

Two new interesting genera of Gastrotricha (Macrodasysida and Chaetonotida) from the Brazilian freshwater psammon

Jacek Kisielewski

Zakład Zoologii WSRP, ul. Prusa 12, 08-100 Siedlce, Poland;

and Departamento de Zoologia, Instituto de Biociências, Universidade de São Paulo, Brazil

Keywords: Gastrotricha, freshwater psammon, Brazil

Abstract

Two new genera and species of Gastrotricha are described from the psammon of a freshwater body in Brazil: *Redudasys fornerise* and *Arenotus strixinoi*. The former is the first undoubted member of the order Macrodasysida recorded from a freshwater environment. It is characterized by the reduction in number of adhesive tubes, the absence of male sexual organs and the presence of a well-developed protonephridial system. The latter belongs to the order Chaetonotida (family Chaetonotidae) and is characterized by the uniform body covering with a thick layer of soft homogeneous cuticle. A possible mode of colonization of fresh waters by marine Macrodasysida, involving colonization of freshwater areas underlying marine beaches, is discussed.

Introduction

During the study of freshwater gastrotrichs conducted in the state of São Paulo, Brazil in the year 1984, in the psammon of a water body I had the venture to find specimens belonging to new genera. One of them could be assigned to the order Macrodasysida, and the other to the order Chaetonotida. This paper contains the descriptions of both taxa. Other gastrotrichs found at the same locality, as well as remaining species detected in Brazil during the study, will be described in a separate paper.

Material and methods

All records of both new taxa derive from the freshwater reservoir Represa do Lobo. It is an artificial lake 7.5 km in length, 0.9 km in average width and 3.0 m in average depth (Strixino, 1973). It is located in the subtropical zone, in the middle-east region of the São Paulo state, about 16 km south from the town São Carlos (geographical coordinates of the reservoir are 22°15' S and 47°49' W). The distance from the Atlantic shore is

about 280 km. Represa do Lobo was formed in 1936 by damming a small river, Ribeirão do Lobo, belonging to the basin of Tietê river – one of the eastern tributaries of the river Paraná. Soils in the region are holocenic (Trindade, 1980). No marine-originated sediments were detected and the main geological formation consists of volcanic basalt rocks. Relatively recent marine sediments, estimated as plio-pleistocenic, occur only about 100 km SE away (de Almeida, 1974).

Samples were taken from the NW part of the reservoir, near the mouth region of the stream Córrego das Perdizes. The water body borders at this place on the savanna ('cerrado'). *Redudasys fornerise* gen. et sp. nov. and *Arenotus strixinoi* gen. et sp. nov. were found in a sample taken on 22 August 1984 (one and three individuals respectively) and during the period between 25 September and 1 October 1984 (about fifty and sixteen individuals respectively). The substrate consisted of a medium and fine sand, poor in organic matter. The material was collected near the shore from the 5 cm surface layer of the sand and kept in 0.5–2 dcm² containers for several days after sampling. Only the uppermost layer of sand was taken

from a container for analysis. The animals were selected directly from the substratum and/or using $MgCl_2$ technique of extraction. Living material narcotized by means of $MgCl_2$ or crystalline novocaine was studied first and then animals were fixed in 4% formalin neutralized and salt. A majority of animals studied, including type-specimens, was mounted in formalin-glycerin and sealed with glyceel. Several specimens of both taxa were fixed in 2% glutaraldehyde and will be used for histological examination in the future. Brightfield and phase contrast microscopy were used for the study. The drawings were realized mostly from living specimens.

Order Macrodasysida Remane, 1925

Incertae sedis

Redudasys gen. nov. (Fig. 1a–c)

Etymology: from the Latin 'reductio' – reduction and Greek 'dasus' – hairy, referring to the paucity of ventral ciliation.

Diagnosis: Macrodasysid with weakly marked head bearing no protrusions. No cuticular armature. Ventral cilia distributed in groups arranged in paired longitudinal series along the anterior part of body and unpaired median ones along the posterior trunk part. Two pairs of ventral anterior adhesive tubes arising from small body elevations. The caudal region distinctly bilobed, with two pairs of posterior adhesive tubes and no median protrusion. Lateral tubes absent except for a few short dorso-lateral ones occurring in minority of specimens. Pharynx with ventro-lateral pores located near its end. Non-cuticularized mouth cavity, narrow and located terminally. Paired lateral ovary. Protonephridia occurring. Ventral muscles cross-striated.

Type species: *Redudasys fornerise* sp. nov.

Etymology: The species is dedicated to Dr. Liliana Forneris, professor of the University of São Paulo.

Type specimens: Holotype deposited with the Department of Zoology, University of São Paulo; 5 paratypes kept in the author's collection.

Diagnosis: the same as the genus.

Description

Body length of mature specimens ranges from 300–414 μm . Ventral surface is flat and dorsal one convex. A weakly marked head is as wide as the middle part of trunk. No tentacles or other kinds of cephalic protrusions occur. A slight narrowing at the posterior pharynx extremity and a distinct one at the caudal base are present. There are to elongated caudal lobes 8–12 μm long and 7–10 μm wide. No median caudal cone was detected.

The body surface is smooth and transparent, without any cuticular formations. Epidermal glands were not detected. Cephalic cilia occur in one transverse dorsal spaced row as well as in irregularly distributed tufts located at the antero-lateral head margin. The mouth opening is surrounded with slightly more rigid cilia reaching length of 10 μm . The ventral ciliation of the anterior body region consists of three paired ciliary fields (Fig. 1b). Two closely located series of ventral cilia are distributed irregularly and form fields of unequal size along the posterior part of pharyngeal region and anterior trunk region. An unpaired longitudinal series of four ventral cilia fields, each of them consisting of 10–12 cilia, run along the posterior trunk region. The rearmost field is located near the caudal base. Usually one pair of dorso-lateral tactile bristles at the mid-pharynx region, five pairs along the trunk, and one pair on the caudal lobes occur.

Only anterior and caudal adhesive tubes are typically present. There are two pairs of anterior tubes, which are located about 45 μm from anterior body extremity and arise from small body elevations. The tubes, unequal in length, are placed one above another and directed slightly backward. The tube situated above is 9–14 μm in length, being at least twice as long as the other and having its tip projecting from the lateral body margin. There are two pairs of caudal adhesive tubes as well. The inner tube (8–12.5 μm long) is usually 1/4 shorter than the external one (11–17 μm long). In one individual of the 30 examined, two supplementary dorso-lateral tubes were observed. The tubes were located at 100 and 50 μm from the posterior body extremity and were 9.5 and 6 μm long respectively. Like anterior and caudal tubes, the supplementary ones did not bear any tactile bristles.

The mouth cavity is 15–25 μm long, slightly

narrower than the pharynx and non-cuticularized. The triangular pharynx lumen position corresponds to an inverted letter Y: λ . A pair of pharyngeal pores occurs at about $15 \mu\text{m}$ from the pharynx end. Apparently the pores are functional

since their course in the muscle as well as canals opening by ventrolateral funnels were observed in several specimens studied. The intestine is considerably thicker in its anterior half than in the posterior one. The anus is ventral.

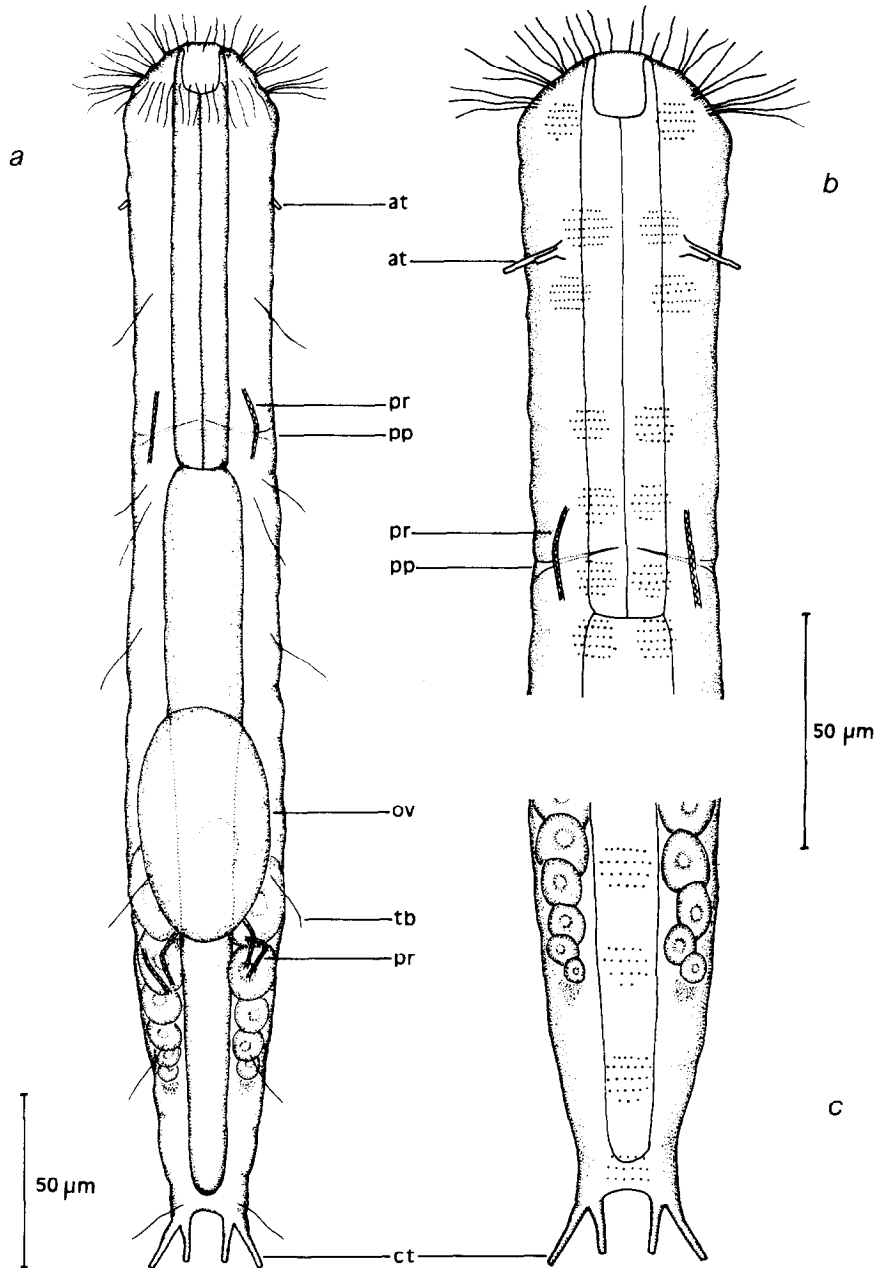


Fig. 1. *Redudasys fornerise* gen. et sp. nov.; a – general dorsal view, b – ventral view of the anterior body region, c – ventral view of the posterior body region. at – anterior adhesive tubes,

ct – caudal adhesive tubes, ov – ovum, pp – pharyngeal pore, pr – flame bulbs of protonephridia, tb – tactile bristle.

The protonephridia with at least three pairs of flame bulbs occur laterally. A pair of them is located at the level of pharyngeal pores and two remaining ones, being placed close to one another, are at 2/3 of the trunk length. The flame bulbs may be bent forming a right or even acute angle. The longitudinal ventral muscles with distinct transverse striations were observed along the whole body of several animals.

A paired lateral ovary with the oocytes maturing anteriorly is present. The most mature ovum is kept in the dorsal body cavity above the intestine. No male or accessory female sexual organs were detected.

Both body shape and animal movement are typical for the macrodasyid and resemble most of all the members of the genus *Turbanella* Schultze, 1853. A teased *Redudasys* withdraws rapidly, 'striding' by means of muscle contraction and alternating adhesions of anterior and posterior tubes.

Discussion

Redudasys fornerise gen. et sp. nov. is the first undoubted macrodasyid recorded from the freshwater environment. Its affiliation with the order Macrodasyida is shown by the presence of pharyngeal pores, as well as the λ -like pharynx lumen position. The lack of male and/or accessory female sexual organs makes impossible the classification of the genus into one of the existing families. The paired ovary and the presence of parallel anterior adhesive tubes which arise from body elevations eliminates the possibility of assignment of the family Thaumastodermatidae Remane (Hummon, 1982). The distribution of the anterior tubes as well as the clearly bilobed caudal region excludes *Redudasys* from the family Macrodasyidae Remane; the former feature makes doubtful the affiliation of *Redudasys* also with the family Planodasyidae Chandrasekhara Rao and Clausen. *R. fornerise* differs from the majority of members of the family Lepidodasyidae Remane in having a paired ovary and bilobed posterior body end. Only the genus *Paradasys* Remane shows occasionally those characters (Hummon, 1982), however, it has anterior tubes borne directly from body surface.

Redudasys has the most common characters with the family Dactylopodolidae Strand and, in partic-

Table 1. Measurements of *Redudasys fornerise* gen. et sp. nov. (in μm)

| | Range | \bar{x} | n |
|--|-----------|-----------|----|
| length of mature animal | 300 – 414 | 352.0 | 16 |
| length of pharynx including mouth cavity | 101 – 154 | 121.9 | 12 |
| length of longer anterior tube | 9 – 14 | 12.4 | 10 |
| length of shorter anterior tube | 3 – 6.5 | 5.2 | 9 |
| length of external caudal tube | 11 – 17 | 14.8 | 20 |
| length of inner caudal tube | 8 – 12.5 | 10.8 | 20 |

\bar{x} = mean value; n = number of measured individuals

ular, with Turbanellidae Remane. The members of both mentioned families have the anterior adhesive tubes originated from the body elevations, a pair of well-developed caudal lobes and (in Dactylopodolidae) easily seen cross-striated trunk musculature. All the three genera of Dactylopodolidae differ considerably from *Redudasys*: *Dactylopodola* Strand in having distinct lateral tubes, more numerous anterior and caudal adhesive tubes and cuticularized mouth, *Dendrodasy* Wilke in having cephalic lateral lobes and distinctly furcate (or bifurcate) posterior body end, and *Xenodasy* Swedmark in having two pairs of cephalic tentacles, cuticular armature and chordoid organ (Hummon, 1982). Amongst the family Turbanellidae Remane, the genus *Turbanella* Remane shows the most common characters with *Redudasys*, having often both a head lacking protrusions and non-cuticularized mouth. The ability of *Redudasys fornerise* to 'stride' rapidly backwards using alternatively the anterior and caudal adhesive tubes is an additional character in common with *Turbanella*, since this peculiarity may be quite often observed amongst the species of the latter genus (my own observations). *Redudasys fornerise* differs however from *Turbanella* in having anterior adhesive tubes directed laterally, whereas the tubes of the compared genus are directed forwards. The number of both anterior and caudal tubes of *Redudasys* is lower than recorded for *Turbanella*, and its lateral tubes are lacking (or reduced to a few rudimentary ones occasionally), whereas *Turbanella* shows always a dis-

tinct group of them. Although belonging of *Redudasys* to the family Turbanellidae seems to be the most probable, the newly described genus should be provisionally considered as incertae sedis, since no data are available on its male reproductive organs.

Ruttner-Kolisko (1955) described a new genus and species of gastrotrich, *Marinellina flagellata*, from Austrian river psammon. Unfortunately, the description is not complete, and both the pharynx: intestine length ratio and lack of sexual organs suggest in addition that only juvenile material was analysed. The author classified *M. flagellata* into the order Macrodasyida based on the occurrence of one anterior and two posterior pairs of adhesive tubes. Remane (1961) transferred the taxon to the chaetonotid family Dichaeturidae Remane based on the fact that the pharyngeal pores were not detected and Macrodasyida is a group of exclusively marine animals. In addition, he considered that cephalic protrusions of *M. flagellata* are not anterior adhesive tubes, and should be regarded as tentacles. The last Remane's assumption is very problematic. It based on the fact that the Ruttner-Kolisko's drawing of *M. flagellata* suggests a dorsal position of the protrusions, whereas anterior adhesive tubes are always situated ventrally. It should be mentioned that a dorsal position of protrusions was not confirmed in the original description, and the protrusions shown on the drawing (Ruttner-Kolisko, 1955, Fig. 8a), the left one in particular, have the appearance of typical short adhesive tubes born from a thick base and do not resemble any chaetonotid tentacle. Therefore, to consider the occurrence of anterior adhesive tubes in *M. flagellata* seems to be more proper, and their dorsal position on the Ruttner-Kolisko's drawing should be rather regarded as an author's mistake. The pharyngeal pores, which were not observed in *M. flagellata*, are sometimes difficult to detect even amongst typically marine Macrodasyida. Therefore, this inadequately described taxon should rather be classified, according to the intention of Ruttner-Kolisko, into the order Macrodasyida, as incertae sedis.

The discovery of *Redudasys fornerise*, clearly a macrodasyid living in a freshwater environment, is of evolutionary interest. Up to now, only few macrodasyids adapted to brackish water of low salinity have been known, belonging to the family Turbanellidae in particular (d'Hondt, 1971a; Hum-

mon, 1971). Riemann (1966) found *Turbanella* cf. *cornuta* Remane, 1925 on the oligohaline zone of the Elbe estuary, including a region of salinity as low as 1 p 1000. Recently, I found a numerous population of *Turbanella lutheri* Remane, 1953 in the depth of a freshwater spring (the salinity lower than 1 p 1000) on the marine beach in Roscoff, France (unpublished data). All these records show that members of the order Macrodasyida can overcome the physiological barrier in the colonization of fresh waters. The finding of *R. fornerise* and the mentioned above record of *Turbanella lutheri* from Roscoff suggest that colonization of inland waters by marine macrodasyids could have occurred in water bodies formed round about beach springs during the marine regression.

The morphology and anatomy of *Redudasys fornerise* shows interesting modifications in relation to its marine relatives. The number of adhesive tubes is reduced to only four pairs in the majority of specimens. Reproduction is apparently based mainly, if not exclusively, on parthenogenesis. It is interesting to note that the pharyngeal pores, which are a peculiar adaptation of macrodasyids to life in sea water, are still preserved and probably functioning. The protonephridia are well-developed and easy to detect.

Order Chaetonotida Remane, 1925

Suborder Paucitubulatina d'Hondt, 1971

Family Chaetonotidae Zelinka emend. Hummon, 1969

Arenotus gen. nov. (Fig. 2a–b)

Etymology: from the Latin 'arena' – sand, beach and the Latin 'notus' – known; referring to the habitat of the animal.

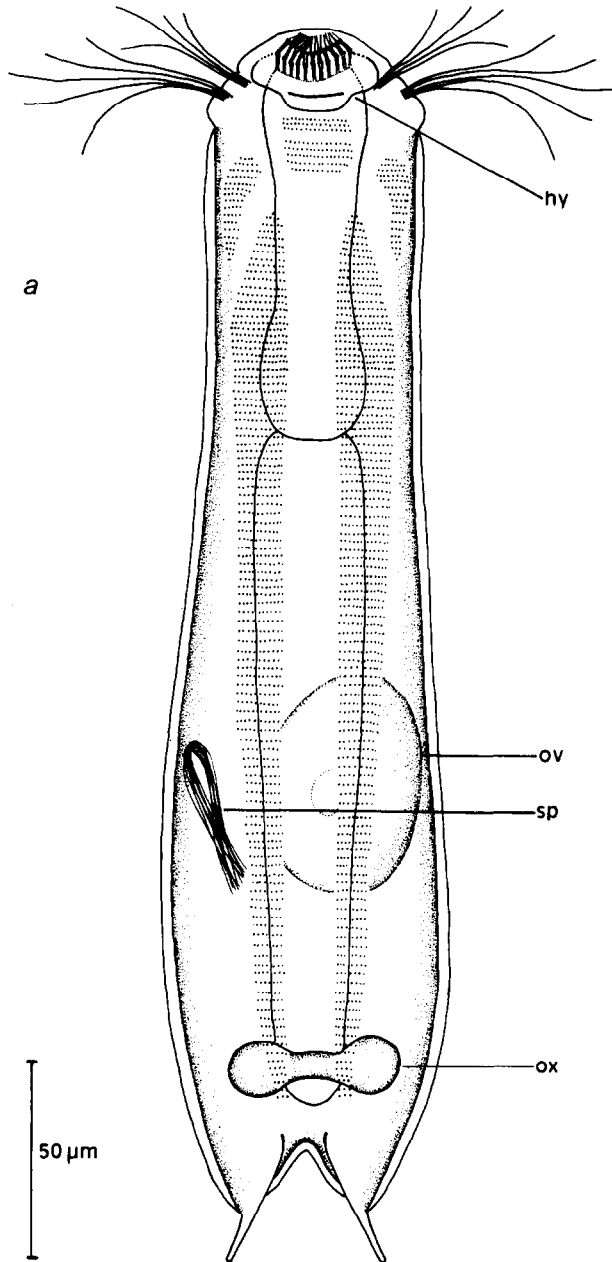
Diagnosis: Chaetonotidae with the whole body, including ventral ciliary areas, covered with thick and soft homogeneous cuticular layer, clearly distinct from the epidermis; only the cephalion, the two pairs of pleuria, the hypostomion and the terminal parts of adhesive tubes are developed separately. No other cuticular formations are present. Mouth ring long and of complicated structure. Pharynx with anterior and posterior thickenings and a pair of strong teeth. Adhesive tubes short and non-articulated.

Type species: *Arenotus strixinoi* sp. nov.

Etymology: The species is dedicated to Dr. Giovanni Strixino, professor of the University of São Carlos.

Type specimens: Holotype deposited with the Department of Zoology, University of São Paulo; 5 paratypes kept in the author's collection.

Diagnosis: the same as the genus.



Description

The body length ranges from 271–336 μm . The body shape is typical for the majority of members of the family. The head outline is five-lobed. The cephalion adheres entirely to the head surface and is considerably larger than pleuria, being 17–18 μm in length and 38–43 μm in width. The pleuria of the first and second pairs are 9.5 μm and 7.5 μm long respectively. The hypostomion is a large shield bordering with the mouth ring in its anterior part (Fig. 2a). A relatively weak transverse furrow, 15–18.5 μm in length, occurs in its posterior part. Two pairs of well-separated tufts of cephalic cilia are present; they are antero-ventral and postero-lateral in position. The short adhesive tubes (13.5–18 μm in length) arise from rather short and thick basal regions. The dorsal side of the tube is prolonged in a rigid rod extending far in the body; the total tube-rod length ranges from 38 to 42 μm .

The ventral ciliature extends along the whole body. The main two series of cilia, which run from the head to the posterior region of trunk, are distinctly separated; the space between them reaches 14 μm in the pharyngeal region. Each of the series is broad along the pharyngeal body region, having about 15 cilia in each transverse row, and becomes more and more narrow posteriorly, having only 3–5 cilia in each of the rearmost transverse rows. Two isolated groups of cilia occur on a median line

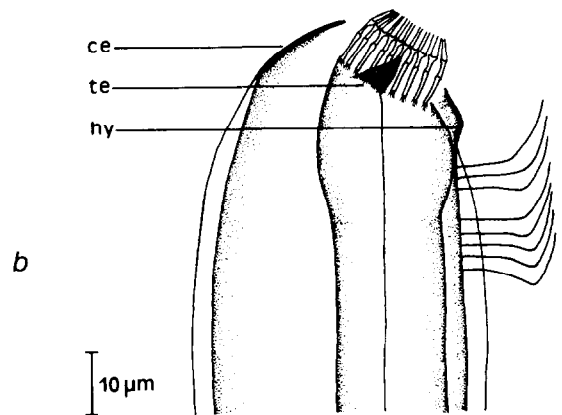


Fig. 2. *Arenotus strixinoi* gen. et sp. nov.; a – general ventral view, b – lateral view of the anterior body region. ce – cephalion, hy – hypostomion, ov – ovum, ox – organ x, sp – sperm bundle, te – pharyngeal teeth.

just behind the mouth ring, the anterior one consists of 3–4 transverse rows of cilia, the posterior one of 5–6 rows. Two other similar groups are located more laterally (Fig. 2a).

The whole body, excluding the cephalion, pleuria, hypostomion as well as free terminal parts of adhesive tubes, is uniformly covered with soft homogeneous thick layer of cuticle. The layer is easily visible in optical section of living animals in every position of them. The cuticle is easily distinguished from the epidermis in a brightfield microscopic image, as is differently light-refracting than the body tissues. The thickness of the layer is almost the same along the whole body and ranges from 1.7–4 μm in the material studied, reaching 2.5–3 μm usually. It is of particular interest that the ventral areas bearing cilia are covered with the cuticle. The basal parts of cilia are surrounded by the cuticular layer (Fig. 2b). Similarly, the proximal parts of tactile bristles, both on the neck and the trunk, are covered by the layer and I observed in only one case that the base of posterior bristle was free from the cuticle.

The nearly terminal mouth ring is long (8.5 μm in length) and broad (16.5–21 μm in diameter), showing complicated structure (Fig. 2b). A crown of rigid units arises from the foremost part of the pharynx. Every unit is connected with the pharynx by means of a separate bundle of fibres. The frontal extremity of each unit is movably jointed with the terminal unit having its free end bifurcated and bearing rigid bristles 5.5–7.5 μm long. A pair of

strong teeth, 9 μm long and 5 μm thick at their base, is borne dorso-laterally from the front of the pharyngeal muscle. The tooth ends contact one another when resting. The pharynx is relatively long (82–130 μm) and has two thickenings, the posterior larger than the anterior. The intestine is thick in its anterior part and considerably thinner in the posterior one.

The anatomy of sexual organs is typical for the family. Mainly parthenogenic females have been found. However, the bilobed organ x and one or two packets of thread-like sperm were detected in three specimens. Another individual bore a mature egg whose surface was covered with regularly distributed warts.

Discussion

The body covering of *Arenotus* gen. nov. superficially resembles that of *Ichthydium* Ehrenberg. The latter taxon, undoubtedly heterogeneous, is defined as having a cuticular covering without distinct scales and/or spines. However, the majority of well-studied species of the genus shows the presence of minute cuticular structures which give to the body surface the appearance of undulations of longitudinal ridges (d'Hondt, 1971b; Balsamo, 1983b; and my own unpublished data). *Ichthydium tanytrichum*, a recently described species studied with Nomarski interference contrast optics, has a completely smooth cuticle, but nevertheless shows the presence of terminal ventral scales and basal scales of posterior tactile bristles (Balsamo, 1983a). In contrast with *Ichthydium*, *Arenotus* shows a thick layer of homogeneous and soft cuticle, which is distinct from the epidermis and covers also ventral field between ciliary bands as well as proximal parts of ventral cilia and tactile bristles. *Arenotus* differs also from *Ichthydium* in having a large mouth ring of complicated structure, a pair of strong pharyngeal teeth and in being of considerably larger size. A similar structure of the mouth ring suggests the affinity between *Arenotus* and some undescribed psammic species belonging to the genus *Chaetonotus* Ehrenberg and *Heterolepidoderma* Remane (my own unpublished data from Brazil).

The finding of the two described genera in the Brazilian freshwater psammon, as well as earlier

Table 2. Measurements of *Arenotus strixinoi* gen. et sp. nov.

| | range | \bar{x} | n |
|-------------------------|-------------------------|-----------|----|
| body length | 271 – 336 μm | 314.0 | 3 |
| length of adhesive tube | 13.5 – 18 μm | 15.0 | 13 |
| pharynx length | 82 – 130 μm | 94.2 | 10 |
| at: ph ratio | 12 – 17% | 15.8 | 8 |
| pharynx formula | a 21 – 27% | 24.6 | 3 |
| | m 19 – 24% | 21.2 | 3 |
| | p 27 – 32% | 28.6 | 3 |
| mouth diameter | 16.5 – 21 μm | 18.9 | 9 |

\bar{x} = mean value; n = number of measured individuals; at: ph ratio = length of adhesive tubes to pharynx length ratio; pharynx formula: a = width of the anterior pharynx thickening to pharynx length ratio, m = width of the middle pharynx part to pharynx length ratio, p = width of the posterior pharynx thickening to pharynx length ratio. Indices used after Kisieleski (1981).

description of *Marinellina flagellata* from the Austrian river psammon (Ruttner-Kolisko, 1955) show that freshwater sandy environments are a habitat for phylogenetically interesting gastrotrichs and merit more intensive study.

Acknowledgements

This research was supported by grants from Fundação de Amparo à Pesquisa do Estado de São Paulo (Proc. Zoologia 83/2615-5) and the University of São Paulo (Proc. CODAC 141/83).

I acknowledge with gratitude Dr. L. Forneris, University of São Paulo, Brazil who came to aid and stimulated me during my study in Brazil. I wish to thank Dr. G. Strixino, University of São Carlos, Brazil for making possible the study in the region of São Carlos and his kind assistance during field works. I am very grateful to Dr. W. D. Hummon and Dr. M. R. Hummon, Ohio University, USA for revising the manuscript and their helpful criticism. I also thank Dr. C. Navarra, University of São Paulo, for geological comment.

References

- Almeida, F. F. M. de, 1974. Fundamentos geológicos do relevo Paulista. IGEOG, São Paulo, Sér. Teses e Monogr. 14: 99 pp.
- Balsamo, M., 1983a. Three new gastrotrichs from a Tuscan-Emilian Apennine lake. *Boll. Zool.* 49: 287-295.
- Balsamo, M., 1983b. Gastrotrichi (Gastrotricha). Guide per il riconoscimento delle specie animali delle acque interne italiane, Verona 20: 92 pp.
- Hondt, J.-L. d', 1971a. Gastrotricha. *Oceanogr. Mar. Biol. Ann. Rev.* 9: 141-192.
- Hondt, J.-L. d', 1971b. Note sur quelques gastrotriches Chaetonotidae. *Bull. Soc. zool. France* 96 (2): 215-235.
- Hummon, W. D., 1971. The marine and brackish-water Gastrotricha in perspective. *Smithsonian Contrib. Zool.* 76: 21-23.
- Hummon, W. D., 1982. Gastrotricha. In: *Synopsis and classification of living organisms*, S. P. Parker, ed. McGraw-Hill, New York. Vol. 1, pp. 857-863.
- Kisielewski, J., 1981. Gastrotricha from raised and transitional peat bogs in Poland. *Monogr. Fauny Pol.* 11: 142 pp.
- Remane, A., 1961. *Neodasys uchidai* nov. spec., eine zweite *Neodasys*-Art. *Kieler Meeresforsch.* 17: 85-88.
- Riemann, F., 1966. Die interstitielle Fauna im Elbe-Aestuar Verbreitung und Systematik. *Arch. Hydrobiol., Suppl.* 31: 1-279.
- Ruttner-Kolisko, A., 1955. *Rheomorpha neiswestnovae* und *Marinellina flagellata*, zwei phylogenetisch interessante Wurmtypen aus dem Süßwasserpsammon. *Österr. Zool. Z.* 6 (1-2): 55-69.
- Strixino, G. B. M. A., 1973. Sobre a ecologia dos macroinvertebrados do fundo, na Represa do Lobo. Tese de Doutorado. USP, São Paulo, 212 pp.
- Trindade, M., 1980. Nutrientes em sedimentos da Represa do Lobo (Brotas-Itirapina, SP). São Carlos. UFSCar, São Carlos, 151 pp.

Received 11 December 1985; in revised form 20 June 1986; accepted 1 August 1986.