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Preliminary studies on aquatic Oligochaeta in and around Chennai, Tamil Nadu, India

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Abstract: Aquatic oligochaetes were studied in 2 lowland regions (the Chennai and Tiruvallur districts) and a mountainous area (Ooty) in Tamil Nadu, southern India. Quantitative core samples, 2.5 cm in diameter, were collected monthly from April 2005 to March 2006 in Kodungaiyur Swamp and Pandinellur Swamp, the 2 main sites commercially exploited for aquatic Oligochaeta in Chennai. Random qualitative samples were collected from other sites using corers or strainers. In total, 9 naidids and 4 tubificids were identified during this survey. *Dero indica*, *D. zeylanica*, *D. digitata*, and *Pristina jenkinae* are first reports from Chennai. *L. hoffmeisteri*, the worm commercially marketed here as "Tubifex," was the only tubificid species collected from Chennai. *Tubifex tubifex* and *Limnodrilus udekemianus* were recorded only from the cooler waters of Ooty. The finding of *L. udekemianus* constitutes a first report from India. *Branchiodrilus semperi*, *Dero dorsalis*, *Aulophorus michaelseni*, *Pristina breviseta*, and *Branchiura sowerbyi* constitute first reports for Tiruvallur. The diversity of the naidids was more than that of the tubificids in Chennai and Tiruvallur, but only tubificids were recorded in the samples collected from Ooty.

Key words: Naidids, tubificids, aquatic Oligochaeta, Chennai, India

Introduction

The fauna of aquatic Oligochaeta from India has been studied by Stephenson (1923, 1930), Mehra (1925), Aiyer (1929), Radhakrishna and Saibaba (1977), Subba Rao et al. (1979), Arunachalam et al. (1980), Sobhana and Nair (1984), Marian and Pandian (1984), Sundér and Vass (1988), Battish and Sharma (1991), Mukhopadhyay (1998), and Nesemann et al. (2004). The latest compendium by Naidu (2005) was the most recent attempt to update our knowledge on aquatic Oligochaeta from the Indian subcontinent and an effort to bring together all of the information available in the literature on the aquatic oligochaetes known from the Indian subcontinent. "Some problems in the field of nomenclature have arisen with the latest developments in phylogeny. A strange thing happened to the Tubificidae: after the clades of Naididae and Pristinidae were incorporated in the Tubificidae as subfamilies by Erséus et al. (2002), the whole cast should bear, according to the rules of the nomenclature, the oldest name Naididae (see Erséus et al. 2008). However, it is reasonable to treat leeches separately from oligochaetes, and the larger group of sediment-dwelling tubificids separately from the epibenthic naidids and pristinids that have derived from them, in all other branches of biology except phylogeny" (Timm, 2009). As in Timm's publication

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(2009), the traditional evolutionary system accepting Tubificidae as an easily distinguishable separate family is followed in this paper. Based on the literature survey and the work performed by various authors on aquatic Oligochaeta, the work pertaining to this group from Tamil Nadu, India (Figure 1), was found to be meager. The present work is therefore an attempt to study the aquatic Oligochaeta in and around Chennai (Figure 2), Tamil Nadu, with the following objectives: to identify the commercially important aquatic Oligochaeta from samples marketed at some major aquarium shops in Chennai; to conduct a preliminary survey of aquatic Oligochaeta in and around Chennai; and to study the distribution, abundance, and diversity of aquatic Oligochaeta in relation to some physicochemical parameters at 2 main locations commercially exploited for aquatic Oligochaeta.

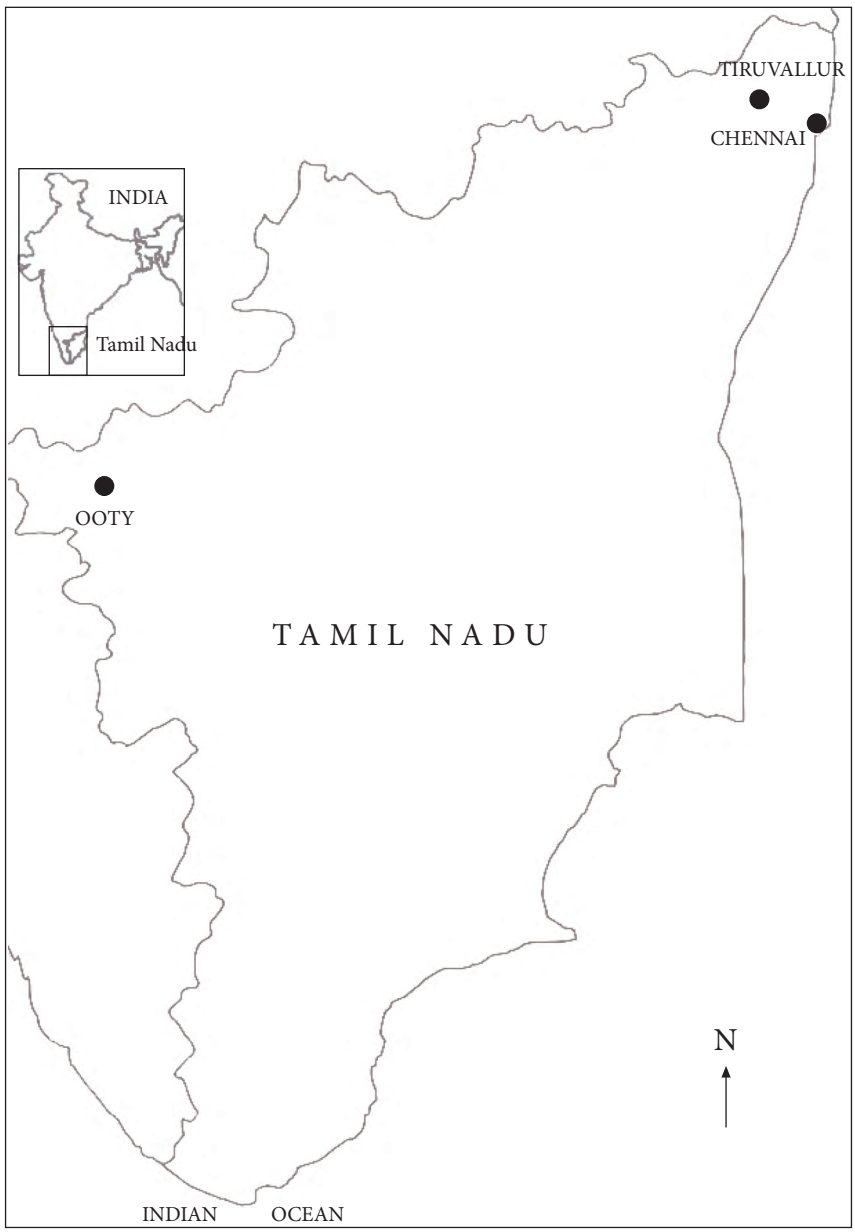

Figure 1. Location of the sampling sites in Tamil Nadu.

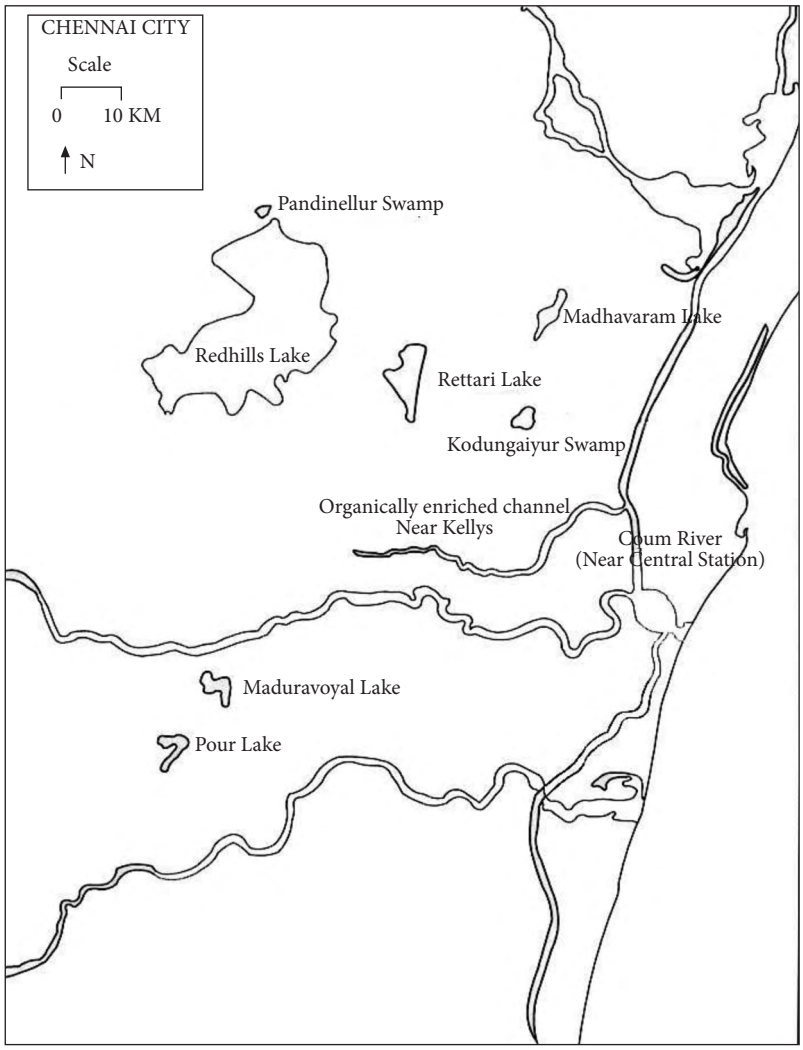

Figure 2. Location of the bodies of water sampled in Chennai.

Study area

Kodungaiyur Swamp, designated location A (13°08′48″N, 80°15′51″E), and Pandinellur Swamp, designated location B (13°12′41″N, 80°10′44″E), in Chennai are the 2 main locations exploited by aquarium owners and traders for aquatic Oligochaeta. These 2 swamps were studied seasonally from April 2005 to March 2006. Both locations had common features such as limited depth (3-10 cm), a slow current, and organic pollution. The Kodungaiyur Swamp occupies an area of about 3.5 km^2 and receives water from the municipal sewage treatment plant at Kodungaiyur, Chennai. Wild grass *Chloris barbata* predominates in the adjoining regions of this swamp and large numbers of water buffalo are often found basking in the swamp. The Pandinellur Swamp occupies an area of about 1 km^2 and receives effluents from the rice mills in the adjoining area, along with domestic sewage. The amphibious herb *Portulaca oleracea* was found to be abundant in this swamp, while wild grass *Chloris barbata* predominated in the adjoining regions. Hundreds of ducks (*Anas* sp.) were often seen paddling in this swamp. Aquatic oligochaetes were abundant at both of these locations and were periodically exploited by aquarium traders.

In addition to those of the Kodungaiyur and Pandinellur swamps, qualitative samples were also collected from Redhills Lake (13°11′32″N,

80°10′26″E), Porur Lake (13°02′09″N, 80°09′08″E), Maduravoyal Lake (13°04′18″N, 80°08′54″E), Rettari Lake, Madavaram Pond (13°08′52″N, 80°12′41″E), Manali Pond (13°09′04″N, 80°15′00″E), Cooum River near Chennai Central Station (13°04′20″N, 80°16′28″E), and an organically enriched channel near Kellys (13°04′02″N, 80°13′41″E); all of the sampling sites were located in Chennai.

Qualitative samples were collected from November 2007 to February 2008 at Satharai Lake, which is located 50 km away from Chennai in the village of Satharai, Tiruvallur District (13°17′55″N, 80°03′21″E). It covers an area of about 3 km^2. The depth of water ranges from 0.3 to 2.5 m, depending on the rainfall. The lake is full of aquatic vegetation and inhabited by diverse fauna, including varieties of crabs, snails, fish, frogs, snakes, and aquatic birds. A shallow area of this lake with sufficient aquatic vegetation was selected as a sampling spot.

Oligochaeta were also collected from an organically enriched channel at Ooty (11°24′59″N, 76°42′51″E), which is about 570 km away from Chennai and roughly 2323 m above MSL, characterized by a cooler climate. During summer (March to May), the average temperature in Ooty ranges from 15 to 20 °C, while the maximum temperature never exceeds 25 °C. During winter (November to January), the temperature ranges from –4 °C to a maximum of about 15 °C (http://www.mustseeindia.com/Ooty-weather). Chennai is much warmer and more humid when compared to Ooty. The temperature rises to 40 °C during the summer months, with April and May being the hottest months of the summer season. Temperatures as high as 43 °C have been recorded. Chennai experiences cooler temperatures from October to December, while the lowest temperatures range between 18 and 20 °C in the months of December and January (http://www.chennai.org.uk/weather.html).

Materials and methods

Different corer tubes were used for collecting qualitative and quantitative samples. Qualitative samples were collected using tea strainers in the shallow regions, while a PVC corer tube was designed with an internal diameter of 3 cm and a length of 180 cm for use in deeper areas. The samples were brought to the lab in polyethylene bags. Live oligochaetes were extracted from bottom sediment samples using the wet funnel method (O'Connor, 1955) with minor modifications. Aquatic vegetation was also rinsed in a large bucket containing water, followed by swirling and immediately straining the water through fine mesh. Monthly quantitative samples were collected from the swamps of Kodungaiyur and Pandinellur between April 2005 and March 2006 (12 months); 3 replications were performed in each location by plunging a PVC corer tube with an internal diameter of 2.5 cm to a depth of 10 cm in the sediment. Sediment samples for physicochemical analyses were collected separately.

The samples were washed through a 200-µm mesh sieve and the worms were sorted manually by diluting small portions of the sediment residue in a white porcelain dish or a petri dish. With the help of a dissection microscope and hand lens, the worms were picked with pincers and preserved in 10% formalin in separately labeled vials. Some of the specimens were examined alive under a compound microscope in a drop of water. The worms preserved in 10% formalin were examined as whole mounts on slides in a few drops of glycerin. Some specimens were embedded in Canada balsam as permanent whole mounts following dehydration and clearing. The monographs by Brinkhurst and Jamieson (1971), Timm (1999), and Naidu (2005) were used for the identification of the worms. Drawings were made using a camera lucida. Physical and chemical parameters such as the temperature, pH, and dissolved oxygen (Winkler method) of the water samples were determined immediately at each location during sampling. The depth of the water was also noted using a meter scale. The pH and the organic matter (OM), organic carbon (OC), nitrate, phosphorus, and potassium contents of the sediments from each location were analyzed at the National Agro Foundation in Chennai.

The data from both stations were subjected to calculations of mean and standard deviation. A correlation analysis was carried out between the population density of the Oligochaeta and various physicochemical parameters of the respective locations. Student's t-test was performed between the related physicochemical parameters from both the

locations and the population density of *Limnodrilus hoffmeisteri*. The indices of dominance (c) (Simpson, 1949), general diversity (Ĥ) (Shannon and Weaver, 1949), and evenness (e) (Pielou, 1966) were applied to the data from location B.

Results

Environmental parameters

Information on the dissolved oxygen, pH, temperature, and depth of the water, and the pH, nitrate, available phosphorus, available potassium, percentage of OC, and percentage of OM recorded in sediment samples from locations A and B between April 2005 and March 2006 is presented in the Table. A wide fluctuation in the annual water temperature, ranging between 19 and 31 °C and between 19 and 30 °C, was observed in locations A and B, respectively. Temperatures recorded from other sampling sites were: Satharai Lake, 20-26 °C; Madavaram Pond, 26 °C; Rettari Lake, 29 °C; Manali Pond, 22 °C; Redhills Lake, 21 °C; Porur Lake, 27 °C; and Ooty, 9 °C. The Student's t-test analyses of the physicochemical parameters of locations A and B were found to be significant for water parameters such as dissolved oxygen, pH, and depth ($P < 0.05$). Sediment parameters like pH, OC percentage, and OM percentage showed significant results ($P < 0.05$). Analysis of correlation coefficients between the abundance of *L. hoffmeisteri* at locations A and B with that of their respective physicochemical parameters revealed that *L. hoffmeisteri* showed a significantly high degree of positive correlation with OC and OM at both locations. The mean values for OM at locations A and B were observed to be 7.29% and 4.51%, respectively. The other physicochemical parameters were not significantly correlated with the population density of *L. hoffmeisteri* at location A. Both water temperature and pH showed significant negative correlation with the density of *L. hoffmeisteri*. Potassium showed a significant correlation with the population density of *L. hoffmeisteri* at location B. The other parameters were not found to be significantly correlated at location B. The higher value of OM during May 2005 corresponded to the maximum density of *L. hoffmeisteri* (186,000 ind m^{-2}) recorded during the present study at location A. Thus, OM was found to be an important factor influencing the population density of *L. hoffmeisteri* at A, irrespective of the other physicochemical factors at that location. Organic and inorganic matter could be recognized as factors promoting these worms.

Table. Minimum and maximum values of environmental parameters at locations A and B.

	Location A	Location B
Water parameters	**Range**	**Range**
DO, mL L^{-1}	2.21-2.96	1.59-2.2
pH	7-8	6.5-7
Water temperature, °C	19-31	19-30
Depth, cm	5-9	3-8
Sediment parameters		
pH	6.24-6.44	6.56-6.95
EC, mS cm^{-1}	0.65-1.57	0.82-1.46
N as NO_3, mg L^{-1}	10.1-52.8	7.5-33.2
P, mg L^{-1}	335.4-490.2	516.1-293.1
K, mg L^{-1}	440-681	242-551
% OC	3.74-5.06	2.04-2.96
% OM	6.44-8.72	3.51-5.11

Oligochaeta composition and population density at locations A and B

Limnodrilus hoffmeisteri was identified as a commercially exploited aquatic oligochaete species and was found to occur at both locations A and B. *Dero indica* and *Pristina jenkinae* were found only at B, while *L. hoffmeisteri* was the only dominant species at location A. At location B, *L. hoffmeisteri* was the dominant species, contributing about 81% of the total abundance, while *D. indica* contributed about 14% and *P. jenkinae* about 5%. The population density of the oligochaete species at A and B showed monthly fluctuations (Figure 3). The population density of *L. hoffmeisteri* differed significantly ($P < 0.05$) between locations A and B during the study period.

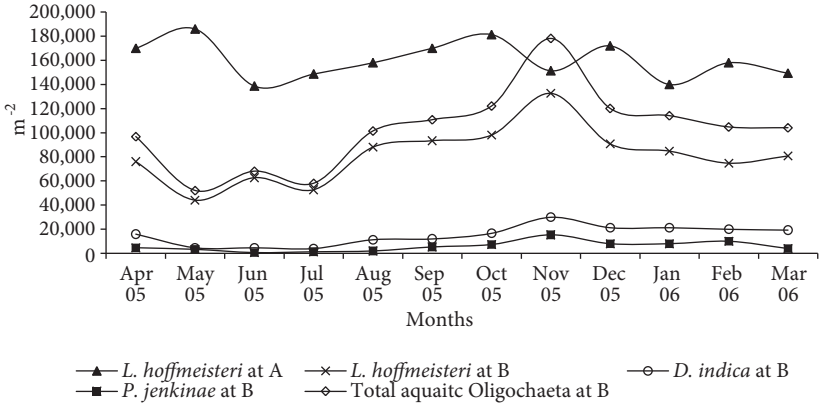

Figure 3. Population density of aquatic Oligochaeta.

Ecological indices at location B

With regard to the dominance, diversity, and evenness of aquatic oligochaetes at location B, ecological indices showed peaks and dips. In general, the index of dominance was found to be inversely proportional to the indices of diversity and evenness during the period of study (Figure 4). A total of 4 peaks were observed in the species diversity during November 2005 (0.73), December 2005 (0.69), January 2005 (0.72), and February 2005 (0.78) with corresponding temperatures of 20 °C, 19 °C, 20 °C, and 22 °C, respectively. A decrease in the diversity was observed during May 2005 (0.53), June 2005 (0.30), July 2005 (0.27), and August 2005 (0.44) with corresponding higher temperatures of 30 °C, 27 °C, 25 °C, and 23 °C. These results suggest that temperature has a negative role in determining the diversity.

Systematic account

Family Naididae

***Branchiodrilus semperi* (Bourne, 1890)**

Material examined: Satharai Lake, on 25 November 2007, collected from mud and aquatic vegetation (2 specimens).

Morphological observations: Length 4 mm. Worms brownish. Prostomium blunt and conical. Gills finger-like, dorsolateral, 2 per segment, only on the anterior half of the body. Dorsal chaetae from VI. Hair chaetae smooth. Needle chaetae simple-pointed, with a peculiar bayonet-shaped distal curve (Figure 5A). Ventral chaetae 1-3 per bundle, with distal tooth longer and thinner than proximal, with nodulus (Figure 5B).

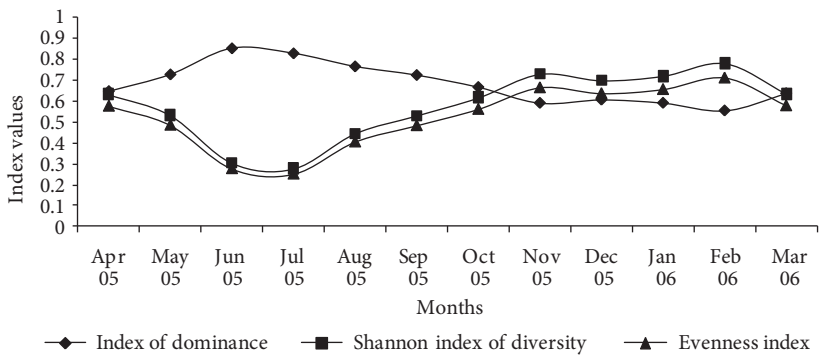

Figure 4. Index of dominance (c), index of diversity (H), and index of evenness (e) of aquatic oligochaetes at location B.

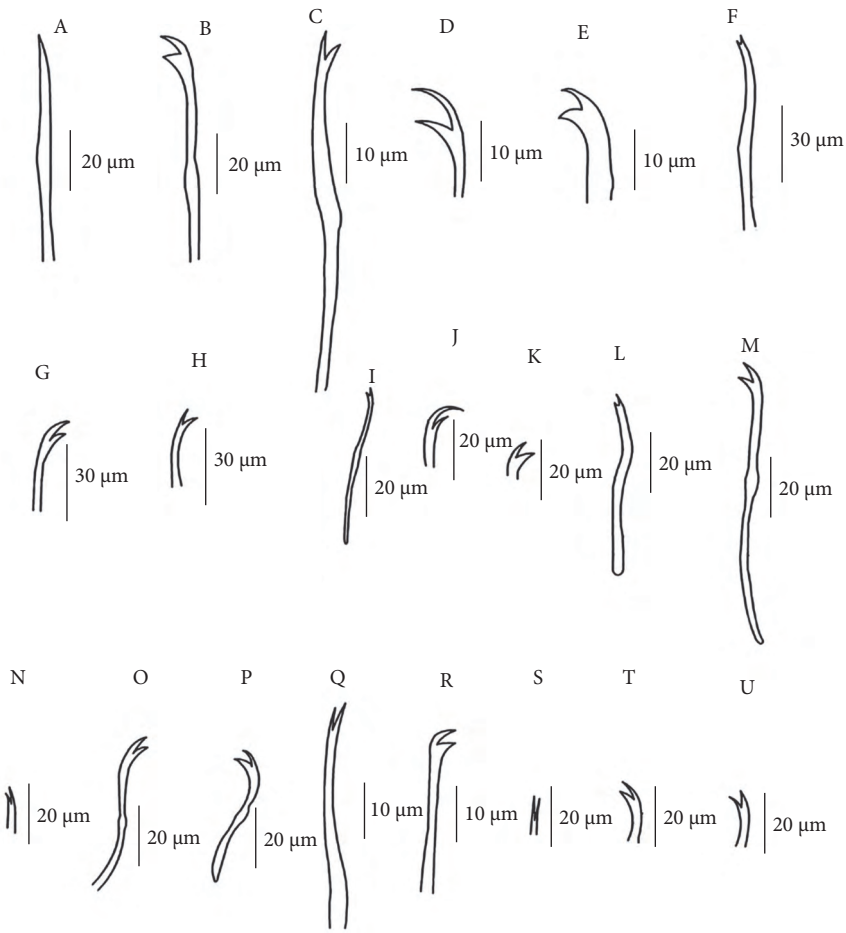

Figure 5. *Branchiodrilus semperi*: A) needle chaeta, B) ventral chaeta. *Dero indica*: C) needle chaeta, D) ventral chaeta of II, E) ventral chaeta of posterior segment. *D. zeylanica*: F) needle chaeta, G) ventral chaeta of II segment, H) ventral chaeta of posterior segment. *D. digitata*: I) needle chaeta, J) ventral chaeta of II segment, K) ventral chaeta of the posterior segment. *D. dorsalis*: L) needle chaeta, M) ventral chaeta. *Aulophorus michaelseni*: N) needle chaeta, O) ventral chaeta of the II segment, P) ventral chaeta of the posterior segment. *Pristina jenkinae*: Q) needle chaeta, R) ventral chaeta. *P. breviseta*: S) needle chaeta, T) ventral chaeta of the II segment, U) ventral chaeta of the posterior segment.

Remarks: First report for Tiruvallur District. No other individuals were found despite careful sampling in the same lake and other water bodies. *Branchiodrilus semperi* is characterized by the presence of dorsolateral gills. The dark brown patches on the anterior end are a specific character, which distinguishes this species from *Branchiodrilus hortensis*. Only 2 species belonging to the genus *Branchiodrilus* have been recorded from India (Naidu, 2005).

***Dero indica* Naidu, 1962**

Material examined: Madavaram Pond, on 2 November 2004 (3 specimens); Pandinellur Swamp, April 2005 to March 2006 (306 specimens).

Morphological observations: Worms 6-8.5 mm in length, red in color; 36 to 70 segments with unsegmented posterior regions. Prostomium bluntly triangular. Dorsal bundles of chaetae begin in VI and consist of 2 hair and 2 needle chaetae in the

anterior segments, while in the posterior segments the number is reduced to 1 hair and 1 needle. Hair chaetae are long and not serrated. Needle chaetae are bifid, sickle-shaped, with distal nodulus. Distal tooth of the needle chaetae is slightly thinner and longer than the proximal (Figure 5C). Ventral bundles in the foremost segments from II-V consist of 4 long, thin, and slightly curved chaetae per bundle with the upper tooth longer than the lower (Figure 5D). In the rest of the segments, 3-4 ventral chaetae per bundle, shorter than II-V with upper tooth almost equal to lower (Figure 5E). Branchial fossa opening posterodorsally, with 4 pairs of gills. Chloragogen cells from VI. Sexual organs not observed.

Remarks: First report from Chennai. This species is intermediate between *D. digitata* and *D. zeylanica* in having 2 hair and 2 needle chaetae in the anterior segments and in having pronounced needle teeth. These worms constituted about 14% of the oligochaetes in Pandinellur Swamp. Some of the worms collected from Pandinellur Swamp were found with fungal hyphae attached at the posterior end.

***Dero zeylanica* Stephenson, 1913**

Material examined: Rettari Lake, on 24 April 2004 (8 specimens); Manali Pond on 14 December 2004 (4 specimens).

Morphological observations: Length 5-6 mm, number of segments 40-67. Prostomium triangular. Dorsal chaetae begin in VI, each bundle with 3 hair and 3 needle chaetae. Needle chaetae bifid, sickle-shaped, with distal tooth longer than proximal (Figure 5F). Ventral chaetae in II-V with 4-6 per bundle, longer and thinner, the distal tooth twice as long as the proximal (Figure 5G). In the rest of the segments, ventral chaetae with almost equal teeth (Figure 5H). The needle teeth of this species were not as distinct as in *D. indica* and were similar to those of *D. digitata*. The main diagnostic character of this species when compared to the above species is the presence of 3 hair and 3 needle chaetae in the anterior segments.

Remarks: First report for Chennai.

***Dero digitata* (Müller, 1774)**

Material examined: Redhills Lake on 27 December 2005 (3 specimens); Satharai Lake on 25 November 2007 and 14 January 2008 (7 specimens).

Morphological observations: Length 4-6 mm, segment number 25-48. Prostomium triangular. Dorsal bundles from VI, with 1 hair and 1 needle. The distal tooth of the needles longer than the proximal (Figure 5I). Ventral chaetae 4-5 in II-V with distal teeth longer than the proximal (Figure 5J). From VI on, ventral chaetae 2- 4 with distal and proximal teeth almost equal (Figure 5K). Branchial fossa with 4 pairs of gills. The presence of 1 hair and 1 needle in the dorsal bundle is a characteristic feature of this species.

Remarks: First report for Chennai.

***Dero dorsalis* Ferronière, 1899**

Material examined: Satharai Lake, 25 November 2007, from mud and aquatic vegetation (8 specimens).

Morphological observations: Length 8-10 mm. Prostomium triangular. Dorsal chaetae from IV, each bundle with 1 hair and 1 needle chaeta. Needle chaetae sickle-shaped, bifid, with distal tooth longer and thinner than proximal (Figure 5L). Ventral chaetae with distal tooth longer and thinner than proximal (Figure 5M). Branchial fossa with 5 pairs of gills.

Remarks: First report for Tiruvallur District. *Dero dorsalis* and *Dero digitata* are characterized by the presence of 1 hair and 1 needle chaeta in the dorsal bundle. The difference between the 2 is that in *D. dorsalis*, the hair and needle begin in the IV segment, but in *D. digitata*, the hair and needle commence from the VI segment backwards. Furthermore, *D. dorsalis* is peculiar in having 5 pairs of gills, and *D. digitata* is characterized by the presence of 4 pairs of gills in the branchial fossa (Naidu, 2005).

***Aulophorus furcatus* (Müller, 1774)**

Material examined: Porur Lake, mud, 29 July 2005 (6 specimens).

Morphological observations: Prostomium bluntly conical. Dorsal chaetae begin from V with 1 hair and 1 bifid needle chaeta. Ventral chaetae 3-5 per bundle, in anterior bundles, upper tooth slightly longer, decreasing to 2-3 posteriorly. Branchial fossa cup-shaped with a pair of noncontractile palps and 3 pairs of gills.

Remarks: *Aulophorus furcatus* as identified from the qualitative samples has already been reported from Chennai (Naidu, 2005).

***Aulophorus michaelseni* Stephenson, 1923**

Material examined: Satharai Lake, mud, 14 February 2008 (2 specimens).

Morphological observations: Length 3-4 mm, pale red in color. Prostomium conical. Dorsal chaetae from V, with 1 hair and 1 needle chaeta. Needle chaetae bifid with small teeth, the distal tooth longer than the proximal (Figure 5N). Ventral chaetae 2-4 per bundle in II-V, with distal tooth longer than proximal (Figure 5O). In the rest of the segments, ventral chaetae with distal tooth about equal in length with the proximal (Figure 5P). Branchial fossa with 2 noncontractile palps and 4 pairs of gills.

Remarks: First report for Tiruvallur District. *Aulophorus michaelseni* was identified by the presence of noncontractile palps and 4 pair of gills in the branchial fossa. "Stephenson (1923) gave the name, *Aulophorus michaelseni* for earlier (?) *A. palustris* (Michaelsen, 1905). This was validated by Naidu (1963a) as he found, needles distinctive with equally thick teeth at base with distal tooth 1½ times longer than proximal, with four pairs of digitiform gills and very long palps both curling like tentacles in contraction as opposed to needles with proximal tooth thicker and equal or slightly shorter than distal, with three pairs of stumpy foliate gills and shorter palps not curling like tentacles in contraction of *A. furcatus*" (Naidu, 2005). Brinkhurst and Jamieson (1971) made this species synonymous with *Aulophorus furcatus*, but in the present study, there is a noted discrepancy between the red color of the worms with 4 pairs of digitiform gills and very long palps both curling like tentacles in contraction as compared to *A. furcatus*, which is brown in color with a pair of noncontractile palps and 3 pairs of contractile foliate gills. This suggests that the revalidation of *A. michaelseni* by Naidu (1963) may be justified.

Family Pristinidae

***Pristina jenkinae* (Stephenson, 1931)**

Material examined: Pandinellur Swamp, April 2005 to March 2006 (126 specimens).

Morphological observations: Length 2.5-3.2 mm, worms pale white in color; 25-31 segments. Prostomium conical without proboscis. No eyes. Dorsal and ventral chaetae from segment II. Dorsal bundles consist of 1 hair and 1 needle chaeta. Distal teeth of the needle shorter than the proximal (Figure 5Q). Ventral chaetae 4-6 per bundle in the anterior segments and 2-3 in the posterior segments. Ventral chaetae all with equally long teeth (Figure 5R).

Remarks: First report for Chennai. *P. jenkinae* is most easily recognized by the needle chaetae with parallel bifid teeth and the upper tooth much shorter and thinner than the lower, but according to Kathman (1985), who compared a number of specimens identified as *P. jenkinae*, there is much variation in the length of the needle teeth, both absolutely and relatively. These variations were the main reason for synonymizing *P. idrensis* (Sperber, 1948) with *P. jenkinae* (Kathman, 1985). In the present study, *P. jenkinae* resembled the description by Brinkhurst and Jamieson (1971).

***Pristina breviseta* Bourne, 1891**

Material examined: Satharai Lake, 14 February 2008 (3 specimens).

Morphological observations: Length 3.2-3.6 mm. Prostomium with proboscis. Dorsal chaetae begin in II, 1 hair and 1 needle. Needle chaetae with weak nodulus and with equal distal and proximal teeth (Figure 5S). Ventral chaetae 3-5 per bundle, anteriorly the distal tooth longer than proximal (Figure 5T), but in posterior segments the proximal tooth is thinner and slightly longer than the distal (Figure 5U).

Remarks: First report for Tiruvallur District. *Pristina breviseta* is characterized by the presence of a proboscis with a very conspicuous character. The hair setae are nonserrated, which confirms the identification of this species (Naidu, 2005). The absence of serrated hair setae differentiates this species from *Pristina proboscidea*, which also has a proboscis. The bifid needle setae with equal distal and proximal tooth is another important supporting character in the identification of this species. This species had been reported from Chennai before (Naidu, 2005), but this constitutes the first report for the Tiruvallur District.

Family Tubificidae

***Limnodrilus hoffmeisteri* Claparède, 1862**

Material examined: Kodungaiyur Swamp, April 2005 to March 2006 (2876 specimens); Pandinellur Swamp, April 2005 to March 2006 (1482 specimens).

Morphological observations: Worms 4-50 mm long and red in color when living. Segments number 41 to 147, with undifferentiated caudal regions. Prostomium conical. Dorsal and ventral chaetae commence from II segment, all bifid and similar, with distal tooth thinner and equal in length with the proximal. Anterior segments bear 3-9 chaetae per bundle. The number of chaetae per bundle decreases in the succeeding segments, with about 3-5 in the middle segments and 1-2 in the posteriormost segments. Clitellum occupies the XI and XII segments. The penis sheath is one of the diagnostic characters used in identification of these worms and can be very clearly seen through the transparent body surface. The penis sheath is much longer than broad (length-to-width ratio of about 9) and ends with an asymmetrical, plate-like extremity. Chloragogen tissue in this species starts from the V segment.

Remarks: Naidu (2005) suggested that chloragogen tissue begins in VI, but in the present study, chloragogen tissue in this species starts from the V segment; this is one of the most notable differences observed in the present work when compared to the description by Naidu (2005). The beginning of the chloragogen tissue in V is typical for this species (Brinkhurst and Jamieson, 1971; Timm, 1999).

***Limnodrilus udekemianus* Claparède, 1862**

Material examined: Ooty, 21 February 2005 (7 specimens).

Morphological observations: Length 36-48 mm. Segment number 80-120. Prostomium bluntly conical. Dorsal and ventral chaetae begin in II. Both dorsal and ventral chaetae similar. Anterior chaetae in II with 3-8 per bundle, with distal tooth thicker, much longer than proximal, and curved. Chaetae in the posterior segments with almost equal distal and proximal teeth. Beginning of the chloragogen tissue in the VI segment. Penis sheath short (length-to-width ratio of about 1½) in comparison with that of *L. hoffmeisteri*.

Remarks: First report for India. This species also differs from *L. hoffmeisteri* in having a long, curved distal tooth in the anterior chaetae and being much larger than *L. hoffmeisteri*.

***Tubifex tubifex* (Müller, 1774)**

Material examined: Ooty, 21 February 2005 (3 specimens).

Morphological observations: Length 20-30 mm. Segment number 120-130. Prostomium bluntly conical. Dorsal bundles from II with hair and bifid chaetae. The dorsal bifid chaetae with distal tooth thinner than proximal, simply bifid in II but pectinate in several subsequent segments, with small outgrowth (denticles) between teeth. Anterior ventral chaetae with thinner and longer distal tooth than proximal, the distal tooth becoming shorter in both ventral and dorsal posterior segments.

Remarks: Collected from Ooty, a mountainous area with a much cooler climate that is comparable with the conditions *T. tubifex* inhabits in its main distribution range.

***Branchiura sowerbyi* Beddard, 1892**

Material examined: Satharai Lake, November 2007 to February 2008 (79 specimens).

Morphological observations: Worms very large, 70-130 mm long. Prostomium conical. Posterior third of body length with hollow cylindrical gills, a dorsal and a ventral gill per segment, with a total of 60-70 pairs of gills. Dorsal chaetae from II with 1-3 hair and needle chaetae. Ventral chaetae 5-6 anteriorly, gradually decreasing to 1-2 posteriorly.

Remarks: First report for Tiruvallur District. Presence of gills in the posterior region is the most striking taxonomic character of this species.

Discussion

Limnodrilus hoffmeisteri, identified as the main commercially important aquatic oligochaete species in Chennai, is commonly called "Tubifex" here. It was collected from study locations A and B by aquarium owners and is widely used as live feed for ornamental fishes. "*L. hoffmeisteri*, a cosmopolitan species occurring in a wide variety of surface water habitats, is perhaps the most ubiquitous and commonly collected freshwater tubificid worldwide, despite its sexual mode of reproduction" (Swayne et al. 2004). "Slow moving water with weak current

enables more pollution and more organic debris to accumulate, and tubificids prefer such habitats" (Yıldız and Balık, 2006). Locations A and B, both of which featured similar conditions such as limited depth and low dissolved oxygen with organic enrichment, provide convenient living conditions and breeding ground for *L. hoffmeisteri*. The absence of other tubificid species in the commercial sample and in the water bodies surveyed in Chennai during the present study may be due to the tropical conditions. "In tropical waters oligochaetes with asexual mode of reproduction dominate" (Timm, 1987). The higher density of *L. hoffmeisteri* (138,666-186,000 ind m^{-2}) at location A when compared to B (44,000-132,666 ind m^{-2}) may be due to a higher content of OM in the sediment at A. The higher OM content at A may be due to cattle dung, as many water buffalos have been seen basking at A. The quality of the OM can also be an important determinant in the distribution, abundance, and diversity of aquatic oligochaete species. At location B, large populations of ducks are reared by the aquarium traders as an alternative business. The influence of ducks as predators of aquatic oligochaetes can also be a reason for the lower density of oligochaetes at B when compared with A.

Naidids occur mainly among the filamentous algae and aquatic vegetation (Naidu, 2005), and the absence of naidids at location A may therefore be due to poor vegetation. The presence of the naidids *Dero indica* and *Pristina jenkinae* at location B may be the result of the presence of the herb *Portulaca oleracea*, which grows profusely at this location and was found to survive in organically enriched water with low oxygen values ranging between 1.59 and 2.2 mL L^{-1}. "Low Shannon-Weaver index values can be caused by high relative abundance of certain species" (Statzner, 1981). The fall in the diversity values at B are due to the abundance of *L. hoffmeisteri*. The absolute dominance of *L. hoffmeisteri* at location A and its very high density recorded at location B clearly indicate that this species is hardy and able to tolerate fluctuations in the environmental conditions of the polluted waters much more efficiently than naidids and other oligochaete species. Species diversity at location B may be favored by environmental conditions such as temperature and the growth of aquatic vegetation. *L. hoffmeisteri* may become better adapted to the ecological conditions and may dominate at this location due to its ability to breed profusely, which leads to a steep fall in the index of diversity. Thus, there is a clear spatial and temporal distribution of peaks in the indices of dominance, diversity, and evenness.

The Indian subcontinent is represented by 102 species of aquatic Oligochaeta, comprising 8 species of Aeolosomatidae, 59 species and 2 subspecies of Naididae, 16 species of Tubificidae, 1 species of Phreodrilidae, 8 species of Enchytraeidae, 1 species of Lumbriculidae of Microdrili, and 7 species of Microchaetidae of Megadrili. This number is more than double the number of species known in Stephenson's time (Naidu, 2005). Stephenson (1923) described 46 species of aquatic Oligochaeta comprising 4 species from Aeolosomatidae, 29 species from Naididae, 6 species from Tubificidae, 1 species from Phreodrilidae, 3 species from Enchytraeidae, and 3 species from Microchaetidae. Out of these 102 species, 9 species have been reported from Chennai: 6 species of Naididae, 2 species of Tubificidae, and 1 species of Enchytraeidae (Naidu, 2005). *L. hoffmeisteri* was the only tubificid species identified from several samples marketed at the leading aquarium shops and commonly available in the water bodies surveyed during the present study in Chennai. *D. zeylanica* and *D. digitata* recorded from the qualitative samples during the survey, along with *D. indica* and *P. jenkinae*, are the first reports from Chennai. *Aulophorus furcatus*, identified from the qualitative samples, has already been reported from this area (Naidu, 2005). The 3 species of *Dero* differ from each other in the number of dorsal chaetae: *D. digitata* is characterized as having 1 hair and 1 needle chaeta, *D. indica* as having 2 hair and 2 needle chaetae, and *D. zeylanica* as having 3 hair and 3 needle chaetae. In their global compendium on aquatic Oligochaeta, Brinkhurst and Jamieson (1971) regarded *D. indica* as most likely to be identical to *D. digitata*. The ambiguity about *D. indica* outlined by Brinkhurst and Jamieson (1971) is clarified in the present report with the studying of several live and preserved specimens of *D. indica*,

which were commonly available at location B. The absence of tubificid species other than *L. hoffmeisteri* in Chennai prompted a preliminary survey in the cooler regions of Ooty, a western, mountainous region in Tamil Nadu. In that investigation, *Tubifex tubifex* and *Limnodrilus udekemianus* were found living profusely in the organically enriched canals of Ooty along with specimens of *L. hoffmeisteri*. *T. tubifex* has characteristic chaetal morphology (Timm, 2009) and is one of the numerous cosmopolitan tubificids with hair chaetae. It is generally lacking in tropical climates such as the Chennai region, but finds suitable living conditions in the much cooler bodies of water in Ooty. Findings from the present work, a preliminary attempt to study the fauna of aquatic Oligochaeta in and around Chennai, reveal that 4 of these naidids constitute first reports for Chennai, while 5 naidids and 1 tubificid constitute first reports for the Tiruvallur District. Additionally, *Limnodrilus udekemianus* constitutes the first report for India.

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