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THE COPEPODA (CRUSTACEA) OF THE SOUTHERN PANTANAL, BRAZIL

REID, J.W.* e MORENO, I.H.**

RESUMO - OS COPEPODA (CRUSTACEA) DO PANTANAL SUL, BRASIL

Nas amostras de copépodes (Crustacea) bentônicos e planctônicos coletadas em rios, lagos e lagoas (baías) de água doce, e de lagoas salobras (salinas) da subregião da Nhecolândia, Pantanal Sul, Brasil, ocorreram quatro espécies da ordem Calanoida, onze da ordem Cyclopoida e três da ordem Harpacticoida. A fauna dos rios se mostrou semelhante à das baías, sendo maioria das espécies comum a ambas. Os corpos de água com maior número de espécies foram a Baía Jacadigo, uma grande lagoa situada perto de Corumbá e isolada dos efeitos das enchentes sazonais; e da Baía da Carandazal, uma baía rasa sem peixes, situada na Fazenda Nhumirim. As três salinas pesquisadas suportam grandes populações de uma só espécie de ciclopoide, *Metacyclops mendocinus*; esta não foi registrada nos corpos de água doce. Os dados da presença e ausência de espécies sugerem a possibilidade de controle de algumas espécies por peixes planctívoros. A fauna de Copepoda, principalmente Calanoida, parece depauperada quando comparada a outros sistemas.

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* Smithsonian Institution, USA

** ENGEVIX S/A - Brasília

ABSTRACT - THE COPEPODA (CRUSTACEA) OF THE SOUTHERN PANTANAL, BRAZIL

Collections of benthic and planktonic copepods (Crustacea) from rivers, freshwater lakes and ponds, and saline ponds of the Nhecolândia Subregion, southern Pantanal, Brazil, yielded four species of Calanoida, eleven of Cyclopoida and three of Haroacticoida. The faunas of rivers and freshwater lakes and ponds appear essentially similar, comprising the majority of species. Individual bodies of water containing highest species numbers were Baía Jacadigo, a large lake situated near Corumbá and isolated from seasonal flooding by the Rio Paraguai; and Baía da Carandazal, a small shallow fishless pond on the Fazenda Nhumirim. The three saline ponds investigated contained large populations of one species of cyclopoid, *Metacyclops mendocinus*, which did not occur in the fresh waters. Data regarding the presence or absence of species suggest the possibility of regulation of certain species by planctivorous fish. The copepod fauna, particularly the calanoids, appears impoverished compared to those of other systems.

INTRODUCTION

The aquatic microinvertebrates of the Pantanal, the world's largest wetland, are poorly known. Three species of calanoid copepods are known to inhabit the northern Pantanal (BRANDORFF, 1976; MATSUMURA-TUNDISI, 1986). We describe collections of planktonic and benthic Copepoda from representative waters in the southern Pantanal near Corumbá (Nhecolândia Subregion, Mato Grosso do Sul, Brazil), and review knowledge of the distribution and ecology of selected species. Some records of *Thermocyclops* spp. from these present collections have been

listed briefly elsewhere (REID, 1989; SILVA et alii, in press). Taxonomic descriptions will be published separately.

AREA INVESTIGATED

Most of this region can be characterized as "Baixo" Pantanal (lowlying, almost completely flooded during the rainy season); for a general description of habitats in the Pantanal, see ALHO et alii (1988). BONETTO (1975) reviewed the relationships of the hydrological regime of the Rio Paraná and surrounding lands, summarizing effects of cyclical water level changes on flora and fauna of the middle and lower Paraná. BRUM & SOUSA (1985) analyzed mineral content of water in lakes of the Nhecolândia Subregion, including some waters of the Fazenda Nhumirim.

The waters investigated fall into four broad categories (Tab. 1). The Rio Paraguai mainstream and inlets are considered together, although inlets vary in depth and degree of current and coverage by macrophytes; nevertheless, inlets are directly and immediately affected by cyclical flooding from the river. Samples from Rios Verde and Capivari are also from riverine habitats. Baía Jacadigo, a large lake, has no connection to the Rio Paraguai. Six small shallow freshwater ponds ("baías") on the Fazenda Nhumirim were sampled; some contained many species of fish, some a few species, and others no fish. Collections were also made from two saline ponds ("salinas") on the Fazenda Nhumirim and a salina on the Fazenda Berenice. Waters of all habitats except salinas is "fresh"; in baías, which are mostly no deeper than 2 m and support extensive, diverse communities of macrophytes, principal cations are, in order, K, Na, Ca, Mg and Fe. In salinas, which are also shallow, lack macrophytes, and

Table 1 - Sampling localities in the southern Pantanal, region of Corumbá, Mato Grosso do Sul, Brazil.

	Geographical Coordinates		Date
1. Rio Paraguai near Marinha Ladário	57°34'W	19°02'S	2.4.86
2. Rio Paraguai near Port, Corumbá	57°40'W	19°00'S	2.4.86
3. Rio Paraguai near Rabicho			12.4.86
4. Rio Paraguai, ponto 2, near airport, Corumbá	57°40'W	19°00'S	2.4.86
5. Rio Paraguai, entrada near Corumbá	57°40'W	19°00'S	12.4.86
6. Rio Paraguai, 2º acesso, Corumbá	57°40'W	19°00'S	12.4.86
7. Rio Capivari, Fazenda Berenice			10.9.86
8. Rio Verde II			19.2.85
9. Baía Jacadigo, Corumbá	57°41'W	19°01'S	03.4.87
10. Baía Jacaré, Fazenda Nhumirim	18°59'S	56°39'W	27.2.86
11. Baía Arame, Fazenda Nhumirim	"	"	29.8.86
12. Baía da Carandazal (Baía 29), Fazenda Nhumirim	"	"	04.4.87
13. Baía 32, Fazenda Nhumirim	"	"	05.4.87
14. Baía 56, Fazenda Nhumirim	"	"	05.4.87
15. Baía 57, Fazenda Nhumirim	"	"	05.4.87
16. Baía 58, Fazenda Nhumirim	"	"	05.4.87
17. Salina do Meio, Fazenda Nhumirim	"	"	04.4.87
18. Salina Cabecinha (Baía 86), Fazenda Nhumirim	"	"	04.4.87
19. Salina, Fazenda Berenice	"	"	30.9.86

support dense phytoplankton populations, the order is Na, K, P, Ca and Mg (BRUM & SOUSA, 1985). Mean Na concentrations measured at the end of the dry season were 11.3 mg/l in baías; in salinas, mean Na was 484 mg/l and maximum 1,212 mg/l, although some salinas may reach higher concentrations (CUNHA, 1943). Salinas contain no fish, and fish species found in neighboring baías do not survive in water from salinas (MOURÃO et alii, 1988).

Most collections were made in April, at the end of the rainy season. At most sites, samples from among macrophytes (except salinas) and bottom and shore sediments as well as plankton were taken. Samples were also made from mosses, moist earth and leaf axils near baías at the Fazenda Nhumirim, but failed to yield copepods.

RESULTS

Tab. 2 lists the species of copepods recovered from each locality. Four species of Calanoida, eleven of Cyclopoida and three of Harpacticoida were collected. The observed species diversity of a particular habitat or body of water depends, of course, partly upon the methods and duration of collections. From the limited samples at hand we can make only a beginning sketch of the relative diversity of the copepod communities of the various types of water bodies in the Pantanal.

The faunas of all the freshwater habitats are essentially similar, comprising the majority of the species collected. Taken together, the baías of the Fazenda Nhumirim support 12 species of copepods; however, from no single baía were more than nine species collected. Four species at Nhumirim were not collected elsewhere: *Argyrodiaptomus* sp., *Neutrocyclops brevifurca*, *Ectocyclops phaleratus* and *M. meridionalis*. Nine species in all were collected from the various localities of the Rio Paraguai;

Table 2 - Species of Copepoda from 19 sampling localities in the southern Pantanal, region of Corumbá, Mato Grosso do Sul, Brazil. Tab. 1 lists the localities.

Species	Locality																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Calanoida																			
Argyrodiaptomus sp												+			+				
Notodiaptomus coniferoides	+	+	+	+					+			+							
Notodiaptomus sp	+	+			+	+	+			+		+	+	+	+	+			
Notodiaptomus cf. *spinuliferus*	+	+			+	+	+												
Cyclopoida																			
Thermocyclops minutus	+	+	+	+	+	+	+	+	+	+	+			+					
T. decipiens	+				+														
Mesocyclops longisetus	+											+			+				
M. meridianus		+	+	+			+					+	+						
M. meridionalis													+	+					
Mesocyclops sp, copepodites									+							+			
Microcyclops ceibaensis			+						+		+			+	+	+			
M. anceps									+		+	+	+			+			
Neutrocyclops brevifurca												+							
Paracyclops fimbriatus chiltoni			+						+										
Ectocyclops cf. *phaleratus*												+		+					
Metacyclops mendocinus																	+	+	+
Harpacticoida																			
Parastenocarididae sp									+										
Attheyella (Chappuisiella)									+										
Elaphoidella bidens												+							
Total number of species	6	5	5	3	4	3	4	1	8	2	3	9	4	5	4	4	1	1	1

Baía Jacadigo, with eight species, supports the next most diverse fauna. With only one sample taken from each, the faunas of Rios Verde and Capivari are not comparable.

The salinas harbor large populations of but one species, *Metacyclops mendocinus*. The only other crustacean to appear in a salina was a species of Macrothricidae (Cladocera), present in large numbers in Salina Cabecinha (Baía 86).

Freshwater Baías 56, 57 and 58 at Fazenda Nhumirim lie close together and are approximately the same area and depth. The number of species of copepods in each is similar. However, the fauna of the fishless Baía 57 is remarkable for the presence of the large calanoid *Argyrodiaptomus* sp. and the large cyclopoid *Mesocyclops longisetus*. Both species also inhabit Baía Carandazal, the other fishless baía at Nhumirim.

The number of species of copepods inhabiting the Pantanal appears low in comparison to other systems. In addition to the three species of Calanoida recorded herein from the southern Pantanal, from the northern Pantanal three other species have been collected (BRANDORFF, 1976; MATSUMURA-TUNDISI, 1986). Ten species are known from the middle Paraná, its affluents and associated ponds, although no more than five species and usually only one are present at any time in a particular sample (BONETTO & MARTÍNEZ de FERRATO, 1966; DUSSART & FRUTOS, 1985/86, 1986/87; PAGGI, 1980; PAGGI & JOSÉ de PAGGI, 1974). DUSSART (1984) reported 13 species of calanoids from the Rio Orinoco and associated floodplain lakes, with up to seven species appearing per sample. Amazonia supports a very diverse calanoid fauna, with 25 species and subspecies recorded to date. DUSSART & FRUTOS (1985/86, 1986/87) recorded 30 species and subspecies of cyclopoids from the middle Paraná, in a single series of collections.

COMMENTS ON SELECTED SPECIES

Argyrodiaptomus sp.

Except for *Argyrodiaptomus azevedoi* (Wright), which inhabits small pools and large lakes from São Paulo to Amazonia and the Brazilian Northeast, and *A. robertsonae* Dussart, described from the State of Pará, Brazil, species of this genus occur mainly in the basin of the Rio Paraná (BRANDORFF, 1976). Accordingly, the occurrence of at least one species in the southern Pantanal is to be expected. The surprising aspect of this collection is the registry of this species in only two small ponds, both lacking fish, on the Fazenda Nhumirim. In the Paraná Basin, species of *Argyrodiaptomus* usually occur sporadically in small ponds (RINGUELET, 1958a), though some, such as *A. denticulatus* (Pesta) occasionally comprise a high significant proportion of the crustacean plankton in larger lakes (BONETTO & MARTÍNEZ de FERRATO, 1966). There may be a negative relationship between the presence of *Argyrodiaptomus* and nutrient loads: of 17 reservoirs in the State of São Paulo investigated by SENDACZ & KUBO (1982), *A. furcatus* (Sars) occurred only in Represa Itupararanga, which had more transparent water with lower concentrations of nutrients than the norm.

It is possible that in clear, shallow water, these large, bluepigmented copepods are more subject to visual predation by fish than are smaller diaptomids such as members of the genus *Notodiaptomus*. In Lobo (Broa) Reservoir, São Paulo, *A. furcatus* is the preferred prey of young and adults of the characid *Astyanax fasciatus* Cuvier (BARBOSA & MATSUMURA-TUNDISI, 1984). In Lobo Reservoir during the dry season, when water levels dropped severely, populations of *A. furcatus* were reduced almost to zero (ROCHA et alii, 1982); this reduction may have been due less to a direct influence of lack of rainfall and

temperature, as suggested by ROCHA et alii (1982), than to areal reduction of macrophyte beds to serve as refuges, as well as to clearing of the water and consequent increased predation efficiency by the fish. In the zooplankton of Lago Castanho, Amazonas, *A. azevedoi* maintained less than one-tenth the adult numbers of each of the three other calanoid species, all of which are smaller in size (BRANDORFF, 1977). In the deep, oligotrophic Lago Dom Helvécio, Minas Gerais, population levels of *A. furcatus* in the middle of the lake remain stable at low numbers (MATSUMURA-TUNDISI & OKANO, 1983). This information does not go far to explain the absence of species of *Argyrodiaptomus* from most waters investigated in the Pantanal. It is possible that the shallowness and clarity of most of these waters permits very efficient predation by fish, even in dense beds of macrophytes found in the smaller baías.

Notodiaptomus spp.

At least two of the three species of *Notodiaptomus* occurred in most habitats investigated. However, *Notodiaptomus* sp., occurring alone, was more broadly distributed in the small baías of Fazenda Nhumirim, whether fish were present or not. *Notodiaptomus* sp. is the middle-sized of the three species (Tab. 3). Continuing the consideration of possible effects of predation on species presence and absence, if predation by fish is an important factor in determining the survival of species of copepods in the small baías, small size alone does not, apparently, confer a particular advantage. One would expect *Notodiaptomus* cf. *spinuliferus* Dussart to be most successful in situations of intense predation, whereas this species occurred not in the small baías but only in river samples. Perhaps significantly, however, the relatively large *N. coniferoides* (Wright) was present at Nhumirim only

Table 3 - Ranges of lengths (mm) of females of four species of calanoid copepods from different populations in the southern Pantanal. Sampling localities from Tab. 1; brackets = number of specimens measured.

Locality	*Notodiaptomus coniferoides*	*Notodiaptomus* sp	*Notodiaptomus* cf. *spinuliferus*	*Argyrodiaptomus* sp
1	1.42 [1]	1.38 [1]	1.13-1.23 [4]	
2	1.35 [2]	1.26 [1]	1.10-1.15 [2]	
3	1.43 [1]			
4	1.15-1.20 [2]			
5		1.32-1.42 [3]	1.09-1.16 [5]	
6		1.25 [1]	1.05-1.15 [7]	
7		1.25-1.45 [8]	1.15-1.30 [10]	
9	1.15-1.25 [10]			
10		1.15-1.18 [2]		
12	1.35-1.47 [5]	1.23-1.43 [10]		1.98-2.05 [2]
13		1.17-1.27 [9]		
14		1.07 [1]		
15		1.20-1.33 [8]		
16		1.18-1.30 [10]		

in the fishless Baía 29, the only baía to support three species of calanoids.

N. coniferoides is broadly distributed in the Paraná, São Francisco, Amazon and Orinoco systems (BRANDORFF, 1976; DUSSART, 1984). Preferred habitats of this species seem to be rivers and associated floodplain lakes and marshes. It occurred consistently in all samples from the Rio Paraguai and was the dominant crustacean zooplankter in the isolated Baía Jacadigo. Its absence from most baías on Fazenda Nhumirim may reflect an inability to survive in clear, shallow waters, possibly due to predation pressure. On the other hand, BRANDORFF (1976, 1977) noted that predation by fish on this species and other diaptomids in Lago Castanho, Amazonas, was apparently negligible.

Knowledge of the ecology of *N. coniferoides* is fragmentary and sometimes contradictory. In Amazonia it is present in white-water várzea lakes such as Castanho, Jacaretinga, and Redondo, but absent from black-water lakes (BRANDORFF, 1978). The species usually appears in samples only during low-water periods, and may or may not come to predominate among diaptomid species in any particular lake (HARDY, 1980). In Lago Camaleão, low oxygen levels seem to inhibit the survival of adults of this and other species during most of the low-water period (HARDY et alii, 1984). Populations of this species have reached high levels concurrently with those of *N. amazonicus* (Wright) during low-water period in Lakes Jacaretinga and Castanho (BRANDORFF, 1977; BRANDORFF & ANDRADE, 1978; MATSUMURA-TUNDISI et alii, 1983). These autors explained this phenomenon is Lago Jacaretinga on the basis of *coniferoides* being the smaller species and thus possibly having a different mode of feeding. However, BRANDORFF (1977) was unable to postulate the same mechanism in Lago Castanho since in that lake the measured lenghts of adults of the two species of diaptomids present were similar. He suggested (BRANDORFF, 1976, 1977) that at this season the

two species were not in direct competition for food, due to large populations of phytoplankton. Certainly in the Pantanal systems, there were distinct differences in length among all species of diaptomids, although the range of lengths of each species might differ in different bodies of water (Tab. 3). (It is interesting that both *N. coniferoides* and *Notodiaptomus* sp. tended to be smaller in bodies of water in which they were the only species present, although this observation should be confirmed with more extensive material). Also, since theories of interspecies competitive elimination apply only to steady-state systems, it is perhaps meaningful that *N. coniferoides* is the only calanoid copepod present in Baía Jacadigo, a large, deep lake without significant macrophyte coverage and unaffected by flooding from the Rio Paraguai. In contrast, all three species of *Notodiaptomus* were consistently present in the constantly changing Rio Paraguai and its inlets, and two present in Rio Capivari.

Of these species, only *N. coniferoides* may be called a true potamoplankter, as it is in the middle Paraná (PAGGI & JOSÉ de PAGGI, 1974; RINGUELET, 1958a). There, this species was usually present in samples from the river and two affluents (PAGGI & JOSÉ de PAGGI, 1974), while the characteristic diaptomids of floodplain ponds in the area were *Diaptomus* (s.l.) *spiniger* Brian and *N. incompositus* (Brian) (PAGGI, 1980).

Thermocyclops minutus (Lowndes) and *T. decipiens* (Kiefer)

T. minutus was present in the majority of the Pantanal samples, being the most numerous copepod in most samples from the Rio Paraguai and inlets. It was absent from most baías of the Fazenda Nhumirim, and from all salinas investigated. Like *N. coniferoides*, *T. minutus* is often collected in rivers, but it is also frequently numerically dominant among planktonic cyclopoid copepods in

large and small natural lakes and reservoirs (BRANDORFF, 1977; HARDY, 1980; MATSUMURA-TUNDISI & OKANO, 1983; SENDACZ & KUBO, 1982). Its distribution is similar to that of *N. coniferoides*, except that it occurs only sporadically in northern Argentina, including the middle Paraná (PAGGI, 1980; PAGGI & JOSÉ de PAGGI, 1974; REID, 1989; RINGUELET, 1958a). In Amazonia its ecological range extends to black-water as well as white-water lakes (HARDY, 1980).

T. decipiens, a broadly distributed species which shows a distinct preference for more productive waters than those in which *T. minutus* is commonly encountered (REID, 1989; SENDACZ et alii, 1985), occurred in only two inlets of the Rio Paraguai. *T. decipiens* has been collected occasionally in ponds of the middle Paraná region (BONETTO & MARTÍNEZ de FERRATO, 1966).

Mesocyclops longisetus (Thiébaud), *M. medidianus* (Kiefer) and *M. meridionalis* Dussart & Frutos

M. longisetus, largest of the three congeners, is a benthic species normally found in marshes and in littoral areas associated with macrophytes. It is the most broadly distributed, being found from Argentina to the southern United States (REID, 1985). Not common in the Pantanal samples, it occurred only in the two fishless baías at Fazenda Nhumirim, as well as in one locale in the Rio Paraguai.

M. meridianus, present in the Rios Capivari and Paraguai and in two baías at Fazenda Nhumirim, is distributed from Argentina to Venezuela (REID, 1985). It is more characteristic of open-water habitats than *M. longisetus*. The present record constitutes the first from rivers, although DUSSART & FRUTOS (1985/86) recorded the species from a rice-paddy at Corrientes, Argentina, which was periodically inundated by water from the Rio Paraná.

M. meridionalis was recently described by DUSSART

& FRUTOS (1985/86) from a ricefield and an experimental pond near Corrientes, Argentina. The present records from two baías at Fazenda Nhumirim extend its known range about 1000 km northwards, and agree with the previously described habitat.

Metacyclops mendocinus (Wierzejski)

Collected in the Pantanal only in salinas, where all samples revealed high densities of this species, *M. mendocinus* is otherwise known from the entire continent of South America, Central America, the Antilles and the Azores (REID, 1985). The species is eurythermal, euryhaline, and eurytopic in groundwaters, lakes and rivers. In reservoirs of the State of São Paulo, it was frequently associated with *T. decipiens* and sometimes also with *Scolodiaptomus corderoi* (Wright) (SENDACZ et alii, 1985), both species associated with conditions of high algal productivity (REID, 1987, 1989). In the extremely eutrophic Represa Billings, it tended to become numerically dominant (over *T. decipiens*) during the dry season (SENDACZ, 1984), but became relatively less important in the Riacho Grande arm of Billings after that arm was isolated and water conditions there improved (SENDACZ et alii, 1984). With *Boeckella gracilis* (Daday), *M. mendocinus* is the characteristic crustacean plankter of mesohaline lagoons (salinity 0.62-12.15 o/oo) in the middle Pampas (RINGUELET, 1985b, 1972; RINGUELET et alii, 1965). MONTÚ (1980) reported it at salinities of 0-31.3 o/oo in the estuary of the Lagoa dos Patos. Therefore the presence of this species in the slightly brackish salinas is expectable.

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ENDEREÇO DOS AUTORES

REID, J.
Department of Invertebrate Zoology
NHB-163 National Museum of Natural History
Smithsonian Institution, Washington, D.C.
20560 USA

MORENO, I.H.
Engevix S/A
SCS Quadra 2, Ed. Cedro II, 2º andar
70300 Brasília, DF, Brasil