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Article

Gamasina mite communities (Acari: Mesostigmata) in grain production systems of the southwestern Brazilian Amazon

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Abstract

Emphasis has been given in the Brazilian state of Mato Grosso to the implementation of more sustainable production practices, including what has been termed agrosilvopastoral production system (ASPS), which involves the integration of different types of land use in a same area along time, seeking increased ecological stability. The Gamasina mite group (order Mesostigmata) is usually diverse and abundant in non-cultivated soils, where they can prey on arthropods and nematodes; some are commercialized for biological pest control. The objective of this study was to evaluate the diversity and abundance of edaphic Gamasina in plots of grain production managed under conventional (alternating cultivation) system and under ASPS, both with the adoption of no-tillage cultivation, in the municipality of Sinop, Mato Grosso state. In samples of soil and litter taken biweekly from August 2015 to May 2016, 762 Gamasina representing 32 species of 21 genera and nine families were collected. Considering both systems together, the dominant Gamasina were quite different from those of other parts of Brazil. Calculated ecological indexes showed no major differences between the two systems, possibly because of the relatively short time since the implementation of ASPS. In both systems, Rhodacaridae was one of the dominant families (37.5% of the Gamasina), followed by Macrochelidae (20.9%) and Laelapidae (18.8%). The most abundant species were *Multidentirhodacarus squamosus* Karg (Rhodacaridae), a new species of *Holostaspella* (Macrochelidae) and *Cosmolaelaps barbatus* Moreira, Klompen and Moraes (Laelapidae). Future studies are warranted, allowing more time for the adoption of ASPS to produce possible ecological changes.

Introduction

Brazil is among the main agricultural producing countries in the world, with a large crop area and considerable use of modern technology (Pereira *et al*. 2012). Mato Grosso is the largest Brazilian grain producing state, located in the western part of the country. In 2018/2019, the cultivated area in the state was about 16 million ha, where about 67 million tons of grains were produced (Conab 2019). In parallel with the improvement of cultivation practices to increase yield and quality research has focused on minimizing negative impacts on the soils, such as compaction, erosion and loss of biodiversity (Primavesi 2002; White *et al*. 2012).

No-tillage production has been extensively used in the state in grain production, since the beginning of this century, with the large scale incorporation of land for agricultural production, mainly for soybean and corn production (alternating cultivation) (Triplett Jr. & Dick 2008). An innovative production system has been evaluated in Mato Grosso, integrating agricultural, livestock and forest production systems in the same area, in an extended concept of intercropping and alternating cultivation. This new system is locally known as agropastoral, silviagricultural, silvopastoral or agrosilvopastoral system (ASPS) (Balbino *et al*. 2011). It is considered appropriate for western Brazil, where vegetation growth is high because of the constantly adequate light availability for plant growth, high temperature and high summer rainfall. The focus of this system is the improvement of soil physical and chemical properties, intended to lead to increased biodiversity and consequently reduced pest, disease and weed problems. However, quantitative information on the effect of that system on soil mite fauna has not been conducted so far.

Mites are usually among the most abundant components of the soil mesofauna (Plowman 1979; Adis 1988; Walter & Proctor 2013). Mites of the order Mesostigmata, especially those of the Gamasina cohort, are most abundant in the edaphic environment (Lindquist *et al*. 2009). The Gamasina represent about 20% of the world known mite species (Beaulieu *et al*. 2011), and they are known mainly for the predatory habit (Lindquist *et al*. 2009). Great attention has been given to the study of the gamasine family Phytoseiidae in the last 50 years, mostly because they are the most common predatory mites on plants worldwide. Several phytoseiid species have been produced commercially for pest control (McMurtry *et al*. 2015; Knapp *et al*. 2018). Although phytoseiids are also found in the soil, other gamasine families usually predominate in this environment (Lindquist *et al*. 2009). Some Laelapidae and Macrochelidae (Gamasina) species have been commercialized for pest control (Azevedo *et al*. 2015; Moreira & Moraes 2015). Gamasina of other families have not been used, but studies have indicated their potential in this regard (Carrillo *et al*. 2015; Knapp *et al*. 2018).

Nonetheless, the diversity of edaphic gamasine is still little known in Brazil, particularly in Mato Grosso. The lack of information of this type hampers the evaluation of the effect of new, intendedly to be more sound production systems (as ASPS) on the mite fauna and, consequently, on ecosystem sustainability. In a broader sense, knowledge of the edaphic mite fauna in this region may contribute to the discovery of new predatory species potentially useful for pest control locally and elsewhere (DeBach & Rosen 1991).

The objective of this study was to determine the diversity and abundance of edaphic Gamasina in grain production areas under conventional production systems and ASPS, both under no-tillage cultivation, in Mato Grosso.

Material and methods

Site description and growing practices

The study site was located at Embrapa Agrossilvopastoral experiment station (11° 50′ 90″ S; 55° 22′ 12″ W, alt. 384 m), at Sinop, Mato Grosso state, Brazil, in a transition region between Cerrado and Amazon Rainforest (Araújo *et al*. 2009). According to Köppen's classification, the climate of the region is of the Aw type (Köppen 1948; Peel *et al*. 2007), with a tropical winter, annual average temperature of 25ºC, relative humidity of 82.5% and annual rainfall of 2,550 mm (National Institute of Meteorology 2018). The soil type is Dystrophic Red Yellow Latosol (LVA), according to the classification of EMBRAPA (2013).

The study was conducted in two side-by-side plots of 2.0 ha each, in both of which no-tillage cultivation had been used since 2012. One of the plots was cultivated using a system conventionally used in the region (conventional), whereas the other was cultivated using ASPS (Fig. 1). In both areas, agricultural production consisted of the cultivation of soybean (variety BRSMG 850RR) and corn (two varieties, as subsequently indicated), involving basically the same techniques, as shown in Table 1.

TABLE 1. Activities conducted in the two production systems considered in this study (1: conventional; 2: ASPS).

Date	Activity	Production system	
		1	2
October 2011	Eucalyptus stands settled		x
February 25	Corn (cultivar DKB 390 VTPRO) and grass (*Urochloa brizantha*) seeded as intercrops	x	x
July 6	Corn harvested	x	x
July 7	Fallow started	x	
July 7	Grazing started		x
August	*Sampling started*	x	x
October 16	Fallow ended	x	
October 16	Grazing ended		x
October 17	Herbicides (glyphosate, RoundUp Ultra WG® at 2.5 Kg/ha; and carfentrazone, Aurora® at 50 mL/ha) applied to desiccate the grass and weeds	x	x
October 26	Soybean planted and NPK (02-20-20) applied at 400 kg/ha	x	x
February 23	Herbicide (ammonium glyphosate, Finale® at 2 L/ha) applied	x	x
February 25	Soybean harvested	x	x
February 28	Corn (cultivar DKB 177 PRO) and *U. brizantha* seeded as intercrops	x	x
May	*Sampling ended*	x	x
July 7	Corn harvested	x	x

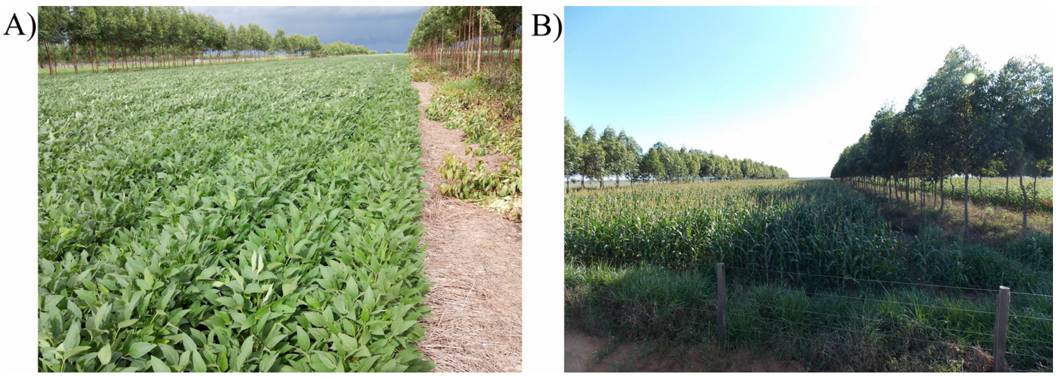

FIGURE 1. ASPS production system with cultivation of soybean (November 2013) (A) and corn (April 2014) in Mato Grosso, Brazil.

The main differences between the two systems referred to: a) agricultural activities were conducted over the whole area in the conventional system and in between eucalyptus (*Eucalyptus urograndis*) triple-row stands in the ASPS b) between July 7 and October 16, 2015 the area remained fallow in the conventional system and was used as a pasture in the ASPS.

Plants were grown at the following spacings: soybean: 0.45; corn: 0.45; grass: seeded by haul; eucalyptus, 3 m between rows in the stand, 2.5 between plants in the row, and 30 m between stands. In the ASPS plot, use as pasture involved the managed release of a herd of male Nelore cattle at a variable number of animals/ha, so as to maintain grass 15–35 cm high.

In both plots, pests and diseases were controlled with the use of the following chemicals: defoliating caterpillars—*Bacillus thunrigiensis* var. *kurstaki* (Dipel®), 0.5 L/ha, on 16 Nov. 2015; sucking bugs—lambda-cyhalothrin + thiametoxan (EngeoPleno®), 250 mL/ha, on 17 Dec. 2015;

Asian soybean rust—pyraclostrobin + fluxpyroxade (Orkestra®), 0.3 L/ha, on 13 and 29 Dec. and 2015, and trifloxystrobin + protioconazole (Fox®), 0.4 L/ha, on 16 Jan. 2016.

Mite sampling and identification

Samplings were carried out every two weeks between August 2015 and May 2016 (20 sampling dates), that is, between the time the area was fallow in the conventional system and was used as a pasture in ASPS, including the complete soybean cultivation, until the middle of the cycle of the second corn cultivation. Four sampling sites (at least 10 m apart) were established in the area of each production system; from each of those sites, three soil and three litter samples were collected (about 7 m apart). Each soil sample was taken using a soil corer (5 cm depth×9 cm in diameter, corresponding to an area of about 63.5 cm^2/sample), while each litter sample was obtained by hand collecting the material within a square of the same area as the soil corer. Each sample was placed in a plastic bag, and the bags were put in a styrofoam box with a freezing gel (Gelox®) for transport to the Entomology Laboratory of the Federal University of Mato Grosso (UFMT), at Sinop, maintaining the temperature inside the box below 21°C.

In the laboratory, the collected samples were placed in modified Berlese-Tullgren equipments and over seven days mites were extracted into vials with 70% ethanol (Oliveira et al., 2001). The material was transferred from each vial to a Petri dish for observation under a stereomicroscope, mounting the Gamasina in Hoyer's medium on microscope slides. Other mites were not processed, for being much less abundant (Sarcoptiformes: Astigmatina and Trombidiformes: Prostigmata) or for having very different feeding behavior (Sarcoptiformes: Oribatida).

The Gamasina specimens were identified to family using the key provided by Lindquist *et al*. (2009) and then grouped in morpho-species under a phase contrast microscope (Leica, DMLB). Adult females were identified to genera using dichotomous keys (Chant & McMurtry 2007; Castilho *et al*. 2012, 2016; Moraes *et al*. 2016; Barros *et al*. 2020).

Statistical and ecological data analysis

SAC and Vegan packages of the R program® were used to generate Gamasina species richness accumulation curves according to numbers of specimens examined. Graphics of the accumulation curves were constructed using Sigmaplot® vers. 12.3 program. PAST program was used (Hammer *et al*. 2013) to calculate Shannon-Wiener index (H') (Kenney & Krebs 2000) and Equitability (E). For each type of habitat (soil or litter), calculated Gamasina diversity indexes of both systems were compared with Diversity t-tests available in PAST. Also for each type of habitat, calculated mean abundance (total number of mites) and mean species richness of the 20 sampling dates were compared by the Manny-Whitney tests (α=0.05), as data did not have normal distribution.

Similarity between sites in relation to the species found and their respective abundances was determined by a cluster multivariate analysis (in R program®), using the Vegan package and Ward´s method to calculate the Euclidean distances.

Results

In total, 762 Gamasina mites of nine families were collected (Figure 2), 530 in the conventional and 232 in the ASPS systems. The proportions of Gamasina from soil and litter of these systems were respectively 68.5 and 31.5% and 44.8 and 55.2%.

Based on the adult females (the life stage most reliably identified) collected in both systems and substrates, the most abundant families were Rhodacaridae (37.3% of the Gamasina), Macrochelidae

(20.9%), Laelapidae (18.8%) and Ascidae (12%). Each of the other families collected contained at most 5.8% of the gamasine mites.

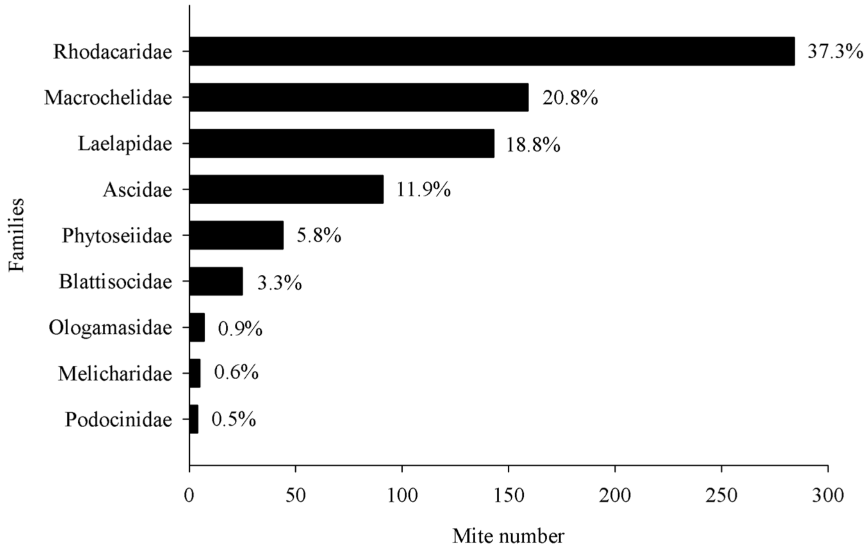

FIGURE 2. Abundances and corresponding proportions of gamasine mite families from soil and litter samples collected in fields under conventional (A) and ASPS (B) production systems in Mato Grosso, Brazil in August 2015–May 2016.

In the conventional system, about 43% of the gamasine mites belonged to Rhodacaridae (Table 2), but these were found almost exclusively in soil samples (98.9%). The second most abundant group, Macrochelidae, accounted for about 21% of the gamasine mites. In the ASPS, Rhodacaridae and Laelapidae were the most abundant families, accounting for respectively about 25 and 24% of the gamasine mites. In this system, rhodacarids were found exclusively in soil samples, and Macrochelidae was the third most abundant family, accounting for about 20% of the gamasine mites.

TABLE 2. Abundance and corresponding proportion of gamasine mite families from soil and litter samples collected in fields under conventional and ASPS production systems of Mato Grosso, Brazil in August 2015–May 2016.

Families	Conventional				ASPS[1]			
	Soil		Litter		Soil		Litter	
	Total	%	Total	%	Total	%	Total	%
Ascidae	29	8.0	20	12.0	11	10.6	31	24.2
Blattisocidae	6	1.7	10	6.0	4	3.8	5	3.9
Laelapidae	26	7.2	61	36.5	17	16.3	39	30.5
Macrochelidae	55	15.1	56	33.5	9	8.7	39	30.5
Melicharidae	1	0.3	1	0.6	-	-	3	2.3
Ologamasidae	3	0.8	3	1.8	1	1.0	-	-
Phytoseiidae	16	4.4	13	7.8	4	3.8	11	8.6
Podocinidae	4	1.1	-	-	-	-	-	-
Rhodacaridae	223	61.4	3	1.8	58	55.8	-	-
Total	363	100	167	100	104	100	128	100

[1]Agrosilvopastoral System (Balbino *et al*. 2011).

In both systems, the number of species in the species accumulation curves was still increasing at the end of the study (Figure 3). By that time, the number of species was slightly higher in the soil of the conventional production system (23 species), than in other combinations of substrates and production systems (19 in litter of the same production system, and respectively 19 and 17 in the soil and litter of ASPS).

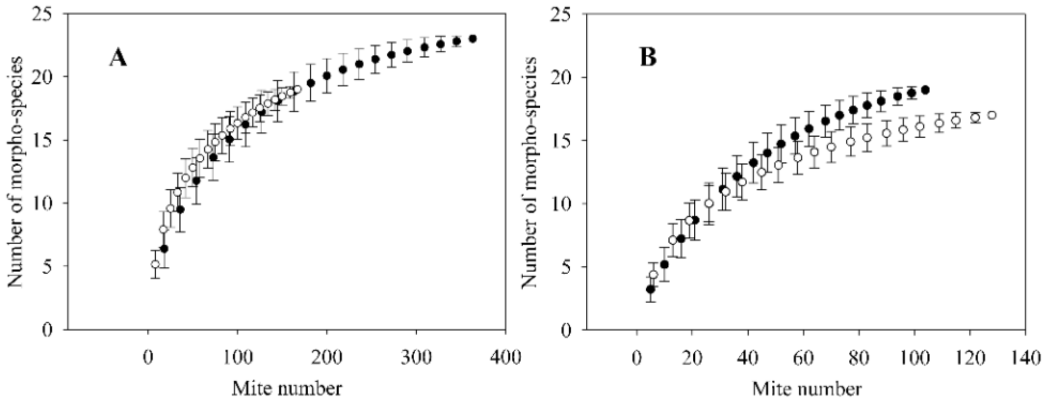

FIGURE 3. Rarefaction curves of gamasine morpho-species from soil (black circles) and litter (white circles) samples collected in fields under conventional (A) and ASPS (B) production systems in Mato Grosso, Brazil in August 2015–May 2016, in relation to numbers of mites collected.

Abundance (total number of Gamasina collected at each sampling date) and species richness were significantly higher in soil of the conventional system than in soil of ASPS system (Mann–Whitney test, α=0.05, *P*=0.0039 and 0.0159, respectively), while for each of those parameters, difference was not significant for mites in the litter of both systems (Table 3). However, for none of the substrates, Shannon-Wiener indexes were significantly different between systems. Equitability was numerically lower in soil of the conventional system than in any of the other three combinations of substrate and production system.

TABLE 3. Abundance and richness (mean ± standard deviation), Shannon diversity and Equitability indexes of gamasine mites from soil and litter samples collected in fields under conventional and ASPS systems in Mato Grosso, Brazil in August 2015–May 2016.

		Abundance		Species richness		Shannon diversity index (H')		Equitability
Conventional	Soil	18.2 ± 6.44	*	2.5 ± 0.42	*	1.765	n.s	0.563
ASPS	Soil	5.2 ± 1.64		1.4 ± 0.36		1.971		0.667
Conventional	Litter	8.4 ± 2.68	n.s.	2.3 ± 0.39	n.s.	2.241	n.s.	0.761
ASPS	Litter	6.4 ± 1.70		1.9 ± 0.35		2.269		0.801

(*) For the same substrate (soil or litter): Abundance (p = 0.0039 for soil and 0.7032 for litter) and Species richness (p = 0.0159 for soil and 0.0308 for litter), both compared with Mann–Whitney test; Shanon diversity index (p = 0.3715 for soil and 0.8709 for litter), compared by Diversity t test.

Taking into account both systems together, 32 morpho-species of 21 genera and nine families were found (Table 4). Laelapidae was the family with the largest number of genera (four genera), followed by Ascidae, Blatiisociidae, Phytoseiidae and Rhodacaridae (three genera in each). Laelapidae was also the family with the largest number of morpho-species (eleven morpho-species), followed by Rhodacaridae (five), Ascidae and Blattisociidae (four each). The number of gamasine morpho-species was similar in both systems, 27 in the ASPS and 25 in the conventional, and 20 of these occurred in both systems.

TABLE 4. Number and proportion of adult female gamasine mites from soil and litter samples collected in fields cultivated under conventional and ASPS systems in Mato Grosso, Brazil in August 2015–May 2016.

Species	Conventional				ASPS			
	Soil	(%)	Litter	(%)	Soil	(%)	Litter	(%)
Ascidae								
Asca sp.	2	(0.6)	9	(5.4)	2	(1.9)	10	(7.8)
Gamasellodes seminudus	-	-	-	-	-	-	1	(0.8)
Gamasellodes lavafesii	7	(1.9)	9	(5.4)	5	(4.8)	16	(12.5)
Protogamasellus mica	20	(5.5)	2	(1.2)	4	(3.8)	4	(3.1)
Blattisocidae								
Blattisocius sp.	-	-	-	-	-	-	1	(0.8)
Cheiroseius sp.	1	(0.3)	3	(1.8)	2	(1.9)	4	(3.1)
Lasioseius barbensiensis	5	(1.4)	7	(4.2)	1	(1.0)	-	-
Lasioseius sp.	-	-	-	-	1	(1.0)	-	-
Laelapidae								
Cosmolaelaps barbatus	6	(1.7)	41	(24.6)	4	(3.8)	-	-
Cosmolaelaps busolii	1	(0.3)	-		-	-	1	(0.8)
Cosmolaelaps confinisetarum	1	(0.3)	1	(0.6)	1	(1.0)	-	-
Cosmolaelaps jaboticabalensis	-	-	-		-		1	(0.8)
Gaeolaelaps sp. 1	13	(3.6)	14	(8.4)	5	(4.8)	17	(13.3)
Gaeolaelaps sp. 2	-	-	-		2	(1.9)	3	(2.3)
Gaeolaelaps sp. 3	3	(0.8)	2	(1.2)	3	(2.9)	11	(8.6)
Gaeolaelaps sp. 4	2	(0.6)	2	(1.2)	-		4	(3.1)
Gaeolaelaps sp. 5	-	-	-		-		2	(1.6)
Laelaspis sp.	-	-	-	-	2	(1.9)	-	-
Pseudoparasitus sp.	-	-	1	(0.6)	-	-	-	-
Macrochelidae								
Holostaspella sp.	53	(14.6)	45	(26.9)	7	(6.6)	39	(30.5)
Macrocheles sp.	2	(0.6)	11	(6.6)	2	(1.9)	-	-
Melicharidae								
Proctolaelaps paulista	1	(0.3)	1	(0.6)	-	-	3	(2.3)
Ologamasidae								
Gamasiphis sp.	3	(0.8)	3	(1.8)	1	(1.0)	-	-
Podocinidae								
Podocinum bengalensis	4	(1.1)	-	-	-	-	-	-
Phytoseiidae								
Amblyseius sp.	-		1	(0.6)	1	(1.0)	-	-
Euseius sp.	3	(0.8)	1	(0.6)	-		2	(1.6)
Proprioseiopsis sp.	13	(3.6)	11	(6.6)	3	(2.9)	9	(7.0)

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TABLE 4. (Continued)

Species	Conventional				ASPS			
	Soil	(%)	Litter	(%)	Soil	(%)	Litter	(%)
Rhodacaridae								
Afrodacarellus sp.	3	(0.8)	-	-	-	-	-	-
Multidentirhodacarus paulista	5	(1.4)	-	-	3	(2.9)	-	-
Multidentirhodacarus squamosus	202	(55.6)	3	(1.8)	55	(53)	-	-
Multidentirhodacarus tocantinensis	10	(2.8)	-	-	-	-	-	-
Protogamasellopsis sp.	3	(0.8)	-	-	-	-	-	-

Also taking into account both systems together, the most numerous species was *Multidentorhodacarus squamosus* Karg (Rhodacaridae) (260 individuals), followed by *Holostaspella* sp. (Macrochelidae) (144 individuals). The first of these species account for 53–55% of the Gamasina collected in soil samples of both production systems. Among the Laelapidae, the most numerous species was *Cosmolaelaps barbatus* Moreira, Klompen and Moraes, followed by an unidentified *Gaeolaelaps* species (respectively 51 and 49 individuals).

The cluster analysis of morpho-species showed greater similarities between communities of the same type of substrate (soil or litter) of both production systems, with higher similarity for litter (Figure 4).

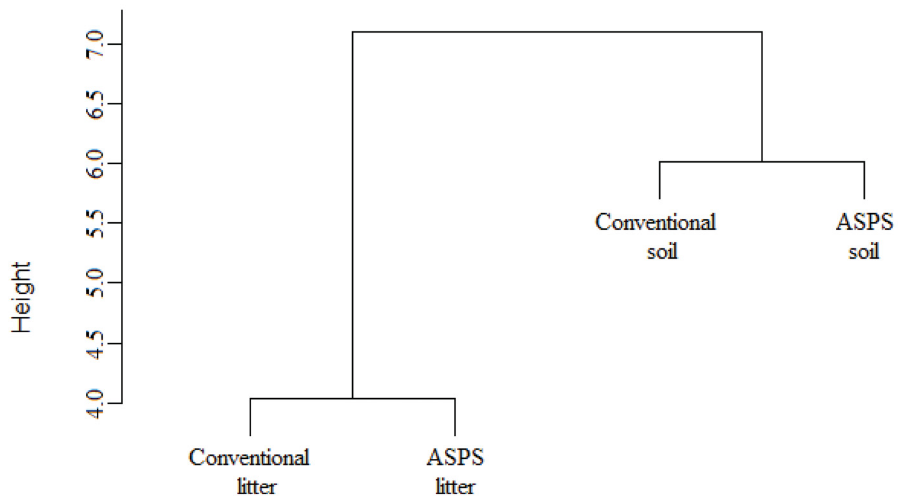

FIGURE 4. Similarity of mite communities collected in soil and litter samples collected in fields under conventional and ASPS production systems of Mato Grosso, Brazil.

Discussion

The higher proportion of mites in the soil of the conventional system is directly related to the occurrence of a single species, the rhodacarid *M. squamosus*, which by itself accounted for more than half the Gamasina in samples of that substrate from both production systems. The number of *M. squamosus* in soil samples of the conventional system corresponded to 1.2 times the number of all Gamasina found in the litter samples of this production system and to almost the same number of all Gamasina found in both substrates of the ASPS system.

The predominance of *M. squamosus* in the soil of the region where the study was conducted seems evident, but the reason for its outstandingly high number in the soil of the conventional system could not be determined. Although *M. squamosus* was found in the soil of the conventional system in about half of the sampling dates, more than half of the total number of this mite in this combination of substrate and production system was found on the last sampling date, suggesting it to be an r-strategist, as common for Mesostigmata (Hasegawa *et al*. 2012).

Multidentorhodacarus squamosus seems to have a wide distribution in Brazil, where it has been found in Cerrado areas of Tocantins state (Azevedo *et al*. 2020), Atlantic Forest areas of São Paulo (Junqueira 2017) and Caatinga areas in Pernambuco (Torris 2019). However, this is the first report of this mite in relatively high abundance in grain cultivation. An aspect that could have favored its high abundance is the fact that the areas of the present study had been cultivated to grain under no-tillage since 2012, which allowed the accumulation of a layer of about 5 cm of organic matter, maintaining higher soil humidity and promoting the development of organisms onto which the predatory mites could prey. Mites of this genus have been reported to prey on nematodes, springtail and other mites (Walter *et al*. 1988; Walter & Ikonen 1989; Walter & Kaplan 1990; Castilho *et al*. 2015).

The higher Shannon diversity indexes in litter of both systems were related to the higher levels of equitability, rather than to the higher number of species, the latter being actually higher in the soil samples, especially in the conventional production system. Had the discrepancy in number of *M. squamosus* not occurred, the mite communities of both production systems would be much more similar, except for the higher number of mites in the conventional system.

The difference between expected and observed species suggests that additional sampling effort would show very rare species, given that several of the species were detected in low numbers. The relatively large number of singletons in this study could be related to the insufficient effort to determine the complete set of gamasine species in the region, as suggested by raising species accumulation curves throughout the study. It is noteworthy that the calculated expected number of Gamasina species were similar for both systems within each of the two types of substrate (soil or litter), and that the estimated numbers (Jackknife 1 range: 24.6–35.4) were similar to the observed number (32 morpho-species) when both systems and substrates were considered together, increasing the sampling effort.

In what refers to the faunistic composition, the results were quite different from results of similar studies in other parts of Brazil. This is the first study in Brazil in which Rhodacaridae is found as one of the predominant families of edaphic mites in agricultural crops. In a study conducted by Azevedo *et al*. (2020), Ascidae was the predominant family, whereas in a study conducted by Junqueira (2017), Blattisociidae and Melicharidae were the predominant families. Interestingly, Ascidae, Blattisociidae and Melicharidae constituted what until some years ago was considered to be a single family, Ascidae (Lindquist *et al*. 2009). In those studies, Rhodacaridae accounted respectively for only 12.5% and 1% of the gamasine individuals. The reasons for these differences are quite difficult to determine, given the wide differences between sites and cultivation practices. The region where the present study was conducted (Sinop, Mato Grosso state) is located about 1,000 and 1,700 km in straight line from Sucupira (Tocantins state) and Jaboticabal (São Paulo state), where respectively the studies of Azevedo *et al*. (2020) and Junqueira (2017) were conducted. The natural vegetation of the region where the first study was conducted was of the type called Cerrado, whereas that of the second study was Atlantic Forest; soil types were also different, Dystrophic Latosol and Eutrophic Red Latosol types in Sucupira and Jaboticabal, respectively. Other differences were the crops grown, cultivation practices, etc.

No Rhodacaridae species has been so far commercially used for the control of pest organisms. However, several studies have suggested their potential as biological control agents (Castilho *et al*.

2015). These mites, taxonomically similar to part of the Ascidae (Sourassou *et al*. 2015), are eudaphic (Silva *et al*. 2004; Castilho *et al*. 2015). For being tiny, they can move deeper in the soil than other mites, where they have access to nematodes, several of which can inflict severe damage to cultivated plants. Some of the major grain production problems refer to the incidence of nematodes (Jones *et al*. 2013). Hence, use of practices that conserve those mites in the environment should be beneficial.

Another major difference in relation to other studies was the common occurrence of Macrochelidae in the present work. In previous studies conducted in sites of natural vegetation and cultivated areas in Brazil, Macrochelidae has accounted for less than 3% of the Gamasina (Mineiro & Moraes 2001; Silva 2002; Santos 2013; Junqueira 2017; Azevedo *et al*. 2020). The relatively high proportion of mites of this family may be a function of the proximity of the study sites with cattle raising areas. Macrochelids are most often associated with immature flies, especially in vertebrate dung, preying on the flies as well as on co-occurring nematodes (Azevedo *et al*. 2015). Silva (2020) reported Macrochelidae as the predominant family in pastures of northwestern São Paulo state. The actual impact of these mites on the level of nematodes pathogenic to livestock needs further investigation (Azevedo *et al*. 2015).

The abundance of Laelapidae species was expected, based on previous studies in the country. Mites of this family have been found in proportions higher than 10% of the gamasine individuals in different agricultural crops (Mineiro & Moraes 2001; Silva 2002; Santos 2013; Junqueira 2017; Azevedo *et al*. 2020). Some laelapid species have been cited as predators of soil pests, a few being used commercially for that purpose (Moreira & Moraes 2015).

The effect of production system on Gamasina faunistic composition and abundance was suggested in the present study, in which the different systems were applied to areas located side by side. By the methodology adopted in the study, it was not possible to ascertain why Rhodacaridae was over twice as abundant as the second predominant family (Macrochelidae) in the conventional system, but it was about as abundant as Laelapidae and only slightly more abundant than Macrochelidae in the ASPS. The results showed that the differences in proportions were due to the lower level of occurrence of Rhodacaridae rather than to the higher level of occurrence of Laelapidae in the ASPS system.

Still seemingly more unexpected, why was Macrochelidae more abundant in the conventional than in the ASPS? The answer to this question is possibly related to the absence of cattle in the grain plots throughout the sampling period (August 2015 to May 2016). Cattle was only present in the area between July and September 2015. It is known that Macrochelidae species are favored by cattle dung only until it starts to dry, period in which fly larvae are also present. As soon as that micro-patch becomes unfavorable to fly development, the mites move away to other newer dung patches, phoretically, on adult flies or beetles (Azevedo *et al*. 2015). Had samples been taken when cattle were present in the area, the proportion of Macrochelidae in the ASPS would certainly have been much higher than in the area of conventional crop.

The genus *Holostaspella* (Macrochelidae), to which the second most abundant species belongs, consists of 33 species (Azevedo *et al*. 2015), but very little is known about their habits and predatory potential. Species of this genus were also relatively abundant in Pernambuco in grape cultivation (Torris 2019). But this is the first time a *Holastaspella* species is reported as abundant in a grain cultivation area.

The most abundant species of Laelapidae in the present study, *C. barbatus*, has been reported in areas of natural vegetation and in cultivated forests in the Atlantic Forest and Cerrado biomes in São Paulo state (Moreira *et al*. 2014), being also one of the most abundant Gamasina in grape cultivation in Pernambuco (Torris 2019). In laboratory studies, *C. barbatus* was reported to feed on *Frankliniella occidentalis* (Pergande), a major thrips pest of several crops (Moreira 2014).

Ascids of the genus *Protogamasellus* are taxonomically close to Rhodacaridae (Sourassou *et al*. 2015). *Protogamasellus mica* (Athias-Henriot), the most common species of this genus found in the present study has also been reported from several locations in Brazil (Santos *et al*. 2020), mainly in cultivated areas in the Atlantic Forest in São Paulo (Mineiro & Moraes 2001; Junqueira 2017), Cerrado in Tocantins (Azevedo *et al*. 2020), Caatinga in Pernambuco (Torris 2019) and Pantanal in Mato Grosso do Sul (Yamada & Moraes 2020). This species seems to be adapted to the conditions of cultivated areas, being reported at depths of up to 8 m along roots (Walter & Kaplan 1990; Walter *et al*. 1993). In addition, it can tolerate low soil moisture levels (Walter & Kaplan 1990; Walter *et al*. 1993). In contrast, *P. mica* has not been reported as abundant in areas of natural vegetation (Junqueira 2017; Torris 2019). Research work has shown that mites of this genus prey on nematodes and springtails, feeding also on fungi (Moraes *et al*. 2015).

In conclusion, this benchmark study allowed a preliminary evaluation of the ecological impact of a newly proposed agricultural practice, and the detection of new potentially useful biological control agents, candidate for use locally or elsewhere for the control of pests that spend part of their lives in the soil. However, with the conduction of this experiment, the ecological advantage of ASPS over the conventional system could not ascertained. But this could reflect in part the fact that both systems involved the use of no-tillage, widely implemented in Mato Grosso for soil conservation.

Additionally, as indicated before, ASPS had been implemented in the area only three years before the study was conducted, and this may not be a period sufficiently long to allow major differences between systems. Poggiani & Schumacher (2000) reported that the process of nutrient cycling in the ASPS system generally intensifies when the canopies of the planted trees touch each other. At this stage, soil organic matter would increase significantly, and this could lead to greater food supply to the species of the soil micro, meso and macrofauna. Thus, repeating this study some years at later stages seems recommendable, to conclude about the possible positive cumulative effect of the adoption of ASPS on the ecosystem along time.

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