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FRESHWATER NEMATOFAUNA (NEMATODA) IN A SEMI-ARID REGION

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ABSTRACT

Nematodes are a group of invertebrates found in all aquatic ecosystems, exhibiting great abundance and diversity. The present study was undertaken in the towns of Araruna, Cacimba de Dentro and Tacima, located in the microregion of eastern Curimataú, in the state of Paraiba. Three sampling points were determined with three replicates each, using a PVC tube with an internal area of 15.68 cm² for the removal of the material, and the samples were taken to the laboratory for analysis. The Nematofauna community exhibited 16 genera. The processes of drought and consequently the evaporation, precipitation and salinity allied to the same, as well as the urbanization of certain reservoirs, are factors that contribute to the establishment of nematofauna assemblies.

Key words: Limnology; Meiofauna; Paraíba.

RESUMO

Nematoda é um grupo de invertebrados que encontrados em todos os ecossistemas aquáticos, sendo, por sua vez, representado em grande abundância e diversidade. Essa pesquisa foi realizada nas cidades de Araruna, Cacimba de Dentro e Tacima que se localizam na microrregião do Curimataú Oriental Paraibano. Foram determinados três pontos com três réplicas cada, com uso do cano de PVC de 15,68 cm² de área interna, para a retirada do material,

sendo levadas ao laboratório para análises. A comunidade da Nematofauna foi caracterizada por 16 gêneros. Os processos de seca, consequentemente evaporação/precipitação/salinidade aliados a isso, à urbanização de certos reservatórios são fatores contribuintes para o estabelecimento das assembleias nematofaunística.
Palavras-Chave Limnologia; Meiofauna; Paraíba.

INTRODUCTION

Nematoda is a phylum that occupies diverse environments from plant parasites to vertebrate and invertebrate animals, and also inhabits aquatic ecosystems (Webster, 1980; Coull, 1988; Viglierchio, 1991). It is the most relevant phylum and its greatest diversity is in aquatic sediments, allowing it to exist in any limnic environment (Abebe *et al.*, 2008). It is accepted among zoologists that Nematoda is the most diverse group of individuals (Viglierchio, 1991).

Nematodes are an important group in all benthic habitats. Nevertheless, knowledge of the taxonomy and ecology of freshwater nematodes remains minimal, especially in relation to those in lotic habitats (Traunspurger, 2000; Barbuto & Zullini, 2005). It has been stated, however, that the Nematoda have greater abundance and diversity than other organisms of freshwater environments (Zullini & Ricci, 1980; Traunspurger 2000).

Studies of interstitial benthic organisms have focused on coastal marine environments (Pinto, 2006; Felix *et al.* 2016 and Baia & Venekey, 2019) or estuarine regions, such as in the studies of Meurer (2010), Citadin *et al.* (2018) and Tilbert *et al.* (2019). However, the study of freshwater meiofauna has received little attention. In addition, works on the biodiversity of continental reservoirs are rare and when available, do not address the aquatic biota, as they include meiofauna. It is important to mention the study of Lucena *et al.* (2015), which analyzed meiofauna individuals in the semi-arid region of Paraíba, characterizing the meiofauna and nematofauna biodiversity of the western Curimataú microregion. The present study complements the list of the biodiversity

of the semi-arid region of the northeast of Brazil, continuing the exploration of Curimataú, but in the eastern part of this region.

MATERIAL AND METHODS

The samples were taken from reservoirs in the microregion of the eastern part of the Curimataú Paraibano (Figure 1): Lagoa da Serra, located in the city of Araruna (06º33'30"S, 35º44'30"W), a well-preserved location; in the Cacimba da Várzea dam, located in the city of Cacimba de Dentro (06º38'30"S, 35º47'24"W); and in the city of Tacima (6º29’18"S, 35º38’14"W), which have a closer anthropic relationship.

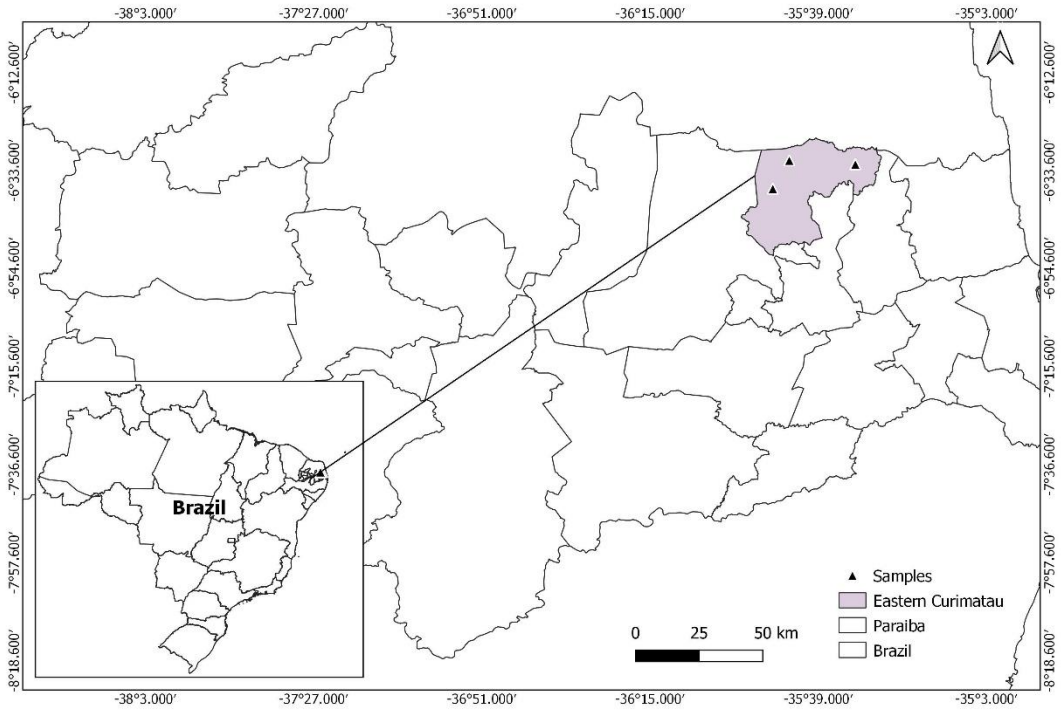

FIGURE 1: Geographical location of the study area, in the microregion of eastern Curimataú Paraibano, Brazil.

Sampling was carried out at four points distributed around the reservoir, with three replicates performed at each point. Sedimentary material was taken using a PVC tube with an internal area of 15.89cm², introduced vertically to a

depth of 10cm, and the samples were later fixed in formaldehyde 4%. Sediments were also collected for organic matter analysis., and water was collected to measure temperature, oxygen and salinity. The sediment samples were fixed with formalin and taken to the Meiofauna Laboratory of Universidade Federal de Campina Grande (LabMeio - UFCG) for analysis.

In the laboratory the sediment samples taken in the field were washed to separate the organisms from the sand grains to facilitate visualization of the meiofauna animals. This separation process was performed by manual elutriation using a geological sieve with a mesh size of 0.045mm, and was repeated eight times to obtain greater efficiency. After washing, the samples were placed on a Dolffus plate with 250 squares, each with an area of 0.25cm³, for counting of the phyla with a stereomicroscope. All the Nematoda were removed for the preparation of permanent slides using the Cobb method (1917). Subsequently, the Zullini, (2010); Platt & Warwick, (1983), Platt *et al.* (1988) and Warwick *et al.* (1998) methods were used for identification at the genus level.

For statistical analysis, MDS (non-metric sort analysis), Analysis of variances (ANOVA) and ANOSIM were applied to the number of organisms recorded in the samples. Statistically significant differences between the samples were verified using a level of significance $\alpha = 0.05$. SIMPER was used to verify which individuals contributed to the different groups.

BIOENV, an analysis using both abiotic and biotic data matrices, was used to analyze community structure. The correlation coefficient used was that of Spearman (Clarke & Gorley, 2001).

RESULTS

In each reservoir, the highest salinity concentration was in Cacimba da Várzea, located in Cacimba de Dentro, with 11. Both Araruna and Tacima have a salinity concentration of 1 (Table 1). The dissolved oxygen saturation of the studied environments ranged from 6.24 mg/l to 6.96 mg/l, with the highest found in the Araruna reservoir. The temperature of each surveyed area ranged from 25°C to 29°C. The highest temperature was recorded in the Tacima reservoir.

Table 1: Abiotic factors recorded in the reservoirs surveyed in the Brazilian semiarid region of the eastern Curimataú Paraibano.

Abiotic factors	Cacimba de Dentro	Araruna	Tacima
Salinity (‰)	11	1	1
Water temperature (ºC)	27	25	29
Dissolved oxygen (mg/l)	6.24	6.96	6.61
Organic matter (g)	8.11	2.38	11.52

The number of genera found in the eastern region was 16: *Monhystera* Bastian, 1865*, Crocodorylaimus* Andrássy, 1988*; Aporcelaimus* Thorne and Swanger*,* 1936; *Mononchus* Bastian, 1865*; Dorylaimus* Dujardin, 1845*; Eudorylaimus* Andrássy, 1959; *Epidorylaimus* Andrássy, 1986*; Laimydorus* Siddiqi, 1969*; Nygolaimus* Cobb, 1913*; Oxydirus* Thorne, 1939*; Rhabdolaimus* De Man, 1880*; Hemicycliophora* De Man, 1921*; Mesodorylaimus* Andrássy, 1959*; Plectus* Bastian, 1865*; Dichromadora* Kreis, 1929*; Daptonema* Cobb, 1920*.* The preeminence of the Tacima region is evident at the generic level, with 14 genera (Figure 2).

The high densities were found for *Monhystera* at the three sampling sites, with 21.39 ind.10cm² in Araruna. Other genera presented lower densities: *Aporcelaimus, Epidorylaimus, Nygolaimus, Oxydirus, Rhabdolaimus, Hemicycliophora, Mesodorylaimus, Plectus, Dichromadora, Daptonema* (Figure 3).

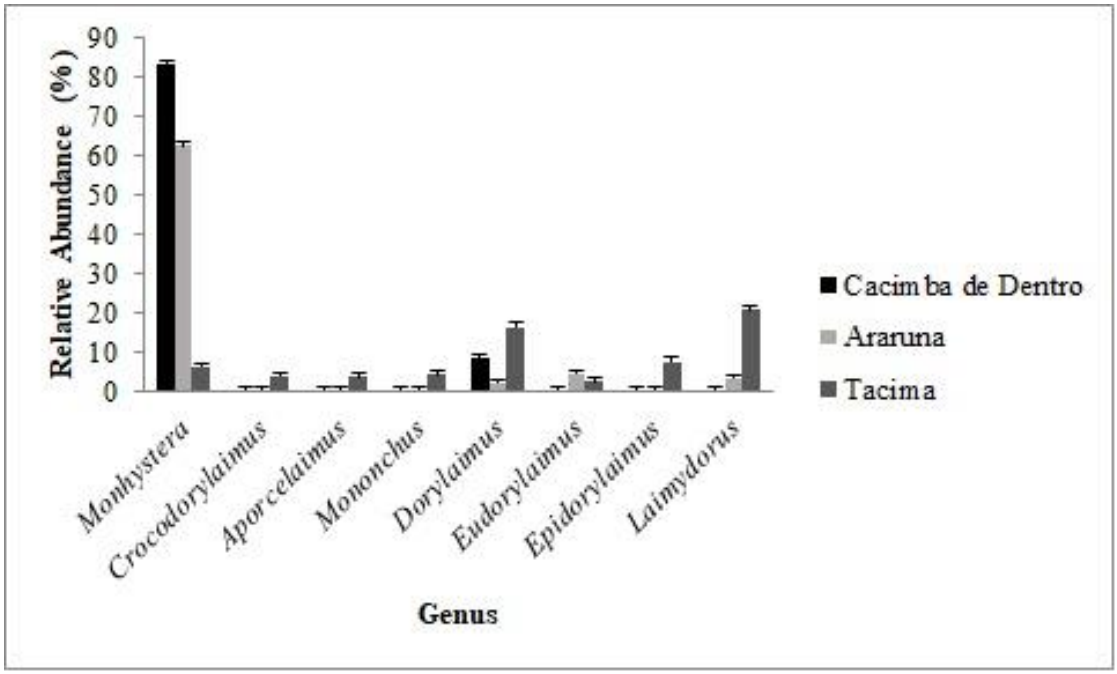

Figure 2: Relative Abundance (%) of the Nematoda genera in microregion of the eastern Curimataú Paraibano, Brazil.

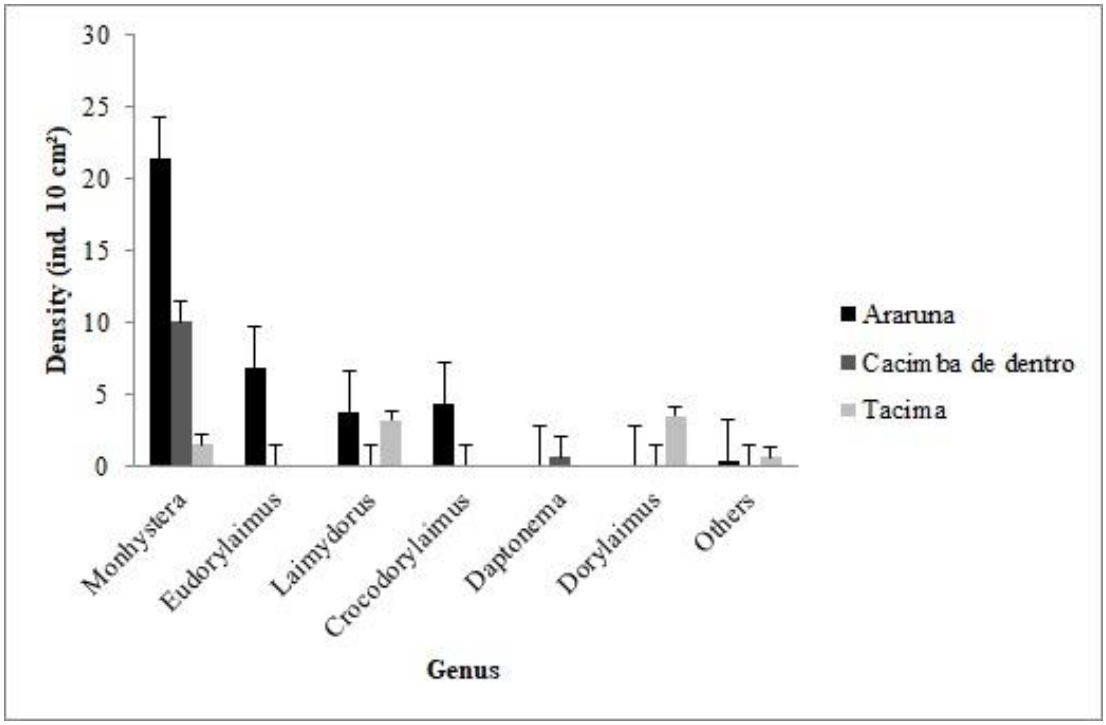

Figure 3: Nematoda genera densities in a microregion of the eastern Curimataú Paraibano, Brazil.

ANOSIM showed that there were statistically significant differences among the nematofauna community of the studied reservoirs (Global R: 0.227; *p* 0.006).

The ANOSIM test is based on the matrices of nematode fauna similarity (R values, significance level adopted = *p* <0.05) found in the reservoirs of the eastern Curimataú Paraibano.

The non-metric ordination (MDS) shows the differences among the populations of the sampling sites, with Cacimba de Dentro differing from Tacima.

In statistical terms, the nematode community among the reservoirs also showed significant differences (ANOSIM - Global R: 0.227; *p* 0.006). These differences are graphically evident in the MDS. It was observed that the population of Tacima formed one group of samples, while the other two locations presented some similarity. The atypical characteristics of Tacima have already been mentioned above, and the generic occurrence emphasizes these differences (Figure 4).

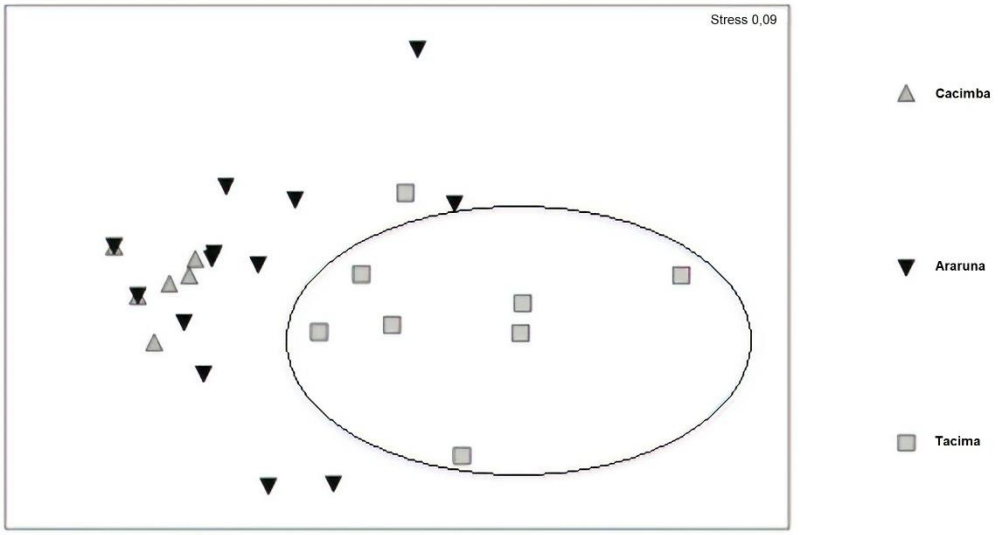

Figure 4: Non-metric (MDS) ordination of nematofauna in the eastern Curimataú paraibano microregion, Brazil.

The Shannon index (H') showed that the nematofauna diversity between the reservoirs varied, and that a considerable diversity of 1.201 was detected in Tacima. The greatest evenness (Pielou J') of the nematofauna genus was recorded in the Tacima reservoir. Both indexes are shown in table 2.

Table 2: Indexes of Shannon-Wiener diversity (H') and evenness (Pielou J') of the Nematoda genus in the region of the eastern Curimataú Paraibano, Brazil.

Reservoirs	H'	J'
Cacimba de Dentro	0.198	0.285
Araruna	0.445	0.491
Tacima	1.201	0.903

Regarding species diversity, a variance analysis (ANOVA) showed significant differences between reservoirs (F = 16,697; p <0,0001). Comparison of multiple means by Tukey test indicated that differences were not statistically significant between reservoirs 1 (Cacimba de Dentro) and 2 (Araruna), and statistically significant between both reservoirs 1 e 3 (p <0,01) and reservoirs 2 e 3 (Tacima) (p <0,01). For species evenness, analysis of variance (ANOVA) revealed significant differences between reservoirs (F = 6,5931; p <0,0045). Comparison of multiple means by Tukey test indicated that differences were not statistically significant between reservoirs 1 and 2, and statistically significant between reservoirs 1 and 3 (p <0,01) and between reservoirs 2 and 3 (p <0,05).

The SIMPER analyzes revealed that the *Monhystera* genus contributed the most to the dissimilarity among the reservoirs (Table 2). The BIOENV test analyzed the correlations between abiotic factors and the structure of the nematofauna community, and resulted in low correlations (0.197), while indicating that of the analyzed factors temperature most influenced the nematode fauna population.

The genera that contributed most to the dissimilarity between the reservoirs are shown in table 3, with *Monhystera* contributing 48.79% of the total.

Table 3: Results of SIMPER analysis, with the main genera and their individual (%) and cumulative (%) contributions to the dissimilarities among the reservoirs of the eastern Curimataú Paraibano.

Genus	Reservoirs	% Individual Contribution	% Accumulative Contribution
Monhystera	**Cacimba de dentro**	48.79	48.79
Crocodorylaimus	**and Araruna**	13.55	62.34
Eudorilaymus		12.25	74.59
Laimydorus		17.71	17.71
Monhystera	**Cacimba de Dentro**	17.65	35.36
Plectus	**and Tacima**	16.92	52,28
Dorylaimus		15,24	67.52
Monhystera		17.30	17.30
Laimydorus	**Araruna and Tacima**	16.45	33.75
Plectus		15.42	49.17
Dorylaimus		14.70	63.87

DISCUSSION

The concentrations of dissolved oxygen found in the present study are lower than the values found by Lucena *et al.* (2015) in the region of western Curimataú Paraibano or by Oliveira (2017) in Rio Grande do Norte in studies of coastal lakes. Although different, the scale of variation is not large. The temperatures measured were consistent with those described by Barbosa *et al.* (2012), but higher than those found by Lucena (2015) in a study of meiofauna biodiversity in aquatic ecosystems of western Curimataú Paraibano, which found temperatures ranging from 23.5 °C to 27 °C. The salinity recorded in the present study was lower than the values found in the Paraiba semiarid region by Lucena *et al.* (2015). The Cacimba de Dentro reservoir has a very similar physical/geological feature to that of Olivedos, studied by Lucena *et al.* (2015), mainly specific salinity values, considered high by a National Environmental Council Resolution (CONAMA, 2005). These regions need further study to better understand these particularities.

The organic matter in the reservoirs of the eastern Curimataú Paraibano shows that Araruna exhibited low values in comparison with Cacimba de Dentro and Tacima. These results are related to organic waste, as in Araruana the collection site was a preserved dam in the urban area, unlike the other reservoirs, with a great deal of anthropic influence. For the western Curimataú region, the results found by Lucena *et al.* (2015) were lower than those presented in this study, whereas the results of Lopes (2017) and Barros (2018) are similar to the values of the present study. The values recorded by Oliveira (2017) and Paiva (2017) for Rio Grande do Norte lagoons were lower than the values described herein.

The abundance of *Monhystera* was 83% (Figure 2). This genus is widespread in freshwater environments and where there is an organic enrichment process. Its highest abundance occurred in the reservoir of Cacimba de Dentro, where the sediments have a very thick layer of mud substrates, characterizing organic deposition. It is the first record of this genus for the region, but another member of the Monhysteridae family has already been identified has highly abundant in the eastern region (Lucena *et al.* 2015). *Monhystera* belongs to the Monhysteridae family and the Monhysterida order (Lorenzen, 1994). In many habitats, species of the Monhysterida order are dominant, but there are differences between the species that inhabit lotic and lentic environments (Traunspurger, 2014).

The *Dorylaimus* genus was the second most representative genus in the region, with an abundance of 8% among the population (Figure 2). Representatives of the Dorylaimida order, which belongs to this genus, are almost all found in freshwater, with little tolerance for salt variations (Abebe *et al.* 2008). Tacima reservoir contributed to higher diversity, supported by ANOVA and diversity index. The Tacima reservoir has a different topography, characterized by a continuous flow, unlike the others studied, which formed in depressions, establishing a lake. These topographic features also favor the process of evaporation and salt concentration, as in the case of Cacimba de Dentro, which presented the highest salinity and the lowest occurrence of this genus. The

Dorylaimida order is one of the most diverse orders found in terrestrial and freshwater environments (Traunspurger, 2014) and its representatives have the ability to colonize these habitat types in any situation (Jairajpuri & Ahmad, 1992).

Nematoda, as the dominant meiofauna group, is potentially crucial in freshwater habitat processes for a variety of reasons (Traunspurger, 2014). The author states that this phylum is functionally important within freshwater ecosystems. Current knowledge strongly supports its critical role in the functioning of these systems, with significant effects on microorganisms and the environmental algae community (Giere, 2009). The taxonomic value and contribution to biodiversity of the present study should not be overlooked. However, the fauna found are similar to another previous study in the Curimataú region, as 16 genera of Nematoda were identified, corroborating the results of the study by Lucena *et al.* (2015), which found the same amount in the same Curimataú region. Also, abiotic factors, together with the urbanization of some reservoirs, influenced the studied community, as individuals are clearly more susceptible to conditions imposed by the environment.

CONCLUSION

In terms of generic composition, the biodiversity of the nematofauna community in the Western Curimataú is very similar to that of the Eastern region. The processes of drought, and consequently evaporation, precipitation, and salinity, together with the urbanization of certain reservoirs, are decisive for the establishing of assemblies.

REFERENCES

Abebe, E.; Decraemer, W & De Ley, P. 2008. Global diversity of nematodes (Nematoda) in freshwater. Hydrobiologia 595 (1): 67-78.

Baia, E & Venekey, V. 2019. Distribution patterns of meiofauna on a tropical macrotidal sandy beach, with special focus on nematodes (Caixa d'Água, Amazon Coast, Brazil). Brazilian Journal of Oceanography, 67.

Barbosa, J.E.L.; Medeiros. E.S.F.; Brasil J.; Cordeiro. R. S.; Crispim. M. C. B & Silva. G.H.Z. 2012. Aquatic systems in semi-arid Brazil: limnology and management. Acta Limnologica Brasiliensia 24(1): 103-118.

Barros, F.L.O. 2018. Colonização meiofaunística e nematofaunística em substrato artificial em um ecossistema lêntico. Universidade Federal de Campina Grande. Cuité-PB. Trabalho de Conclusão de Curso.

Barbuto, M & Zullini, A. 2005. The nematode community of two Italian rivers (Taro and Ticino). Nematology, 7(5), 667-675.

Citadin, M.; Costa, T. M. & Netto, S. A. 2018. Response of estuarine meiofauna communities to shifts in spatial distribution of keystone species: An experimental approach. Estuarine, coastal and shelf science. 212, 365-371.

Clarke, K.R & Gorley, R. N. 2001. Software PRIMER. Primer-ELTD. Plymouth.

Cobb, N.A. 1917. Notes on nemas. Contribution Science of Nematology 5: 11.

CONAMA. Resolução CONAMA Nº 357, de 17 de março de 2005. Dispõe sobre a classificação dos corpos de água e diretrizes ambientais para o seu enquadramento, bem como estabelece as condições e padrões de lançamento de efluentes, e dá outras providências. Disponível em: <www.mma.gov.br/port/conama> Acesso em: 12 Agos. 2019.

Coull, B.C. 1988. Ecology of marine meiofauna. Introduction to the study of meiofauna, p. 18-34. In: Higgins. R. P. & Thiel. H (Ed.). Introduction to the study of meiofauna. Smithsonian Institution Press, Washington. 488 p.

Felix, G.; Marenzi, R. C. & Netto, S. A. 2016. Landscape visual quality and meiofauna biodiversity on sandy beaches. Environmental management, 58(4): 682-693.

Giere, O. 2009. The microscopic motile fauna of aquatic sediments. Meiobenthology. 2ª ed. SpringerVerlag: Berlin-Heidelberg. 527 p.

Jairajpuri, M.S. & Ahmad, W. 1992. Dorylaimida: free-living, predaceous and plant-parasitic nematodes. E.J. Brill, Leiden, New York, Kobenhavn, Koln.458 p.

Lopes, T.S. 2017. Caracterização da meiofauna e da nematofauna da barragem de poleiros, Barra de Santa Rosa-Paraíba, Brasil. Universidade Federal de Campina Grande. Cuité-PB. Trabalho de Conclusão de Curso.

Lorenzen, S. 1994. The Phylogenetic Systematics of Freeliving Nematodes. The ray Society, London. 383 p.

Lucena, B.K.P.; Silva, M.C & Castro, F.J.V. 2015. Nematode Community lakes with different concentrations of salts. Revista Nordestina de Zoologia 9 (1): 27–40.

Lucena, B.K.P. 2015. Biodiversidade meiofaunística em ecossistemas aquáticos do Curimataú Ocidental Paraibano. Universidade Federal de Campina Grande. Cuité-PB, MSc diss.

Meurer, A.Z. 2010. Alteração da estrutura e composição da meiofauna estuarina em diferentes ciclos de maré no estuário do rio Itajaí-Açú SC. Universidade Vale do Itajaí. Itajaí, MSc diss.

Oliveira, M.F.C. 2017. Nematofauna de três lagoas costeiras do estado do Rio Grande do Norte. Universidade Federal de Campina Grande. Cuité-PB, MSc diss.

Paiva, J.M.S. 2017. Estudo de comunidade meiofaunística em lagoas costeiras do Rio Grande do Norte. Universidade Federal de Campina Grande. Cuité - PB. Trabalho de Conclusão de Curso.

Platt, H.M. & Warwick, R.M. 1983. Free-living Marine Nematodes – Part I British Enoplids. Synopses of the British Fauna (New Series) Eds: Doris M. K. & Barnes, R.S.K. p. 37-217.

Platt, H.M.; Warwick, R.M & Somerfield, P. 1988. Free living Marine Nematodes. II. British Chromadorids. In: Sermack, D.M. & Barnes, R.S.K. (Eds), Synopses of the British fauna (New Series). Linn. Soc. London, Est. Brackish-water Sc. Ass.

Pinto, T.K.O. 2006. Estrutura da comunidade de meiofauna no banco de areia da Coroa do Avião, Itamaracá-PE-Brasil. Atlântica 28 (2): 117-127.

Tilbert, S.; Castro, F. J. V.; Tavares, G. & Júnior, M. N. 2019. Spatial variation of meiofaunal tardigrades in a small tropical estuary (~6ºS; Brazil). Marine and Freshwater Research. 70(8): 1094-1104.

Traunspurger, W. 2000. The biology and ecology of lotic nematodes. Freshwater Biology, 44(1), 29-45.

Traunspurger, W. 2014. Ecology of Freshwater Nematodes, p. 153-169. in: Schimidt-Rhaesa, A. (Ed.). Handbook of Zoology. Nematoda. Germany: De Gruyter. 759 p.

Viglierchio, D.R. 1991.The world of nematodes. AgAccess. California, USA. 266 p.

Warwick, R.M.; Platt. H.M & Somerfield, P.J. 1998. Free-living marine nematodes. Part III. British monhysterids. Synopses of the British Fauna (New Series). Vol 53. Field Studies Council, Shrewsbury, UK. 296 p.

Webster, J.M. 1980. Biocontrol: the potential of entomophilic nematodes in insect management. Journal of nematology 12 (4): 270.

Zullini, A. & Ricci, C. 1980. Bdelloid rotifers and nematodes in a small Italian stream. Freshwater Biology 10, 67-72.

Zullini, A. 2010. Identification Manual for Freshwater Nematode Genera. Università di MilanoBicocca.112 p.

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