-segmented (Fig. 6A). Segment 9 without aesthetasc. Aesthetasc present on segments 11 and 12. Setal formula 8, 4, 2, 6, 4, 1, 1, 3, 2, 2, 2 + 1 aesthetasc, 7

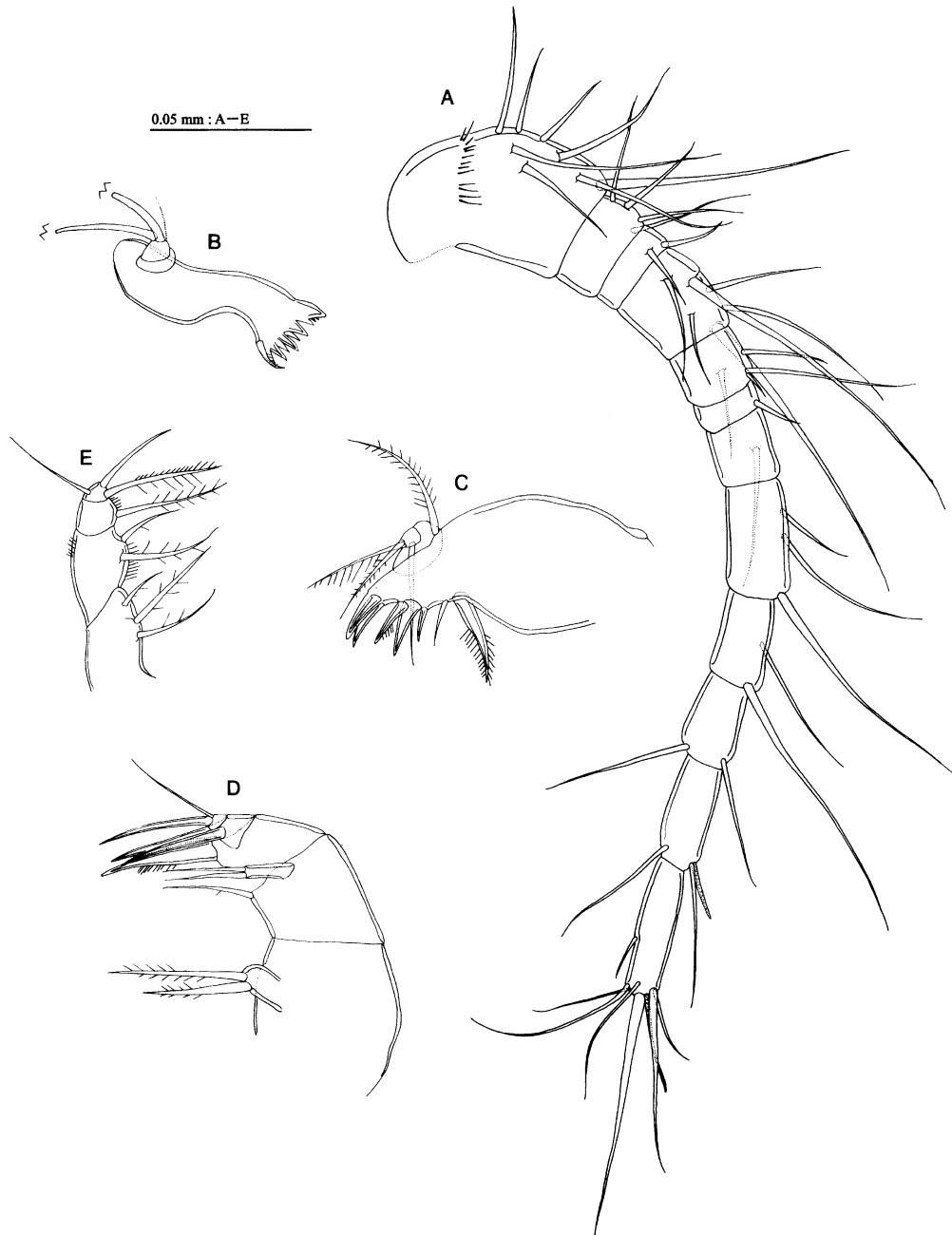


Fig. 6. *Ochridacyclops nepalensis* sp. nov. Adult female, holotype (NSMT-Cr 16047). A, antennule, ventral view; B, mandible, posteroventral view; C, maxillule, ventral view; D, maxilla, posterior view; E, maxilliped, anterior view.

+ 1 aesthetasc; seta on segment 6 not spiniform.

Antenna (Fig. 5G), coxobasis armed with 2 inner seta;
outer spinulose seta representing exopod.

Labrum lost during dissection.

Maxilla (Fig. 6D) coxa, distal endite with well developed
process carrying 2 naked setae apically. Basis armed with
strong claw with spinular row along convex margin. First
endopodal segment carrying 2 stiff setae, second carrying 2

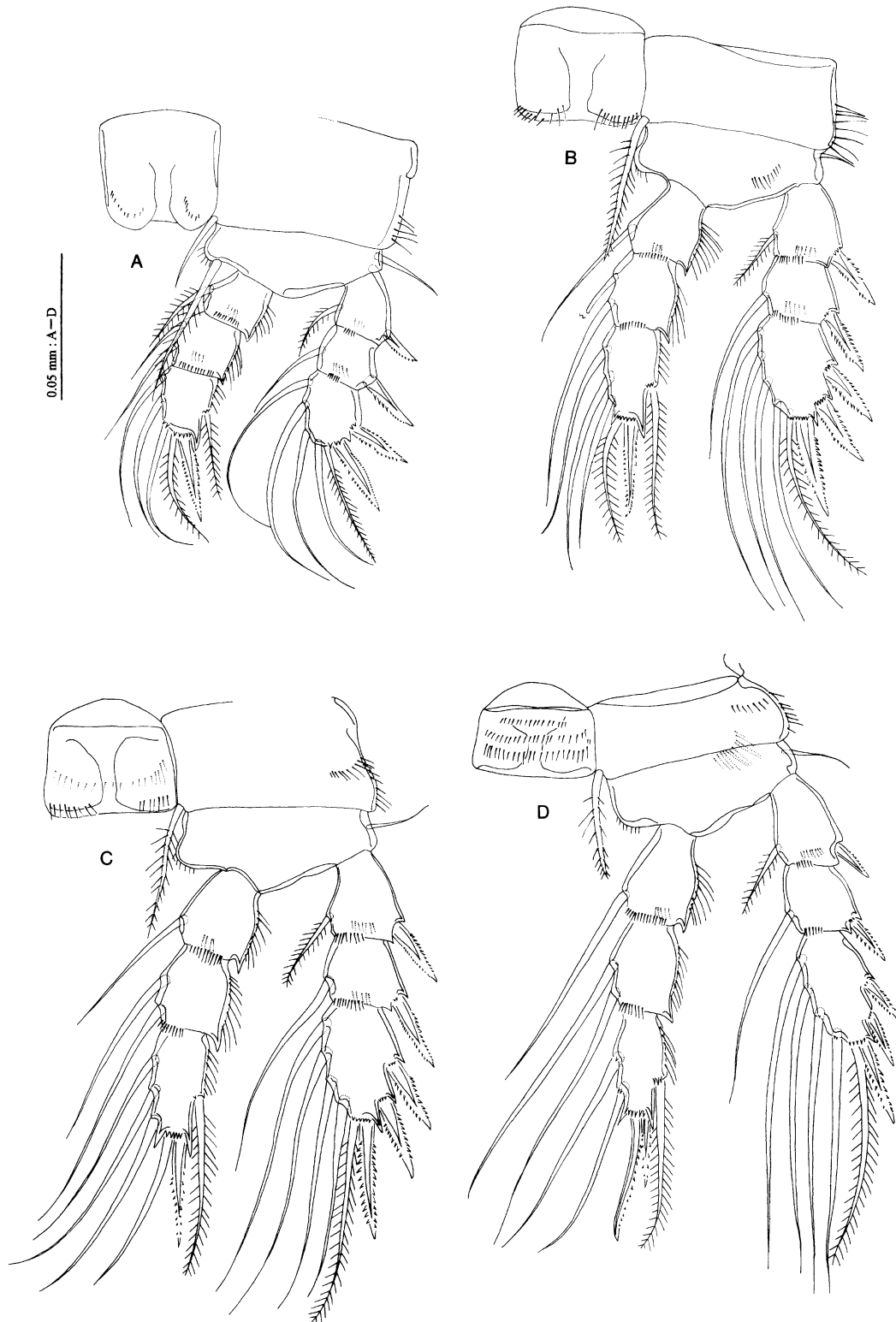


Fig. 7. *Ochrudacyclops nepalensis* sp. nov. Adult female, holotype (NSMT-Cr 16047). A, leg 1, anterior view; B, leg 2, anterior view; C, leg 3, anterior view; D, leg 4, anterior view.

setae, one of which stiff.

Leg 1 (Fig. 7A), coxa with inner naked seta. Terminal spine of exopodal segment 3 length $1.1 \times$ segment.

Leg 2 (Fig. 7B), basis with outer angle seta length $0.6 \times$ exopodal segment 1. Terminal spine of exopodal segment 3 as long as segment. Terminal spine of endopodal segment 3 as long as segment.

Leg 3 (Fig. 7C), terminal spine of exopodal segment 3 as long as segment. Terminal spine of endopodal segment 3 length $1.1 \times$ segment.

Leg 4 (Fig. 7D), terminal spine of exopodal segment 3 length $0.8 \times$ segment. Inner terminal spine length $1.7 \times$ outer terminal spine.

Seta and spine formula of legs 1–4 as shown in Table 2.

Table 2. Armature of legs 1–4 of *Ochridacyclops nepalensis* sp. nov. Roman numerals indicate number of spines, and Arabic numerals indicate number of setae.

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-1	I-1; I-1; I, I, 5	0-1; 0-2; 1, I, 4
Leg 2	0-1	1-0	I-1; I-1; II, I, 5	0-1; 0-2; 1, I, 4
Leg 3	0-1	1-0	I-1; I-1; II, I, 5	0-1; 0-2; 1, I, 4
Leg 4	0-1	1-0	I-1; I-1; II, I, 5	0-1; 0-2; 1, II, 2

Table 3. A comparison between *Ochridacyclops* species.

Character	<i>O. arndti</i>	<i>O. brevicaudatus</i>	<i>O. iriomotensis</i>	<i>O. kenyaensis</i> sp. nov.	<i>O. nepalensis</i> sp. nov.	<i>O. nipponensis</i>
Body length	0.75 mm	0.46 mm	0.51–0.63 mm	0.59–0.71 mm	0.61–0.62 mm	0.55 mm
Spinular row on anal somite	absent	?	present	present	present	present
Antennule, number of segments	11	11	12	12	12	12
Spine formula, exopods 1–4	3. 4. 3. 3	3. 4. 4. 3	3. 4. 4. 3	3. 3. 3. 3	2. 3. 3. 3	3. 4. 4. 3
Leg 1, number of setae on exopodal segment 3	5	5	5	4	5	5
Leg 2, exopodal segment 3, length ratio, terminal spine : segment	?	?	0.7 : 1.0	1.3 : 1.0	1.0 : 1.0	0.7 : 1.0
Leg 2, endopodal segment 3, length ratio, terminal spine : segment	?	?	?	1.6 : 1.0	1.0 : 1.0	1.0 : 1.0
Leg 3, exopodal segment 3, length ratio, terminal spine : segment	?	?	0.6 : 1.0	1.5 : 1.0	1.0 : 1.0	0.5 : 1.0
Leg 3, endopodal segment 3, length ratio, terminal spine : segment	?	?	0.7 : 1.0	1.4 : 1.0	1.1 : 1.0	0.6 : 1.0
Leg 4, exopodal segment 3, length ratio, terminal spine : segment	?	0.4 : 1.0	0.5 : 1.0	1.3 : 1.0	0.8 : 1.0	0.5 : 1.0
Leg 4 endopod, length ratio, inner terminal spine : outer terminal spine	2.0 : 1.0	1.5 : 1.0	3.0 : 1.0	1.1 : 1.0	1.7 : 1.0	2.0 : 1.0
Leg 5, inner seta	spiniform	spiniform	spiniform	slender	slender	spiniform
Leg 5, length ratio, inner seta : free segment	0.6 : 1.0	0.8 : 1.0	1.0 : 1.0	2.7 : 1.0	2.7 : 1.0	0.6 : 1.0
Leg 5, minute spinules on segment at base of inner seta	?	?	absent	present	absent	present
Caudal rami, length : width	2.5 : 1.0	1.4 : 1.0	2.7 : 1.0	2.5 : 1.0	3.4 : 1.0	2.2 : 1.0
Caudal rami, distal end of outer terminal seta (IV)	tapering sharply	tapering sharply	tapering sharply	blunt	tapering sharply	tapering sharply
Caudal setae, length ratio, seta III : seta VI	0.7 : 1.0	0.6 : 1.0	0.4 : 1.0	1.7 : 1.0	0.8 : 1.0	1.0 : 1.0
Caudal setae, length ratio, seta IV : seta V	0.8 : 1.0	0.6 : 1.0	0.6 : 1.0	0.8 : 1.0	0.7 : 1.0	0.6 : 1.0
References	Kiefer (1937)	Shen & Tai (1964)	Ishida (2002)	herein	herein	Karaytug <i>et al.</i> (1996)

Leg 5 (Fig. 5F), minute spinules absent on segment at base of plumose seta.

Male: unknown.

Condition of material

The labrum is missing. The mandible has two plumose setae distally broken off.

Etymology

The specific name is derived from the type locality.

Remarks

Ochridacyclops nepalensis is readily distinguishable from its congeners by exopodal segment 3 of leg 1 with two spines, and by the long caudal rami ($3.4 \times$ width). The new species is similar to *O. kenyaensis*, which is described above, in having 12-segmented antennule, exopodal segment 3 of leg 2 with three spines, and a long inner seta on leg 5. Further distinguishing characters from *O. kenyaensis* are as follows (character states of *O. kenyaensis* are in parentheses): posterolateral seta (III) length $0.8 \times$ terminal accessory seta (VI) ($1.7 \times$), terminal spine of exopodal segment 3 of leg 2 as long as segment ($1.3 \times$), terminal spine of endopodal segment 3 of leg 2 as long as segment ($1.6 \times$), terminal spine of exopodal segment 3 of leg 3 as long as segment ($1.5 \times$),

terminal spine of endopodal segment 3 of leg 3 length $1.1 \times$ segment ($1.4 \times$), terminal spine of exopodal segment 3 of leg 4 length $0.8 \times$ segment ($1.3 \times$) and leg 5 without minute spinules at the base of inner seta (present).

Habitat

This species was collected from the bottom of un-named mountain streams leading into Bhrung River, Pokhara, central Nepal.

DISCUSSION

Ochridacyclops is almost identical to *Paracyclops* in most respects, including the segmentation and setation of swimming legs 1 to 4 and the form of the seminal receptacles. Karaytug *et al.* (1996) indicated that *Ochridacyclops* is distinguished from *Paracyclops* by the elongated leg 5 and by the relatively smaller inner spine on leg 5. However, both sexes of *O. kenyaensis* (Figs. 1F, 4A) and female *O. nepalensis* (Fig. 5F) share a long inner spine (described as 'seta' in the present paper) on leg 5. Thus, the present investigation revealed that an elongated leg 5 is the only character distinguishing *Ochridacyclops* from *Paracyclops*. Karaytug *et al.* (1996) mentioned that comparison between the male antennules of the two genera might provide new data of significance at the generic level. In the present study, we collected male specimens of *Ochridacyclops* for the first time, but failed to detect any differences between the male antennule of *O. kenyaensis* and that of *Paracyclops*, except for seta A on segment 1, which is simple in *O. kenyaensis* but large and modified in most members of *Paracyclops*. Thus *Ochridacyclops* is distinguishable from *Paracyclops* only by the elongated leg 5 still as Karaytug *et al.* (1996) mentioned, but the leg 5 of *O. nipponensis* (Karaytug *et al.*, 1996, Fig. 1D) does not seem to be elongated. The difference in the relative length of leg 5 may be not sufficient to justify discrimination between these two genera. Molecular analyses will be indispensable to exam-

ine the validity of *Ochridacyclops*.

Ochridacyclops may be separable into two species groups: *O. arndti* and *O. brevicaudatus* vs. *Ochridacyclops iriomotensis*, *O. kenyaensis*, *O. nepalensis*, and *O. nipponensis*, the former possess an 11-segmented female antennule while in the latter it is 12-segmented.

ACKNOWLEDGMENTS

This study would not have been possible without the cooperation and assistance of Dr. T. Ishida. We express our sincere gratitude to Dr. A. Ohtaka (Hirosaki University) who generously donated samples to us. Thanks are also due to Dr. G. A. Boxshall (The Natural History Museum, London) and two anonymous reviewers for reading and commenting on the manuscript. Dr. M. Takeda (The National Science Museum, Tokyo) kindly provided catalogue numbers for the type material deposited at the NSMT.

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(Received October 13, 2004 / Accepted February 4, 2005)