THE HARPACTICOID AND CYCLOPOID COPEPOD FAUNA IN THE CERRADO REGION OF CENTRAL BRAZIL. 2. COMMUNITY STRUCTURES

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RESUMO: A fauna de copépodes (Harpacticoida e Cyclopoida) da região do cerrado no Brasil central. 2. A estrutura das comunidades. Foram comparadas as comunidades de copépodes harpacticóides e ciclopóides de 70 localidades da região do cerrado no Brasil central. Terras úmidas perenes com substratos compostos de solos orgânicos hospedaram as comunidades mais ricas; foi coletado nestes habitats um número médio de seis espécies, e no campo úmido mais completamente investigado foi coletado um total de 29 espécies. As comunidades de solos orgânicos foram dominadas pelos harpacticóides das famílias Parastenocarididae e Canthocamptidae. Comunidades também ricas foram as das pequenas lagoas perenes circundadas por brejos; nestas foi constatado um número médio de três espécies, e foi coletado um total de 19 espécies na lagoa mais rica. Nas pequenas lagoas dominaram os harpacticóides cantocamptídeos e os ciclopóides mais característicos de águas abertas. Brejos perenes também suportaram uma fauna relativamente rica, com número médio de quatro espécies, contudo o número mais alto em um só brejo foi somente sete espécies. Habitats lóticos, o intersticial arenoso, algas e musgos úmidos perto de cachoeiras e riachos, terras úmidas efêmeras, e habitats especiais hospedaram entre uma e cinco espécies. A comparação de pares destas localidades por meio do índice de similaridade de Sørensen revelou alto grau de similaridade entre os vários habitats, esta similaridade sendo devido à presença freqüente de três espécies: *Tropocyclops prasinus meridionalis*, *Ectocyclops herbsti* e *Paracyclops fimbriatus chiltoni*. Houve uma tendência das comunidades mais pobres em número de espécies serem as mais produtivas e sujeitas a influências humanas. Membros dos gêneros ciclopóides *Mesocyclops* e *Thermocyclops* foram comumente encontrados nessas águas. As águas menos produtivas foram freqüentemente habitadas por *Tropocyclops prasinus meridionalis*.

ABSTRACT: The Harpacticoid and Cyclopoid copepod fauna in the cerrado region of central Brazil. 2. Community structures. *The harpacticoid and cyclopoid copepod (Crustacea) communities of 70 localities in the cerrado region of central Brazil were compared. Perennial wetlands with organic-soil substrates harbored the most species-rich communities; in these habitats a median number of six species was collected, and in the most completely investigated wet campo a total of 29 species was collected. The communities of organic-soil substrates were dominated by parastenocaridid and canthocamptid harpacticoids. The next richest communities were small perennial ponds surrounded by marshes; in these was found a median number of three species, in the richest pond a total of 19 species being collected. In small marshy ponds canthocamptid harpacticoids and cyclopoids more characteristic of open water dominated. Perennial marshes also supported a relatively rich fauna,* *with a median of four species, however the highest number of species in a particular marsh was seven. Lotic habitats, the sand-interstitial, mosses and west algae near waterfalls and streams, ephemeral wetlands, and special habitats harbored one to five species. Comparison of paired localities using Sørensen's index of similarity revealed much overlap in the faunas of most habitat types, due mainly to the frequent presence of three species:* Tropocyclops prasinus meridionalis, Ectocyclops herbsti *and* Paracyclops fimbriatus chiltoni. *The communities of waters subject to human influences and the more productive waters tended to be more species-poor. Members of the cyclopoid genera* Mesocyclops *and* Thermocyclops *were commonly found in these waters. Less productive waters were frequently inhabited by* Tropocyclops prasinus meridionalis.

INTRODUCTION

This article describes the faunas of harpacticoid and cyclopoid copepods (Crustacea) which were collected from 70 localities representing all types of wetlands existing in the cerrado region of central Brazil. Community structure and composition are compared according to habitat type. Because of their abundance and central position in aquatic food chains, copepods have been the focus of innumerable studies. Because of sampling and taxonomic difficulties, however, planktonic species are customarily the first and frequently the only species to be studied in a given system, although benthic copepod communities are usually more diverse and potentially more important for understanding such questions as the amount of secondary production available to higher-level consumers such as fish. The present study is the first effort to compare faunas of benthic as well as planktonic copepods in tropical wetlands. Only ten of the localities investigated harbored calonoid copepods. Since taxonomic questions have yet to be resolved in the case of several species, calanoids were omitted from the community analyses. Taxonomic and distributional information for calanoids from some of the waters investigated is available elsewhere (Reid, 1987a, 1990; Reid *et al.*, 1988).

AREA OF STUDY

The wetlands investigated lie within the cerrado (savanna) region of central Brazil (Reid, 1984, 1993). During a period of several years, collections were made from numerous localities in the cerrado, principally in the Distrito Federal, but also from the states of Mato Grosso, Goiás, Minas Gerais and Bahia. 70 of the best-collected localities were selected for comparison of the harpacticoid and cyclopoid copepod faunas (tab. I).

MATERIAL AND METHODS

Collections were made by plankton net from open water and among macrophytes. Samples of sediment were taken by Ekman grab in larger bodies of water, and by hand from nearshore and humid semiterrestrial sites. Localities in tab. I were grouped according to classifications used in the preceding article (Reid, in press): A, Open waters; B, Littoral-benthic; C, Perennial marshes; D, Wet campos and moist organic soils; E, Lotic habitats; F, Sand-interstitial habitats; G, Dripping moss, splash and spray zones; H, Ephemeral wetlands; and I, Special habitats such as a thermal pond and caves. 20 of the 70 localities were visited more than once, some more than 12 times. At each locality several sub-habitats were sampled; for example, in most ponds, open water, bottom and shore sediments, macrophytes, and algae were investigated. Moist organic soils around the shores of perennial ponds, if present, were also sampled and reported as distinct localities (Type D).

As a rule, one visit is insufficient to collect the full range of species inhabiting a complex wetland such as a pond surrounded by macrophytes, or a wet campo marsh. All zooplankton species and most inhabitants of the littoral zone are usually collected on the first visit, but successive collections tend to add more cryptic inhabitants of the littoral zone, such as species inhabiting sediment among macrophyte roots, and occasionals from adjacent shore soils. In the case of Lagoa Bonita (fig. 1), a typical shallow pond with extensive macrophyte coverage, a more or less complete species list of 8 was accomplished by the third visit, but occasional finds eventually doubled the number of species. A similar pattern occurred during the first series of collections at the Lagoa da Península Norte (fig. 1), where no species was added from the fourth to seventh visit. In the case of this small pond, rainy-season flooding from a nearby stream and siltation from uphill construction promoted a faunal change during the second year of observation, with the establishment of several previously uncollected species of littoral copepods, notably *Microcyclops anceps, Attheyella jureiae*, and *Elaphoidella bidens*, and the replacement of *Notodiaptomus* sp. (Calanoida) and *Tropocyclops prasinus meridionalis* by *Thermocyclops decipiens* in the plankton. The Campo Úmido da Onça is an undisturbed perennial flush marsh with a deep, well-oxygenated organic soil layer supporting a rich copepod fauna (Reid, 1982, 1984, 1987b). Sampling problems in this marsh derive chiefly from the aggregated distribution of the meiofauna and the necessity to sample the various microhabitats and soil levels thoroughly. In the Campo Úmido da Onça, 22 species were collected after three visits, but during successive visits, additional species were regularly encountered, the total eventually reaching 29 (fig. 1). Therefore, faunal similarities among some wetland types, particularly those harboring species-rich communities such as organic-soil habitats and some perennial marshes, are doubtless underestimated by this collection series. Faunal similarities between these habitats and habitats with fewer species, but which share the same few ubiquitous generalist species, are correspondingly overestimated.

Matrices of faunal similarity between paired localities were calculated taking species of cyclopoids and harpacticoids together, for all 70 localities; and for the harpacticoid species separately, for the 38 localities where members of this order occurred. The matrices were calculated using the index of Sørensen (1948) for species presence-absence:

$$QS = \frac{2c}{a + b} \times 100$$

where a = the total number of species in locality a

b = the total number of species in locality b

c = the total number of species common to the two localities.

The coefficient obtained is expressed as a percent. The matrices generated are too large to be included in the present article, but are available from the author upon request. Locality records of individual species will be presented elsewhere in full. Dendrograms

Table I – Location and classification of cerrado wetland habitats where copepods were collected. Habitat types: A, Open waters; B, Littoral-benthic; C, Perennial marshes; D, Wet campos; E, Lotic; F, Sand-interstitial; G, Dripping moss; H, Ephemeral; I, Special; classifications are discussed in the preceding article (Reid, in press). Abbreviations for states: BA, Bahia; DF, Distrito Federal; GO, Goiás; MG, Minas Gerais; MT, Mato Grosso.

1. Lagoa da Península Norte,Brasília,DF, 15°43'30"S 47°51'30"W	A,	B
2. Lagoa Bonita, Planaltina, DF, 15°35'S 47°42'W	A	B
3. Lago Paranoá, Brasília, DF, 15°44'S 47°51'W	A,	B
4. Lagoa do Jaburu, Brasília, DF, 15°47'S 47°49'W	A,	B
5. Represa Santa Maria, Parque Nacional, DF, 15°40'07"S 47°57'00"W	A,	B
6. Lagoa do Parque Nacional, DF, 15°41'15"S 47°55'40"W	A,	B
7. Pond near Divisor de Águas monument, Águas Emendadas Biological Reserve, DF, 15°32'30"S 47°34'57"W		B
8. Lagoa do Campo de Vereda Grande, Águas Emendadas Biological Reserve, DF, 15°32'30"S 47°34'57"W		B
9. Represa do Santo Antônio do Descoberto, DF/GO, 15°44'S 48°10'W	A,	B
10. Lagoa Formosa, GO, 15°30'S 47°36'W		B
11. Tanque near Córrego do Rego at park headquarters, Parque Nacional, DF, 15°43'30"S 47°56'02"W		B
12. CAESB reservoir between Sobradinho and Planaltina, DF, 15°37'02"S 47°43'55"W		B
13. Tanque, Fazenda Mocambinho, DF, 15°50'40"S 47°44'55"W	A,	B
14. Pond near Ribeirão da Papuda, DF, 15°54'00"S 47°46'50"W	A,	B
15. Pool near Córrego Rajadinha, Rio São Bartolomeu Basin, DF, 15°44'15"S 47°39'40"W		B
16. Shallow dug well near Córrego Capão da Onça, DF, about 15°49'S 47°39'W		B
17. Cowpond on Fazenda Santa Helena, about 20 km north of Rio Cana Brava, GO, about 15°00'S 47°04'W		B
18. Duckpond, Chácara Roma, Caldas Novas, GO, about 17°40'S 48°40'W		B
19. Cowpond on BR 070, 10 km west of Goiás Velho, GO, about 15°52'S 50°13'W		B
20. Lagoa da Lontra, GO, 15°19'15"S 47°24'18"W	A,	B
21. Lagoa da Lontra, GO, 15°19'15"S 47°24'18"W	A,	B
22. Pool in open-pit quartz mine, Cristalina, GO, 16°43'S 47°41'W		B
23. Lagoa Rica, Paracatu, MG, 17°07'55"S 46°45'50"W		B
24. Lagoa da Margem, Paracatu, MG, 17°07'40"S 46°00"W		B
25. Lagoa Santa Rita, Paracatu, MG, 17°08'05"S 46°47'45"W		B
26. Represa da Pampulha, Belo Horizonte, MG, 19°52'S 44°00'W		B
27. Lagoa das Codornas, Belo Horizonte, MG, 20°08'S 43°56'W	A,	B
28. Lagoa dos Ingleses,Belo Horizonte, MG, 20°10'S 43°58'W	A,	B
29. Lagoa do Sítio Miguelão, Belo Horizonte, MG, 20°04'S 43°58'W	A,	B
30. Pond in Brejo do Jóquei, Belo Horizonte, MG, 19°47'S 43°57'W	B,	C
31. Lagoinha, Lagoa Santa, MG, 19°38'S 43°53'W	A,	B
32. Small reservoir, Fazenda Boa Vista/Clarião, Inhaúmas, Santa Maria da Vitória, BA, 13°03'S 44°38'W		B
33. Lagoa do Centro Político Administrativo, Cuiabá, MT, 15°35'S 56°06'W	A,	B
34. Marsh at Córrego Cabeça do Veado, Estação Florestal, DF, 15°52'S 47°51'W		C
35. Lago Paranoá, DF, marsh, north arm, 15°44'25"S 47°50'00"W		C
36. Lago Paranoá, DF, marsh near CAESB-ETA Norte treatment plant, 15°44'26"S 47°51'17"W		C
37. Marsh at head of Córrego do Acampamento, DF, 15°46'50"S 47°58'07"W		C
38. Vereda Grande, Águas Emendadas Biological Reserve, DF, 15°32'30"S 47°34'57"W		C
39. Marsh near Rio Crixás, Formosa, GO, 15°06'S 47°05'W		C
40. Marsh of Córrego Poções, Formosa, GO, 15°33'20"S 47°10'30"W		C
41. Campo Úmido da Onça, Fazenda Água Limpa, DF, 15°56'40"S 47°54'20"W		D
42. Murundu area, Fazenda Água Limpa, DF,15°56'40"S 4754'20"W		D
43. Campo úmido, Lagoa Bonita, Planaltina, DF, 15°35'S 47°42'W		D
44. Campo de murundu, valley of Ribeirão do Torto, Parque Nacional, DF, 15°41'20"S 47°56'00"W		D
45. Campo úmido at Lagoa do Campo de Vereda Grande, Águas Emendadas Biological Reserve, DF, 15°32'30"S 47°34'57"W		D
46. Saturated organic soil near vereda at Divisor de Águas monument, Águas Emendadas Biological Reserve, DF, 15°33'00"S 47°35'30"W		D
47. Campo úmido at Lagoa Formosa, GO, 15°30'S 47°36'W		D
48. Buritizal at Cachoeira Salgadeira, Chapada dos Guimarães, MT, 15°21'S 55°47'W		D
49. Ribeirão do Torto, Brasília, DF, 15°43'12"S 47°52'00"W		E
50. Córrego Capão Comprido, Parque Nacional, DF, 15°43'30"S 47°57'53"W		E

51. Córrego Rajadinha, DF, 15=o44'15"S 47°39'40"W	E
52. Córrego Açude, DF, 15°54'00"S 47°37'58"W	E
53. Ditch at headwaters of Córrego Cariru, DF,15°52'00"S 47°36'58"W	E
54. Stream, affluent of Rio Paraím, near Jota Ka, GO, 16°04'S 47°08'W	E
55. Rivulet in open-pit quartz mine, Cristalina, GO, 16°43'S 47°41'W	E
56. Stream, Hotel Parque das Primaveras, Caldas Novas, GO, about 17°40'S 48°40'W	E
57. Rio Coxipó, Cuiabá, MT, 15°35'S 56°06'W	F
58. Cachoeira da Itiquira, GO, 15°22'06"S 47°27'09"W	G
59. Hotel Turismo, Caldas Novas, GO, moss and algae on rocks of stream	G
60. Hotel Parque das Primaveras, Caldas Novas, GO, mosses near stream	G
61. Cachoeira Salgadeira, Chapada dos Guimarães, Cuiabá, MT, 15°21'S 55°47'W	G
62. Cachoeira Cachoeirinha or Pedra Furada, Chapada dos Guimarães, Cuiabá, MT, 15°21'S 55°47'W	G
63. Shallow puddle by Rio Cana Brava, GO, 15°00'S 47°04'W	H
64. Stagnant water by Highway BR 020 near Vila Boa Água, GO, about 15°S 47°W	H
65. Pool in gravel bed at confluence of Córregos Conceição and Brejo, GO, 15°21'30"S 47°23'07"W	H
66. Pools on forest floor, MT, about 11°S 59°W	H
67. Cave Gruta da Clarona, GO, 14°12'S 46°21'W	I
68. Cave Abismo do Dedé, GO, 15°00'S 48°00'W	I
69. Cave "Matilde II", GO	I
70. Lagoa Pirapitinga, Caldas Novas, GO, about 17°40'S 48°40'W	I

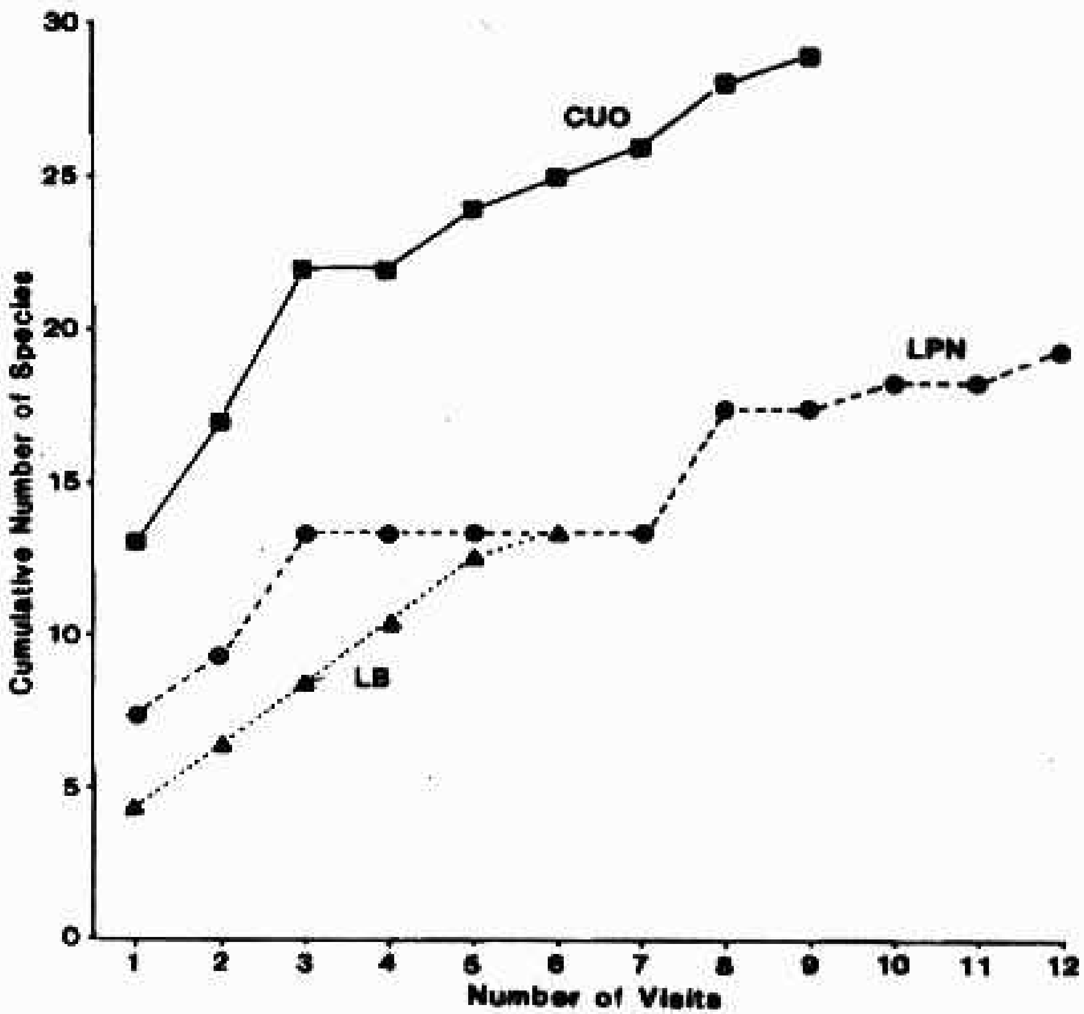

Figure 1 – Cumulative numbers of species of harpacticoid and cyclopoid copepods recorded per collecting visit over a period of three to four years for a wet campo (CUO = Campo Úmido da Onça) and two ponds (LPN = Lagoa da Península Norte; LB = Lagoa Bonita) in the Distrito Federal, central Brazil.

(figs. 3,4) to display the most parsimonious grouping of localities, were constructed from the matrices, beginning with the pair of localities with the highest index of similarity and grouping the next most closely related localities in descending order. In the discussion following, localities may be referred to by number (from tab. I) rather than name. Species indicated by letters are in process of being described; the letters correspond to those used in tab. I of the preceding article (Reid, 1993).

Species richness in relatively undisturbed wetlands was compared with that in wetlands subject to external influences from agricultural and construction activities and organic and other pollutant loading, for Types A-B combined, C, D, and E. Types G, H, and I were note compared in this way because of an inadequate number of samples. Wetlands protected in parks and biological reserves, except for reservoirs and other artificial waters, were categorized as "undisturbed". Criteria for categorizing wetlands outside these reserves were less objective, and indeed most are affected in some way by human activity unless they are located in isolated areas. The number of "disturbed" wetlands, particularly Types A and B, is therefore much larger than the number of "undisturbed" wetlands investigated.

RESULTS AND DISCUSSION

Type D was the most species-rich habitat type investigated (fig. 2). Numbers of species at the eight localities of this type investigated ranged from three to 29 (at 41, Campo Úmido da Onça), with a median of six species. Reid (1984, 1987b) listed several environmental factors which might promote the development of the unusually diverse communities of Type D habitats, particularly wet campos. These include the array of complex subhabitats, including small open water pools, springs, algal mats, and the deep, well-oxygenated organic soil layer which provides an ideal habitat for the interstitial parastenocaridids which are the most characteristic faunal element of these marshes. Two species of the small soil and moss-dwelling cyclopoid genus *Muscocyclops* also accur almost exclusively in organic-soil habitats (Reid, 1984, 1987b, 1993).

Types A and B habitats were combined for purposes of Figure 2, since there is often extensive overlap between species of the littoral and planktonic zones of open waters. The 34 type A-B habitats sampled yielded a median three species, ranging from one to 19 species. Small ponds with extensive macrophyte coverage and adjoining marshes typically sustain ten or more planktonic and benthic species, although the median species number reported for Type A-B habitats is low, partly because of undersampling of some waters, and partly because of the many species-poor reservoirs and tanks included in this category.

Type C habitats harbored a median four species, ranging from two to seven species. The comparative species richness in small ponds and in perenial marshes (Type C) is easily accounted for by the rich array of microhabitats, particularly the protection from fish predation offered by macrophytes and the frequently present adjacent saturated organic shoreline sediments.

The remaining habitat types yielded between one and five species each, with two species being the median number for most. Lotic habitats typically yielded few species, the maximum number being five, which was recorded for the Córrego Rajadinha (51). However, in this small stream, collections made from smal leaf-filled pools in depressions in the streambed and

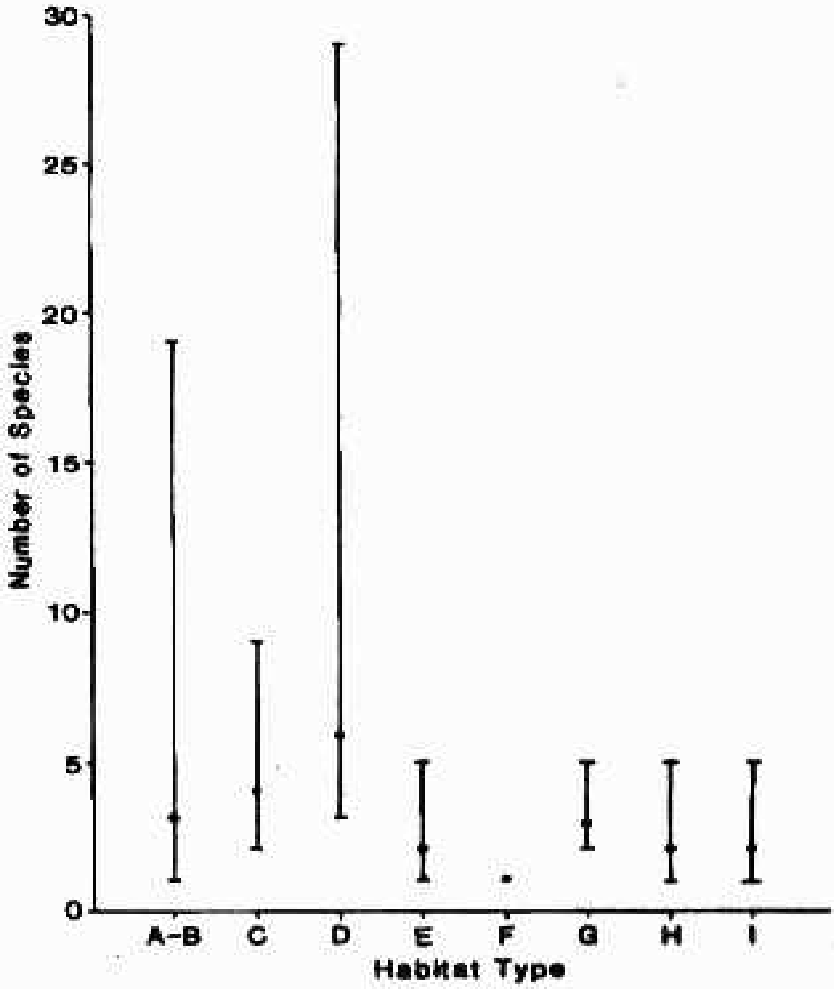

Figure 2 – Ranges and median values (indicated by dot) of numbers of species of harpacticoid and cyclopoid copepods recorded per type of wetland habitat in the cerrado region of central Brazil. Habitat types as in tab. I; types A and B (open waters and littoral-benthic zones of open waters) combined.

included in the "lotic" category contributed several species not found in the stream proper. Although collections from sand-interstitial habitats in large rivers in the Amazon and Paraná basins and from mountain streams in eastern Brazil have yielded a diverse array of parastenocaridids (for example, Jakobi, 1972), an analogous fauna was not found in small cerrado streams, possibly due to filling of sand interstices by fine clays (Reid, 1993; R. Whitman, personal communication). Only one record of a parastenocaridid was made from the sand-interstitial in the cerrado, from coarse surface sand sediments in the relatively large Rio Coxipó at Cuiabá (57). Ten species of harpacticoids and two cyclopoid species were collected in Type G habitats (Reid, in press), but species richness in any single locality was low. Species richness in types H and I habitats was low as well. This comparative faunal sparseness may result from the physical homogeneity of most habitats in these categories. More intensive collecting efforts in caves may alter this initial impression, since diverse continental copepod faunas have been recorded from extensive karst systems in Europe (Brancelj, 1987; Rouch, 1982).

Six localities each harbored species which occurred at no other site, and were not included in the calculations of faunistic relationships among localities. These localities with their respective species are: 13 (*Macrocyclops* cf. *fuscus*), 16 (*Tropocyclops prasinus* s. l.), 57 (*Potamocaris cuiabaensis*), 61 (*Attheyella g*), 63 (*Thermocyclops tenuis*), and 70 (*Microcyclops* *a*). *Macrocyclops fuscus* has one possible prior record in South America, from Paraguay (Daday, 1905); the present record is from Stage V copepodids. The taxonomic relationships of *Tropocyclops prasinus* s. l. have been discussed elsewhere (Reid, 1991a). *Potamocaris cuiabaensis* occurred in the only sand-interstitial habitat which was found to harbor parastenocaridid copepods; this species and *Attheyella g* are known only from the region of Cuiabá (Reid, 1993). Although *Thermocyclops tenuis* is a broadly distributed American species, in Brazil it has been recorded only in Pernambuco and in two localities in the cerrado region (Reid, 1989). The thermal pond Lagoa Piratininga (70) harbors a species of *Macrocyclops* which is so far known only from that locality.

The remaining 64 localities showed a high degree of similarity of the combined cyclopoid and harpacticoid faunas (fig. 3). This similarity is due in part to the presence in most waters of the eurytopic benthic cyclopoids *Ectocyclops herbsti* and *Paracyclops fimbriatus chiltoni*, and in many Type A-B waters of the planktonic *Tropocyclops prasinus meridionalis*. However, examination of the dendrogram reveals some more or less clear faunistic groups.

The first group, localities 4, 5, 6, 11, 12, 22 and 39 (top of dendrogram, fig. 3) is linked by the presence of *Tropocyclops prasinus meridionalis* alone (6, 11, 22) or together with a few other species. The localities include mostly clear waters of low productivity (apparent or measured) and without significant macrophyte development that would permit the establishment of a more diverse community of littoral species. *T. prasinus meridionalis* also occurred in several ponds with more extensive macrophyte coverage and in some cases apparent higher productivity levels (1, 29, 43), so its presence did not necessarily indicate oligotrophy. In fact, this small species is a characteristic component of the zooplankton in mesotrophic reservoirs in São Paulo (Sendacz *et al.*, 1985).

A second group of localities, mostly Type A-B and E habitats (7, 9, 15, 17, 18, 19, 27, 28, 29, 32, 33, 37, 49, 50, 53, 54, 55, 64) is linked at the 60% level or higher by the presence of *P. fimbriatus chiltoni* and *E. herbsti* alone or together with a few other species, mostly canthocamptids and cyclopoids of ponds and other open waters.

The following group, linked at the 50% level or higher, comprises a large number of localities, mainly Types A-B, D, G, and I. These are mostly wetlands and some caves, geographically located in the central cerrado region of Goiás - Distrito Federal - Minas Gerais, with faunas of middle levels of diversity. The Campo Úmido da Onça (41) is related in lower degree to this general grouping because of its highly species-rich, endemic fauna.

Still less closely related are several localities which are distinguished by a few species peculiar to them. These localities are either geographically distant from the central cerrado region (48 and 66 from Mato Grosso; 56 and 60 from southern Goiás), or, although located in the central cerrado, include one or more rare species (14, 23, 51, 65).

The cyclopoid and harpacticoid fauna of the cerrado region seems in spite of its diversity to be broadly similar over most of the region. In particular, there is not much difference in the faunas of the major river basins, except for a distinction as regards some species between the Amazon basin and the other two basins to the south and east, the Paraná and São Francisco (Reid, 1993). Species of open waters occur over the entire vast area. The major geographical faunistic break discernible from the dendrogram grouping and from the records of individual species is that occurring between the Cuiabá - Mato Grosso area, where several benthic species of Types D, F, G, and H habitats were found in that region and nowhere else. Closely related species associated with similar habitats in the central and eastern cerrado regions did not occur in Mato Grosso. A similar faunal discontinuity was established for species of the genus *Muscocyclops* by Rocha & Bjornberg (personal communication). These observations agree with the general rule that the geographical distributions of substrate-bound species tend to be more limited than those of planktonic species.

Faunistic distinctions between habitat types become more evident if only the harpacticoid communities are compared (fig. 4). A group of Type A-B and C localities (1, 2, 3, 9, 18, 21, 26, 30, 32, 34, 40, 49) is linked by the presence of *Elaphoidella bidens* str., sometimes as the only harpacticoid species (18, 21, 30, 34, 49). These localities include most of the reservoirs surveyed, except for the very oligotrophic Represa Santa Maria, which does not harbor *E. bidens*, and several of the natural waters most subject to organic enrichment and other human influences. The closely related *E. bidens a* occurred in two of the same localities (1, 3) as well as two other Type A-B localities (5, 10).

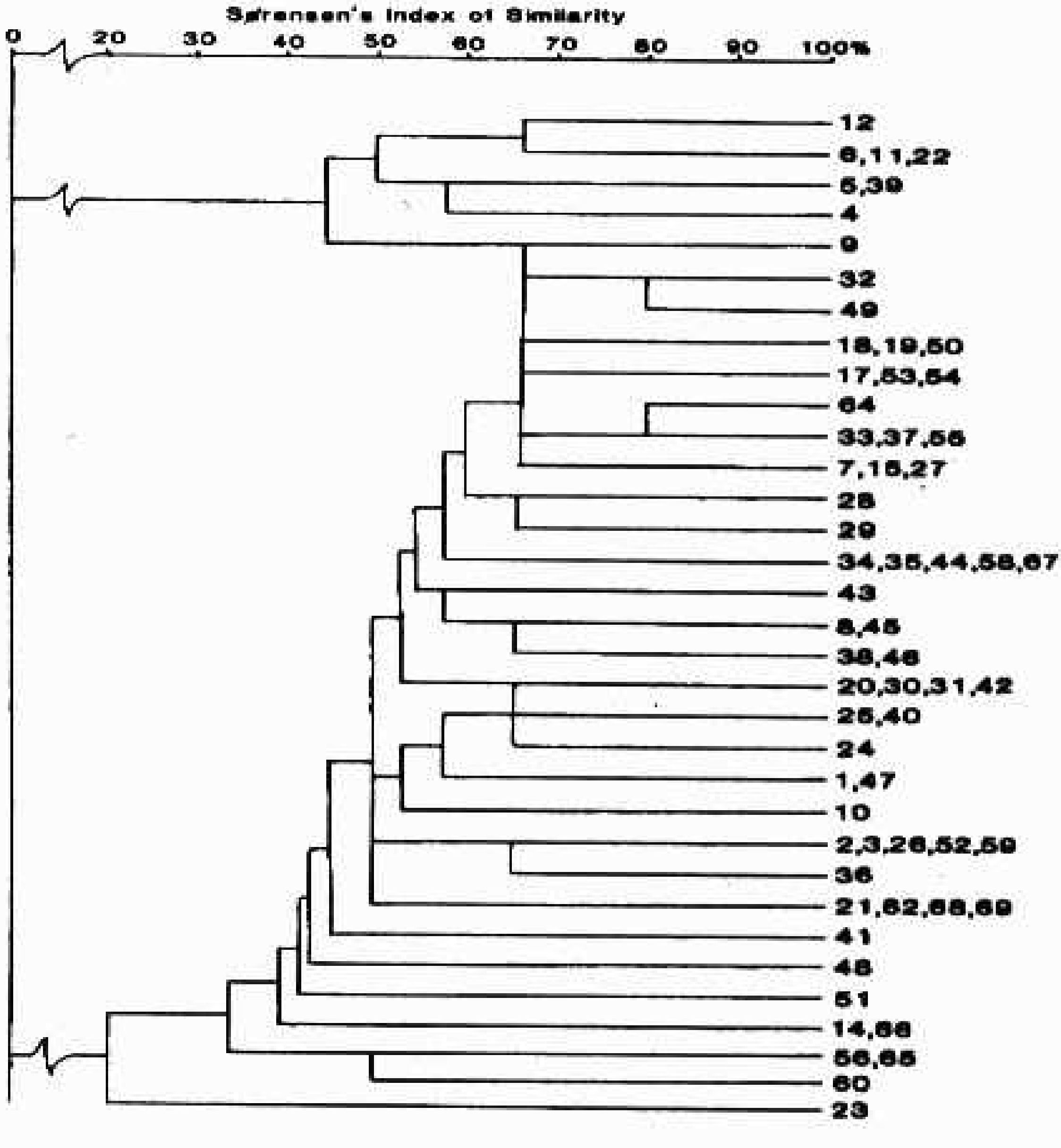

Figure 3 – Dendrogram of similarity of faunas of harpacticoid and cyclopoid copepods among cerrado wetland localities; numbers as in tab. I.

Most type D habitats (42, 43, 44, 45, 46, 47) are closely grouped, reflecting the dominance of parastenocaridids. Campo Úmido da Onça (41) is also linked to this series, although at a lower level because of the high proportion of species found only in that marsh.

The eurytopic canthocamptid *Attheyella jureiae* links the faunas of open waters (localities 1, 2, 8, 10) and Type D habitats (41, 43, 44, 45). The closely related *Attheyella j* was also common in open waters (1, 2, 3, 8, 9, 10, 28, 32) and in Type D habitats adjacent to lakes (43, 47). As in fig. 3, the faunas of Caldas Novas (56, 59, 60), caves (67, 68, 69), and Mato Grosso Types D and G habitats (48, 61, 62) are relatively distinct. There is no obvious faunistic break between the central and eastern cerrado elements as there is between those of the central and western cerrado.

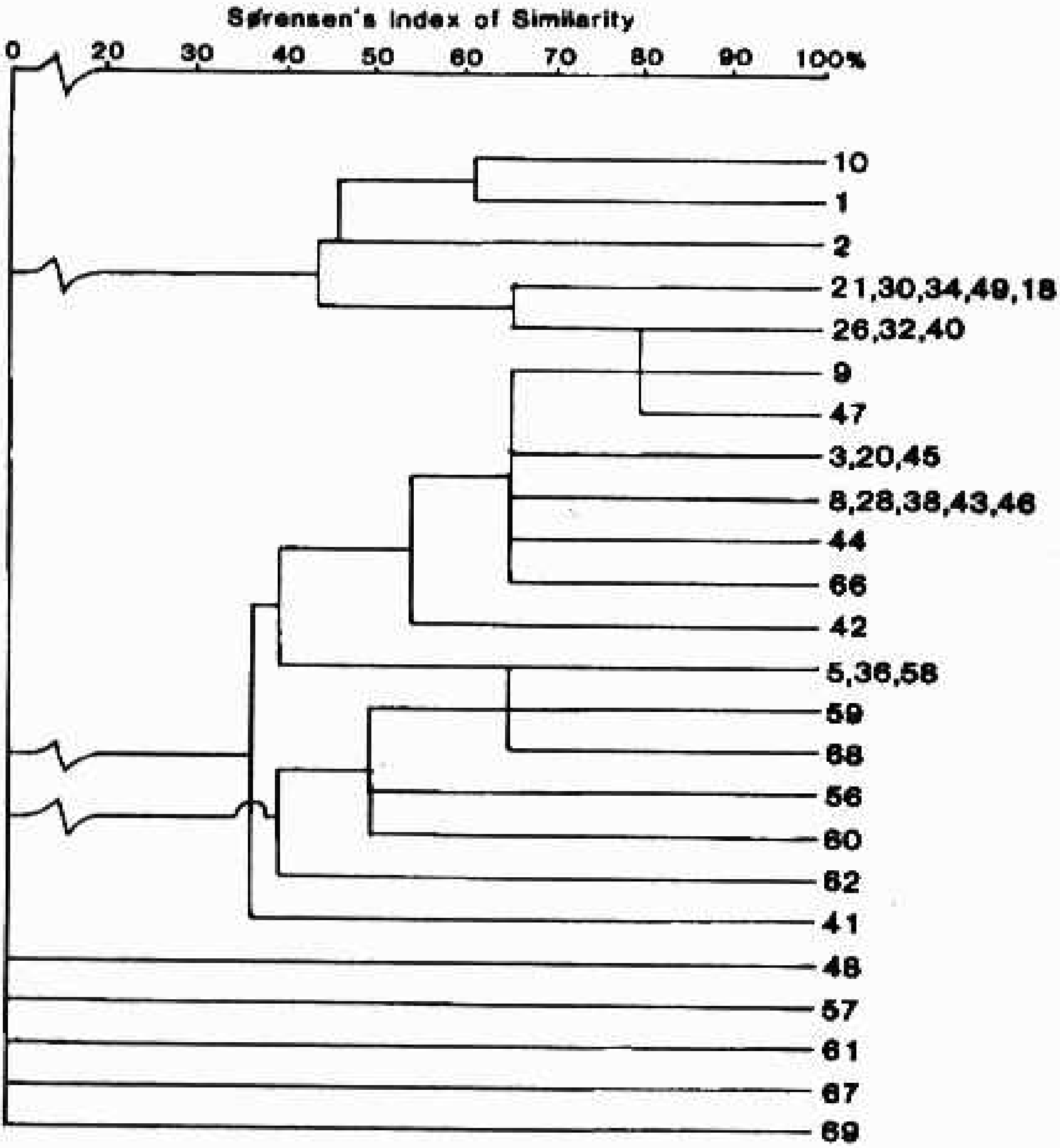

Figure 4 – Dendrogram of similarity of harpacticoid copepods among cerrado wetland localities; numbers as in tab. I.

Table II – Numbers of cyclopoid and harpacticoid copepod species in undisturbed and disturbed wetland Types A-B, C, D and E, and for all samples merged, compared by Student's t-test. N = number of localities compared; mean = mean number of species per locality; range = range of numbers of species per wetland; SD = one standard deviation from the mean.

Habitat	N	Mean	Range	SD	value of t, df
Type A-B					
undisturbed	5	5.6	1-13	4.9	
disturbed	28	4.0	1-19	3.9	0.8024, df = 31, NS
Type C					
undisturbed	3	4.6	4-5	0.5	
disturbed	4	4.2	2-9	3.2	0.2141, df = 5, NS
Type D					
undisturbed	6	9.8	4-29	9.6	
disturbed	2	7.0	3-11	5.6	0.3816, df = 6, NS
Type E					
undisturbed	2	1.5	1-2	0.7	
disturbed	6	1.8	1-3	0.7	0.5422, df = 6, NS
Overall					
undisturbed	16	6.5	1-29	6.8	
disturbed	40	3.8	1-19	3.7	1.9640, df = 54, NS

Table III – Numbers of known species of cyclopoid copepods and two families of harpacticoid copepods from several regions of South America (including unpublished data). CE, Cerrado region; AM, Amazonia; SP, State of São Paulo; ARG, Argentina; VEN, Venezuela; SA, all South America.

Copepod taxon	CE	AM	SP	ARG	VEN	SA
Cyclopoida	38	23	25	42	42	125
Harpacticoida						
Canthocamptidae	24	11	7	13	4	108
Parastenocarididae	18	16	9	20	2	78

In most of the habitat types compared, except Type E (tab. II), copepod communities of wetlands subject to human influences tended to be composed of fewer species than those of undisturbed wetlands. However, because of high variation in species numbers per locality, this reduction was not statistically significant.

Since organic enrichment, the most common effect of human activities on cerrado waters, tends to increase phytoplankton productivity and consequently raise pH values, the effects of changes in pH and of human disturbance are confounded. No clear relation between pH and species richness was apparent from the data in hand, except to reinforce the observation of Reid (1984) that somewhat acid pH values, in some cases low enough to place severe stress on temperate-zone copepods (Sandoy & Nilssen, 1987), had no apparent negative effect on the ability of well-adapted copepod species to survive in cerrado wetlands. For example, pH values in the most species-rich habitat, Campo Úmido da Onça, were between 4.5-4.95 (Reid, 1984). pH values in two typical oligotrophic ponds in the Distrito Federal, Lagoa Bonita and Lagoa do Parque Nacional, varied from 5.8-7.3 and 4.9-6.5 respectively during 1979 - 1980 (Fernandes, 1981).

The numbers of cyclopoid and parastenocaridid harpacticoid species now known to inhabit the cerrado region are approximately equal to numbers of species of these taxa known from other relatively well-collected South American lowland regions of comparable extent (tab. III). More species of canthocamptid harpacticoids are now known from the cerrado than from other regions. From present information it appears that no single region of lowland South America harbors an especially diverse copepod fauna. However, such comparisons are misleading because of the lack of intensive collections of benthic copepods from most areas of the continent.

ACKNOWLEDGMENTS

Tanks are due to the same persons and organizatións acknowledged in the preceding article.

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