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Two new species of Dicranophoridae (Rotifera: Monogononta) from Peter the Great Bay, Sea of Japan

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Two new species of rotifer belonging to the Dicranophoridae, and provisionally placed in the genus *Encentrum*, are described from littoral psammon from the Ussuriyskiy Bay, Peter the Great Bay, Sea of Japan, Russia. *Encentrum kutikovae* sp. nov. is characterized by a long foot consisting of three pseudo-segments, cylindrical toes, a hexagonal rami outline, and the right ramus showing an accessory chamber with alula. *Encentrum ussuriensis* sp. nov. is characterized by unusual stout toes with claw, an oblong-ovate and latero-caudal weakly angular rami outline, the right ramus bearing an alula, and the left one showing an accessory chamber.

INTRODUCTION

Information on the rotifer fauna of Peter the Great Bay has to date been restricted to a record of *Notholca (=Pseudonotholca) japonica* (Marukawa, 1928) from Patrokl Bay by Tagatz (1933), and two papers by Chaga (1974, 1984) reporting 14 species. Chaga (1984) described two new species, *Synchaeta pacifica* and *S. posjetica*, however, descriptions and figures are very poor, and both are considered *species inquirendae*. Identification of at least two other species are erroneous. *Anuraeopsis fissa* (Gosse, 1851) lacks a foot, while it is figured as having one, and *Colurella adriatica* Ehrenberg, 1831 has an angulate posterior margin, while it is shown with a blunt margin. The sketchy drawings of the other ten species (*Brachionus quadridentatus* Hermann, 1783, *B. urceolaris* Müller, 1773 *(sub B. urceus* (L.)), *B. plicatilis* Müller, 1786, *Notholca labis* Gosse, 1887, *N. acuminata* (Ehrenberg, 1832), *Keratella cruciformis* (Thompson, 1892), *K. quadrata* (Müller, 1786), *K. cochlearis* (Gosse, 1851), *Synchaeta pectinata* Ehrenberg, 1832 and *S. triophthalma* Lauterborn, 1894) generally correspond to the descriptions given by Kutikova (1970). However, the absence of figures of the trophi allows no confirmation of all of these identifications (except *S. triophthalma*, which shows the characteristic morphology of the foot). Recently, Chernyshev (2005a,b) reported 11 species of rotifer from Peter the Great Bay (Sea of Japan). Seven cosmopolitan species were first records for this area: *Synchaeta vorax* Rousselet, 1902, *S. baltica* Ehrenberg, 1834, *Lindia tecusa* Harring & Myers, 1922, *Trichocerca marina* (Daday, 1890), *Proales reinhardti* (Ehrenberg, 1834), *Encentrum marinum* (Dujardin, 1841) and *Colurella colurus* (Ehrenberg, 1830). Four species, *Synchaeta grimpei* Remane, 1929, *Aspelta clydona* Harring & Myers, 1928, *Encentrum algente* Harring, 1921 and *E. graingeri* Chengalath, 1985 were first records for the Pacific Ocean.

During an ongoing study of the psammon fauna of Peter the Great Bay by one of us (A.V.C.), two new rotifer species were found, the description of which is given in the present paper.

MATERIALS AND METHODS

The rotifers were collected in littoral sand and gravel from Ussuriyskiy Bay (Figure 1) of Peter the Great Bay (Sea of Japan) during 2003–2005. Specimens were fixed with formalin and extracted under a stereomicroscope. Extended specimens were obtained after adding boiling water.

Animals were examined and drawn using a Leitz Orthoplan microscope equiped with camera lucida. Preparation of trophi for light and scanning electron microscopy (SEM) was done following De Smet (1998) using NaOCl solution. For SEM a Philips SEM 515 microscope operated at 20 kV was used.

SYSTEMATICS

Phylum ROTIFERA Cuvier, 1812
Class EUROTATORIA De Ridder, 1957
Subclass MONOGONONTA Plate, 1889
Order PLOIMA Hudson & Gosse, 1886
Family DICRANOPHORIDAE Harring, 1913
Genus *Encentrum* Ehrenberg, 1838

Encentrum kutikovae sp. nov.
(Figures 2 &3)

Type locality

Sea of Japan, Peter the Great Bay, Ussuriyskiy Bay, Russia; in psammon (sand with gravel) from intertidal zone (middle mediolittoral). Collected A. Chernyshev, 16 May 2004.

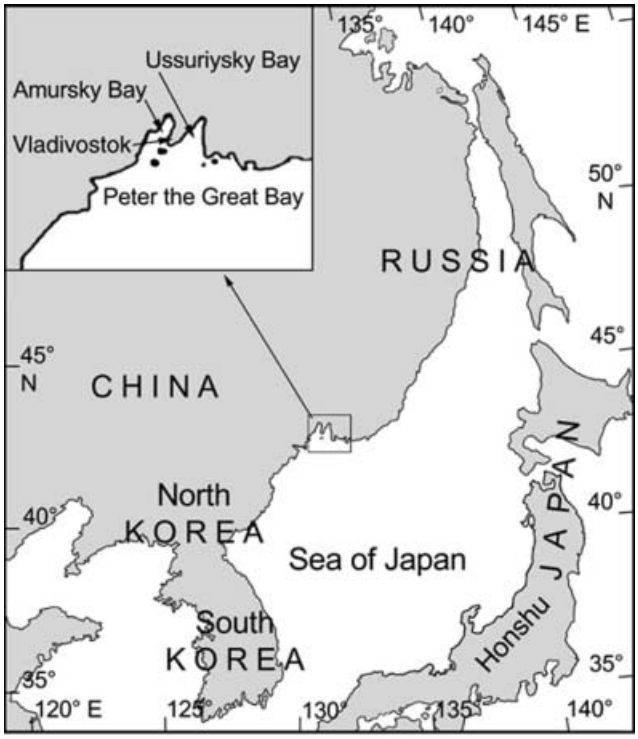

Figure 1. Map of study area.

Type material

Holotype: a parthenogenetic female in a permanent, glycerine glass slide mount deposited in the Koninklijk Belgisch Instituut voor Natuurwetenschappen (KBIN), Brussels, Belgium, No. IG. 30556, RIR156.

Paratypes: 22 females from type locality; collected by A. Chernyshev, 4 June, 20 September, and 10 November 2003, 10 March, 14 April and 16 May 2004. One female and trophi preparation in KBIN (RIR157); 4 mounted paratypes, 4 light microscopy and 9 SEM trophi preparations in Department of Biology, University of Antwerp.

Additional material: one female collected from Aufwuchs among a stand of the brown alga, *Padina pavonia* (L.) Gaillon, from the infralittoral fringe, Réunion, Indian Ocean, 24 December 1998. One female in shelly gravel, −54 m, Bay of Hyères, France, Mediterranean.

Etymology

The species is named after Professor Ludmila Kutikova, in honour of her outstanding work on rotifers.

Diagnosis

Foot long, three pseudosegments. Toes cylindrical, tips decurved ventrally. Trophi of modified *Isoencentrum*-type. Rami outline hexagonal. Right ramus with accessory chamber bearing alula inserted between basal and subbasal chamber. Two pairs of preuncinal teeth.

Description of parthenogenetic female

Body fusiform (Figure 2A,B). Head offset by neckfold, with weak transversal fold medio-dorsally. Rostrum rounded, shallow, with lateral sensory seta. Dorsal antenna near middle of head. Corona oblique. Trunk widest in anterior half, arched dorsally, more or less flat ventrally. Lateral antennae not seen. Foot long, three pseudosegments, distal pseudosegment cylindrical with distal margin somewhat wider. Toes (Figure 2C,D) cylindrical, kinkable towards ventral near midlength; bases weakly swollen; tips short, acute, decurved ventrally, dorsal margin of tips convex, the ventral concave; toes retractable in distal foot pseudosegment. Brain saccate, subcerebral glands present; brain and mastax with several glandular cells/glands. Two colourless light-

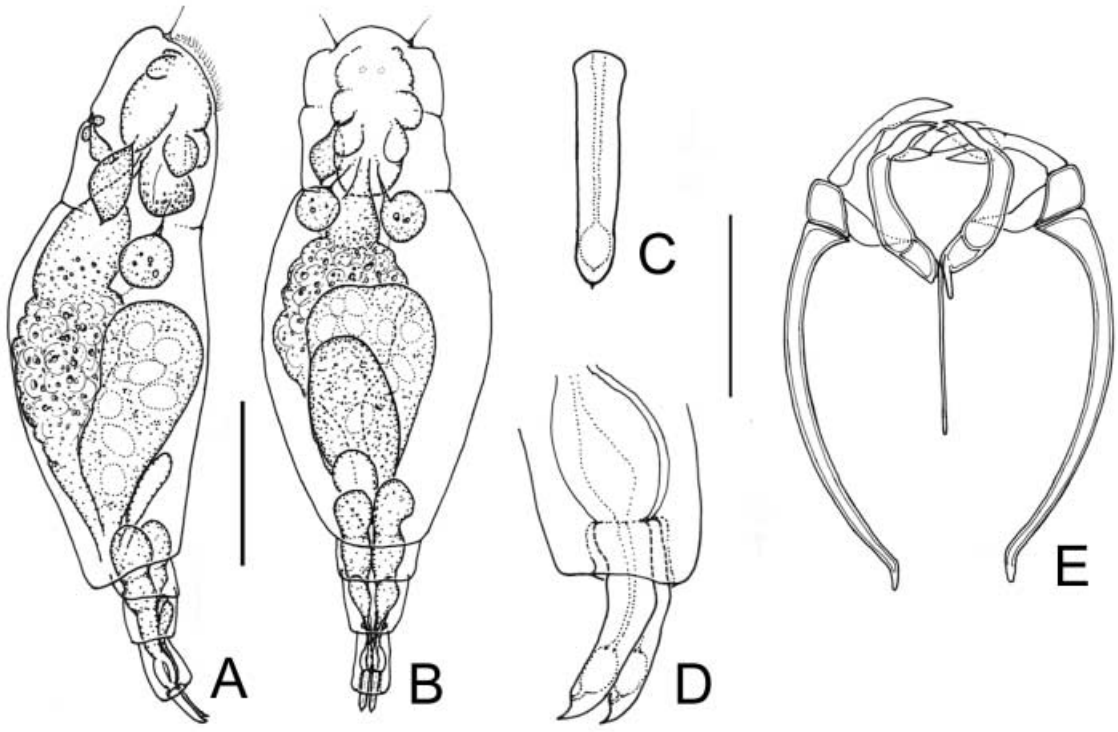

Figure 2. *Encentrum kutikovae* sp. nov.: (A) lateral view; (B) ventral view; (C) toe, dorsal view; (D) toes, lateral view; and (E) trophi, dorsal view. Scale bars: A,B, 50 μm; C–E, 10 μm.

refracting globules near base of rostrum. Two spherical glands at the usual place of the gastric glands, connected to the anterior of the mastax; apparently without duct to the stomach, but a weak ligament-like connection instead. A single large ovate gland at the right of the mastax (Figure 2A,B) or paired symmetrical glands laterally from mastax, connected anteriorly between brain and mastax. Proventriculus present. Bladder normal. Pedal glands large, extending into trunk, club-shaped, with reservoir in distal foot pseudosegment; ventrally two smaller, club-shaped accessory glands in foot. Vitellarium with eight nuclei. Parthenogenetic egg ovate.

Trophi forcipate, of modified *Isoencentrum*-type (Figures 2E & 3). Rami outline hexagonal; median rami opening roughly obovoid. Rami asymmetrical, fairly slender, each with slender, slightly offset and incurved apical tooth set at oblique angle to trophi axis; prior to each apical ramus tooth two preuncinal teeth; ventral preuncinal teeth stout, broadened with fairly long broad shaft and small cardal apophysis, placed at the same angle to the axis as the apical teeth; dorsal preuncinal teeth fairly slender with broad base, set at a right angle to axis. Right ramus proximally with pronounced alula pointing latero-caudally; this alula apparently belongs to a small accessory ramus chamber (Figure 3C,D & G: ac) intercalated between the basal and sub-basal chamber; basal and sub-basal rami chambers with usual openings; accessory chamber with small opening at basis of alula. Left ramus of normal build, but with small vestigial alula proximally (Figure 3C,D: vac). Fulcrum ramus length; narrow and parallel-sided in dorsal/ventral view; in lateral view straight, fairly broad, ventral margin almost straight, dorsal margin slightly decurving ventrally, distal end more or less rounded. Unci with offset head, slightly less shaft length; dorsal and ventral apophyses well developed, ventral ones with acute, small toothlet (Figure 3I: ta); foot of shafts weakly expanded. Intramallei trapezoid in lateral view; antero-ventral margin bearing supramanubria; antero-dorsal margin with two shallow, blunt processes grasping foot of uncinal shaft. Supramanubria plate-shaped, broadly triangular, with drawn-out, recurved tips. Manubria slightly less incus length, evenly curved in dorsal/ventral view, more or less straight in lateral view, slightly tapering and crutched distally; head ventrally with triangular expansion and large opening.

Male and resting egg unknown.

Measurements

Length 196–220 μm (mean=207 μm, N=9), toe 12–17 μm (mean=14, N=7); trophi: 25–28 μm (N=6): left ramus 8.4–10.3 μm, right ramus inclusive alula 9.6–11.6 μm, fulcrum 9.3–10.1 μm, uncus 7.5–9.6 μm, intramalleus (h×w) 2.8–3.2 μm×2.4–3.4 μm, supramanubrium (h×w) 4.2–5.1 μm×1.8–3.7 μm, manubrium 17.1–20.6 μm. Parthenogenetic egg: 64–67 μm×34–36 μm.

Distribution and ecology

Littoral psammon. Salinity 26–33; water temperature varying from 2°C (10 March) to 12°C (4 June). Accompanying rotifers: *Aspelta clydona*, *Colurella* sp., *Keratella cochlearis*, *Notholca squamula* (Müller, 1786), *Notholca* cf. *acuminata* and *Proales reinhardti*.

Comments

The trophi of *Encentrum kutikovae* sp. nov. bear a strong resemblance to those of the subgenus *Isoencentrum* (De Smet, 1997), from which, however, they differ by the presence of an extra ramus chamber with prominent alula, intercalated between the basal and sub-basal chamber.

The external morphology, especially the fairly long foot and cylindrical kinkable toes, appear to indicate a close relationship with the marine *Wierzejskiella ambigua* (Tzschaschel, 1979), *W. marina* Remane, 1949, and *W. subterranea* Remane, 1949. *Encentrum kutikovae* sp. nov. shares: (1) three foot pseudosegments with *W. subterranea* (two in *W. ambigua* and *W. marina*); (2) a hexagonal rami outline with *W. marina* (oval or rounded in *W. subterranea* and *W. ambigua*); and (3) evenly curved manubria with *W. ambigua* and *W. subterranea* (kinked in *W. marina*). Two pairs of preuncinal teeth is another character shared with *W. subterranea*, whereas only one pair has been reported in the other species, although one pair may have been overlooked. The new species is obviously distinct by its asymmetrically developed alula pointing caudally (alulae absent in *W. marina* and *W. subterranea*, two symmetrical triangular alulae laterally on basal chambers in *W. ambigua*).

Wiszniewski (1934) created the genus *Wierzejskiella*, characterized by the morphology of the long foot and cylindrical toes, to accommodate the limno-psammic *Encentrum elongatum* Wiszniewski, 1932, *E. sabulosum* Wiszniewski, 1932 and *E. velox* Wiszniewski, 1932, and the submerged moss dwelling *E. ricciae* Harring, 1914. Remane (1949), describing *Wierzejskiella marina* and *W. subterranea* from marine psammon, placed the new species in the genus in question on basis of similarities in body morphology with *W. velox*. He pointed to some differences, which in our opinion are relevant at the species level only, e.g. shape of the rostrum, more or less pronounced neck-fold, presence of subcerebral glands, and to more fundamental differences in trophi morphology, i.e. the much shorter intramallei and less angular latero-caudal rami outline. Relying on what he considered derived features of the toes, foot and body surface, Tzschaschel (1979) recognized five species groups in the genus *Encentrum*. One of them is the *E. velox*-group including *Encentrum ambiguum* Tzschaschel, 1979, *E. lineatum* (nom. nov. for *W. elongata*), *E. ricciae*, *E. sabulosum*, *E. subterraneum*, *E. vagneri* Koniar, 1955, *E. velox* and *E. wierzejskii* (nom. nov. for *W. marina*). This *E. velox*-group is characterized by a long to very long foot, cylindrical toes and habitat, i.e. limnic or marine psammon (with *E. ricciae* reported 'auch in Moosen', but in fact to date only collected from that microhabitat). De Smet (1997) retained the genus *Wierzejskiella* for the aforenamed species, but points out that several of them differ too much in trophi morphology to warrant their inclusion in a single genus, and calls for more exhaustive SEM studies of the trophi before redefining it. With the exception of the accessory ramus chamber, trophi of *E. kutikovae* sp. nov. are typically *Encentrum* (*Isoencentrum*), and lack manubria with bifurcate head, as well as strongly elongate intramallei and the typical rami outline characteristic for *W. elongata*, *W. ricciae* and *W. velox*. It follows that, since trophi morphology is the most important feature in the establishment of generic limits in Dicranophoridae,

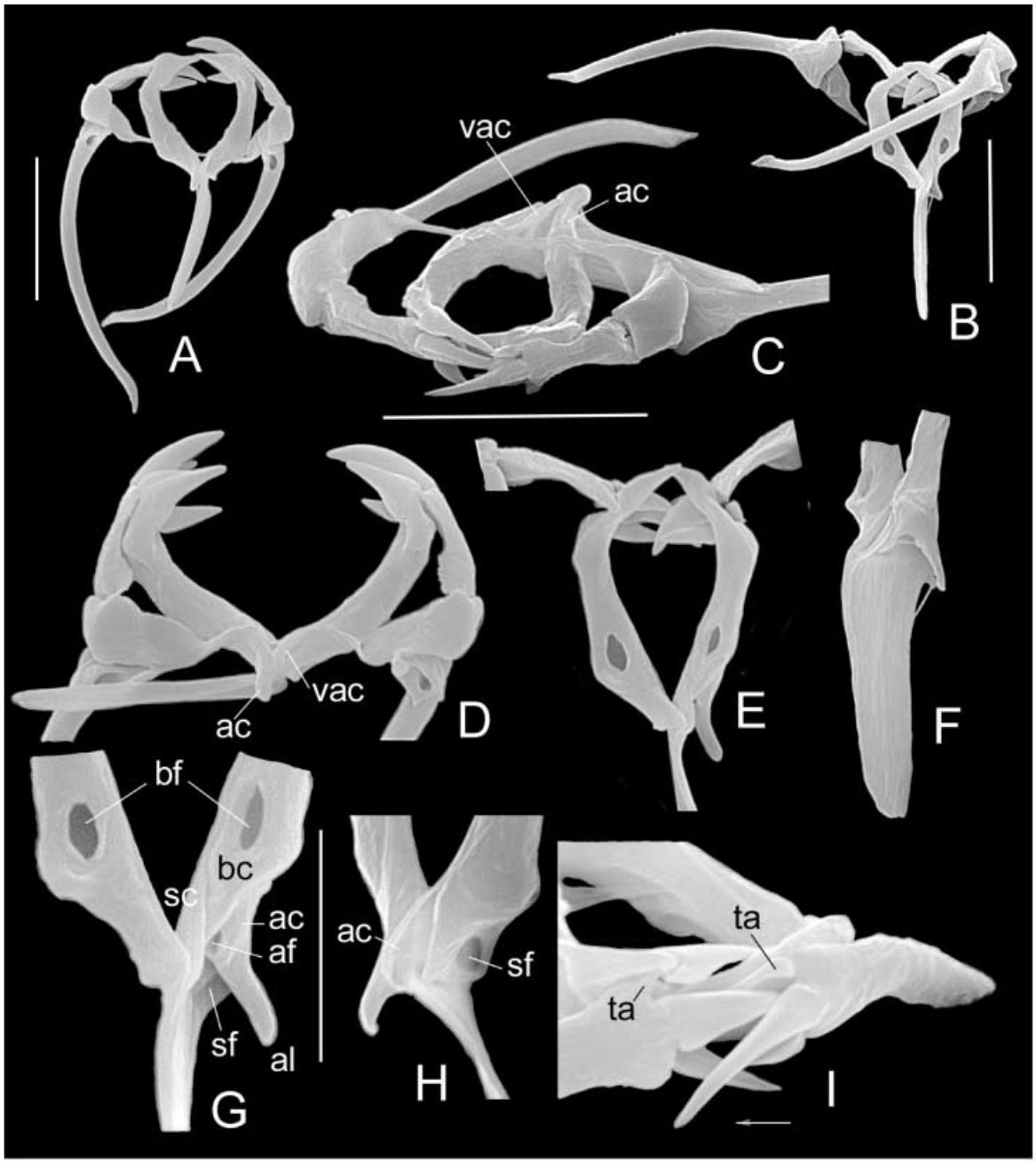

Figure 3. *Encentrum kutikovae* sp. nov., scanning electron microscope photographs of trophi: (A) ventral view; (B) dorsal view; (C) ventro-apical view; (D) detail, ventral view; (E) detail, dorsal view; (F) fulcrum, lateral view; (G) detail of rami chambers and alula, dorsal view; (H) same as (G), lateral view; and (I) detail uncinal teeth. ac, accessory chamber; af, fenestra of accessory chamber; al, alula; bc, basal chamber; bf, basifenestra; sc, sub-basal chamber; sf, sub-basifenestra; ta, toothlet on ventral uncinal apophysis; vac, vestigial accessory chamber. Scale bars: A–F, 10 μm; G,H, 5 μm; I, 1 μm.

the genus *Wierzejskiella* must be considered polyphyletic, and only *W. elongata*, *W. ricciae* and *W. velox* should be assigned to it. The generic placement of the other species remains to be settled after thorough study of the trophi by SEM: if the presence of accessory ramus chambers is a constant feature, in combination with a long foot and cylindrical toes, the creation of a new genus would be justified. The placement of the new species into the genus *Encentrum* should therefore be considered provisional.

According to Markevich (1989) and Markevich & Kutikova (1989), in Ploima (their superordo Pseudotrocha) each ramus is composed of three longitudinally oriented chambers, called apical, basal and sub-basal chamber (this is also the definition followed in the present descriptions). In Antrorsiramida (*sensu* Markevich, 1989), including Dicranophoridae, Lindiidae and Ituridae, the densely fused basal and sub-basal chambers form the main body of the rami, the apical rami chambers only being rudimentary, and tending to become isolated from the rami as e.g. oral platelets, pseudomallei, branching appendages, etc., or to participate in the formation of the apical region of the rami. However, the position of what was called the accessory chamber in the new species, suggests that this chamber might be the basal chamber, and what is generally called basal chambers in

Dicranophoridae might be the elongate apical chambers, implying a reduction of the basal chambers instead of the apical ones.

Encentrum ussuriensis sp. nov.
(Figures 4–6)

Type locality

Sea of Japan, Peter the Great Bay, Ussuriyskiy Bay, Russia; in psammon from intertidal zone (middle mediolittoral). Collected A. Chernyshev, 10 November 2003.

Type material

Holotype: a female in a permanent, glycerine glass slide mount deposited in the Koninklijk Belgisch Instituut voor Natuurwetenschappen (KBIN), Brussels, Belgium, No. IG. 30556, RIR158.

Paratypes: a female in glycerine glass slide mount, KBIN (RIR159); two SEM trophi preparations in Department of Biology, University of Antwerp.

Additional material: one female from type locality, 16 November 2005.

Etymology

The name of the new species is an adjective, derived from the type locality of the species.

Diagnosis

Toes stout, straight in dorsal/ventral view, decurved ventrally, with large claw. Trophi of modified *Isoencentrum*-type; rami outline oblong-ovate, weakly angular latero-caudally; right ramus with sub-basal/accessory chamber elongated into caudally pointing alula; left ramus with proximal accessory chamber.

Description of parthenogenetic female

Parthenogenetic female. Body fusiform, stout. Head broad, offset from trunk by neckfold, with dorsal transversal fold near midlength; dorsal antenna medially in anterior half; rostrum large, semi-circular. Corona almost frontal, weakly oblique. Trunk short, broad, only slightly less higher than broad. Lateral antennae small, near midlength of trunk. Foot large, conical, two large pseudosegments; apparently with weakly offset small distal pseudosegment. Toes (Figure 5B,C) stout, broad in dorsal/ventral view, with large pointed claws, bases weakly swollen, in lateral view decurved ventrally. Brain large, saccate. Gastric glands large, stalked. Pedal glands club-shaped, foot-length. Vitellarium large, eight nuclei.

Figure 4. *Encentrum ussuriensis* sp. nov.

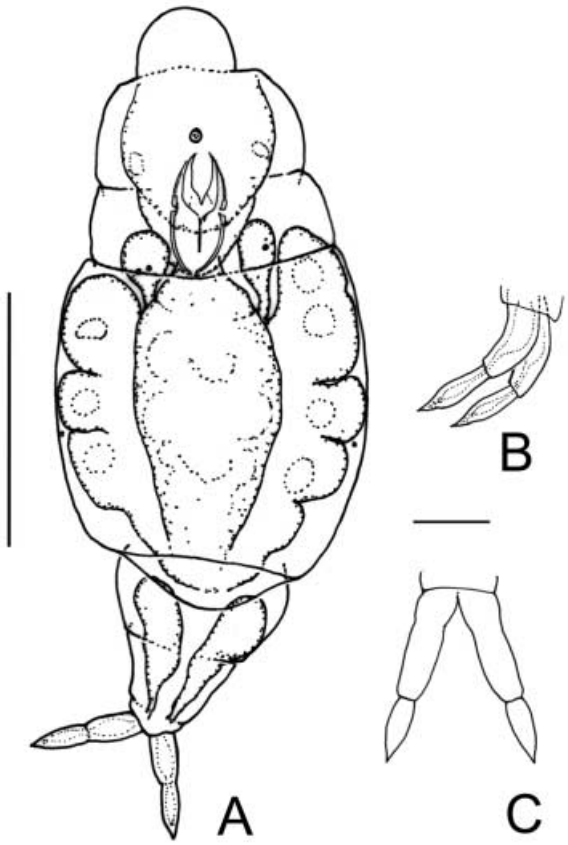

Figure 5. *Encentrum ussuriensis* sp. nov.: (A) dorsal view; (B) toes, lateral view; and (C) toes, dorsal view. Scale bars: A, ~50 μm; B,C, 10 μm.

Trophi forcipate, of modified *Isoencentrum*-type (Figure 6). Rami outline oblong-ovate, weakly blunt-angular latero-caudally; median rami opening broadly lanceolate. Rami asymmetrical, elongate, tapering distally to incurved apical tooth; apical teeth not offset from rami; somewhat distally from midlength of rami a single preuncinal tooth; left preuncinal tooth smallest, tapering to acute tip; right preuncinal tooth swollen medially, with more or less abruptly incurved acute tip. Right ramus proximally with pronounced alula pointing caudally; it could not be decided whether this extension is part of the sub-basal ramus chamber or an accessory chamber inserted between the basal and sub-basal chamber; basifenestra normal, sub-basifenestra absent? Left ramus in dorsal view of normal build, with basi- and sub-basifenestra; in ventral view proximally from sub-basal chamber apparently with small triangular ventral accessory chamber (Figure 6B: ac) with sickle-shaped opening (Figure 6B: af). Fulcrum ~$^2/_3$ ramus length,

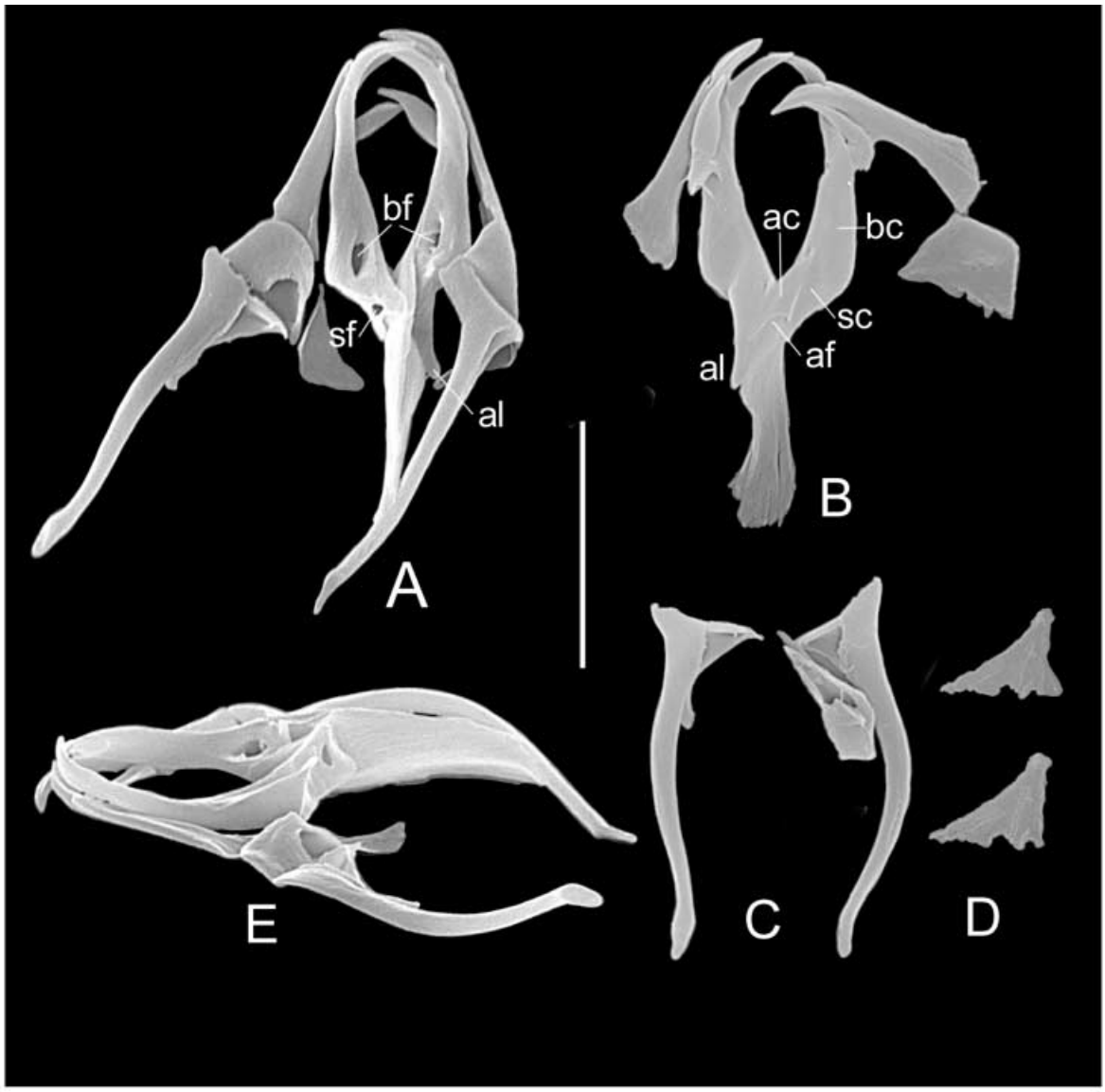

Figure 6. *Encentrum ussuriensis* sp. nov., scanning electron microcope photographs of trophi: (A) complete set, dorsal view; (B) incus and unci (ventral view), right intramalleus (lateral view outer side); (C) manubria (lateral view inner side), left intramalleus (lateral view inner side); (D) supramanubria; and (E) complete set, lateral view. ac, accessory chamber; af, fenestra of accessory chamber; al, alula; bc, basal chamber; bf, basifenestra; sc, sub-basal chamber; sf, sub-basifenestra. Scale bar: 10 μm.

narrow and parallel-sided in dorsal/ventral view; in lateral view fairly broad, very weakly decurved ventrally, tapering to rounded distal end. Unci with two appressed teeth; major tooth ventral with short, slightly incurved acute head $\sim^{1}/_{4}$ uncus length; the long shaft is gradually broadening ventrally and proximally; minor tooth dorsal, tiny, shorter than major tooth, shaft fused to major tooth, head free, small, apparently functioning as uncinal apophysis. Intramallei trapezoid in lateral view, right intramalleus smaller and less wide distally; both intramallei with large opening basally at inner side. Manubria almost symmetrical, evenly curved in dorsal/ventral view, in lateral view almost straight, head large, with fairly large triangular ventral chamber opening at inner side; cauda slightly crutched and outcurved.

Male, and parthenogenetic and resting eggs unknown.

Measurements

Length ~185 μm; toe 19–24 μm (mean=22 μm, N=6), claw 8–10 μm (mean=9 μm, N=6); trophi left/right (N=2): ramus 13.6 μm/11.5 μm, fulcrum 8.2–8.5 μm, uncus 9.3 μm/10.0 μm, preuncinal tooth 5.1 μm/3.8 μm, intramalleus (h×w) 3.0×4.8 μm/2.5×4.6 μm, supramanubrium 5.5×3.9 μm/4.6×3.6 μm, manubrium 14.5/15.5 μm.

Distribution and ecology

Encentrum ussuriensis sp. nov. is to date only known from its type locality, Ussuriyskiy Bay. Intertidal psammon. November. Salinity 33; water temperature ~10°C. Accompanying rotifers: *Encentrum kutikovae* sp. nov., *Proales reinhardti*.

Comments

The new species is easily recognized by its short and stout fusiform body, the semi-circular rostrum, the characteristic shape of its toes, and the structure of the trophi. It cannot be confused with any other congener. Toes with large claws, reminiscent of some members of the genus *Dicranophorus*, have never been reported in *Encentrum* (De

Smet, 1997). The new species is placed near the subgenus *Isoencentrum* on basis of the general trophi morphology. However, it differs from the *Isoencentrum* species studied by SEM to date (De Smet, 1997, 2000, 2003), by the asymmetrical rami with elongate right sub-basal/accessory chamber, and the presence of a proximal accessory chamber in the left ramus. Other differences concern the apparently two-toothed unci with the head of the major tooth continuous with the unilaterally expanded shaft (head usually distinctly offset, and shaft with apophyses and basal expansions in *Isoencentrum*), and the head of the minor tooth functioning as uncinal apophysis. In *Isoencentrum* the head of the manubria shows a triangular ventral expansion with ventral opening, whereas in the new species there is a distinctly delimited triangular ventral chamber opening at the inner side of the manubria.

In view of the above mentioned differences in trophi morphology with *Encentrum* (*Isoencentrum*), the placement of the new species in the genus *Encentrum* is provisional.

As for *E. kutikovae* sp. nov. and contrary to the view of Markevich (1989), the apparent presence of an accessory ramus chamber in *E. ussuriensis* sp. nov. rather suggests an elongation of the apical chambers, instead of a reduction.

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