

The art status of rotifer studies in natural environments of South America: floodplains

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ABSTRACT. The present study aimed to carry out a compilation concerning the art status of rotifer studies in natural environments of South America, with distinction to floodplains. This compilation was carried out based on available informations in literature until now and demonstrated a single distribution of studies and research advances. The majority of studies was recorded only for three South-American countries, Brazil, Argentina, Venezuela, and mainly for the three greatest watersheds, Amazon, Paraná and Orinoco. In this way, besides the ecological importance of these organisms, it could consider that there are few studies about rotifers face to the vast and heterogeneous territorial extent, and the various floodplain environments not even explored, in which more investigations are necessary to enlarge knowledge on ecology of the group and consequently to ecology of tropical floodplains.

Key words: rotifers, zooplankton, richness, abundance, floodplain, South America.

RESUMO. O estado da arte dos estudos de rotíferos em ambientes naturais da América do Sul: planícies de inundação. No presente estudo objetivou-se realizar uma compilação à respeito do estado da arte dos estudos de rotíferos em ambientes naturais da América do Sul, com destaque para planícies de inundação. Esta compilação foi realizada com base nas informações disponíveis na literatura até o momento, demonstrando uma distribuição impar dos estudos e avanços nas pesquisas. A maioria dos estudos foi relatada apenas para três países sulamericanos, Brasil, Argentina, Venezuela e principalmente para as três maiores bacias hidrográficas, Amazônia, Paraná e Orinoco. No restante dos países, a existência de pesquisas sobre rotíferos é escassa ou inexistente. Dessa forma, além da importância ecológica desses organismos, pode-se considerar que há poucos estudos sobre os rotíferos, frente à vasta extensão territorial e os diversos ambientes ainda não explorados, sendo que maiores investigações são necessárias para o conhecimento da ecologia do grupo, e consequentemente para a ecologia de planícies de inundação tropicais.

Palavras-chave: rotíferos, zooplâncton, riqueza, abundância, planície de inundação, América do Sul.

Introduction

Floodplains are ecosystems characterized for the predominance of periodic disturbances, provided by the alteration in the hydrological level. Concomitant to that, they show a great diversity of habitats with its respective biota able to explore the spatial heterogeneity of these environments and, due to that, present high biodiversity (Ward *et al.*, 1999).

Among zooplanktonic groups present in these ecosystems, are found rotifers, and in accordance with Armengol (1980), they play an important role in the plankton, performing as a link transferring energy between producers and the upper trophic levels. These organisms stand out for the opportunistic character, with high rate of consumption and assimilation of a large variety of food resources, making possible to colonize even unsteady environments (Allan, 1976).

The phylum Rotifera, is composed of some of the smallest animals known, invertebrates metazoarian, not much larger than ciliate protozoaries, measuring

between 0.04 and 2mm of length. Principally in limnics environments, these organisms show approximately 2000 species described (Margalef, 1983).

The knowledge concerning rotifers of South America has initiated with the studies of Schmarda in a voyage around the world in 1855, describing, in 1859, species of Monogononta and Bdelloidea rotifers of Chile, Peru and Ecuador. However, until the latter of 19th century it was not accomplished any additional research concerning these organisms (Koste and José de Paggi, 1982).

After Schmarda (1859), the first studies in the light of 20th century, emphasizing South American rotifers, were based on samples taken at random in environments disperse by the American sub-continent, as studies carried out by Wierzejski (1892), Daday (1902a, b; 1905) e Murray (1913). Subsequent studies became to be more restrict to a determined region, however, they were brief taxonomic descriptions, with scarce additional

informations: Beauchamp (1939), Hauer (1956, 1965), Thomasson (1953, 1963), since then in the second half of the 20th century was possible to observe in literature more detailed studies (Koste and José de Paggi, 1982).

According to Koste and José de Paggi (1982), the phylum remain shortly studied, specially in regions of the south hemisphere, in contrast to those of north hemisphere (Palearctic and Nearctic). Besides, Seisona and Digononta rotifers are practically neglected, in wich taxa of the superorder Monogononta are the most studied, due to the difficulties in the identification.

In contrast to its large territorial extent and its countless floodplains, rotifers present in these ecosystems of South America were shortly studied. The most researches of this nature carried out in South American continent, concentrate in floodplains pertaining to the three largest watersheds of the subcontinent, that is, of the Amazon, Paraná and Orinoco rivers. Territorially, it can stand out these researches are totally pertinent to Brazil, Argentina and Venezuela, in which are scarce studies carried out in other regions of the subcontinent.

Paggi and José de Paggi (1990) emphasize that these organisms are predominant in richness and abundance in these ecosystems, as much in lotic as in lentic environments, existing differences only in structure and dynamic of this group. Besides, in accordance with Neves *et al.* (2003), in virtue of the highest temperature and, consequently, of higher productivity, the great abundance of Rotifera has been related to the tropical aquatic ecosystems.

A total amount of 488 species, subspecies and forms of rotifers were recorded to Neotropical region by Koste and José de Paggi (1982). In a compilation carried out by Rocha *et al.* (1994), the number of taxa in the region was increased to 519. The Neotropical rotifers had been studied of the taxonomic and ecological point of view. However, all this information is still fragmentary and great areas lack of studies (Koste and José de Paggi, 1982). In a work carried out by José de Paggi and Koste (1995), were added to this list 105 new taxa recorded for the neotropical region, increasing the number for 624 species, subspecies and forms recorded in this zoogeographic area. Due to the high number of taxa described to this day by taxonomists and taking into account the innumerable regions not explored in the continent, it can be considered that a high number of studies on taxonomy and ecology of this group, describing possible ecological relations, are potentially important for a better understanding of the structure and dynamic of rotifers assemblage in floodplains.

The art status of rotifers studies in floodplains of South America, reported in this study, are principally, with reference to floodplains existent in Brazil, Argentina and Venezuela. Floodplains found in other countries in South America are discussed jointly. The

geographical, morph metrical and hydrological characteristics of watersheds of main rivers of these floodplains are described in Canevari *et al.* (2001).

Brazil

The first relates in literature on the occurrence of rotifers in Brazil were the studies carried out by foreign researchers, which in scientific expeditions have studied the fauna of several places of South America, among these, Murray (1913), which has studied South American rotifers.

According to Medeiros and Hadel (1999), one of the first studies, less spacious and more significant, about rotifers richness in Brazil has related the occurrence of 141 species (Krau, 1966). After this phase, Schaden (1970), removing synonymia, stood out the register of 131 species. In the period that separates these two inventories, little was published about Brazilian rotifers. R. Schaden and W. Koste have inaugarated, in the 70's, the period of intensification of limnic studies that extend until nowadays, in wich allowed to increase to 467 (Oliveira-Neto and Moreno, 1999) the occurrent number of species in Brazil. Worth to emphasizing these studies are not referent specifically to about studies carried out in floodplains.

In Brazil, approximately 6.3% of the territory is covered by flooded areas, which have been submitted to most of the several human impacts (Esteves, 1998). However, there are few studies that emphasize the study of rotifers in floodplains. The predominance of these organisms in aquatic environments, present in these ecosystems, has been considered characteristic and related by several authors, as Koste and Robertson (1983), Sendacz and Costa (1991) and Bozelli (1992) to the amazonic region; Reid and Turner (1988) to the Mearim River in Maranhão State; Neumann-Leitão and Nogueira-Paranhos (1989) and Dabés (1995) to the São Francisco River; Sendacz (1993) to the Superior Paraná River (São Paulo State); Lansac-Tôha *et al.* (1993, 1997, 2004) to distinct environments of the Upper Paraná River floodplain (Mato Grosso do Sul and Paraná States); Turner and da Silva (1992), Bonecker *et al.* (1997), Espíndola *et al.* (1996); and Heckman (1998) to the Pantanal (Mato Grosso and Mato Grosso do Sul State). These authors still consider, this fact can be considered characteristic to these ecosystems.

Despite of the high number of rotifer species in floodplain environments, according to Pennak (1957), most of the limnetic communities is represented by few species, exceptionally abundant and numerically dominant on the others, fact which is verified by several authors, as Hardy (1980), Dabés (1995), Lansac-Tôha *et al.* (1997).

The composition of rotifers assemblage in floodplain environments is composed of several families, which the principal are Lecanidae, Brachionidae, and Trichocercidae, that show the highest number of taxa and the predominant genera

Lecane, *Brachionus*, *Keratella* and *Trichocerca* (Robertson and Hardy, 1984; Reid and Turner, 1988; Koste, 1989; Sendacz, 1993; Dabés, 1995; Lansac-Tóha *et al.*, 1997).

In relation to the geographic distribution of the studies, rotifers seem to subvert the common sense about the art status concerning Brazilian fauna diversity. Brazilian and Peruan Amazonian, had as a great mystery, is the more known area of Neotropics and with the highest number of researchers involved. The highest number of scientific studies on the richness of this group is concentrated in Brazilian Amazonian region, where floodplain lagoons are far frequent (Thomasson, 1953; Hauer, 1953, 1965, 1966; Gillard, 1967; Marlier, 1967; Koste, 1972; Schaden, 1976; Fisher, 1978; Carvalho, 1983; Brandorff *et al.*, 1982; Koste and Hardy, 1984; Bozelli and Esteves, 1991; Junk and Robertson, 1997). Brandorff and Andrade (1978), Hardy (1980), Koste and Robertson (1983), Hard *et al.* (1984), Fisher *et al.* (1983), Koste *et al.* (1984), Robertson and Hardy (1984) and Sousa (2003), have emphasized essentially rotifers specific composition of amazonic lagoons. Aproximately 300 species of rotifers are known (Koste, unpublished data), in which that diversity upper than the Cladocera and Copepoda in the same region (Day and Davis, 1986). This number of species registered, to this vast area, is for its turn underestimated and the possibility to be higher is more due to the scarcity of researches than a real absence of organisms (Robertson and Hardy, 1984).

Still in the north of the country, other studies were carried out in floodable environments of other localities, as Sendacz and Costa (1991) and Keppeler and Hardy (2004) in Acre State, Bozelli and Esteves (1991) and Bozelli (1992) in Pará State, and Koste and Robertson (1990), Sergers *et al.* (1993) and Segers and Sarma (1994) in Roraima State. Sendacz and Costa (1991) and Keppeler and Hardy (2004) have studied rotifers of some environments of Acre River Floodplain, recording the occurrence of 46 and 48 species of rotifers respectively. According to Sendacz and Costa (1991), rotifers studies of amazonic region are restrict, in majority, to Central Amazonian, existing few informations on the Amazon white-water tributaries, in which the Acre River. Furthermore, worth to mention that the number of studied environments and researchers involved are exceptionally higher in the Central Amazonian, when compared to other areas of north of the country.

The Brazilian north-east presents some knowledge on rotifers of estuarine and coastal areas, as the studied by Neumann-Leitão *et al.* (1992) and Rocha *et al.* (1998), besides dams (Ahlstrom, 1937; Neumann and Souza, 1987), standing out the Pernambuco State, but much little is known on rotifers in north-east region floodplains yet. The studies on rotifers in northeast started with studies

carried out by Ahlstrom (1937) and Hauer (1953), and much little has been published from then on. Among the few studies carried out in floodplains of this region, worth to mention Reid and Turner (1988) in Maranhão State and a study carried out by Neumann-Leitão and Nogueira-Paranhos (1989) in the main channel of the São Francisco River, in a stretch with large section of floodplain associated. In this study was recorded the occurrence of 52 species.

In the Minas Gerais State, despite to verify a vast hydrographic net and countless marginal lagoons, few are the registers on the planktonic fauna of these environments too, which of them worth to mention a study carried out in a varzea lagoon, from Paraopeba River, in the São Francisco River Basin, by Sampaio and López (2000) and other in the own São Francisco River (Dabés, 1995), stretch of the south-east region, in which was recorded the occurrence of 108 generic and infrageneric taxa, and other in the Jequitinhonha River Basin (Landa, 1997), where were found 46 taxa.

In the Mato Grosso and Mato Grosso do Sul States, is found the Pantanal, large plain of floodable areas, considered as the largest continuous humid area of the world. In this plain, exist some studies approaching rotifers, among them, pioneer studies as Daday (1905) and Green (1972), and more recent studies as Oliveira-Neto (1990), Turner and da Silva (1992), Heckman (1994), Espíndola *et al.* (1996), Bonecker *et al.* (1997), Koste (1999) and Neves *et al.* (2003), but there are few studies with respect to these organisms in this ecosystem, considering its magnitude.

According to Neves *et al.* (2003), while various studies were carried out in recent decades in Brazil, on the taxonomy and abundance of zooplanktonic community populations in several waterbodies, it can be seen that for the Mato Grosso and Mato Grosso do Sul States such informations are relatively sparse, in which the number of carried out investigations is little. In accordance with the authors, in lotic environments, inventories were carried out to Abobral, Miranda, Itaqueri (Oliveira-Neto, 1990; Segers *et al.*, 1993; Bonecker *et al.*, 1997; Bezerra *et al.*, 1999), and Paraguai Rivers (Oliveira-Neto, 1990; Segers *et al.*, 1993). In lentic environments, studies were carried out in connected lagoons to the rivers, as the meander lagoons of the Suiá Missú River (Green, 1972), Albuquerque Lagoon (Espíndola *et al.*, 1996), Baía Acuziral Lagoon (Turner and da Silva, 1992), and Baía Sinhá Mariana Lagoon (Morini-Lopes, 1999); isolated lagoons which only become connected to rivers during large floods, as the Buritizal Lagoon (Pinto-Silva, 1991); isolated lagoons which are not influenced by the floods, as the Recreio Lagoon (Pinto-Silva, 1991; Lima, 1996); and small lagoons, both of fresh and salt water (Mourão, 1989; Turner and da Silva, 1992; Kretzschmar *et al.*, 1993; Medina-Junior, 2000).

Among the studies carried out in Pantanal, few refer exclusively to rotifers study, considering all the zooplanktonic community. Besides, the most of these studies are pertinent to the Mato Grosso State, which in the Mato Grosso do Sul State is lesser the number of carried out researches, among them: Bonecker *et al.* (1997), Bezerra *et al.* (1999), Koste (1999) e Medina-Junior (2000).

Turner and da Silva (1992) listed a total of 172 taxa of rotifers to the Mato Grosso State, gathering together faunistic inventories from the Pantanal do Poconé (Turner and da Silva, 1992), Pantanal de Barão de Melgaço and the Suiá Missú River (Green, 1972). Bonecker *et al.* (1997) recorded a total of 57 taxa of rotifers in lagoons connected to Miranda River and in the own river, in the Pantanal of Mato Grosso do Sul State, pertaining to the Paraguay River basin in its Brazilian stretch, and Koste (1999) registered a total of 216 taxa in the own Paraguay River and in some shallow lagoons of floodable environments near the Corumbá City, being one of the few existent studies concerning rotifers study in floodplains of the Paraguay River basin.

Also are relatively well studied areas joined to the upper Paraná River basin (Mato Grosso do Sul and Paraná States), which can be mentioned studies carried out by Bonecker *et al.* (1994, 1998), Bonecker and Lansac-Tôha (1996), Lansac-Tôha *et al.* (1992, 1993, 1997, 2004), Campos *et al.* (1996), Serafim (1997), Garcia *et al.* (1998), Serafim *et al.* (2003), Aoyagui and Bonecker (2004) and Bonecker *et al.* (no prelo), totalysing 230 species of rotifers. Still in the Paraná River basin could be cited the Sendacz (1997) study in the Superior Paraná River (São Paulo State). The author registered a total of 59 taxa of rotifers in marginal lagoons of the Paraná River floodplain, in the Paulistan stretch.

In floodplains, highest richness values of rotifers generally are registered during the high water period, due to the more intense inter-linkage among the environments, promoting a higher faunistic homogenization. Besides, occur an increase in the number of taxa due to the flooding of varzea of floodplain and a higher communication among the environments that remain isolated during the low water period (Hardy, 1980; Bozelli, 1992; Bonecker *et al.*, 1994; Lansac-Tôha *et al.*, 1997). According to Koste and Robertson (1983) and Bonecker *et al.* (1994), the richness of rotifers in lentic environments tends to increase during the high water as a consequence of the incorporation of bentic and periphitic taxa favored by the higher availability of food resultant of decomposition of aquatic vegetation. Higher richness in floodplain environments is registered generally in the marginal regions, mainly in lentic environments, due to great amount of vegetation in these regions, providing a higher diversification of habitats, and the absent of an intense current gradient of water in these

environments (Hardy, 1980; Lansac-Tôha *et al.*, 2004).

According to Aoyagui and Bonecker (2004), the spatial and temporal variation of the rotifers richness is related with the gradient of connectivity existent among the distinct hydrological periods (high and low water) in the different types of environments of a floodplain (rivers, connected lagoon and isolated lagoons). In addition, the increase of richness during the high water period depends on the depth variation of environments, suggesting also as importance of the flood of the varzea to richness, the consequent spatial increase and the number of habitats. The authors registered higher values of richness in the rivers during the high water periods, attributing to these results the contribution of lagoons to the increment of richness in the rivers, suggesting that the rivers could be functioning as a fauna information collector, which the fauna of the rivers could be characterizing the whole fauna of the floodplain in such periods.

Quantitatively, the lowest densities of rotifers in environments of Brazilian floodable areas, generally, occur during the high water periods (Brandorff, 1978; Hardy, 1978; Hardy, 1980; Hardy *et al.*, 1984; Lansac-Tôha *et al.*, 1993; Bozelli, 1994; Serafim, 1997; Rossa, 2001). Paggi and José de Paggi (1974) considers the variations in the water level as a complex variable that means not only changes in the watershed volume, but also in current velocity, having a positive or negative effect on rotifers density. The density variation of these organisms, concerning the water level changes, also could be correlated with other environmental variables, as the transparence, water temperature, pH, concentration of solid suspended, chlorophyll-a and dissolved oxygen, which its relation can be direct or indirect, dependent on the peculiar characteristics of each water body and the effects of the alteration of the water level on the limnological variables, which difficult to establish a general pattern of density variation. Rothhaupt (1995) mention an indirect relation of environmental variables in the density variation of rotifers, such as the importance of nutrients (N and P) concentration in the nutritional quality of phytoplankton, which this planktonic component is an important food resource for rotifers. Bonecker and Lansac-Tôha (1996) showed that the highest densities of some of the most abundant species in a river and a lagoon in the upper Paraná River floodplain were associated with high concentrations of chlorophyll-a and dissolved oxygen and low temperature values and water level. According to Garrido and Bozelli (1997), a decrease in abundance of phytoplankton caused by suspended sediments, diminishing the light penetration in the environment, affect indirectly zooplanktonic populations, limiting growth rates of rotifers populations. Hardy *et al.* (1984) mentioned that the lowest densities of rotifers, during a flood had direct relation to the high values of hypoxia registered in the lagoon. In the marginal lagoons of São Francisco

River, Minas Gerais State, Dabés (1995) mentioned that the temperature was a variable which contributed a lot to the predominance of rotifers in this environments, seen that, according the author, rotifers are considered in literature as the organisms which present higher adaptation to higher temperatures (> 25°C).

Brandorff and Andrade (1978), Hardy (1978, 1980), Bozelli and Esteves (1991), Lansac-Tôha *et al.* (1993), Espíndola *et al.* (1996), Serafím (1997), Bonecker *et al.* (2002) and Rossa and Bonecker (2003) consider dilution effect as a factor responsible for the low density observed during the flood period. According to Bonecker *et al.* (2002), the significant difference of rotifers abundance in lagoons between hydrological periods can be due to the plankton dilution and by the stress conditions during the high water period; but in the river, current velocity probably is the most important factor on populations development of rotifers, which rotifers abundance, in the studied area, influenced by regional factors in lagoons (fluviometric levels) and local factors in rivers (current velocity).

Some studies also constated other results on density variation of these organisms concerning fluctuation of water level. Lansac-Tôha *et al.* (1997) registered lower values on rotifers density during high water period in lotic environments of the upper Paraná river floodplain and higher values of density during the high water period in lentic and semi-lentic environments. The authors attributed these results to a lower current velocity and a higher stability of lentic environments in relation to lotic environments.

Hamilton *et al.* (1990) pointed out that the presence of extensive banks of aquatic macrophytes can influence density of these organisms due to the contribution of associated fauna with this vegetation or the fauna present in the plankton in regions where these banks develop. The authors stand out this influence is expressive during the high water period, due to, among other factors, the flooding of vegetation and the mixture of water masses inside and among environments. Twombly and Lewis (1987) and Brandorff (1978) mentioned that the increase of water volume, in this hydrological phase, seems to function as a reproductive trigger for some species, with physiologic adaptations to floodable environments, as the perception of this hydric fluctuation, leading to an increase of density. The authors stand out, also, that lagoons can present better nutritional conditions for the zooplankton.

Garrido and Bozelli (1997) mention that rotifers density in Batata Lake (Pará State) increases during the high water period in impacted environments, in this case, by bauxite rejects from a local minerator, due to the stress condition during low water period, caused by resuspension processes of the sediment by the wind action. This situation is minimized during the high water period by sedimentation of suspended material, and increase of water transparence, making

the environment more suitable and previsible, with consequent increase of rotifers diversity and density, favored, also, by the phytoplankton development.

In the upper Paraná River, was observed that rotifers density follow the same pattern of richness, observing a higher density of rotifers in the marginal region of lentic environments, higher density in the central region of semi-lotic environments, due to a reduced marginal vegetation and high concentrations of chlorophyll-a, and a more homogeneous distribution of abundance between the littoral and central region in lotic environments (Bonecker and Lansac-Tôha, 1996; Lansac-Tôha *et al.*, 1997).

In relation to the vertical distribution, rotifers tend to be localized in the oxygenated superficial layers, and probably, with elevated densities of phytoplankton. In Calado Lake, pertaining to Amazon system, Fisher *et al.* (1983) observed at a 9m depth, the zooplankton organisms concentrate in the 4m oxygenated superior layer and disappear in the anoxic inferior layer. Bonecker (1994), in the upper Paraná River floodplain, found higher density values of rotifers in the superficial layers of water column from Baía River, however, in a marginal lagoon, the highest densities were registered in the intermediary and deep layers, suggesting, by the fact of rotifers present migratory vertical movements in short scale, could be avoiding predation through vertical migration. According to the author, few studies describe vertical distribution of rotifers in floodplain environments.

Argentina

Rotifers fauna of Argentina is little known yet, which are scarce researchers who have been occupied on their study. In this sense, first studies on rotifers from the country were carried out by researchers who sampled Argentinean aquatic environments during European scientific expeditions to South America, as Wierzejski (1892), Murray (1913) and Olivier (1952). First studies with ample covering on rotifers in Argentina were carried out by Thomasson (1954) in Patagonia, Olivier (1965) in several localities of the country, Ringuet *et al.* (1965) in the Argentinean Pampas, and Dioni (1975) in temporary lagoons in Buenos Aires Province.

In the last thirty years a series of studies and episodes led to an explosive development of Limnology in Argentina (López and Mariazzi, 1994). In 1962, two big happening occurred in Argentina, the publication of the book “Ecología Acuática Continental” by Raul A. Ringuet, and the establishment of the first institute of Limnology in Argentine (INALI) in San Tomé, in Santa Fé Province, by Argentino A. Bonetto. INALI carry out limnological researches which comprise the vast geographical area of the Plata River Basin and floodplains of Paraná River, which has been carried out more than 500 studies, including some limnological studies in Patagonia and in the Antarctic

regions, reflecting in a large development on rotifer studies of floodplain environments of the country.

Other studies were carried out lately by Corrales (1979), Corrales and Frutos (1985) in the High Paraná River floodplain, Argentina stretch; Bonetto and Martínez de Ferrato (1966), Paggi and José de Paggi (1974), José de Paggi (1980), Paggi (1980), Bonetto and Corrales de Jacobo (1985/86) in the Middle Paraná River floodplain; José de Paggi (1978), Modenutti (1991), Frutos (1993) among the few studies carried out in the Lower Paraná River; Kuczynski (1984), and Modenutti (1987) in the Plata River basin; Martínez (1984), Martínez and Frutos (1986), Martínez and Paggi (1988) in floodable environments of the Eastern Chaco; José de Paggi (1989) in some provinces of Argentina north-west; Ferrato (1967), José de Paggi (1976), José de Paggi and Koste (1988) in some hydrographic basins in Santa Fé Province, Thomasson (1953, 1955), Boltovskoy and Urrejola (1977) in the Tierra del Fuego; Ahlstrom (1940), Olivier (1961), Hauer (1965), Ringuelet *et al.* (1965), Macluf *et al.* (1998), Modenutti (1987, 1991) and Kuczynski (1991) in Buenos Aires Province.

Rotifers, generally, are the most representative group among zooplankton in floodplains environments of Argentina. In all stretches of the Paraná River basin (José de Paggi, 1978; José de Paggi, 1981; Cabo *et al.*, 1998), Plata River Basin (Macluf *et al.*, 1998; Kuczynski, 1984), Eastern Chaco (Frutos, 1998), Santa Fé River (José de Paggi, 1976), temporary lagoons, little streams and swamps rotifers presented dominance in number and species. These remarks are in accordance with Ahlstrom (1943) and Ruttner-Kolisko (1974), mentioning that the predominance of rotifers in the plankton composition is well characteristic. According to Paggi and José de Paggi (1974) and José de Paggi (1980), the dominance of rotifers in the Middle Paraná River answers the main oscillations of zooplankton. According to José de Paggi (1990), the rotifers fauna of Argentina is partially documented and approximately 300 species were registered to the country.

Argentina possesses an ample latitudinal spectrum (22° to 56° S), joined with an ample altitudinal variation. Consequently, exist a great diversity of weather and environments, which can favor the distribution of opportunistic organisms, as rotifers. Biogeographically, the Argentinean territory is included in 2 large sub regions: Guyana-Brazilian and Andean-Patagonia. The greatest richness of rotifers was registered to the first sub region, which presents a large number of rivers and lagoons of floodplain. However, there are several areas unexplored in these sub regions, and the most of investigations was carried out in pelagic regions of aquatic environments. The vegetated littoral zone was relatively less studied, which can explain the

occurrence of few littoral species described in the faunistic inventory of rotifers to that country.

In turns, Andean-Patagonia sub region is a cold weather area, which has been little studied for rotifers. In Patagonia, area biogeographically included in Andean-Patagonia sub region of Neotropical region, located in the austral portion of South America, are scarce registers on rotifer fauna, which has been firstly described by Thomasson (1954, 1955, 1959, 1963) in the cordilheirana portion of the region, followed by few studies, among them, Balseiro and Modenutti (1998) and Peralta and Claps (2002) recently. Other studies were carried out by Daday (1902a), José de Paggi (1981) and Kuczynski (1987) in the extra Andean Patagonia. However, the studies carried out in Patagonia are referent to lagoons of altitude.

In Corrientes Province, north-east of Argentina, rich in floodable lands, rivers, streams and shallow lagoons of subtropical environments, close to the Paraná River, José de Paggi (1996) identified 136 taxa of rotifers pertaining to 37 genera, which 20 are new record to the country. The most of the taxa found by the author are from (sub) tropical distribution, among these taxa, 8% are endemics to South America.

In the Paraná River, in Argentinean stretch of the High Paraná River, Corrales (1979) identified approximately 70 species of zooplankton, which the highest number of taxa was represented by rotifers. This value was similar to the found by Corrales de Jacobo and Frutos (1985), approximately 55 species, in a floodplain lagoon (Sirena Lagoon) at the left margin of the High Paraná River. However, the middle stretch of the Paraná River presents the highest number of rotifer taxa (300 species) (Paggi and José de Paggi, 1990), when compared to the other stretch from the river extent in Argentina, which is similar to the Upper Paraná River in Brazilian stretch (284 species) (Lansac-Tôha *et al.*, 2004). This high value of the taxa number in the Argentinean stretch was due to two characteristics existent in the middle stretch: the contribution of the Paraguay River, in the confluence of the Paraná and Paraguay River, and the extensive alluvial plain, nearby Santa Fé Province.

In a floodplain fluvial basin in Santa Fé Province, basin from the Middle Paraná River, José de Paggi (1976) recorded 28 taxa of rotifers.

Observing that from the whole floodplain environments of Argentina, the Paraná River Basin, in the middle stretch, is the place of highest diversity of species of rotifers, due to its extensive floodplain. Besides, Paraná River is the largest river of the country and the second of South America, however it is not of full jurisdiction of the country, taking part in the hydrograph of adjacent countries.

In relation to the Lower Paraná, including the own river and its tributaries, exist few informations respecting rotifers diversity, such as verified for the

Delta of the Paraná River and in the Plata River Basin. Equally to the Argentinean stretch of the High Paraná River, in the lower stretches of the Paraná River, diversity of rotifer species is lower than in the middle stretch of the river, due to the existence of a smaller floodplain in the lower stretch, which soon confuses to the delta of the river, and ends draining in the Plata River. Modenutti (1991) recorded a total of 59 rotifer taxa in the Delta Paraná River sub basin and Modenutti and Claps (1998) recorded a total of 76 rotifer taxa for 14 rivers from the Pampas of Argentina, pertaining to the Delta Paraná River sub basin, revealing a much inferior number of taxa than the found in the Middle Paraná River.

In the Plata River Basin, Macluf *et al.* (1998) found 83 rotifer taxa in a tributary, Pescado stream; Kuczynski (1984) recorded 28 taxa in the Reconquista River, and Modenutti (1987) verified the occurrence of 43 taxa in a little stream which is channeled to the Plata River, Rodriguez Stream.

In the Eastern Chaco are found rivers, little streams and swamps of floodplain. Frutos (1998), recorded in this region a higher richness in the Negro River (76 taxa) than in relation to the Salado River (55 taxa), considering that the first possess a larger associated floodplain than the second. Also observed a higher richness, principally of planktonic taxa during the high water period, and considered as the drag effect of the associated varzea the dilution of salt concentrations produced by the floods. Lower diversity during dry periods, represented especially by euhaline taxa, was due to the stress of environmental conditions in these periods, associated with changes in conductivity and temperature, which these taxa adapted to environments with higher salinity.

Paggi (1981) observed in several secondary channels interrelated to the Middle Paraná River, a decrease in the number of species during the high water period. It can consider that the variation in number of species not seems to show a general pattern, finding related in higher or lower degree to the particular variables of each body water, occurring significant differences in rotifer associations related to the development of littoral vegetation, the size and the depth, variables which for it turns, are find related to the hydrometric oscillations of the flood system.

Contrasting to the high specific diversity, only few species are numerically dominants, and of constant presence in Argentinean floodplain environments, principally that pertaining to the planktonic genera as observed by Paggi and José de Paggi (1974) and José de Paggi (1980; 1981) in the Middle Paraná River, which *Keratella*, *Polyarthra*, *Trichocheerca*, *Filinia* and *Brachionus* were the dominant genera, *Keratella* was also dominant in the Argentinean stretch of the High Paraná River (Corrales, 1979). The predominance of some species pertaining to these planktonic genera in the middle stretch of Paraná River, not allows to classify them as

a potamozooplankton, although some species have been recorded only in the river, these species are found in lakes and lagoons of Argentina and other countries (Paggi and José de Paggi, 1974).

In the shallow and densely vegetated lakes of Corrientes, was observed that the rotifer assemblage was composed mainly of 70% of littoral taxa. *Lecane* was the most diverse genus (29%), in the pelagic region; in other hand, *Brachionus* was relatively less present by the predominance of acid waters (José de Paggi, 1996). In the Reconquista River and Plata River Basin, *Brachionus*, *Filinia* and *Asplanchna* were dominant to be common species in alkaline waters (Kuczynski 1984). In the Eastern Chaco, during the flood period dominated *Polyarthra* and *Keratella*, and during the dry period dominated *Brachionus plicatilis* and *Hexarthra fennica* (Frutos, 1998).

Regarding the assemblage abundance, the highest number of individuals in the Paraná River was recorded in the middle stretch (José de Paggi, 1980), due to the influence of water entrance of the Paraguay River. Horizontal distribution of density in the Paraná River adjust to the typical model of large rivers, which has been observed an increment of this attribute in direction to the mouth, as well as its biomass, besides the charge of suspended matter (José de Paggi, 1980).

Besides high values of density, rotifers tend to be the most important numerically zooplanktonic organisms in rivers, followed by nauplies, bosminids and cyclopid copepods (Pace *et al.*, 1992).

The highest values of rotifer density in these water bodies are recorded generally during the low water period (José de Paggi, 1981; Bonetto and Corrales de Jacobo, 1985; Cabo *et al.*, 1998; Frutos, 1998). This inverse relation, according to these authors, could be the result of the concentration effect of organisms, also the occurrence of favorable conditions to their development, such as the diminishing of the current velocity and concentration of solid suspended. These physical factors can favor the development of phytoplankton, one of the main resources for rotifers. In this hydrological period also can occur a higher number of temporary refuges along the river margins named channel habitats, and a climatic seasonality characteristic of certain Argentinean regions. On the other hand, this inverse relation of density in relation to the water level, also can results in the dilution effect, besides the increase in solid suspended concentration, which would be influencing negatively the phytoplankton production.

Frutos (1998), in the Eastern Chaco, recorded during the high water periods of Negro River, a higher abundance of rotifers, which was negatively correlated to the solid suspended values and positively to the phytoplankton, hidrometry and water transparency.

In relation to vertical distribution of rotifers in floodplain environments of Argentina, few are the

informations, also adopting as a consensus, a tendency the organisms to concentrate in the superficial layers of the environments. Balseiro e Modenutti (1990), in the Escondido Lake, cite that rotifers are located preferentially in the superior layers of the water column. In lotic waters of the Middle Paraná River (Paggi and José de Paggi, 1974), the water turbulence homogenizes zooplankton (Hynes, 1970), but the zooplankton migration moves community with tendency to establish at surface. José de Paggi (1980) still verified that in this river, close to the Paraguay River confluence, rotifers presented a tendency to be distributed, along the vertical axis, in a quantitatively homogeneous way, but qualitatively heterogeneous. The author, in other study, also observed this quantitative distribution, and attributed this homogeneity to the reduced locomotion capacity of rotifers. However, despite of the organisms are distributed in a uniform way in the vertical gradient during the whole year, there was a tendency of them concentrate close to the surface, mainly during the isolation phase of lagoons. Additionally, were not verified relevant changes in this distribution between flood and dry (José de Paggi, 1985).

Venezuela

Presently, the advances in knowledge of diverse Venezuelan continental aquatic ecosystems, especially floodplain environments, have been product of individual effort concentration or workgroups in certain geographical areas, which generates a disparity in the knowledge of the more varied freshwater systems, although is verified a several variety of water bodies and a large number of floodable savannahs.

Of fundamental importance for research advances on floodplain rotifers in Venezuela was the participation of European and North-American researchers, which through formal or informal cooperation programs, have stimulated the institutional interchange of researchers, contributing in a direct way on the recruiting of Venezuelan human resources (Cressa *et al.*, 1993).

According to Vásquez *et al.* (1998), rotifer studies in Venezuelan continental water bodies have started with the F. Gessner collection during the memorable Germany scientific expedition to Venezuela in 1952, and the publications of Thomasson (1954), Hauer (1956) and Gessner (1956). Since that epoch there were approximately 25 studies on rotifers in the country, and more recent studies were carried out in the main lakes, lagoons and rivers located in non-floodable regions, among them are the studies published by Berzins (1962), Gessner (1968), De Ridder (1977), Infante (1976, 1978, 1980), Pourriot and Zoppi de Roa (1981), Díaz and Castellano (1988), López (1991, 1993), López and Ochoa (1994), Pardo *et al.* (1994) and Infante *et al.* (1993, 1995). Recent studies on floodplain environments

were developed by Michelangelli *et al.* (1980), Vásquez (1984a, 1984b), Medina and Vásquez (1988), Saunders and Lewis (1987, 1988), Vásquez and Rey (1989, 1992), Zoppi de Roa *et al.* (1990), López and Ochoa (1995) and Vásquez *et al.* (1991).

The systematic study of Michelangelli *et al.* (1980) was the first contribution on rotifer studies in floodable áreas and was carried out in Matecal floodable savannah, low Llanos, Apure State. This region is that presents, among diverse floodable savannah from the country, the greatest climatic variation, with extensive dry period.

The continuity of these studies occurred, mainly in the Orinoco River Basin and its tributaries, as the Apure River (white waters tributary), Caroni River (black waters tributary), and in the floodplain lagoons associated with their plains, and in the Caura River Basin. On the other hand, Negro and Cuyuni River Basins, the most distant and inaccessible, still remain incognitos.

In the fluvial system of the Orinoco River, the first study that included rotifers was the Hauer's one (1956). However, the spatial and temporal extent was limited, studying only composition of species. Were not carried out additional studies in the region until an evaluation carried out by Vásquez and Sánchez (1983) and Vásquez (1984a), which carried out studies on rotifers in the Middle Orinoco, Lower Caroni River and in some floodplain lagoons. The authors recorded a total of 116 taxa, which 36 species are considered as new record to the country. The inventory enlarges considerably the number of 48 taxa previously recorded by Hauer (1956) in the Orinoco River. Astlz and Alvarez (1998) found 88 taxa of rotifers in the high and middle section of the Orinoco River and Vásquez and Rey (1989) recorded 100 taxa of rotifers for the lower section of the Orinoco River and its delta. Vásquez *et al.* (1998) mentioned that floodplain water bodies are the continental aquatic environments type which exhibit the highest number of rotifer taxa, which in some environments the specific diversity was more related to the richness than the evenness (Medina and Vásquez, 1988; Vásquez, 1984b).

Rotifers were the most representative group among zooplankton in all stretches of the Orinoco River (Vásquez, 1984a; Vásquez and Rey, 1989; Astlz and Alvarez, 1998) and Caura River (Saunders and Lewis, 1987). The predominance of this group on the plankton composition is well characteristic and was mentioned by some authors, among them, Ahlstrom (1943) e Ruttner-Kolisko (1974).

Rotifer species composition of the Orinoco River consist of a typical association from tropical areas, with predominance of species of the genera *Brachionus* e *Lecane* in the middle stretch of the Orinoco River, Lower Caroni River and is floodplain lagoons associated with these (Vásquez, 1984a); *Brachionus*, *Lecane*, *Keratella*, *Trichocerca* and *Filinia*, in the High and Middle Orinoco River

stretches (Astlz and Vásquez, 1998), and *Keratella*, *Brachionus*, *Trichocerca* e *Lecane*, for the Lower Orinoco River stretch and its delta (Vásquez and Rey, 1989). In the black-water rivers, such as Atabapo, Caura and Caroni River, the most frequent genera are *Keratella* e *Lecane*.

From a total of 48 species of the genus *Brachionus* listed by Koste and José de Paggi (1982) for the Neotropical region, 21 were present in the Orinoco River. According to Pejler (1977), the genus *Brachionus* increase its importance when is getting close to the Equator, where it is very representative.

Besides Venezuela possess a considerable diversity of continental water bodies, from the biogeographically point of view, it's possible to extend the distribution of some amazonic species, can relates a faunistic homogeneity between the Orinoco and Amazon fluvial systems, because that to the south the country rotifer fauna takes part of the Amazon Basin, which the Orinoco River is connected by the Casiquiare River to the Negro River. The composition of species in this region, also consist of a typical association from tropical areas, with the predominance of species from the *Brachionus* and *Lecane* genera.

The floodplain water bodies, among other Venezuelan freshwater environments, possess the highest number of taxa. The most common taxa in this type of environment, occurrent in approximately 50%, are *Brachionus dolabratus*, *B. falcatus*, *B. havanaensis*, *Plationus patulus*, *Keratella americana*, *Lecane bulla*, *L. leontina*, *Platyias quadricornis* and *Polyarthra vulgaris*.

Besides, the planktonic rotifer genera are very representative in these environments, as much Astlz and Alvarez (1998) found a dominance of these genera in the main channel of the High and Middle Orinoco River, and Saunders and Lewis (1987, 1988) found this same pattern in Caura and Apure River, excepting *Lecane proietta*, which presented higher values of density during low water phase in the middle section of the Orinoco River (Vásquez and Rey, 1989), and in the Caura and Apure Rivers. This genus has been recorded in association with aquatic vegetation; however, this specie seems to possess a facultative phase on plankton, due to its globoid body, allowing its existence in the river main channel. In the Lower Orinoco, planktonic genera, or semi-planktonic, play 50% of the present taxa. In the Caroni River, littoral or bentic-periphytic species are predominant and peculiarly characteristic for that environment (Vásquez, 1984a).

Zoppi de Roa *et al.* (1993) did a review about rotifers present in plankton collections obtained between 1980 and 1990 in several regions from the country, recording a total of 126 taxa, with 23 new records for Venezuela and 7 for South America. Besides, in this study authors increased rotifer fauna known for Mantecal floodable savannahs with 49 additional taxa to the 97 taxa found by Michelangelli

et al. (1980), in a total of 146 taxa corresponding to 28 genera. Rotifers were constituted of cosmopolitan, subtropical, and tropical forms, with few cases of Neotropical endemism. The most representative genera in sampled regions were *Lecane* (36, 5%), *Brachionus* (19, 8%) *Keratella* (8, 7%), *Testudinella* (7, 1%) and *Trichocerca* (5, 6%). According to Fernando (1980), the presence of *Lecane*, *Brachionus* and *Keratella* indicates a typical association from tropical areas. Also, is common the register of a higher richness of *Lecane* in this group fauna in Neotropical continental water (Koste and José de Paggi, 1982), additionally, a higher representativity of *Brachionus* was mentioned by Green (1972b) for the tropics. On the Other Hand, in Mantecal floodable savannahs, which present areas of distinct features, was recorded a mixture of littoral (*Lecane*, *Trichocerca*, *Filinia*) and pelagic forms (*Brachionus*, *Keratella*), observing a clear association of species commonly found in tropical areas.

Vásquez *et al.* (1998) did a new review of rotifer fauna from Venezuela using of pre-existent literature and by means of new observations. A total of 268 taxa pertaining to 44 genera was recorded. The genera *Lecane* (57 táxons), *Brachionus* (45 táxons) and *Trichocerca* (30 táxons), one more time were the most diverse. Among recorded taxa, consist of 68% cosmopolitan, 19% pantropical, 11% Neotropical and 2% neartic. The proportion of endemic taxa is comparable to other tropical regions of the world, where verify a great endemism of the genus *Brachionus*; nevertheless the number of endemic taxa is higher than the found in Africa, similar to Australia and other Neotropical regions.

Of the total of rotifer taxa (268) recorded to Venezuela, a large portion rarely was found in all environments; only a reduced number of species are common and occur in an ample spectrum of habitats. Despite the number of rotifer studies remains still insufficient to provide a full understanding on its geographical distribution in Venezuela, two interesting tendency in distribution of the most known genera, *Lecane* and *Brachionus*, indicates some pattern. While some amazonic endemic taxa, such as *Brachionus ahlstromi* and *Lecane amazonica*, can be found above latitude 10°N, other species such as *Brachionus gessneri*, *B. mirus*, *B. voighti*, *B. zahniseri*, *Lecane melini* and *L. proietta* are restrict in the country, to the Orinoco River basin, and usually are found only bellow latitude 10°N. Other taxa recorded in watersheds close to Caribbean Sea not occur in Orinoco River, neither in the costal region of the Atlantic Ocean.

In addition, according to Vasquez *et al.* (1998), some genera found in other localities of South America were not recorded for Venezuela, probably as a consequence of scarce number of rotifer studies associated to bentonic and periphytic communities, and aquatic vegetation. The knowledge on Bdelloidea order is very limited. The first record was made by

Hauer (1956) and some occasional records can be found in literature, in which *Dissotrocha*, *Philodina* and *Rotaria* are the recorded genera.

According to these authors, white-water floodplain environments, present a higher rotifer richness during high water period, as the values registered for the Orinoco River and its associated floodplain lagoons, and for the Ventuari River (Vásquez, 1984a). On the other hand, in black-water river, Atabapo, Caroni, Caura (Vasquez, 1984a; Saunders and Lewis, 1987) and also in a black-water floodplain lagoon associated with Caroni River (Medina and Vasquez, 1988), richness is higher during low water due to a higher stability of environmental variables and availability of food resource.

In these environments, vegetation cover in relation to lagoon total surface is very scarce and rotifers are predominantly euplanktonics and with herbivore tendency. Ventuari River is the High Orinoco main tributary and was similar in species richness, because both drain watersheds with similar biogeochemical features.

Vasquez and Rey (1989) consider that, although exist a large number of species recorded in floodable environments, only few are numerically dominant. In the High and middle Orinoco River, 7 rotifer species presented higher densities during the dry period, while during the rest of the year dominated only 3 rotifer species (Astlz and Alvarez, 1998). Similar results were recorded for the Lower Orinoco, with 14 dominant species during low water and 9 species during high water (Vásquez and Rey, 1989), and in Apure River, white-water important river, with 9 species numerically dominant during the whole study period (Saunders and Lewis, 1988).

Rotifers in Venezuela, also present high density values in floodplain water bodies. Astlz and Alvarez (1998), Vásquez (1984a) and Vásquez and Rey (1989) recorded the highest density values of this group, among all zooplanktonic groups, in all Orinoco River stretches (high, middle and lower).

This higher abundance in floodable areas is recorded, generally, during low water period. Twombly and Lewis (1987) justify that the zooplanktonic populations real size can be larger during high water, seen that during low water occur a retraction of lagoons, which can favor this group abundance superestimation. In all Orinoco River stretches, the highest density of rotifers was recorded during the low and rising water periods (Astlz and Alvarez, 1998; Vásquez, 1984a, Vásquez and Rey, 1989). Equally, were recorded higher density values during low water period for Apure River, Ventuari, and Orinoco floodplain lagoons (Vásquez, 1984a) and in some black-water environments such as Atabapo, Caroni (Vásquez, 1984a) and Punta Vista lagoon black-water floodplain lagoon (Medina and Vásquez, 1988). This inverse relation could be the result of a concentration effect, as well as the

occurrence of favorable conditions for these organisms development, as the diminishing of current velocity and solid suspended concentration, favoring phytoplankton development, one of the main alimentary resources for rotifers, as well as the existence of temporary refuge along river margins named channel habitats (Astlz and Alvarez, 1998).

Besides, this inverse relation in density in relation to water level cans results also of a dilution effect, during high water period. On the other hand, in Caura River were recorded higher densities during high water periods (Vásquez, 1984a), due to the transport, and tributary and floodplain lagoons contribution. Reproduction is generally insignificant in the river, which organisms come from channel refuge, tributaries and floodplain. Abundance patterns are related to hydrological events and not with biological mechanisms.

Astlz and Alvarez (1998) observed a progressive increase in rotifer density along river longitudinal axis, except to rising water and maximum flood phase. However, these results were variable according to the sampled sites, that is, Orinoco River middle section was more diverse and abundant than its high section, and maintaining less important than lower section. That is, was verified a density gradient along longitudinal axis, attributed to diverse affluent which drain successive sub basin.

The Highest rotifer densities are found in white-water rivers, constituting a belief which white-water rivers are the most productive among 3 types of Neotropical waters based on Sioli classification (Fittkau *et al.*, 1975). Lower densities can be characteristic of black-water rivers (Schaden, 1978; Vásquez, 1984; Saunders and Lewis, 1988), however rotifer densities in Caroni (Vásquez, 1984a) and Caura River (Saunders and Lewis, 1987) do not suggest a sterile environment, although rotifer abundance is little known in these environments, supposedly considered sterile by the low pH and large amount of organic matter dissolved, humic acids, originated from terrestrial vegetation (Janzen, 1974).

In relation to vertical distribution of rotifers, there is a tendency of organisms to concentrate at superficial layers (Medina and Vásquez, 1988).

In general, a combination of both factors as biotic as abiotic would affect direct and indirectly variations in zooplankton populations of rivers. Can consider that variations in species number do not seem to present a general pattern, found related in higher or lower degree with particular variables of each water body.

Other Countries

In Paraguay is found one of the most important watersheds of South America, the Paraguay River basin. Studies on these watershed rotifers are scarce, which are totally concentrated in the Brazilian stretch, in which river takes part of Pantanal; and in

its confluence with the Middle Paraná River, in the Argentinean stretch.

Other type of floodplain environment found in country is the Paraguayan Chaco. Chaco is an extensive plain included in Argentina, and the rest is distributed between Bolivia and Paraguay. Due to its extent, is the second eco-region of South America, only preceded by Amazon region (Bucher 1982, 1986; Hueck, 1978). Rich in humid savannahs, occupying large areas, possess an elevated biological diversity, little known and altered by human action. The Argentinean portion was relatively well studied; on the other hand, in Paraguayan portion, the few previous studies are the carried out by Daday (1905), and Carter and Beadle (1930).

In Carter and Beadle (1930), the little which is mentioned, is referent to the general zooplankton, principally cladocerans and copepods, besides, in this study were taken into consideration the inorganic nature of Paraguayan Chaco flooded environments and its effects on fauna more, that is, the physical and chemical report of the aquatic environments, with the purpose to understand life strategy meanings which made possible these organisms to occupy and survive in these type of environments. Furthermore, this was considered as the first of a series of studies that could lead to posterior more detailed studies on the several components of the fauna.

Study carried out by Daday (1905) regards environments of several localities of Paraguay, in the majority, floodplain environments, including in this study the Paraguay River Basin, The Gran-Chaco, little streams, floodplain lagoons, and others. In this study were recorded 6 species distributed into 3 genera and 1 family of Digononta class, and 76 species into 34 genera and 16 families of Monogononta class. Besides few studies carried out in floodplains, worth to mention that independent on the environment type, in general are scarce studies on rotifers from the country. Among scarce rotifer studies in the country, worth to mention the study carried out by Koste (1986), on the rotifer fauna of 5 reservoirs close to Concepción. It was recorded 138 species, in which 24 are planktonics and 114 littoral.

It is remarkable that Koste (1986) found a higher number of species in reservoirs than Daday (1905) in floodplain environments. This uncommon fact can be explained by the advances in researches between distant periods, with a higher sampling effort and also identification carried out by Koste (1986).

In Bolivia, despite to found extent floodplain environments, are rare ecological studies considering rotifers, which the only studies found in literature are the carried out by Segers *et al.* (1998), which describe a short description on rotifers of a floodplain lagoon from Ichilo River; and other study inherent to a scientific expedition, which carried out a short description on zooplankton community in the High Orthon River basin. Rotifers were dominant in almost all environments, playing 40 to 80% of the

zooplankton community, in which the higher species richness recorded in littoral regions and lagoons. Littoral and benthic species were dominant, followed by semi-planktonic and planktonic species (Barbosa *et al.*, 1999). On the other hand, other studies on rotifers regard aquatic environments of altitudinal region, located in Bolivian Andes, such as De Beuchamp (1939), Ueno (1967), Koste (1977); Murray (1913) and Pinto (1992) in Titicaca Lake; and Segers *et al.* (1994) in Kothia Lake.

Segers *et al.* (1998), in Bufeos Lake, found a total of 104 rotifer taxa, in which 67 are new record for Bolivian fauna and 4 for South America. Among these taxa, 11% are Neotropical, 5% pantropical, and 13% tropicopolitans.

Barbosa *et al.* (1999) carried out an assessment of rotifers in lentic and lotic environments of two sub-basins from Orthon River, High Tahuamanu River basin, Low Nareuda River and Middle Tahuamanu River, in Pando State. These sub-basins water are characteristic of white-water rivers, in accordance to Sioli (1950) classification, as described by authors.

Authors recorded the occurrence of 53 taxa, in which rotifers represented 44% of zooplanktonic species composition. The most representative families were the Brachionidae (11 species), Lecanidae (11), e Trichocercidae (7), and the genera with higher number of taxa, *Lecane* (11 especies), *Trichocerca* (7) e *Brachionus* (5). According to Segers (1995), the genus *Lecane* is mainly littoral, reaching higher diversities in tropical and subtropical waters. On the other hand, the most occurrent genera in environments were *Anuraeopsis*, *Trichocerca*, *Polyarthra*, *Brachionus*, *Keratella* and *Lecane*. According to Fernando (1980), *Keratella*, *Lecane* and *Brachionus* are typical compounds of zooplankton fauna of tropical regions.

It is again remarkable that despite of Barbosa *et al.* (1999) had sampled a higher number of environments than Segers *et al.* (1998), and both sites classified as white-water environments and then more productive, richness analysis effort probably was preponderant for the second study which recorded a higher number of taxa only in one lagoon.

In Peru, first studies on rotifers concern the scientific expedition carried out by Schmarda (1859), besides some few taxonomic studies such as the carried out by Beauchamp (1939) in Titicaca Lake.

Peru also possesses extent floodplain areas, which in large portion correspond to Amazon basin located in Peruvian territory. However, few are the rotifer studies in the country and then scarce studies of these organisms in this floodable area, among the last, it is find studies developed by Koste (1988), Samanez (1988, 1991) and Riofrío *et al.* (2003).

Besides these studies it is find described studies in other Peruvian floodplain environments, such as Koste 1981 (not publish.) in Yuyapichis River, Samanez and Riofrío (1995) in Cashibo Lake, Samanez and Zambrano (1995) in Madre de Dios

River, Iannacone *et al.* (1998) in Rimac River, and Ortega *et al.* (1999) in Nanay River.

A first contribution, between the scarce existent bibliographies, on the rotifer fauna of Peruvian Amazonian was published by Samanez (1988), which was recorded the occurrence of 14 genus and 39 species in several sorts of aquatic environments in Ucayali State. In a second study (Samanez, 1991), the author recorded the occurrence of 80 species of rotifer in 15 aquatic environments in Loreto State. According to the author, exist a great resemblance between the composition of recorded species and the found in other tropical regions, principally with Brazil. Remarkable, was recorded a high occurrence of cosmopolitan species, since that the 80 species, 24% was represented by *Brachionus* species and 20% by *Lecane*, in which 32 species of the total amount, common to the Loreto and Ucayali State, and 48 only known for Loreto until the moment, not recorded to other regions of the country.

Iris Samanez, also carried out studies on rotifers in floodable areas in two other Peruvian localities, in Cashibo Lake and Madre de Dios River Samanez and Riofrío, 1995; Samanez and Zambrano, 1995).

In Cashibo Lake, Samanez and Riofrío (1995) recorded the occurrence of 54 species, which in the majority (67,3%) found in littoral region among macrophyte roots, 15,4% comprehend common species to littoral and pelagic zone, and 17,3% typically pelagic species. During the dry period were not recorded 67,3% of the littoral species found in the flood, due to the absent of macrophytes, recording only species typically pelagic. According to authors, these organisms preference by littoral environments is related to the availability of nutrients and the necessity of protection against predators.

Large portion of Peruvian environments studied including Amazonians, refers to black-water environments with slight acid pH, considered less productive (Sioli, 1984), among them are the lentic and lotic environments associated with Madre de Dios, Nanay, and Ucayali Rivers Ucayali (Samanez and Zambrano, 1995; Ortega *et al.*, 1999; Riofrío *et al.*, 2003).

Samanez and Zambrano (1995), in Madre de Dios River basin, sampled several lentic environments, carrying out observations on rotifer diversity (85 species), which are were dominant in zooplankton. Authors recorded the occurrence of many species of genus *Brachionus*, which despite to be considered restrict to alkaline waters, demonstrated, in the black predominant waters of this watershed, their adaptative capacity to an ample spectrum of pH. *Brachionus* presented also the highest species number in environments with aquatic macrophytes. Ortega *et al.* (1999) recorded the occurrence of 71 taxa from 10 environments, mainly of black-waters, in Nanay River basin and Cashibococho Lake, an Amazonian black-water lagoon of Ucayali River Basin. Riofrío *et al.* (2003) found 43 rotifer species,

which were qualitatively (80%) and quantitatively (79%) dominant on the plankton, with higher abundances during the early flood, and having as more abundant species *Platyonus patulus macrachantus* and *Polyarthra vulgaris*.

In Chile exist some studies on lacustrine rotifers and also from altitude environments, such as the studies of Schmarda (1859), Daday (1902b), Murray (1913), De Beuchamp (1939), Hauer (1958), Bucaray (1961), Löffler (1961), Thomasson (1955, 1963), Zuñiga and Dominguéz (1977), Araya and Zuñiga (1985), Campos (1985), e Schmid-Araya (1991). In this country case, the lack of studies on floodplain rotifers is associated with the fact of Chile does not possess this type of ecosystem, in which studies in majority are reported to altitude lagoons of Andean region.

Ecuador is characterized for possess a large diversity of altitude environments, a small coast toward west and a portion of floodplains toward east, associated with Ecuadorian Amazonian. First rotifer studies were carried out by Schmarda (1859) and Murray (1913), existing few studies which gave continuity to those studies. Among few accounts to the country, it cans stand out Koste and Böttger (1989, 1992), who studied 12 different water bodies distributed by the whole country. In this study was recorded the occurrence of 195 species with 178 pertaining to Monogononta class and 17 to Bdelloidea order (Digononta class).

The highest rotifer diversity was found in the lower areas of Ecuadorian Amazonian floodplain, with 161 species recorded; and the lowest was recorded in an altitude lake, Mojanda Lake, with 9 species recorded. In other country areas, were recorded 81 species in the Pacific Coast and 63 species in Andes.

In Uruguay also are few studies on rotifers of floodplain environments. After Dioni (1966), little is related on these organisms in these environments. The most studies found in literature on these organisms is referent to reservoirs constructed along rivers, among them Uruguay River, and coastal and continental lakes and lagoons which do not suffer floodplain influence. Besides, Uruguay River is better studied in its confluence to Plata River with studies carried out in Argentina.

Dioni (1966) carried out a behavioral, anatomic and systematic study of rotifer associations for the constitution of organism societies, studying different species of social rotifers found in Argentina (Santa Fe Province) and several regions of Uruguay such as Punta Gorda, Montevideo, Santiago Vázquez, Florida, and Artigas State, in several types of aquatic environments. The studied organisms are pertaining to Flosculariidae, Conochilidae and Testudinellidae family, which according to the author are wrongly called colonies, in which are preferentially classified as social organisms by their anatomy and behavior, due to they are not merely an aggregated of

organisms, because, beyond their congregation, they possess morphological and functional differentiations with high synchronism.

In Colombia, Guyana, French Guyana and Surinam, practically are inexistent studies on floodplain rotifers, despite to possess large portion of floodplains associated to Amazonian, the most of this nature studies concentrates almost in the whole, in Brazilian Central Amazonian and in Peruvian Amazonian. Hauer (1956), during scientific expedition, by the Orinoco River in Venezuela, analyzed samples from Barranquilla in Colombia. This pioneer study for the country was a short taxonomic description with scarce information on the spatial and temporal extent.

Discussion

This study emphasized the influence of regional differences on the structure and dynamic knowledge of rotifer assemblage in floodplains of South America. The Most of studies refers to Brazil, Argentina and Venezuela, and until in these countries the knowledge on rotifers is well heterogeneous and has been centralized in some localities. In Brazil, Amazonian and Paraná basin regions are the best studied, existing several floodplain areas to be investigated yet, such is the case of Pantanal, in which were developed few studies considering the importance of this ecosystem. In Argentina studies are concentrated mainly in Paraná River basin; and in Venezuela, in Orinoco River basin, whereas several Venezuelan floodplain environments are unexplored and inaccessible.

In other South American countries, literature shows in the majority, short descriptions of rotifer composition in different localities, carried out many times by foreign researchers.

Although does not exists an expressive knowledge on rotifers of South America floodplains, studies show that this group presents elevated richness and abundance in these ecosystems. The elevated species number is characterized by the occurrence of many rare species, due to opportunist characteristic of these organisms. Rotifers also present numeric dominance on the zooplankton of these environments, although only few species present elevated densities.

In a comparative way, regarding the number of studies carried out in South America main countries, Brazil possess the large faunistic inventory of rotifers, in which has been recorded 467 species until the present moment, followed by Argentina with 300 species, and Venezuela with 268 species. Of the 467 species recorded to Brazil, 300 are found in Amazonian region, about 284 in Paraná River basin, and 200 approximately in Pantanal. In Argentina, about 300 species occur in Paraná River basin, in the rest of country until 80 taxa approximately are recorded in inventories of different localities. On the

other hand, in Venezuela, approximately 116 of 268 species recorded for the country are found in Orinoco River Basin.

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