

Paradicranophorus sinus sp. nov. (Dicranophoridae, Monogononta) a new rotifer from Belgium, with remarks on some other species of the genus *Paradicranophorus* Wiszniewski, 1929 and description of *Donneria* gen. nov.

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ABSTRACT. A new dicranophorid rotifer, *Paradicranophorus sinus* sp. nov., is described from periphyton originating from poikilohaline waters in Belgium. The main distinguishing taxonomic features of the new species are intramallei with supramanubria and a pair of preuncinal teeth. Taxonomic problems associated with the genus *Paradicranophorus* are briefly discussed. A new genus, *Donneria*, is proposed to accommodate *Paradicranophorus sudzukii* Donner, 1968. Information is presented on the trophi of *P. hudsoni* (Glascott, 1893) and *D. sudzukii* (Donner, 1968). *Encentrum brevifulcrum* Dartnall, 1997 is synonymised with *P. sordidus* Donner, 1968.

KEY WORDS : Rotifera, taxonomy, *Paradicranophorus*, new species, *Donneria* gen. nov., Dicranophoridae, thalassic waters, Belgium.

INTRODUCTION

Despite the recent upsurge of interest in rotifer biology and taxonomy, our knowledge of brackish and marine species still remains in its infancy world-wide. Information on brackish and marine rotifers from Belgium is largely restricted to plankton studies and opportunistic species records (see overviews in DE RIDDER, 1961, 1989, 1992; DE SMET, 1994, 1997, 2000). Virtually nothing is known about the species inhabiting psammic and periphytic habitats. In this contribution a new species of *Paradicranophorus* discovered among periphyton is described, and information on some other species belonging to the genus is presented. The status of the genus *Paradicranophorus* is discussed, and a new genus is established.

MATERIAL AND METHODS

The species was collected from algae during an ongoing study on the rotifer fauna of littoral thalassic habitats of the Belgian coast. Both samples for live examination and samples fixed with formaldehyde to a final concentration of 4 %, were taken. The rotifers were extracted in the laboratory using the swirl-decantation technique, and consequently concentrated on a 40 µm sieve. Animals were examined and drawn using a Leitz Orthoplan microscope fitted with a camera lucida. Preparation of trophi for light and scanning electron microscopy (S.E.M.) was done following DE SMET (1998) using NaOCl solution. For S.E.M. a Philips S.E.M. 515 operated at 20 kV was used.

RESULTS

Paradicranophorus sinus sp. nov.

(Figs 1-12)

Type locality. Ditch in Zwin Nature Reserve, Knokke Belgium. 22 April 1996.

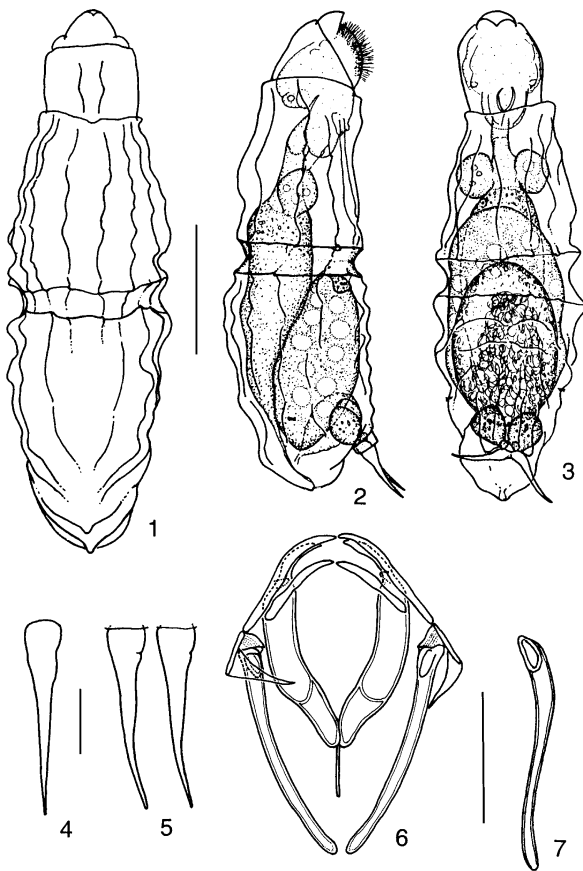
Material. Holotype : a female in a permanent, glycerine glass slide mount deposited in the Koninklijk Belgisch Instituut voor Natuurwetenschappen (K.B.I.N.), Brussels, Belgium, N° IG 29.287.

Paratypes : 62 females from type locality; data the same as for holotype. One female and trophi preparation in the K.B.I.N. One female and trophi preparation in the Laboratory for Animal Ecology, University of Gent, Belgium. Ten mounted paratypes, three light microscopy preparations and five S.E.M. trophi preparations in R.U.C.A.

Additional material : two females collected in the littoral of the Western Scheldt, St. Annastrand, Antwerpen, Belgium, 18 November 1995.

Etymology. The species name *sinus*, *-us* is the Latin noun for creek, bay, and refers to the Middle Dutch meaning of the name Swin of the type locality.

Diagnosis. The provisional generic placement of *P. sinus* sp. nov. is based on the following combination of character states : the overall shape of the body, the presence of transversal furrows in the trunk, the ventrally-displaced foot, and the shape of the elongate trophi. The new species is diagnosed by the presence of (1) 1-2 deep circular transversal



Figs 1-7. – *Paradicranophorus sinus* sp. nov. 1. dorsal view, 2. lateral view, 3. ventral view, 4. toe, dorsal view, 5. toe, lateral view, 6. trophi, ventral view, 7. manubrium, lateral view. Scale bars : 1-3 : 50 μ m, 4-7 : 10 μ m.

folds in the trunk, (2) intramallei and (3) a pair of preuncinal teeth.

Description

Parthenogenetic female. Body fusiform in dorsal view, broadly rounded or obtusely acute posteriorly; in lateral view highest in posterior half, abdomen bulging behind last foot pseudosegment, rounded. Head offset by distinct neckfold. Rostrum conspicuous, broad triangular, decurved ventrally. Submentum indistinct. Ventral papillae absent. Dorsal antenna small, in shallow depression near middle of head. Corona small, oblique. Trunk with longitudinal and transversal folds; 1-2 deep circular transversal furrows near mid-length; 1-2 V-shaped folds postero-dorsally. Cuticle weakly sticky, covered with detritus. Lateral antennae comparatively small, in posterior third of trunk. Foot ventral, two pseudosegments; large basal pseudosegment continuous with trunk, forming bulging section behind small distal pseudosegment; anterior delimitation of distal pseudosegment unclear. Toes swollen at their base, tapering towards acute apices, in dorsal view straight, in lateral view slightly decurved ventrally near posterior third or slightly S-shaped.

Eyespots absent. Brain saccate, short, with Y-shaped duct. Subcerebral glands large, with light-refracting globule. Salivary glands in mastax. Proventriculus absent. Gastric glands large, rounded, very short-stalked. Two large and two small ovate pedal glands. Bladder normal.

Vitellarium with ten nuclei. Subitaneous egg (inside body) ovate. It was impossible to determine whether the new species is viviparous or not.

Trophi forcipate, elongate, simple (Figs 6, 7, 8-12). Outline of rami elliptical; outer margin of rami slightly blunt-angular near transition of basal and sub-basal chambers; inner margin of rami without teeth. Median rami opening elongate drop-shaped; rami almost parallel-sided the greatest part of their length; each ramus with single, stout and distinctly offset apical tooth, set at an oblique angle to the trophi axis; opening of sub-basal chambers distally, small, rounded; opening of basal chambers dorsally, small, rounded, at posterior 1/3 of rami. Fulcrum very short, c. 1/4 ramus length, in lateral view plate-shaped, broad, rounded posteriorly. Unci single-toothed, long; shaft slightly longer than tooth; dorsal apophysis present only, conspicuous, triangular; lateral ribs of shaft weak, most pronounced postero-ventrally; uncinal teeth weakly curved. Each ramus with single preuncinal tooth; preuncinal teeth almost straight, long, c. 2/3 uncus length. Epipharyngeal fans not observed. Intramallei plate-shaped, curved, elongate-triangular, anterior half connected to unci and dorsal triangular expansion of head of manubria respectively; the latter connection by a series of c. ten fairly long and appressed ligaments; posterior half free, pointing latero-distally, bearing supramanubria. Supramanubria elongate-triangular, ending in more or less filamentous part inwardly, outer part of supramanubria grasping inner part of intramallei both anteriorly and posteriorly. Manubria long, c. incus length, very slightly curved in dorsal view, very slightly undulate in lateral view; head with triangular ventral and dorsal expansions.

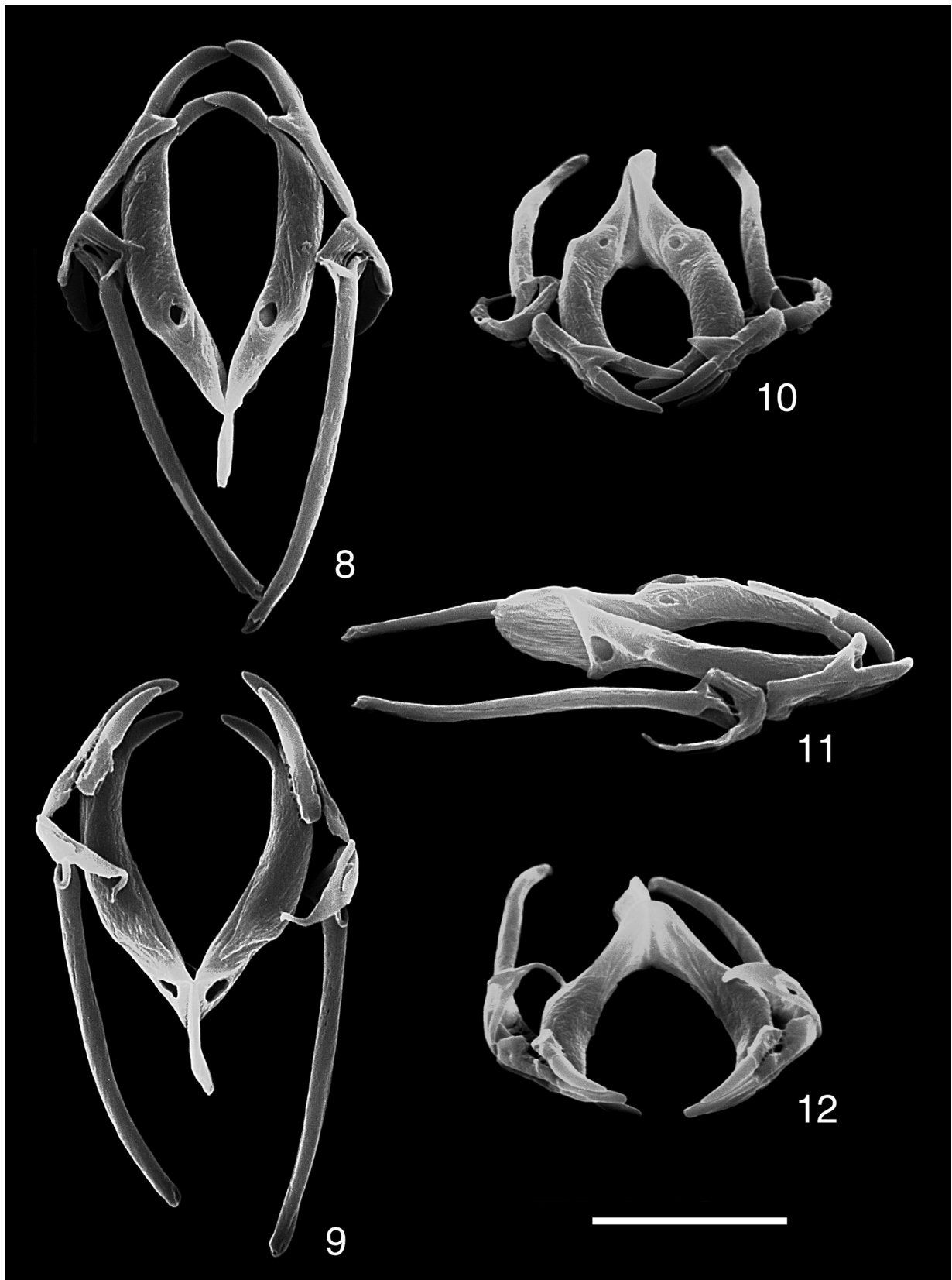
Male unknown.

Measurements. N=14. Total length 165-205 μ m, toe 22-30 μ m. Trophi 22.3-28.6 μ m : ramus 11.4-16.6 μ m, fulcrum 2.9-4.4 μ m, uncus 7.4-10.5 μ m, preuncinal tooth 5.1-7.0 μ m, intramalleus 4.4-5.2 μ m, supramanubrium 5.7-6.6 μ m, manubrium 16.3-19.0 μ m. Subitaneous egg (inside body) 76x46 μ m.

Comments

Five species of *Paradicranophorus* were recognized in a recent revision by DE SMET (1997): *P. aculeatus* (Neiswestnova-Shadina, 1935), *P. hudsoni* (Glascott, 1893), *P. sordidus* Donner, 1968, *P. sudzukii* Donner, 1968 and *P. verae* Bogoslovsky, 1958. A sixth species, *P. wesenbergi*, assigned to the genus was recently described by SØRENSEN (2001). The different species can be discriminated unequivocally by their trophi structure.

P. sinus sp. nov. is easily distinguished from *P. sudzukii* (*Donneria sudzukii* comb. nov., see further) by its elongate rami, which are semi-circular in the latter species. It differs from *P. aculeatus*, *P. hudsoni*, and *P. verae* by the presence of intramallei, which are absent in the latter. The new species shares the characters, presence of intramallei and supramanubria, with *P. sordidus* and *P. wesenbergi*. However, *P. sordidus* exhibits two preuncinal teeth prior to each apical ramus tooth instead of a single one. *P. wesenbergi* likewise displays a single preuncinal tooth, but the outer margins of its rami are angular



Figs 8-12. – *Paradicranophorus sinus* sp. nov., SEM photographs of trophi. 8. dorsal view, 9. ventral view, 10. dorso-apical view, 11. dorso-lateral view, 12. ventro-apical view. Scale bar : 10 μ m.

postero-laterally, instead of gradually incurving towards the fulcrum.

On the basis of external morphology alone, the new taxon could be confused with juvenile forms of *P. hudsoni*.

Distribution and ecology

To date, *P. sinus* sp. nov. is only known from its type locality, the Zwin (Knokke) and St. Annastrand, River Western Scheldt (Antwerp). It was collected in the littoral zone among the green alga *Enteromorpha intestinalis* (L.) Link and tufts of the substrate-bound filament-forming colonial diatoms *Parlibellus delognei* (Van Heurck) Cox and *P. pseudocomoides* (Hendey) Cox in the Zwin, and among the mat-forming siphon alga *Vaucheria* sp. in the Scirpo-Phragmitetum from the littoral of the river Scheldt. It thus can be assumed that *P. sinus* sp. nov. is a periphytic and littoral species. The chloride content of the Zwin water is highly variable, and fluctuates between mesohaline (1-10 g Cl⁻¹) and sea-water (>17 g Cl⁻¹) depending on the tides of the North Sea, evaporation, and dilution by freshwater (rain, supply from inland). A chloride content of 18 g Cl⁻¹ was measured at the time of sampling. The Scheldt estuary is characterized by a deeply-penetrating tidal wave, creating an inland salt gradient. At St. Annastrand the water of the Scheldt ranges from fresh to mesohaline water. It follows that *P. sinus* sp. nov. is an euryhaline species inhabiting poikilohaline waters. The finds of the species in April and November suggest that it prefers low temperatures.

Analysis of the gut-content showed that *P. sinus* sp. nov. feeds on diatoms.

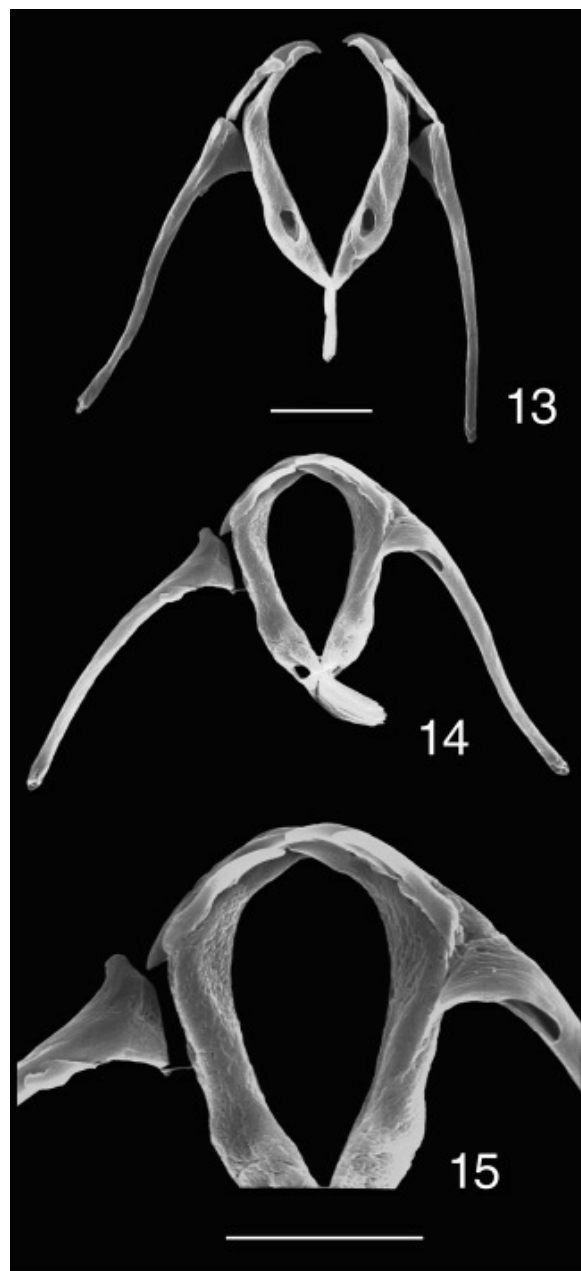
The accompanying rotifer fauna at the type locality consisted of unidentified bdelloids and the monogononts *Proales reinhardti* (Ehrenberg, 1834), *Encentrum algente* Harring, 1921, *E. marinum* (Dujardin, 1841) and *E. obesum* Tzschaschel, 1979. At St. Annastrand *P. sinus* sp. nov. co-occurred with *Cephalodella gibba* (Ehrenberg, 1832), *Encentrum algente*, *E. glaucum* Wulfert, 1936, *E. limicola* Otto, 1936 and *Encentrum* sp.

Remarks on other *Paradicranophorus* spp.

The study of additional material of some *Paradicranophorus* species allows for corrections and new information since the review by DE SMET (1997).

P. hudsoni (Figs 13-15)

SEM of the trophi reveals that the so-called subunci are in fact preuncinal teeth (according to nomenclature used in dicranophorids), participating in the formation of the ramus lock. The rostrum is broadly triangular and not rounded. To date, this probably cosmopolitan species (KOSTE & POLTZ, 1983; DE SMET, 1997) has been recorded in Belgium from benthos of the shallow (depth 1 m) Blokkersdijk, Antwerpen only (DE SMET, 1997). I have now found it also during the cold season in benthos of the Put van Ekeren, Antwerpen to a depth of 8 m.



Figs 13-15. – *Paradicranophorus hudsoni*, SEM photographs of trophi. 13. dorsal view, 14. ventral view, 15. ibidem, detail. Scale bars : 10 μ m.

P. sordidus

Examination of the type material of *Encentrum brevipulcrum*, described by DARTNALL (1997) from fresh and slightly saline lakes in the Vestfold Hills, eastern Antarctica, shows that it is synonymous with *P. sordidus*. Instead of rami “crowned by two small teeth” (DARTNALL, 1997 : 15, Fig. 2a), each ramus exhibits a single apical ramus tooth and two preuncinal teeth as shown by *P. sordidus*. Up to now *P. sordidus* was only known from its type locality Neusiedler See, Austria (DONNER, 1968; KOSTE & ZHUGE, 1995), and Blokkersdijk, Antwerpen, Belgium (DE SMET, 1997).

P. sudzukii
(Figs 16-24)

The trophi of *P. sudzukii* have been studied to date by light microscopy only (DONNER, 1968). Scanning electron microscopy reveals some interesting features of the preuncinal teeth, intramallei, supramanubria, manubria and unci. The apical rami teeth mentioned by DONNER (l.c.) actually prove to be well-developed preuncinal teeth (Fig. 17), extending far beyond the apical rami teeth, which are set at a more or less right angle to the trophi axis. Thus, the rami outline is roundish-depressed instead of rounded-elliptical. The strongly inwardly bent dorsal teeth at the inner margins of the rami prior to the acute tip of DONNER (l.c.) prove to be the apical rami teeth. The dorsal placement of these teeth was questioned by DE SMET (1997), who interpreted them as preuncinal teeth, based on DONNER's misinterpretation of the apical rami teeth. Indeed, the ventrally-located preuncinal teeth are usually set at an equal or less acute angle to the trophi axis than the apical rami teeth. Unique among the dicranophorids studied so far, is the partial fusion between the intramalleus and the head of the manubrium (Figs 17, 22, 23). This fusion mainly concerns the ventral and dorsal margins of both trophi elements. Instead of each having their own opening, intramallei and manubria show a common opening (co; Figs. 22). A small vestigial chamber is present on the ventral edge of the head of the manubria. The supramanubria (s; Fig. 22) deviate from the usual single-element configuration, in being composed of two basally-fused sclerite elements, each with free elongate projection pointing inwardly. DONNER (l.c., p. 225, Fig. 1.f) did not mention intramallei or supramanubria, but indicated the posterior margin of the supramanubria in his figure of the trophi. The unci are two-toothed (Fig. 24) instead of single-toothed. The shortest dorsal tooth is incurved anteriorly and functions as uncincl apophysis. Its incurved part is supported by a small process or uncincl apophysis of the greatest tooth (Fig. 21). Uncinal seams are lacking. Large and stout epipharyngeal fans are distinct (ep; e.g. Figs 17, 20).

Measurements. (N=2). Total length (slightly contracted) 230 µm, toe 28-30 µm, trophi 25-30 µm, ramus 9-10 µm, fulcrum 9-10 µm, uncus 11-12 µm, subuncus 7-7.5 µm, intramalleus 5-5.5 µm, supramanubrium 7.6-7.7 µm, manubrium 18-19 µm.

The specimens used in the present study came from psammon of the Colorado river, Colorado, U.S.A. To date *P. sudzukii* was only known from benthos of its type locality Neusiedler See, Austria.

Remarks on the genus *Paradicranophorus*

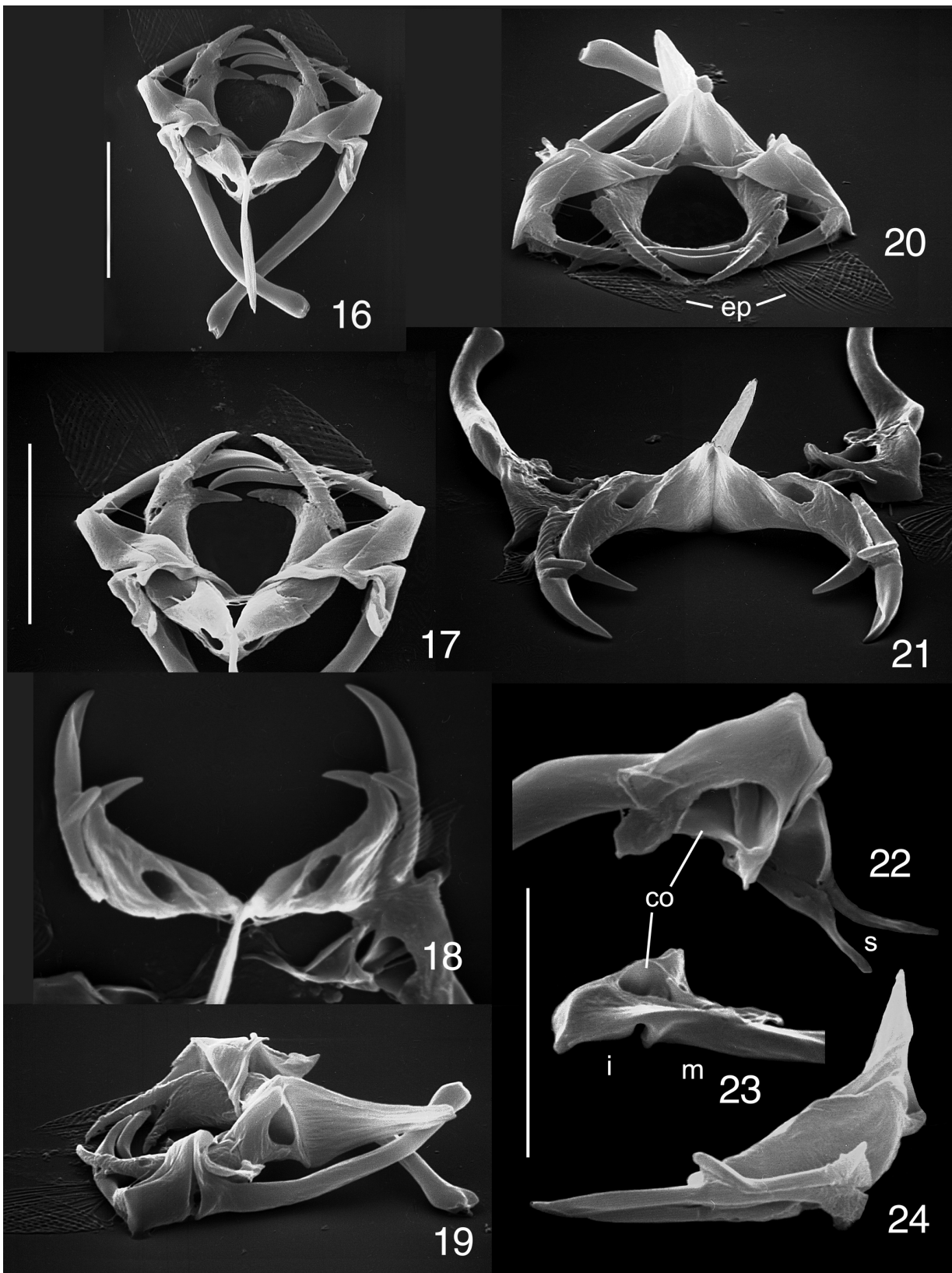
The type species of the genus, *P. hudsoni*, was originally described sub *Diglena hudsoni* by GLASCOTT (1893), and later transferred to *Dicranophorus* by DE BEAUCHAMP (1929), who also suggested that a special genus would not be out of place in view of its individuality. Uninformed of the papers by GLASCOTT (l.c.) and DE BEAUCHAMP (l.c.), WISZNIIEWSKI (1929, 1931/32) described the same species and introduced the generic name *Paradicranophorus* for species of the Dicranophoridae (at that time a subfamily of the Notozomatidae) having: a pyriform body with characteristic furrows, a small and ventrally-displaced foot with two short toes, an almost ventral corona composed of two ciliary fields

without locomotory capacity, and lyrate forcipate trophi, to mention the most important characters. Until recently (KOSTE, 1978, 1985; KOSTE & ZHUGE, 1995) the genus currently comprised six described species. DE SMET (1997) recognized five species (*P. aculeatus*, *P. hudsoni*, *P. sordidus*, *P. sudzukii*, *P. verae*) and assigned *P. wockei* to the new genus *Kosteia* on basis of the notable differences in morphology of the body and trophi. The new data on trophi morphology presented above allow a more detailed comparison of the species. An overview of the characters traditionally considered of taxonomical significance are briefly discussed below.

The body outline varies from fusiform (*P. aculeatus*, *P. sudzukii*, *P. wesenberglundi*) to pyriform (*P. hudsoni*, *P. verae*) with transitions between (*P. sinus*, *P. sordidus*). Consequently body form only helps to a certain extent in distinguishing the species, and is of little value in discriminating the genus from other dicranophorid genera. The pyriform shape of the body is probably an adaptation to the special environment, i.e. the surface of loose mud, in which most of the species live. At least in *P. hudsoni* it helps in anchoring, when during feeding it rotates all around the anterior part of the body prior to the circular transversal fold (pers. obs.). *P. wesenberglundi* has a well-developed corona allowing the species to swim in the water column (SØRENSEN, 2001). The other species display a weakly-formed corona resulting in a reduced swimming ability, and creeping way of locomotion using peristaltic movements (*P. aculeatus*, *P. hudsoni*, *P. sinus*, *P. sudzukii*) and/or snake-like wiggling of the body (*P. aculeatus*, *P. sudzukii*). The pyriform body and the more or less deep transversal and longitudinal folds (reported in all species, *P. verae* excepted), probably are adaptations that may help in obtaining a grip when creeping. There is no consistent patterning of either longitudinal or transversal folds. Deep circular transversal furrows are shared by *P. hudsoni* and *P. sinus* only. It follows that the presence and patterning of folds can not be used as a general character of the genus. The ventral head papillae of *P. aculeatus* are unique structures in rotifers, that probably serve for anchoring in crevices of the sand system or in capillary areas of detritus deposits (KOSTE & ZHUGE, 1995). A prominent submentum has been reported for the poorly-described *P. verae* only. The lateral antennae are situated in the anterior third of the body in *P. sudzukii*, and in the posterior third in the other *Paradicranophorus* spp. To our present knowledge, lateral antennae lying in the anterior part of the body have not been observed for any other dicranophorid species.

Two main types of trophi can be distinguished on basis of the rami outline and relative length of the trophi. In the first type, the rami are elongate and the fulcrum is relatively short (ratio length ramus : length fulcrum varying from 3.5 to 5.7); it is present in *P. aculeatus*, *P. hudsoni*, *P. sinus*, *P. sordidus*, *P. verae* and *P. wesenberglundi*. In the second trophi type, the rami outline is rounded and the fulcrum is relatively long (ratio length ramus : length fulcrum on average 1.0); it is found in *P. sudzukii*.

In the species of the first type with elongate rami and short fulcrum, some display preuncinal teeth (*P. hudsoni*, *P. sinus*, *P. sordidus*, *P. wesenberglundi*), which are reported missing in others (*P. aculeatus* (PAWLOWSKI, 1956, 1958; NEISWESTNOWA-SHADINA, 1935; OVANDER,



Figs 16-24. – *Donneria sudzukii* comb. nov., SEM photographs of trophi. 16. ventral view, 17. as Fig. 16, detail, 18. incus and unci dorsal view, intramalleus and head of manubrium, inner view, 19. ventro-lateral view, 20. ventro-apical view, 21. dorso-apical view, 22. intramalleus, head of manubrium and supramanubrium, inner view, 23. intramalleus and head of manubrium, dorsal view, 24. uncus, lateral view. Scale bars : 10 µm.

1977; KOSTE & ZHUGE, 1995), *P. verae* (BOGOSLOVSKY, 1958)). Care should, however, be taken in interpreting this lack of preuncinal teeth, because it is my experience with the dicranophorid genus *Encentrum* that these elements were often overlooked when light microscopy was used. A probably phyletically more fundamental difference within the group displaying trophi of the first type, is the trait presence/absence of intramallei. Intramallei are present in *P. sinus*, *P. sordidus* and *P. wesenbergi*, and absent in *P. aculeatus*, *P. hudsoni* and *P. verae*. Well-developed intramallei is one of the main diagnostic features in *Encentrum*, although similar but usually less-developed sclerite elements have been reported in *Erigonatha*, *Dicranophorus* (two species considered *incertae sedis*), *Inflatana*, *Kostea*, *Wierzejskiella* and *Wigrella* (DE SMET, 1997). However, the overall similarity of the trophi of intramallei-bearing *Paradicranophorus* spp. is greatest with the genus *Encentrum*, particularly with *E. uncinatum* and related species. Considering this and the above-mentioned diversity in characters of generic value (viz. body shape, corona, transversal folds, placement of foot, etc.), the actual genus *Paradicranophorus* (exclusive of *P. sudzukii*, see below) may include two distinct groups, namely (1) species of the first trophi type without intramallei, (2) species of the first trophi type with intramallei related to, or belonging to *Encentrum*. The placement of the new species into *Paradicranophorus* is therefore provisional, pending new information by molecular techniques.

The species displaying the second trophi type with roundish-depressed rami outline and long fulcrum (*P. sudzukii*), moreover differs considerably from the other *Paradicranophorus* species in the dimension and position of the preuncinal teeth, the shape and structure of the maleus, in particular the partially-fused intramallei and manubria with common opening, the supramanubria composed of two sclerite elements, and the large and stout epipharyngeal fans. This character state, in combination with the lateral antennae located in the anterior third of the body, likewise distinguishes *P. sudzukii* from the other dicranophorid genera, and in my opinion provides sufficient justification for a distinct generic status.

Donneria gen. nov.

Diagnosis. Body fusiform, foot placed ventrally. Lateral antennae in anterior third of trunk. Trophi forcipate, with partially-fused manubria and intramallei, showing common opening. Supramanubria composed of two basally-fused sclerite elements, each with free elongate projection. Rami outline roundish. Preuncinal teeth long, projecting beyond apical rami teeth. Unci consist of two appressed teeth. Fulcrum long, ramus length.

Type species. *Paradicranophorus sudzukii* Donner, 1968, by present designation.

Etymology. The genus is named in honour of the late Josef Donner (1909-1989), eminent Austrian rotiferologist.

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Araya is acknowledged for providing specimens of *Donneria sudzukii*. Dr. L. Denys kindly identified the diatoms. This study was partially supported by a R.A.F.O. fund awarded by R.U.C.A.

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