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Cladocerans (Crustacea: Anomopoda and Ctenopoda) of the Sempre Vivas National Park, Espinhaço Range, Minas Gerais, Brazil

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Abstract: Protected areas are designed to maintain environmental conditions that favor the occurrence of a wide variety of taxa. However, few studies have devoted attention to inventories of biota in these areas. In this study, we provide a checklist of cladocerans for the poorly studied Sempre Vivas National Park, Minas Gerais state. Samples were collected in lotic and lentic environments, with a total of 27 species being recorded and the highest contribution coming from the Chydoridae family (21 spp.). Minas Gerais state is widely studied in relation to cladoceran fauna; nevertheless, the results indicate three new records. The genus *Monospilus* was reported for the first time in the Neotropical region.

Introduction

The Espinhaço Range is a large mountain formation which has an approximate extension of 1200 km, covering a considerable part of the central portion of Minas Gerais state and reaching the north of Bahia state (SEMAD-MG 2005; Kamino *et al*. 2008). In this region can be found formations of the Cerrado, Caatinga and Atlantic Forest biomes, which comprise extremely vulnerable environments; in other words, the Espinhaço Range has been recognized as highly important for conservation strategies (Costa and Rodrigues 2012).

Located in Minas Gerais state, the southern part of the Espinhaço Range is considered a World Biosphere Reserve. In this region, there are several completely protected areas that were created primarily for conservation of environmental conditions appropriate to the maintenance of fauna and flora. The last protected area to be created, in 2002, was the Sempre Vivas National Park (PNSV), which is an area formed by environmental mosaics, besides having a high concentration of headstreams and lentic environments, such as wetlands and shallow lakes.

Although the park is rich in aquatic environments, there are no inventories of the aquatic species in the PNSV, which confirms the absence of studies with this focus in conservation areas in Brazil, as suggested by Agostinho *et al*. (2005). In the case of cladoceran fauna, data are available in the scientific literature for the Emas National Park (Sousa and Elmoor-Loureiro 2008), Ecological Station of Taim (Gazulha *et al.* 2011) and some smaller protected areas in Minas Gerais and São Paulo (Rocha *et al*. 2011; Santos-Wisniewski *et al*. 2011). These studies provided important information for understanding the biodiversity of cladocerans in areas designated for conservation, however, an extension of studies in these areas, with systematic sampling, is important to have a data set of reference areas.

Thus, this paper sought to contribute to the knowledge of cladoceran fauna in areas designed for conservation. Here, we provide a checklist of species found in samples from different aquatic environments in the Sempre Vivas National Park, Minas Gerais state, Brazil.

Materials and Methods

The Sempre Vivas National Park (PNSV) (Figure 1) is located in Olhos d'Água, Bocaiúva, Buenópolis and Diamantina municipalities. The PNSV was created in order to ensure the preservation of natural resources and biodiversity, as well as providing a site for scientific research and educational activities. The area of the PNSV presents altitude ranging from 1000m to 2200m and is composed of savanna on rocky soil and tropical dry forests.

Furthermore, water bodies of two major Brazilian hydrographic regions are found in the park: the San Francisco, covering the western part of the PNSV, and the Eastern Atlantic on the east side. For this study, we selected 43 sites, located in lotic and lentic systems of both these hydrographic regions. The sampling was carried in the Preto, Jequitaí, Inhacica, Jequitinhonha and Silípe Rivers (Table 1). In these environments, sites were selected on slopes starting in the highest region and moving toward the lower areas. The fauna was obtained using a plankton net (80µm mesh), dragged through different substrates: leaves, bryophytes, macrophytes and filamentous algae. The animals were fixed in ethanol with final proportion of 70%.

Lamarão, Rio Preto, Divisor, Bracinho and Redonda Ponds (Table 1) represented the lentic environments. The fauna was obtained using a plankton net (80µm mesh), dragged among the aquatic vegetation and mud. All sites were sampled in May 2010 (end of rainy season) and in September 2010 (dry season).

For each sample collected, sub-samples with a volume of 4ml were examined under stereomicroscope until 50 individuals were reached. Then, five sub-samples were

examined to verify the occurrence of new species. With the addition of new species, new sub-samples were analyzed until stabilization of species richness was observed.

All individuals obtained were counted and identified with the support of taxonomic references (Smirnov 1992, 1996; Elmoor-Loureiro 1997; Kotov *et al*. 2004; Kotov and Stifter 2006; Sinev and Elmoor-Loureiro 2010; Van Damme *et al*. 2011). The voucher specimens are preserved in ethanol and deposited in the Elmoor-Loureiro scientific collection, at the Laboratory of Aquatic Biodiversity of the Catholic University of Brasília (access numbers EL01837-EL01892, EL01930-EL01943, EL02301, and EL2400-EL2438).

Rarefactions analysis was generated based on number of sites to accumulate the number of species in the PNSV. To access the total richness, non-parametric estimators of species richness based on incidence were calculated (ICE, Chao2 and Jackknife1) in EstimateS 8.2 (Colwell 2009). The formulas for the calculation of the estimators are found in Gotelli and Colwell (2010).

Results and Discussion

We observed the occurrence of 27 species distributed in the five families. This species were represented by 17 genera, of which 12 belong to Chydoridae (Table 2). The majority of them has been already reported from Minas Gerais state (Santos-Wisniewski *et al.* 2011), but three species represent new records. Two of them, *Disparalona* cf. *hamata* and *Ilyocryptus sarsi*, are known from other Brazilian regions. Nevertheless, the occurrence of *Monospilus* (Sars, 1862) is remarkable, as the single known species, *Monospilus dispar* Sars, 1862, has been reported only from Africa and Holartic region (Smirnov 1974; Kotov *et al.* 2009). A preliminary assessment of our specimens morphology indicates that they belong to a different species (Figure 2).

Table 1. Geographical localization of lotic and lentic environments sampled in the Sempre Vivas National Park, Minas Gerais, and their respective hydrographic regions.

		NUMBER OF SITES	GEOGRAPHIC COORDINATES
Atlântico Leste Hydrographic Region	Bracinho Pond	1	17°46'34" S 43°37'10" W
	Redonda Pond	1	17°46'39" S 43°36'59" W
	Jequitinhonha River	1	17°45'57" S 43°37'04" W
	Silípe River	9	17°29'-17°54'S 43°21'-43°42' W
São Francisco Hydrographic Region	Divisor Pond	1	17°46'03" S 43°46'02" W
	Lamarão Pond	1	17°54'38" S 43°49'21" W
	Rio Preto Pond	1	17°56'33" S 43°49'49" W
	Inhacica River	7	17°53'-17°54' S 43°47'-43°49' W
	Jequitaí River	11	17°50'-17°51'S 43°37'-43°45' W
	Preto River	10	17°54'-17°55' S 43°48'-43°59' W

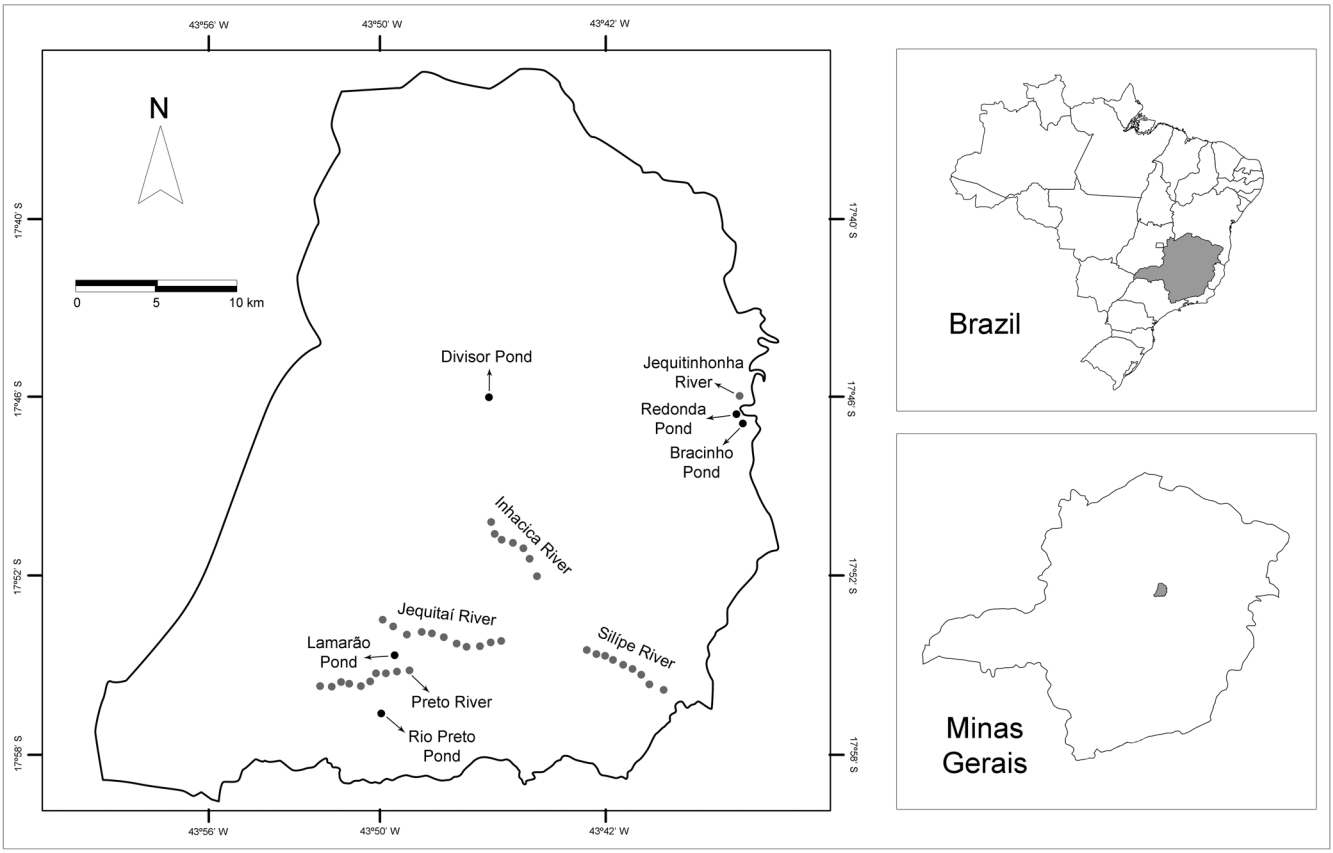

Figure 1. Map of study area. Localization of the Sempre Vivas National Park, Minas Gerais, and sites sampled.

Figure 2. *Monospilus* sp. from Jequitaí and Preto rivers, Sempre Vivas National Park. Scale bar = 100µm.

The highest number of species and genera for the family Chydoridae has been frequently reported in inventories of cladoceran fauna in various Brazilian regions (Elmoor-Loureiro 2007; Rocha *et al*. 2011; Sousa and Elmoor-Loureiro 2009; Soares and Elmoor-Loureiro 2011), which, of course, is the result of the effort directed to sampling the littoral zone of inland waters. According to Elmoor-Loureiro (2000), the studies on cladocerans from the littoral zone were the biggest challenge to recognize the true diversity of these microcrustaceans in Brazil. More than a decade later, many advances have been achieved due to the number of new records and descriptions of new species (Santos-Wisniewski *et al*. 2001; Kotov and Elmoor-Loureiro 2008; Sinev and Elmoor-Loureiro 2010; Sousa and Elmoor-Loureiro 2011).

The evaluation of the rarefaction curve plotted as a function of the number of sites sampled (Figure 3) showed no tendency to asymptote, suggesting that there is still a need to extend the sampling effort to acquire better knowledge of species richness. Theoretically, no sampling method is able to access the species richness altogether in a particular ecosystem or site; thus, the suitability of the inventory is dependent on obtaining more than 50% of the estimated number of species (Heck *et al*. 1975; Williams *et al*. 2007). Although the rarefaction curve did not present an asymptote, our inventory can be considered adequate, since 30 species were estimated, representing sampling of more than 80% of what was expected by estimators.

In another two protected areas located in the Cerrado (Brasília National Park and Campo de Instrução de Formosa – Goiás), estimated values of richness were very close to that observed in this study (Sousa, unpublished data). Although similar richness values were found, it is important to emphasize that in the study above, no samples were collected in lotic environments.

Regarding water bodies sampled in the PNSV, a higher

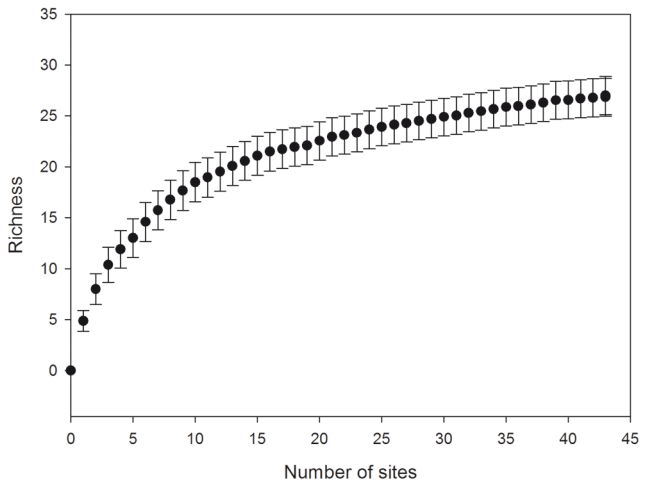

Figure 3. Rarefaction analysis based on the number of sites sampled for the Sempre Vivas National Park, Minas Gerais.

number of species was observed in lotic environments (Table 2). This is not a commonly found result, because lotic environments, especially headstreams, exhibit a strong influence of turbulence (Viroux 2002). We thus suggest two factors that may be the main causes for the richness observed in the lotic water bodies: (1) the sampling effort was greater than that employed in lentic water bodies and (2) the samples were collected in what were termed "pools", located in regions that have lower water flow, more substrates deposited and, therefore, that provide favorable conditions for association of cladocerans.

In addition to the factors mentioned above, we cannot ignore that the samples were taken during the transition between the rainy and dry season and during the dry season. For headstreams, the dry season presents conditions that favor the occurrence of many cladoceran species, and certain ecological processes are involved for this, for example, (1) high input of leaves because of the senescence of the trees in gallery forests (Gonçalves *et al.* 2006), increasing the possibility of colonization, (2) a large amount of light that reaches river beds, helping periphyton to develop and (3) slower flow. These processes provide favorable conditions for different species of cladocerans due to the availability of food contained in periphyton and reduced carrying of individuals, and thus higher stability of the substrates.

On the other hand, in shallow lentic environments, the beginning of the dry season, and the consequent decrease in rainfall, may lead the water body to dry up. As a result, a drastic reduction in habitat may lead to a decline in richness, which could also explain the low number of species found in the lentic water bodies sampled.

In a recent review, Santos-Wisniewski *et al*. (2011) showed the occurrence of 94 cladoceran species in Minas Gerais state. The number of species found in the PNSV represents, in this case, approximately 29% of all species found throughout the state. However, many species recorded on the checklist provided by Santos-Wisniewski *et al.* (2011) have geographic distribution restricted to other regions of the world, for example, the Paleartic, or they represent *nomina nuda*, which does not allow us to affirm the true representativeness of the PNSV in terms

of cladoceran diversity in the state before revising these taxa. The fact is that the number of species found in the PNSV is probably more representative for Minas Gerais state.

In this study, we provide a checklist of cladocerans for different environments of the Sempre Vivas National Park. Additionally, we add three new taxa to the existing list for Minas Gerais state, of which one is recorded for the first time in the Neotropics. The results here described increase knowledge about the richness and composition of cladoceran species in areas designated for conservation of the Cerrado.

Table 2. Cladoceran species from the SempreVivas National Park, Minas Gerais, Espinhaço range, Brazil. BP = Bracinho Pond; DP = Divisor Pond; LP = Lamarão Pond; RP = Redonda Pond; PPR = Pond Preto River; IR = Inhaçica River; JR = Jequitaí River; JQR = Jequitinhonha River; PR = Preto River; SR = Silipe River.

TAXA	BP	DP	LP	RP	PPR	IR	JR	JQR	PR	SR
Sididae Baird, 1850										
Latonopsis australis-group		x				x				
Pseudosida ramosa Daday, 1904				x						
Daphniidae Straus, 1829										
Ceriodaphnia cornuta Sars, 1886				x						
Ilyocryptidae Smirnov, 1992										
Ilyocryptus spinifer Herrick, 1882	x	x		x		x	x	x	x	x
Ilyocryptus sarsi Stingelin, 1913									x	
Macrothricidae Norman and Brady, 1867										
Macrothrix elegans Sars, 1901	x			x		x			x	
Chydoridae Stebbing, 1902										
Acroperus tupinamba Sinev and Elmoor-Loureiro, 2010						x	x		x	x
Alona guttata Sars, 1862						x	x		x	x
Alona iheringula Sars, 1901			x				x		x	x
Alona intermedia Sars, 1862						x	x		x	
Alona ossiani Sinev, 1998	x	x	x			x	x	x	x	x
Alona setigera Brehm, 1931							x		x	
Alona yara Sinev and Elmoor-Loureiro, 2010						x				
Alonella clathratula Sars, 1896		x	x			x	x	x	x	x
Alonella dadayi Birge, 1910				x	x	x	x	x	x	x
Anthalona verrucosa (Sars, 1901)				x	x	x	x		x	x
Camptocercus australis Sars, 1896						x				x
Chydorus eurynotus Sars, 1901		x				x	x			x
Chydorus pubescens Sars, 1901		x				x				
Chydorus sp.		x		x		x				
Disparalona cf. *hamata* (Birge, 1879)						x	x		x	x
Ephemeroporus barroisi (Richard, 1894)				x			x			
Ephemeroporus hybridus (Daday, 1905)				x	x					
Euryalona orientalis (Daday, 1898)	x					x				
Graptoleberis occidentalis Sars, 1901		x				x	x	x	x	
Leydigiopsis curvirostris Sars, 1901										x
Monospilus sp.							x		x	
Total	**4**	**8**	**3**	**9**	**3**	**18**	**15**	**5**	**15**	**12**

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