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Vertical and time distribution of Diplopoda (Arthropoda: Myriapoda) in a monodominant forest in Pantanal of Mato Grosso, Brazil

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ABSTRACT. In this study different sampling techniques for Diplopoda in soil, tree trunks and canopies were applied in an integrated way in the northern region of the Pantanal of Mato Grosso, Brazil. This was done in order to assess the relationship within the fauna in each forest strata, as well as its richness and temporal distribution. In all these habitats there were a total of 1,354 diplopods, distributed in four taxonomic orders, with Polyxenida being predominant over Polydesmida, Spirostreptida and Spirobolida. The largest representation was found on the trunks of the *Vochysia divergens* (721 ind.), intercepted by tree photoeclectors, whereas in the canopies sampling reached only 65 specimens. In the edaphic stratum 568 diplopods were captured, most with the use of the Winkler extractor, followed by pitfall traps and soil photoeclectors. In spite of being an important group in these environments, both in terms of richness and diversity, this was less than has been observed in other Neotropical areas. However, due to seasonal changes in the Pantanal the existence of a relationship between the soil and the tree fauna was found as well as different survival strategies observed during the flood period. Regarding vertical distribution, the greatest richness and variety of taxonomic groups was found in the forest's edaphic environment demonstrating its association mainly with this forest stratum.

KEY WORDS. Diplopoda; ecology; stratification; wetlands.

The causes of the high diversity in the Tropics as well as the mechanisms responsible for their maintenance are still not very well known (Zerm *et al.* 2001). In these areas, arthropods account for a major part of the species richness (Stork & Grimbacher 2006), thus data on to the level of specialization among the strata and the host specificity in these areas are of paramount importance for estimating global biodiversity (Erwin 1982, Stork 1993, Hammond 1995, Ødegaard 2000).

The Pantanal in Mato Grosso state is a suite of ecosystem featuring a mosaic of forests, savannas and grasslands amongst which there are several monodominant vegetational types such as the "cambarazal", with dominance of *Vochysia divergens* Pohl. (Vochysiaceae) (Por 1995, Silva *et al.* 2000). Part of these areas is seasonally flooded, what can directly influence the variety of animal species, considering that many of them depend on special survivability strategies to endure water stress periods (Adis 1997).

Diplopoda are an important component of the Neotropical fauna and are a key participant in the decomposition of plant matter by means of the fragmentation of organic matter (Price 1988, Hopkin & Read 1992). Despite performing vital functions for the functioning of the ecosystems, not very much is known about their diversity, morphology or phylogenics (Sierwald & Bond 2007).

Studies carried out in floodable environments, especially in the Central Amazon region, have demonstrated that several Diplopoda have developed survival strategies in order to endure long periods of flooding such as migration between forest strata, as recorded for *Cutervodesmus adisi* Golovatch, 1992, Fuhrmannodesmidae (Adis *et al.* 1996); *Mestosoma hylaeicum* (Jeekel, 1963), Paradoxomatidae (Adis 1997); *Aporodesminus wallacei* Silvestri, 1904, Pyrgodesmidae (Adis *et al.* 1998b); *Pycnotropis tida* (Chamberlin, 1941), Aphelidesmidae (Vohland & Adis 1999) and *Poratia insularis* (Kraus, 1960), Pyrgodesmidae (Bergholz *et al.* 2004), which move from the soil to tree trunks and canopies. Other species have a plastron, which allows them to move underwater with lower energy expenditure (Adis 1997, Messner & Adis 2000), such as *Myrmecodesmus adisi* (Hoffman, 1985), Pyrgodesmidae (Adis *et al.* 2003).

In the Pantanal of Mato Grosso, the displacement between forest strata has been recorded by Adis *et al.* (2001) for *Plusioporus* *salvatorii* Silvestri, 1895 (Spirostreptidae) during the high water season, which shows a similar behavior to that found in the Amazon. Golovatch *et al.* (2005) have reviewed the studies on the fauna of Diplopoda in Mato Grosso and Mato Grosso do Sul, with emphasis on flooded areas, and have demonstrated that, in spite of being rich, the fauna in these states typically have fewer taxa.

Considering the need to deepen the understanding of the biodiversity in the Pantanal, this study which employed different sampling methods aimed to get a comprehensive inventory of Diplopoda in a monodominant forest in the Brazilian Pantanal and (I) compare the richness and composition of the Diplopoda community associated with different strata of this forest (land and tree fauna), and (II) analyze the seasonal distribution of this community.

MATERIAL AND METHODS

This study was carried out in the Pantanal of Cuiabá-Bento Gomes-Paraguaizinho, called Pantanal de Poconé, located in Pirizal, Retiro Novo Ranch (16°15’24"-17°54’32"S and 56°36’24"-57°56’23"W) in the municipality of Nossa Senhora do Livramento, state of Mato Grosso. Sampling was carried out between January 2004 and March 2005, in a monodominant forest with predominance of *V. divergens* Pohl. (Vochysiaceae), which represents one of the region’s typical phytofisionomies, called “cambarazal”. Only the sampling with the Winkler extractor was performed between 1999 and 2000.

This region is characterized by four well-defined seasonal periods according to Heckmann (1998). The dry season occurs between July and September and is the period in which most of the northern Pantanal is completely dry and rainfall is scarce. The start of the rainy season corresponds to the flood period (between October and December), when some areas may flood up temporarily with water from the rains, but become dry again after periods of sun. The high water period generally occurs between January and March or April when much of the northern Pantanal is submerged and fields and forests are flooded due to the overflow of rivers and lakes. The low water season is the period in which the water level in flooded areas drains rapidly, accompanied by reducing the amount of rainfall in the region, recorded between April and June.

Field procedures. Different collection methodologies were employed for the soil, tree trunks and canopies in periods of the dry season, flood period, high and low water, according to the criteria established by Adis (1977, 1981, 2002).

Pitfall traps. These traps consist of a 20 cm polyethylene flask with a round nozzle of 5-6 cm (Adis 2002). A total of ten unbaited traps were distributed unsystematically in the “murundus”, termite earthmounds that are not submerged in the flood period in the “cambarazal” (Ponce & Nunes da Cunha 1993, Por 1995). Seven traps were filled with 250 ml water solution with picric acid, and three with a 4% formalin solution. These traps were checked each fifteen days, from January 2004 to January 2005.

Soil photoeclectors. These traps are round apparatus with a base area of 1 m² covered with a black fabric with a plastic transparent colleting recipient at the top – containing a water solution with picric acid (250 ml) (Adis 2002) (Fig. 1). Three photoeclectors were installed, which represents a sampling area of 3 m² and remained installed throughout the whole sampling period (January 2004 to January 2005). The material collected was removed every fifteen days to assess the emergence density of the Diplopoda based on the relationship between the number of individuals collected per area. The material collected on February 29th 2004 was lost due to extreme flooding on that day.

Trunk photoeclectors. These traps consist of black fabric capturing funnels (74 cm), forming a ring around the trunks fixed by a 22 cm L-shaped metallic support (Adis 2002). Each trap has a transparent collecting device containing 350 ml of water solution with picric acid. In order to monitor the activity of the groups that migrate between the soil and the canopy three trunk photoeclectors were used (I) one for collecting organisms that migrate from the soil to the canopy installed five meters from the ground (Fig. 2); (II) another in the same direction, but installed 50 cm-high from the ground (Fig. 4) and with a shorter time interval (October 2004 to March 2005) in order to intercept those diplopods located over the trunk along the waterline and which therefore do not reach the highest parts of the trunk; (III) a third one was installed in order to intercept those individuals migrating from the canopy to the soil which was also placed five meters from the ground (Fig. 3). All of them were installed on the trunks with *V. divergens* in the central area of the forest and were monitored every fifteen days between January 2004 and March 2005.

Canopy fogging. Twelve samples by fogging were carried out during the four seasonal periods, making a total of 396 m² of canopies sampled. In each period three individuals of *V. divergens* with 33 m² of canopy area were fogged, in a total of 99 m² per seasonal period. Sampled trees were selected according to the criteria proposed by Adis *et al.* (1998a), and the methodological procedures as presented by Battirola *et al.* (2004) and Marques *et al.* (2006).

Laboratory procedures and analyses. The Diplopoda were separated from the other organisms, identified by Sergei Golovatch (Institute for Problems of Ecology and Evolution, Russian Academy of Sciences, Moscow, Russia), aided by the key proposed by Golovatch *et al.* (2005). Spirobolida and Polyxenida species were not identified to specific levels due to the lack of studies in the area of taxonomy of these groups in the Neotropical region. Pearson correlations were calculated based on monthly capture values and the abiotic data obtained from the Meteorological Station in Cuiabá, Mato Grosso, about 90 km from de study area. All materials sampled are stored at the Ecology and Taxonomy Laboratory for Terrestrial and Aquatic Arthropods at the Bioscience Institute of the Federal University of Mato Grosso in Cuiabá.

Figures 1-4. Devices employed for sampling Diplopoda in a cambarazal in northern region of the Pantanal of Mato Grosso: (1) soil photoeclectors; (2) tree photoeclectors upwards; (3) tree photoeclectors downwards; (4) tree photoeclectors upwards installed 0.5 m high from the ground. Photos by L.D. Battirola.

RESULTS AND DISCUSSION

Land Fauna

A total of 1,354 diplopods were sampled out of which 568 (41.9%) from land samples. The Winkler extractor (213 ind., 37.5%) was the most successful trap, followed by pitfall traps (204 ind., 35.9%) and soil photoeclectors (151 ind., 26.6%). Sampled individuals were distributed among four taxonomic orders with a prevalence of Polyxenida (40.5%), Polydesmida (40.0%), Spirostreptida (15.7%) and Spirobolida (3.9%). Among the five species *Poratia salvator* Golovatch & Sierwald, 2000 (Pyrgodesmidae) (24.5%) and *Promestosoma boggianii* (Silvestri, 1898) (Paradoxomatidae) (15.5%) were the dominant (Tab. I).

Activity density in soil surface. The activity density was evaluated based as the number of individuals captured. A total of 204 individuals were captured in the soil surface, mostly Polydesmida. *Promestosoma boggianii* (Paradoxomatidae) and *P. salvator* (Pyrgodesmidae) were the most active species on the surface soil. Within Spirostreptidae, the second most active group in the soil, the largest activity rate was recorded for *Plusioporus*

Table I. Vertical and time distribution of Diplopoda in soil, trunks and canopies in the "cambarazal", according to the collection method in the Northern region of the Pantanal of Mato Grosso, Brazil.

Habitat/methods	Order/family	Taxa	High water/00	Low water/00	Dry/99	Flood/99		Total	%
Soil (0-5cm)	Polyxenida		–	–	21	7	–	28	2.1
Extractor Winkler	Spirobolida		–	1	1	14	–	16	1.2
	Spirostreptida								
	Spirostreptidae	*P. salvadorii*	–	–	–	11	–	11	0.8
	Polydesmida								
	Pyrgodesmidae	*P. salvator*	20	4	6	26	–	56	4.1
Litter	Polyxenida		–	2	27	15	–	44	3.2
Extractor Winkler	Spirobolida		1	3	–	2	–	6	0.4
	Spirostreptida								
	Spirostreptidae	*P. salvadorii*	2	–	–	7	–	9	0.7
	Polydesmida								
	Pyrgodesmidae	*P. salvator*	11	5	2	25	–	43	3.2
			High water/04	Low water/04	Dry/04	Flood/04	High water/05		
Soil surface (activity)	Polyxenida		–	1	1	5	–	7	0.5
Pitfall traps	Spirostreptida								
	Spirostreptidae	*P. salvadorii*	4	–	8	34	–	46	3.4
		T. (O.) mattogrossensis	9	5	1	4	1	20	1.5
		Urostreptus sp.	–	–	–	1	1	2	0.1
	Spirostreptida		1	–	–	–	–	1	<0.1
	Polydesmida								
	Paradoxomatidae	*P. boggianii*	–	2	1	80	5	88	6.5
	Pyrgodesmidae	*P. salvator*	33	6	–	–	1	40	2.9
Soil surface (emergence)	Polyxenida		4	2	8	134	3	151	11.1
Soil photoeclectors									
Trunk (Upwards 5m)	Polyxenida		2	56	94	114	9	275	20.3
Trunk photoeclectors									
Trunk (Upwards 0,5m)	Polyxenida		–	–	–	80	2	82	6.1
Trunk photoeclectors									
Trunk (Downwards 5m)	Polyxenida		11	171	120	55	7	364	26.9
Trunk photoeclectors									
Canopies	Polyxenida		08	26	15	16	–	65	4.8
Canopy fogging									
Total			106	284	305	630	29	1,354	100.0

salvadorii Silvestri, 1895 and *Trichogonostreptus (Oreastreptus) mattogrossensis* (Silvestri, 1902), followed by *Urostreptus* sp. only one Spirostreptida individual and the Polyxenida were not determined in specific levels in these samples (Tab. I).

The flooding period was the season with the highest activity density (60.8%, 124 ind.), followed by high water (27.0%, 55 ind.), low water (6.8%, 14 ind.) and the dry season (5.4%, 11 ind.) (Tab. I and Fig. 5). In this phase, *P. boggianii* (64.5%) and *P. salvadorii* (27.4%) were the most active species on the soil (Tab. I). This period also corresponded to the highest activity for Polyxenida on the soil surface, although this taxon was not very well represented in these samplings. There was positive correlations between the monthly density for Diplopoda activity in the soil and the mean monthly rainfall (r = 0.69, F = 10.11, p = 0.050).

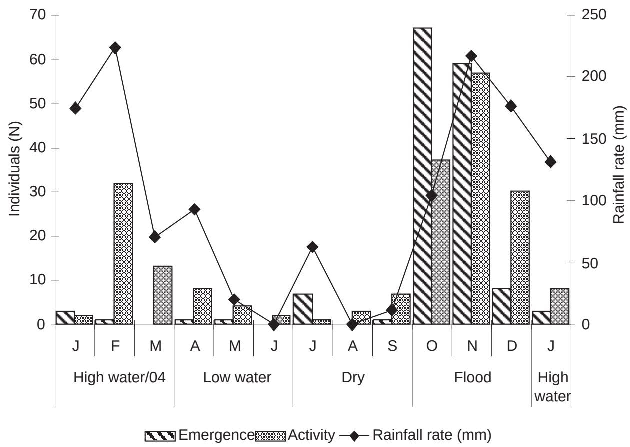

Figure 5. Diplopoda activity and emergence density in the soil surface in the "cambarazal", throughout seasonal periods in the Northern region of the Pantanal of Mato Grosso, associated with the monthly rainfall rate (mm).

During the 2004 high water season the soil activity was reduced probably due to forest flooding which forced soil organisms to migrate to non-flooded environments. In the case of the "cambarazal", the only ground sites that were not flooded were the "murundus" where the traps were installed, in order to assess possible horizontal migrations of the soil fauna from lower areas. This behavior was demonstrated by the considerable capture rate recorded, especially for *P. salvator* e *T. mattogrossensis* that showed in this season 82.5 and 45.0% of total activity recorded for the year, respectively (Tab. I). In the rest of the seasonal periods, low activity was seen for these organisms.

During low water mostly *P. salvator* and *T. mattogrossensis* were captured, whereas in the dry season, probably due to low rainfall, few individuals showed any activity, with *P. salvadorii* achieving the highest capture rates. Species activity periods sampled in the "cambarazal" were quite varied. According to the samplings, *P. salvator* was active on the murundus, exclusively in high water (85.0%) and low water (15,0%), differently from *P. boggianii*, which was mostly active on the soil in the beginning of the rainy season, during flooding (90.9%) and showed low activity in high water (5.7%), low water (2.3%) and the dry season (1.1%), which thus suggests its preference for more humid periods in this stratum.

Amongst the Spirostreptidae, *P. salvadorii* showed greater activity at the end of the dry period (17.4%) and the beginning of the flooding period (73.9%), together with the gradual increase of rainfall in the region. During high water, this species was captured in February, when the flooding level reached a peak in the "cambarazal" (1.25 m), which forced it to migrate towards higher environments. The low capture rate during high water could be associated with the fact that this species also tries to survive by migrating vertically to tree trunks, as already reported for this region (ADIS *et al.* 2001).

Trichogonostreptus (*Oreastreptus*) *mattogrossensis* had low activity density in all seasonal periods, but it was accentuated in the rainy season especially during high water. *Urostreptus* sp. was sampled only during the rainy season in December and January at the end of flooding and beginning of high water respectively. Polyxenida was not very active on the soil (3.4% of total activity), with a single individual captured during the low water, the dry season, and a greater density in October in the beginning of the flooding period. No activity was recorded for this taxon on the soil surface during high water (Tab. I).

Emergence density – Throughout the whole sampling period 151 Diplopoda were captured (4.2 ind./m^2/month) by using soil photoeclectors, all belonging to Polyxenida (Tab, I and Fig. 5). Emergence activity for this group occurred throughout the whole seasonal period, but was higher during the flooding (88.7%, 44.7 ind./m^2) and low in other seasonal periods.

These data show the emergence density of these organisms what coincided precisely with the flooding period, about two months before the forest was flooded and simultaneously with the stage in which there is a gradual increase in rainfall in this region. During the high water season, which is the next period, the emergence density reduced in comparison to the flooding period. During low water and the dry season these values are still reduced, which shows synchronicity of this group with the rainfall distribution in the region. Hence, these organisms probably use the soil as a breeding site and then migrate to tree trunks and canopies, especially before the flooding period, since they are considered typical soil dwellers, a place where they feed on algae and live associated with humus (HOPKIN & READ 1992).

Fauna in surface soil and litter gathered 213 Diplopoda individuals (5.6 ind./m^2) in surface soil (0-5 cm) and litter in the "cambarazal", represented by Polydesmida, Polyxenida, Spirobolida and Spirostreptida. The abundance was higher during the flooding period (50.2%, 10.7 ind./m^2) followed by the dry season (26.8%, 5.7 ind./m²), whereas the high water (16.0%, 3.4 ind./m²) and low water periods (7.0%, 1.9 ind./m²) showed low abundance levels. Spirostreptida was represented by *P. salvadorii* and Polydesmida with *P. salvator* (Tab. I). Surface soil had the greatest abundance when compared to litter in all seasonal periods.

Spirobolida was sampled in all periods with a higher density in the soil (63.6%, 1.4 ind./m²) in the high water, and in the litter (13.6%, 0.4 ind./m²) at low water. Only in high water they were not found on the soil and neither during the dry season in the litter. This oscillation of strata occupation may reflect habitat conditions, since during the high water even the soil over the "murundus", where collections occurred, remained wet, whereas during the dry season there is low humidity in the litter in relation to the soil, which forces these organisms to keep migrating among these strata thus avoiding dehydration.

Polydesmida, represented by *P. salvator*, was also sampled in all seasonal periods especially during the flooding (51.5%, 5.1 ind./m²) and the high water (31.3%, 3.1 ind./m²). In these two periods, the density was higher on the soil when compared to the litter, although the values were quite close especially during flooding. In the low water and the dry season, density was relatively reduced. Only during low water *P. salvator* abundance was greater than in the litter (Tab. I).

Plusioporus salvadorii was only representative during high water and concurrently with the beginning of the rainy season. It was especially abundant in the soil when compared to the litter. Nevertheless, during high water it could only be captured from the litter, probably due to damper soil. Polyxenida, differently from other taxa, was abundant in litter, as seen during the dry season (37.5%, 2.7 ind./m²) and flooding periods (20.8%, 1.5 ind./m²). No specimen was captured during the flooding period in the strata assessed, whereas during the low water, there was low density and only the litter. In the Central Amazon, these organisms were considered as being representatives of the migrating land fauna due to their displacement to other habitats before flooding (Adis 1992, 1997).

Tree Fauna

Activity density on trunks. Photoeclectors installed in the trees 5 m from the ground and directed upwards captured 275 Diplopoda individuals, 20.3% of the total sampled in this forest, all belonging to Polyxenida. The activity of these individuals was more intense in the flooding period (41.4%, 114 ind.), followed by the dry season (34.2%, 94 ind.) and low water (20.4%, 56 ind.). The increase in activity from the soil to the canopy started during low water and reached a peak during the flooding period, some weeks before flooding (Tab. I and Fig. 6). During flooding little activity was recorded on the trunks, from soil to canopy.

These results indicate that these organisms may remain associated to the *V. divergens* trunks, following the waterline during the flooding period and returning to the soil in the low water season. During the flooding period many of these individuals were intercepted with the upward pointing tree photoeclectors installed 0.5m from the ground. This sample during the flooding period/2004 and the high water/2005 indicated that the activity density is greater in the beginning of the rainy season, during the flooding, when compared to flooded period (Tab. I). These results confirm those obtained with tree photoeclectors installed at 5 m, which indicates that vertical migration is used as a survival strategy by the Polyxenida during the flood, about eight weeks before the forest was completely flooded. A weak but significant negative correlation was found between the mean monthly rainfall (mm), and the monthly activity density for Polyxenida over the *V. divergens* trunks from the canopy to the soil ($r = -0.32$, $F = 1.58$, $p = 0.011$).

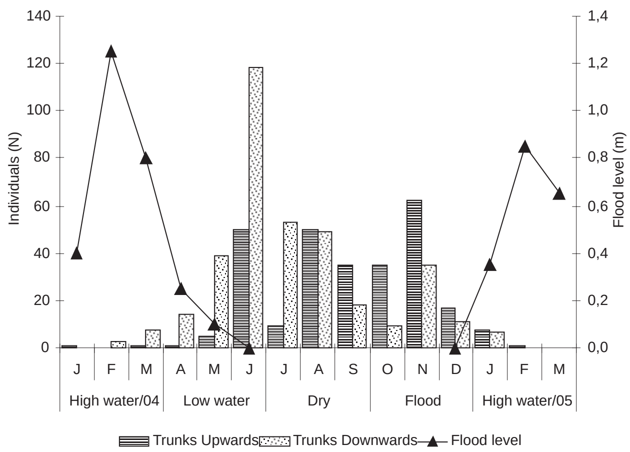

Figure 6. Monthly activity density of Polyxenida (Diplopoda) in *V. divergens* trunks captured by upward and downward pointing tree photoeclectors throughout the seasonal periods, associated with the flood level in the "cambarazal" in the Northern region of the Pantanal of Mato Grosso.

In the photoeclectors installed in the trees 5 m from the ground and directed downwards, 364 Polyxenida were captured, 26.9% of total sampled in this forest. The greatest activity density was during low water (47.0%), coinciding with the end of the flooding period and the rainy season (Tab. I and Fig. 6). This activity increases gradually, beginning in February (maximum flooding = 1.25 m), reaching a peak at the end of the low water, especially in June. During the dry season this activity is reduced (33.0%), reaching the lowest value in September (4.9% of total). In the beginning of the rainy season, the displacement towards the soil increases again gradually when compared to the dry season, reaching a maximum value in November (17.0% of the total). During the flooding period, this activity is much lower on the trunks, as observed in the two periods of high water assessed – 2004 and 2005 (Fig. 6). The correlation between the monthly activity density and the rainfall rate showed a negative relationship between these parameters (r = -0.62, F = 8.24, p = <0.001), which means that as it rains more there is a reduction in the activity of these organisms on the trunks.

Although Polyxenida were not been determined at species level, in general it was seen that the activity rate on the *V. divergens* trunks follows the same distribution pattern throughout the year with movement from the canopy to the soil being most prominent (Fig. 6). Thus, the increase of displacement towards the canopy and higher parts of the trunks during the flood leads to a greater displacement rate from the canopy to the soil during the low water. This indicates that these organisms are still associated with the highest parts of the trunks and canopies during the whole flooding period. ADIS (1981) observed in different types of forests in the Amazon that the diplopods are more abundant in trunks when compared to the soil, due to seasonal migrations coming prior to periodic flooding.

These results become more evident when associated with those obtained for activity density of these organisms on the soil, as well as the emergence rate in this same stratum, which indicated greater density, precisely during flooding, together with the highest migration rate between soil and canopy or additionally, where Polyxenida is more abundant on the soil and litter during the dry season and flood periods.

Abundance in *Vochysia divergens* canopies. A total of 65 Diplopoda (4.8% of total, 0.2 ind./m²) were captured from the 12 fogged trees, all belonging to Polyxenida. The greatest abundance was recorded in the low water (26 ind., 40.0%, 0.3 ind./m²), followed by flood (16 ind., 24.6%, 0.2 ind./m²), the dry season (15 ind., 23.1%, 0.2 ind./m²) and high water (8 ind., 12.3%, 0.1 ind./m²) (Tab. I).

The low abundance recorded in the canopies during the high water shows that Polyxenida do not occupy the whole canopy as a shelter during the flooding period, but remain associated with *V. divergens* stem probably due to its thick and rugged bark, typical of these savanna species which is where organisms can find food, since they feed mostly on algae and humus (HOPKIN & READ 1992).

The low water period in which Polyxenida was mostly abundant in *V. divergens* canopies coincided with the lowest activity density of this group on the soil as seen in samples from pitfall traps and Winkler extractor (Tab. I). These results show a possible connection between the land and tree fauna especially in relation to Polyxenida which use all strata in the "cambarazal" with oscillating densities according to water conditions in the region. But, since these taxa were not determined at specific levels, it is difficult to further discuss this vertical distribution.

Concluding Remarks

The vertical abundance and distribution of Diplopoda in the "cambarazal" showed marked differences among the soil, trunks and canopies. On the soil more orders, families and species were recorded, although Polyxenida was not determined at the species level. On trunks and in canopies only Polyxenida were found, whereas in the ground Polydesmida, Spirobolida and Spirostreptida were also recorded.

Even during the flooding period there were no records of taxa restricted to soil for the upper parts of trunks and canopies in *V. divergens*, as related for *P. salvadorii* in the same area (ADIS *et al.* 2001). This vertical distribution is also associated with the distribution of resources for these organisms as the majority represents detritivorous species which find an adequate environment population development in the soil.

Although soil and canopies are very distinct habitats with respect to the Diplopoda fauna, considering the fauna composition in this study, a connection between both can be proposed, given the displacement of Polyxenida. Apparently, the high activity rate of Polyxenida found over the *V. divergens* trunks from the canopy to the soil during the low water leads to a greater density of these organisms on the soil and litter during the dry season. Besides a higher breeding rate on the soil, this abundance in the edaphic stratum also makes it possible to have a considerable migration rate from the soil to the canopy in the beginning of the rainy season. In this environment the Polyxenida find favorable survival conditions due to the thick and rugged bark of the *V. divergens* which provides microhabitats thus allowing the permanence of these organisms on the trunks or even the migration to areas in the canopy during the flooding period. At the end of the flooding period, these organisms are active again on the trunks especially from the canopy to the soil, which makes these interlinkages cyclical between these habitats according to the water regime variation in the Pantanal in Mato Grosso state.

GOLOVATCH *et al.* (2005) have pointed out the existence of structural differences for Diplopoda communities in the Amazon and Pantanal in Mato Grosso state, for predominant groups in the Amazon, namely the Pyrgodesmidae and the Furhmannodesmidae, usually have smaller individuals. In Mato Grosso, Spirostreptidae and Chelodesmidae presents larger individuals. These same authors have emphasized that among the factors contributing to the low diversity of species in the Pantanal, there is strong seasonality and the lack of several types of forests such as in the Amazon, plus the prevalence of grasslands with sandy soils and as a consequence, low nutrient loads to sustain a rich fauna for soil and litter.

Other factors mentioned by the authors have to do with natural forest fires and sparse forests in this area. Regarding endemism in the Pantanal in Mato Grosso state, GOLOVATCH *et al.* (2005) have pointed out that any conclusion can be premature as many verifications studies must be carried out even thought Diplopoda in Mato Grosso have been carried for some time.

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LITERATURE CITED

Adis, J. 1977. Programa mínimo para análises de ecossistemas: Artrópodos terrestres em florestas inundáveis da Amazônia Central. **Acta Amazonica 7** (2): 223-229.

Adis, J. 1981. Comparative ecological studies of the terrestrial arthropod fauna in Central Amazonian inundation-forests. **Amazoniana 7** (2): 87-173.

Adis, J. 1992. Überlebensstrategien terrestrischer Invertebraten in Überschwemmungswäldern Zentralamazoniens. **Verhandlungen des Naturwissenschaftlichen Vereins zu Hamburg (N.F.) 33**: 21-114.

Adis, J. 1997. Estratégias de sobrevivência de invertebrados terrestres em florestas inundáveis da Amazônia Central: uma resposta à inundação de longo período. **Acta Amazonica 27** (1): 43-54.

Adis, J. 2002. Recommended sampling techniques, p. 555-576. In: J. Adis (Ed.). **Amazonian Arachnida and Myriapoda. Identification keys to all classes, orders, families, some genera, and lists of known terrestrial species.** Sofia, Pensoft Publishers, 590p.

Adis, J.; S.I. Golovatch & S. Hamann. 1996. Survival strategy of the terricolous millipede *Cutervodesmus adisi* Golovatch (Fuhrmannodesmidae, Polydesmida) in a blackwater inundation forest of Central Amazonia (Brazil) in response to the flood pulse, p. 323-532, In: J.J. Geoffroy; J.P. Mauriès & M.N. Duy-Jacquemin (Eds). **Acta Myriapodologica: Mémoires du Museum National d'Histoire Naturelle 169**, 682p.

Adis, J.; Y. Basset; A. Floren; P. Hammond & K.E. Linsenmair. 1998a. Canopy fogging of an overstory tree – recommendations for standardization. **Ecotropica 4**: 93-97.

Adis, J.; S.I. Golovatch; R.L. Hoffman; D.F. Hales & F.J. Burrows. 1998b. Morphological adaptations of the semiaquatic millipede *Aporodesminus wallacei* Silvestre, 1904 with notes on the taxonomy, distribution, habitats and ecology of this and a related species (Pyrgodesmidae, Polydesmida, Diplopoda). **Tropical Zoology 11**: 371-387.

Adis, J.; M.I. Marques & K.M. Wantzen. 2001. First observations on the survival strategies of terricolous arthropods in the northern Pantanal wetland of Brazil. **Andrias 15**: 127-128.

Adis, J.; S.I. Golovatch & B. Messner. 2003. Morphological structures in some Neotropical *Myrmecodesmus* species (Diplopoda: Polydesmida: Pyrgodesmidae) reveal the ability for plastron respiration. **Arthropoda Selecta 12** (1): 17-21.

Battirola, L.D.; M.I. Marques; J. Adis & A.D. Brescovit. 2004. Aspectos ecológicos da comunidade de Araneae (Arthropoda, Arachnida) em copas da palmeira *Attalea phalerata* Mart. (Arecaceae) no Pantanal de Poconé, Mato Grosso, Brasil. **Revista Brasileira de Entomologia 48**: 421-430.

Bergholz, N.G.R.; J. Adis & S.I. Golovatch. 2004. The millipede *Poratia insularis* (Kraus, 1960) new to the fauna of Brazil (Diplopoda: Polydesmida: Pyrgodesmidae). **Arthropoda Selecta 13** (3): 123-127.

Erwin, T.L. 1982. Tropical forests: Their richness in Coleoptera and other arthropod species. **The Coleopterists Bulletin 36** (1): 74-75.

Golovatch, S.I.; R.L. Hoffman; J. Adis; M.I. Marques; J. Raizer; F.H.O. Silva; R.A.K. Ribeiro; J.L. Silva & T.G. Pinheiro. 2005. Milipedes (Diplopoda) of the Brazilian Pantanal. **Amazoniana 18** (3/4): 273-288.

Hammond, P.M. 1995. Magnitude and distribution of biodiversity, p. 113-138. In: V.T. Heywood & R.T. Watson (Eds). **Global Biodiversity Assessment.** Cambridge, Cambridge University Press, 1125p.

Heckman, C.W. 1998. **The Pantanal of Poconé. Biota and ecology in the northern section of the world's largest pristine wetland.** Dordrecht, Kluwer Academic Publishers, 622p.

Hopkin, S.P. & H.J. Read. 1992. **The Biology of Millipedes.** New York, Oxford Science Publications, 233p.

Marques, M.I.; J. Adis; G.B. dos Santos & L.D. Battirola. 2006. Terrestrial arthropods from tree canopies in the Pantanal of Mato Grosso, Brazil. **Revista Brasileira de Entomologia 50** (2): 257-267.

Messner, B. & J. Adis. 2000. Morphologische Strukturen und vergleichende Biologie plastronatmender Arthopoden. **Drosera 2000**: 113-124.

Ødegaard, F. 2000. How many species of arthropods? Erwin's estimative revised. **Biological Journal of the Linnean Society 35**: 321-337.

Ponce, V.M. & C. Nunes da Cunha. 1993. Vegetated earthmounds in tropical savannas of Central Brazil: a synthesis with special reference to the Pantanal of Mato Grosso. **Journal of Biogeography 20**: 219-225.

Por, F.D. 1995. **The Pantanal of Mato Grosso (Brazil). World's largest Wetlands.** Dordrecht, Kluwer Academic Publishers, 124p.

Price, P.W. 1988. An overview of organismal interactions in ecosystems in evolutionary and ecological time. **Agriculture, Ecosystems and Environment 24**: 369-377.

Sierwald, P. & Bond, J.E. 2007. Current status of the Myriapod Class Diplopod (Millipedes): Taxonomic, Diversity and Phylogeny. **Annual Review of Entomology 52**: 401-420.

Silva, M.P.; R. Mauro; G. Mourão & M. Coutinho. 2000. Distribuição e quantificação de classes de vegetação do Pantanal através de levantamento aéreo. **Revista Brasileira de Botânica 23** (2): 143-152.

Stork, N.E. 1993. How many species are there? **Biodiversity and Conservation 2**: 215-232.

Stork, N.E. & P.S. Grimbacher. 2006. Beetle assemblages from an Australian tropical rainforest show that the canopy and the ground strata contribute equally to biodiversity. **Proceedings of the Royal Society 273**: 1969-1975.

Vohland, K. & J. Adis. 1999. Life history of *Pycnotropis tida* (Diplopoda: Polydesmida: Aphelidesmidae) from seasonality inundated forests in Amazonia (Brazil and Peru). **Pedobiologia 43**: 231-244

Zerm, M.; J. Adis; W. Paarmann; M.A. Amorin & C.R.V. da Fonseca. 2001. On habitat specificity, life cicles and guild structure in tiger beetles of Central Amazonian (Brazil) (Coleoptera: Cicindelidae). **Entomologia Generalis 25** (2): 141-154.

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