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MITES (ACARI: MESOSTIGMATA, SARCOPTIFORMES AND TROMBIDIFORMES) ASSOCIATED TO SOYBEAN IN BRAZIL, INCLUDING NEW RECORDS FROM THE CERRADO AREAS

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ABSTRACT

In Brazil, soybean *Glycine max* (L.) Merrill crops are subjected to incidence of several pests, which are mainly insect species. However, the occurrences of other pest species are growing. In this context, outbreaks of phytophagous mites are becoming more frequent. Nevertheless, records of mites in such crop are available only for Maranhão, Mato Grosso, Minas Gerais and Rio Grande do Sul states. Thus, this work gathers all information published about the diversity of mites found in soybean in Brazil, and also new records of mite species made on samplings taken from the central Cerrado area. In the whole, occurrence of 44 species of plant mites in soybean has been recorded in Brazil. Data from prior studies and the results of this work present the tetranychid *Mononychellus planki* (McGregor) as the mite species most frequently occurring in the Brazilian soybean crops. A large portion of Phytoseiidae species has occurred in crops from Rio Grande do Sul state. In addition, spontaneous soybean has hosted almost half of the phytoseiid species sampled in Cerrado region. High diversity of Tarsonemidae has been found in the cultivated soybean. More studies about soybean mites are needed to clarify the damage potential of phytophagous mites and the biological role of predatory mites in this crop.

Key Words: Acari, *Glycine max*, Brazilian savannah, survey

RESUMO

No Brasil, lavouras de soja *Glycine max* (L.) Merrill estão sujeitas a incidência de várias pragas, as quais são principalmente espécies de insetos. No entanto, a ocorrência de outras espécies-praga tem aumentado. Neste contexto, surtos populacionais de ácaros fitófagos têm se tornado mais frequentes. Apesar disso, os registros de ácaros para esta cultura estão disponíveis apenas para os estados de Maranhão, Mato Grosso, Minas Gerais e Rio Grande do Sul. Assim, este trabalho agrega toda a informação publicada sobre a diversidade de ácaros encontrados em soja no Brasil, além de novos registros feitos através de amostragens na região central do Cerrado. No total, 44 espécies de ácaros foram registradas em soja no Brasil. Dados de estudos anteriores, somados aos resultados deste trabalho, apresentam o tetrânicos *Mononychellus planki* (McGregor) como a espécie de ácaro mais frequente em lavouras de soja brasileiras. Considerável número de espécies de Phytoseiidae tem ocorrido nas lavouras amostradas do Rio Grande do Sul. Além disso, a soja espontânea abrigou quase metade das espécies de fitoseídeos amostrados na região central do Cerrado. Por sua vez, uma elevada diversidade de Tarsonemidae foi encontrada na soja cultivada. Mais estudos sobre ácaros em soja são necessários para esclarecer o potencial de dano dos ácaros fitófagos e o papel biológico dos ácaros predadores nesta cultura.

Palavras-chave: Acari, *Glycine max*, savana brasileira, levantamento faunístico

Soybean *Glycine max* (L.) Merrill (Fabaceae) with approximately 75 million tonnes during the 2010/2011 harvest (Conab 2011). In addition, soybean is one of the most important agricultural crops, and Brazil is ranked as one of the top producers

with approximately 75 million tonnes during the 2010/2011 harvest (Conab 2011). In addition, soybean is grown in most states, and is economically

significant in the Brazilian economy (Corrêa-Ferreira et al. 2000). The soybean crop is especially important in the Cerrado region, which provides the largest portion of domestic production (Embrapa 2000). The Cerrado occupies almost one-fourth of Brazilian territory, or about 200 million ha (Rezende et al. 2005). However, this biome has been severely degraded by agricultural practices, and agriculture, especially soybean production, is responsible for much of the fragmentation (Durigan et al. 2007).

Many pests associated with soybean in Brazil (Embrapa 2008), but arthropods are responsible for most of the yield loss. In recent years, population outbreaks of phytophagous mites have been observed in soybean (Guedes et al. 2007) and some authors believe that such outbreaks result from the improper use of pesticides (Corrêa-Ferreira et al. 2010; Salvadori et al. 2007). In any case, mites (especially phytophagous species) have become important soybean pests because of the lack of basic knowledge about them. There is a need to know the mite species associated with soybean, in order to appropriately manage their populations on this crop. Thus, in this work we have attempted to gather the already published data on mites found in soybean cultivated in Brazil, and, also to include new records from cultivated and spontaneous soybean plants from the central region of the Brazilian Cerrado.

MATERIAL AND METHODS

Records of mites associated with soybean in Brazil were obtained from reports in the literature (Guedes et al. 2007; Leite et al. 2003; Návia & Flechtmann 2004; Neto et al. 2008; Oliveira et al. 2007; Roggia et al. 2008, 2009; Oliveira 2010; Vivan et al. 2011 (Fig. 1, Table 1), and also by new samplings carried out in the Cerrado region (Fig. 1, Table 2). The new records were obtained by 2 samplings carried out in 10 fields during part of the rainy season in Brazil (Nov and Dec/2009, and Jan/2010). In these areas, the surrounding landscape consisted of a Cerrado fragment and others soybean fields. Also, samplings dates coincided with the inflorescence (sampling #1-40 d after sowing) and ended at the pod formation (sampling #2-80 d later) (Table 3). One additional sampling was made in June/2010 (during the dry season), along highway margins in 3 other areas of spontaneous soybean.

The mites were extracted in the field by washing the soybean leaves with 30% ethyl alcohol. The washing was done in plastic buckets with 5 L of the same alcohol. The collected leaves were immersed and stirred for some seconds to dislodge the mites. The washed leaves were withdrawn from the bucket and the alcohol was filtered through nylon micro-sieves with 25 µm porosity. Subsequently, both sides of the mesh were sprayed with 67% ethyl al-

cohol to dislodge the retained material. Such material was transferred into flasks each containing 80 mL of the same alcohol for temporary preservation and transportation.

In the laboratory, the preserved material was examined under stereoscopic microscopes. The mites were assembled on microscopic slides, using Hoyer's medium (Moraes & Flechtmann 2008). Subsequently, the slide borders were sealed with transparent nail polish. Identification of the specimens was done under an optical microscope with phase contrast in accordance with Lindquist et al. (2009a).

In the species listing, the following data have been presented for the new records: collection site, date of collection (month in Roman numerals, and year in Arabic numerals) and the number of individuals in parentheses. In case of former records, the presented data are: collection site and reference.

The voucher material of the samplings is deposited with the Acari collection (DZSJRP) - <http://www.splink.cria.org.br>, of the Zoology and Botany Department, Universidade Estadual Paulista (UNESP), São José do Rio Preto, São Paulo.

RESULTS

The samplings yielded 2,732 mites, belonging to 29 species. Phytoseiidae and Tarsonemidae presented the largest species richness (8 species each). The tetranychid, *Mononychellus planki* (McGregor), was the species most frequently collected in all sampled areas (Table 3). Such data, added to the prior records, result into 44 species found in soybean in Brazil, according to the list subsequently presented.

ORDER MESOSTIGMATA

Ascidae

Asca sp. 1

Origin: Goiás: Cristalina: XII-09 (1); Minas Gerais: Tupaciguara: XII-09 (8), I-10 (1). Diet: Mites of this genus are known as predators (Krantz 2009), but they might also be saprophages (Moutia 1958; De Leon 1967).

Asca sp. 2

Origin: Goiás: Chapadão do Céu: I-10 (1), Cristalina: XII-09 (1), Jataí (area 1): I-10 (1). Diet: Same as *Asca* sp. 1.

Blattisociidae

Lasioseius sp.

Origin: Mato Grosso do Sul: Chapadão do Sul: I-10 (2); Goiás: Jataí (2): XI-09 (1), XII-09 (2), Rio Verde (1): XII-09 (3). Diet: Individuals of this family are known to be predators (Lindquist et



Fig. 1. States (upward diagonal fill) and municipalities (square) where mites on soybean crops were sampled in Brazil. Squares inside the rectangle represent crops sampled during this study.

al. 2009b), but no information is available specifically about the diet of *Lasioseius* sp.

Incertae sedis

Africoseius sp.

Origin: Goiás: Jataí (1): I-10 (1). Diet: Unknown.

Melicharidae

Proctolaelaps sp.

Origin: Goiás: Rio Verde (1): XII-09 (1). Diet: Basically they are predators, but they may be

facultatively pollenophagous or saprophagous (Krantz 2009).

Phytoseiidae

Euseius alatus De Leon, 1966

Origin: Minas Gerais: Araporã: VI-10 (21). Diet: Generalist predator that also feeds on pollen (McMurtry & Croft 1997).

Galendromus (Galendromus) annectens (De Leon, 1958)

Origin: Minas Gerais: Araporã: VI-10 (1). Previous records in Brazil: Rio Grande do Sul: Santa Maria (Roggia et al. 2009). Diet: Selective preda-

TABLE 1. LOCATIONS SAMPLED FOR MITES ON SOYBEAN, AS REPORTED IN PUBLICATIONS BEFORE THE CURRENT STUDY.

STATE	MUNICIPALITY	COORDINATES	CULTIVAR
Maranhão ⁷	—	—	—
Mato Grosso	Cláudia ⁸	11° 30' S 54° 52' W	—
Mato Grosso	Sorriso ⁸	12° 33' S 55° 42' W	—
Minas Gerais	Montes Claros ¹	16° 44' S 43° 51' W	'BRM 94-52273'
Minas Gerais	Unaí ²	16° 21' S 46° 54' W	'Monsoy 8001'
Rio Grande do Sul	Alegrete ³	29° 47' S 55° 46' W	—
Rio Grande do Sul	Barra Funda ³	27° 55' S 53° 02' W	—
Rio Grande do Sul	Caçapava do Sul ³	30° 30' S 53° 29' W	—
Rio Grande do Sul	Cacequi ³	29° 52' S 54° 49' W	—
Rio Grande do Sul	Cachoeira do Sul ³	30° 01' S 52° 55' W	—
Rio Grande do Sul	Caiçara ³	27° 19' S 53° 25' W	—
Rio Grande do Sul	Campos Borges ³	28° 53' S 53° 00' W	—
Rio Grande do Sul	Candelária ³	29° 40' S 52° 47' W	—
Rio Grande do Sul	Canguçu ^{4,5}	31° 24' S 52° 40' W	'A 7001 RG'
Rio Grande do Sul	Condor ³	28° 12' S 53° 29' W	—
Rio Grande do Sul	Cruz Alta ^{3,6}	28° 38' S 53° 36' W	—
Rio Grande do Sul	Espumoso ³	28° 43' S 52° 50' W	—
Rio Grande do Sul	Faxinal do Soturno ⁴	29° 34' S 53° 26' W	'A 6001 RG'
Rio Grande do Sul	Formigueiro ³	29° 59' S 53° 29' W	—
Rio Grande do Sul	Itaara ^{3,4}	29° 36' S 53° 45' W	'A 7001 RG'
Rio Grande do Sul	Jari ³	29° 17' S 54° 13' W	—
Rio Grande do Sul	Júlio de Castilhos ³	29° 13' S 53° 41' W	—
Rio Grande do Sul	Manuel Viana ⁴	29° 35' S 55° 28' W	'A 8100 RG'
Rio Grande do Sul	Não-me-Toque ³	28° 28' S 52° 48' W	—
Rio Grande do Sul	Nonoai ^{3,6}	27° 21' S 52° 46' W	—
Rio Grande do Sul	Nova Palma ⁴	29° 28' S 53° 28' W	'A 8100 RG'
Rio Grande do Sul	Palmeira das Missões ⁴	27° 53' S 18° 24' W	'ANTA 82 ^{3*}
Rio Grande do Sul	Panambi ³	28° 17' S 53° 29' W	—
Rio Grande do Sul	Piratini ⁴	31° 26' S 06° 18' W	'A 8100 RG'
Rio Grande do Sul	Restinga Seca ^{3,4}	28° 13' S 54° 20' W	'A 8100 RG'
Rio Grande do Sul	Rosário do Sul ³	30° 14' S 54° 55' W	—
Rio Grande do Sul	Santa Maria ^{4,6}	29° 41' S 53° 48' W	'A 8100 RG', —
Rio Grande do Sul	São Pedro do Sul ^{3,4}	29° 38' S 54° 11' W	'A 8100 RG'
Rio Grande do Sul	São Sepé ³	30° 10' S 54° 34' W	—
Rio Grande do Sul	Selbach ³	28° 37' S 52° 57' W	—
Rio Grande do Sul	Silveira Martins ³	29° 38' S 53° 34' W	—
Rio Grande do Sul	Victor Graeff ^{3,6}	28° 33' S 52° 44' W	—
Rio Grande do Sul	Vila Nova do Sul ³	30° 20' S 53° 52' W	—

¹Leite et al. (2003), ²Oliveira et al. (2007), ³Roggia et al. (2008), ⁴Guedes et al. (2007), ⁵Návia & Flechtmann (2004), ⁶Roggia et al. (2009), ⁷Oliveira (2010), ⁸Vivan et al. (2011).

tor of tetranychid mites (Luh & Croft 2001; McMurtry & Croft 1997).

Iphiseiodes zuluagai Denmark & Muma, 1973.

Origin: Minas Gerais: Tupaciguara: XII-09 (1). Diet: Predator, but also feeds on pollen (Reis & Alves 1997).

Neoseiulus anonymus Chant & Baker, 1965

Previous records in Brazil: Rio Grande do Sul: Nonoai (Roggia et al. 2009). Diet: Selective pred-

tor of tetranychid mites (Ferla & Moraes 2003; McMurtry & Croft 1997).

Neoseiulus benjamini (Schicha, 1981)

Origin: Minas Gerais: Tupaciguara (1): XII-09 (1). Diet: Unknown for the species. Mites of this genus are considered selective or generalist predators (McMurtry & Croft 1997).

Neoseiulus californicus McGregor, 1954

Previous records in Brazil: Rio Grande do Sul: Cruz Alta, Nonoai, Santa Maria, Victor Graeff

TABLE 2. LOCATIONS SAMPLED FOR MITE FAUNA ON SOYBEAN, IN THE CENTRAL AREA OF THE CERRADO.

CODE	STATE	MUNICIPALITY	COORDINATES	CULTIVAR
A	Distrito Federal	Brasília	15° 38' S 47° 44' W	'BRS Baliza RR'
B	Goiás	Chapadão do Céu	18° 15' S 52° 44' W	'M-Soy 8001'
C	Goiás	Cristalina	16° 17' S 47° 27' W	'AN 8843'
D	Goiás	Edealina	17° 24' S 49° 45' W	'M-Soy 8200'
E	Goiás	Jataí (1) ¹	17° 51' S 51° 45' W	'ANTA 82 ^{3*}
F	Goiás	Jataí (2) ¹	17° 49' S 51° 41' W	'P 98Y11 [*]
G	Goiás	Rio Verde (1) ¹	17° 40' S 51° 02' W	'M-Soy 6101'
H	Goiás	Rio Verde (2) ¹	17° 40' S 51° 02' W	— ²
I	Mato Grosso do Sul	Chapadão do Sul	18° 51' S 52° 35' W	'ANTA 82 ^{3*}
J	Minas Gerais	Araporã	18° 26' S 49° 11' W	— ²
K	Minas Gerais	Tupaciguara (1) ¹	18° 31' S 48° 54' W	'BRS Valiosa RR'
L	Minas Gerais	Tupaciguara (2) ¹	18° 31' S 48° 54' W	— ²
M	Minas Gerais	Unaí	15° 59' S 46° 41' W	'BRS Valiosa RR'

¹Areas 1 and 2 are in different localities of the municipality.

²Spontaneous soybean.

(Roggia et al. 2009). Diet: Predator used in several control managements of pest mites (McMurtry & Croft 1997).

Neoseiulus idaeus Denmark & Muma, 1973

Origin: Goiás: Jataí (2): XI-09 (1). Diet: Predator used in the management of the cassava green mite *Mononychellus tanajoa* (McMurtry & Croft 1997).

Neoseiulus tunus (De Leon, 1967)

Origin: Goiás: Edealina: XII-09 (1), I-10 (1). Diet: As *N. benjamini*.

Phytoseiulus fragariae Denmark & Schicha, 1983

Previous records in Brazil: Rio Grande do Sul: Canguçu (Guedes et al. 2007); Cruz Alta, Santa Maria, Nonoai, Victor Graeff (Roggia et al. 2009). Diet: Predator and promising control agent of *Tetranychus urticae* (Vasconcelos et al. 2008).

Phytoseiulus macropilis Banks, 1905

Previous records in Brazil: Rio Grande do Sul: Victor Graeff (Roggia et al. 2009). Diet: It is considered to be a specialized predator of *Tetranychus* species (McMurtry & Croft 1997).

Proprioseiopsis cannaensis Muma, 1962

Previous records in Brazil: Rio Grande do Sul: Santa Maria (Roggia et al. 2009). Diet: This species has been observed feeding on pollen and Tetranychidae, Tenuipalpidae and Eriophyidae mites. However, the data obtained didn't allow asserting that *P. cannaensis* utilizes these items

as principal sources of food in nature (Bellini et al. 2010).

Proprioseiopsis ovatus (Garman, 1958)

Origin: Minas Gerais: Unaí: I-10 (1). Diet: Same as *P. cannaensis*.

Typhlodromalus aripo De Leon, 1967

Origin: Goiás: Rio Verde (2): VI-10 (1). Previous records in Brazil: Rio Grande do Sul: Canguçu (Guedes et al. 2007). Diet: This species can feed on a variety of food items, including mites, pollen, fungal spores and tetranychid mites (Gnanvossou et al. 2003).

ORDER SARCOPTIFORMES

Acaridae

Tyrophagus putrescentiae (Schrank, 1781)

Previous records in Brazil: Minas Gerais: Unaí (Oliveira et al. 2007). Diet: Species of this genus are considered to be basically fungivorous or graminivorous. But *T. putrescentiae* has also been found feeding on eggs of the southern corn root-worm *Diabrotica undecimpunctata howardi* Barber (Coleoptera: Chrysomelidae) (Krantz 2009).

Galumnidae

Galumna glabra Pérez-Iñigo & Baggio, 1991

Previous records in Brazil: Mato Grosso (Oliveira 2010). Diet: Unknown, but commonly mites of this family are mycophagous and saprophagous (Norton & Behan-Pelletier 2009).

TABLE 3. MITE SPECIES FOUND ON SOYBEAN CROPS LOCATED IN THE CERRADO REGION. THE NUMBERS REFER TO THE DATE OF SAMPLING (1: SAMPLING 40 DAYS AFTER SOWING; 2: SAMPLING 80 DAYS LATER; AND 3: SAMPLING ON SPONTANEOUS SOYBEAN). AREA CODES ARE DEFINED IN TABLE 2.

Mite Species	Area												
	A	B	C	D	E	F	G	H	I	J	K	L	M
<i>Asca</i> sp. 1	—	—	1	—	—	—	—	—	—	—	1, 2	—	—
<i>Asca</i> sp. 2	—	2	1	—	2	—	—	—	—	—	—	—	—
<i>Africoseius</i> sp.	—	—	—	—	2	—	—	—	—	—	—	—	—
<i>Proctolaelaps</i> sp.	—	—	—	—	—	—	1	—	—	—	—	—	—
<i>E. alatus</i>	—	—	—	—	—	—	—	—	—	3	—	—	—
<i>G. annectens</i>	—	—	—	—	—	—	—	—	—	3	—	—	—
<i>I. zuluagai</i>	—	—	—	—	—	—	—	—	—	—	1	—	—
<i>N. benjamini</i>	—	—	—	—	—	—	—	—	—	—	1	—	—
<i>N. idaeus</i>	—	—	—	—	—	1	—	—	—	—	—	—	—
<i>N. tunus</i>	—	—	—	1, 2	—	—	—	—	—	—	—	—	—
<i>P. ovatus</i>	—	—	—	—	—	—	—	—	—	—	2	—	—
<i>T. aripo</i>	—	—	—	—	—	—	—	3	—	—	—	—	—
<i>Czenspinksia</i> sp.	—	—	—	—	1	—	—	—	—	—	—	—	—
<i>Neocunaxoides</i> sp.	—	—	—	—	—	1	—	—	—	—	1	—	—
<i>C. tricholaenae</i>	—	—	2	—	—	—	—	—	—	—	1	—	2
<i>Metapronematus</i> sp.	—	—	—	—	—	2	—	—	—	—	—	—	—
<i>Pronematus</i> sp.	—	—	—	2	—	—	1	—	2	—	—	—	2
aff. <i>Tarsonemus</i> sp.	—	—	2	—	—	—	—	—	—	—	—	—	—
<i>Neotarsonemoides</i> sp.	—	—	—	—	—	—	—	—	—	—	—	—	2
<i>P. latus</i>	—	—	2	—	—	—	—	—	—	—	—	—	2
<i>T. bilobatus</i>	—	1	2	2	—	2	—	—	—	—	—	—	2
<i>T. confusus</i>	—	—	—	2	2	—	1	—	—	—	—	—	2
<i>Tarsonemus</i> sp.	1	—	—	—	—	—	—	—	—	—	—	—	—
<i>Tarsonemus waitei</i>	—	—	—	—	—	—	—	—	—	—	2	—	—
<i>Xenotarsonemus</i> sp.	—	—	—	—	—	—	1	—	—	—	—	—	2
<i>M. planki</i>	2	2	1, 2	1, 2	1, 2	2	1, 2	3	1, 2	3	1, 2	3	1, 2
<i>L. formosa</i>	—	2	—	—	—	—	—	—	—	—	1	—	—

Galumna sp.

Winterschmidtiidae

Previous records in Brazil: Mato Grosso (Oliveira 2010). Diet: Same as *G. glabra*.

Czenspinksia sp.

Origin: Goiás: Jataí (1): XII-09 (4). Diet: This genus is considered to be fungivorous (Krantz 2009).

Oribatulidae

Zygoribatula bonairensis (Willmann, 1936)

ORDER TROMBIDIFORMES

Previous records in Brazil: Maranhão (Oliveira 2010). Diet: Same as *G. glabra*.

Cunaxidae

Zygoribatula translineata (Mahunka, 1985)

Neocunaxoides sp.

Previous records in Brazil: Mato Grosso: Cláudia, Sorriso (Vivan et al. 2011). Diet: Same as *G. glabra*.

Origin: Goiás: Jataí (2): XI-09 (2); Minas Gerais: Tupaciguara (1): XII-09 (2). Diet: Cunaxidae is comprised of predatory species (Walter et al. 2009).

Schelorbitidae

Diptilomiopidae

Schelorbitates praencisus (Berlese, 1910)

Catarhinus tricholaenae Keifer, 1959

Previous records in Brazil: Mato Grosso (Oliveira 2010). Diet: Same as *G. glabra*.

Origin: Goiás: Cristalina: I-10 (1); Minas Gerais: Tupaciguara (1): XII-09 (2), Unai: I-10 (3).

Diet: All species included in Diptilomiopidae are considered phytophagous (Walter et al. 2009).

Iolinidae

Metapronematus sp.

Origin: Goiás: Jataí (2): XII-09 (2). Diet: This genus consists of fungivores and predators of eriophyoid and tetranychid mites (O'Dowd & Wilson 1997).

Pronematus sp.

Origin: Mato Grosso do Sul: Chapadão do Sul: I-10 (1); Goiás: Edealina: I-10 (1), Rio Verde (1): XII-09 (4); Minas Gerais: Unaí: I-10 (1). Diet: One species of this genus (*Pronematus ubiquitous* (McGregor)) is omnivorous, feeding on honeydew, fungi and eriophyoid mites (Walter et al. 2009).

Tarsonemidae

aff. *Tarsonemus* sp.

Origin: Goiás: Cristalina: I-10 (1).

Neotarsonemoides sp.

Origin: Minas Gerais: Unaí: I-10 (2). Diet: Unknown.

Polyphagotarsonemus latus Banks, 1904

Origin: Goiás: Cristalina: I-10 (17); Minas Gerais: Unaí: I-10 (4). Previous records in Brazil: Minas Gerais: Montes Claros (Leite et al. 2003); Rio Grande do Sul: Santa Maria (Guedes et al. 2007), Itaara (Roggia et al. 2009). Diet: Phytophagous, and it has great economic importance in agriculture (Lindquist 1986).

Tarsonemus bilobatus Suski, 1965

Origin: Goiás: Chapadão do Céu: XII-09 (1), Cristalina: I-10 (5), Edealina: I-10 (9), Jataí (2): XII-09 (3); Minas Gerais: Unaí: I-10 (1). Diet: According to Lindquist (1986), this genus consists of fungivorous species.

Tarsonemus confusus Ewing, 1939

Origin: Goiás: Edealina: I-10 (3), Jataí (1): I-10 (1), Rio Verde (1): XII-09 (1); Minas Gerais: Unaí: I-10 (4). Diet: Same as *T. bilobatus*.

Tarsonemus sp.

Origin: Distrito Federal: Brasília: XII-09 (1). Diet: Same as *T. bilobatus*.

Tarsonemus waitei Banks, 1912

Origin: Minas Gerais: Tupaciguara (1): I-10 (1). Diet: Same as *T. bilobatus*.

Xenotarsonemus sp.

Origin: Goiás: Rio Verde (1): XII-09 (1); Minas Gerais: Unaí: I-10 (1). Diet: Possibly members of this genus feed on green plant matter (Lindquist 1986).

Tetranychidae

Mononychellus planki (McGregor, 1950)

Origin: Distrito Federal: Brasília: I-10 (47); Goiás: Chapadão do Céu: I-10 (43), Cristalina: XII-09 (3), I-10 (38); Edealina: XII-09 (2), I-10 (113), Jataí (1): XII-09 (6), I-10 (972), Jataí (2): XII-09 (13), Rio Verde (1): XII-09 (32), I-10 (165), Rio Verde (2): VI-10 (18); Mato Grosso do Sul: Chapadão do Sul: XII-09 (75), I-10 (721); Minas Gerais: Araporã: VI-10 (32), Tupaciguara (1): XII-09 (32), I-10 (242), Tupaciguara (2): VI-10 (14), Unaí: XII-09 (5), I-10 (3). Previous records in Brazil: Rio Grande do Sul: Faxinal do Soturno, Manuel Viana, Nova Palma, Santa Maria, São Pedro do Sul (Guedes et al. 2007), Barra Funda, Cacequi, Cachoeira do Sul, Caiçara, Candelária, Condor, Cruz Alta, Espumoso, Formigueiro, Itaara, Jari, Júlio de Castilhos, Nonoai, Panambi, Restinga Seca, Rosário do Sul, Santa Maria, São Pedro do Sul, Silveira Martins, Victor Graeff, Vila Nova do Sul (Roggia et al. 2008). Diet: All Tetranychidae species are phytophagous. *Mononychellus planki* causes considerable economic damage to some crops (Moraes & Flechtmann 2008).

Tetranychus desertorum Banks, 1900

Previous records in Brazil: Rio Grande do Sul: Canguçu, Manuel Viana, Santa Maria (Guedes et al. 2007); Caçapava do Sul, Caiçara, Campos Borges, Cruz Alta, Formigueiro, Jari, Nonoai, Santa Maria, São Pedro do Sul, São Sepé, Silveira Martins, Vila Nova do Sul (Roggia et al. 2008). Diet: Same as *M. planki*.

Tetranychus gigas Pritchard & Baker, 1955

Previous records in Brazil: Rio Grande do Sul: Canguçu, Santa Maria (Návia & Flechtmann 2004, Guedes et al. 2007), Alegrete, Nonoai, Santa Maria, São Pedro do Sul, Victor Graeff (Roggia et al. 2008). Diet: Same as *M. planki*.

Tetranychus ludeni Zacher, 1913

Previous records in Brazil: Rio Grande do Sul: Alegrete, Rosário do Sul, Santa Maria (Roggia et al. 2008). Diet: As *M. planki*.

Tetranychus sp.

Previous records in Brazil: Rio Grande do Sul: Itaara, Palmeira das Missões, Piratini, Restinga Seca, São Pedro do Sul (Guedes et al. 2007). Diet: Phytophagous (Moraes & Flechtmann 2008).

Tetranychus urticae Koch, 1836

Previous records in Brazil: Rio Grande do Sul: Barra Funda, Cacequi, Cachoeira do Sul, Campos Borges, Cruz Alta, Espumoso, Júlio de Castilhos, Não-me-Toque, Nonoai, Santa Maria, São Sepé, Selbach, Silveira Martins, Victor Graeff (Roggia et al. 2008). Diet: Phytophagous and pest on several crops (Moraes & Flechtmann 2008).

Tydeidae

Lorryia formosa Cooreman, 1958

Origin: Goiás: Chapadão do Céu: I-10 (2); Minas Gerais: Tupaciguara (1): XII-09 (1). Diet: *Lorryia formosa* can be found on some cultivated plants, e.g., rubber trees. However, they were not seen causing evident damage (Hernandes & Feres 2006). Therefore, its feeding habit remains unclear.

DISCUSSION

Of the 31 species found in this study, only *Ga-lendromus* (*G.*) *annectens*, *M. planki*, *P. latus* and *T. aripo* had been reported in previous studies. The other collected species are new records of the fauna found in soybean, in Brazil. Furthermore, the 4 above-mentioned species are the only ones, until the present date, commonly registered in the soybean crops of Rio Grande do Sul and in the country's central region.

The prior data from Montes Claros (Leite et al. 2003) and Unaí (Oliveira et al. 2007), when added to the species recorded in the samplings carried out in this work, show that the species richness of mites associated with soybean in the Cerrado region (31 species) is much higher than observed in the surveys carried out in Rio Grande do Sul (14 species). Twenty seven species of mites have been found exclusively on soybean plants in the Cerrado biome. The lower number of species found thus far in Rio Grande do Sul probably results from the close proximity of the fields analyzed in that state, compared with the samplings carried out more widely in the Cerrado biome. It is known

that increased distances between certain sites results in increased β diversity, i.e., the sum of the various species observed in the respective areas (Nekola & White 1999).

Besides the surveys made in Rio Grande do Sul and Minas Gerais, other studies showed that oribatid mites have been found on soybean (*G. glabra*, *Galumna* sp., *S. praenincisus*, *Z. bonairensis* e *Z. translineata*) in Maranhão and Mato Grosso states (Oliveira 2010; Vivan et al. 2011). There is a suspicion that these species would be related to a recent plant disorder observed in crops in these states and commonly known as "crazy soybean II", which is marked by malformation of flowers and pods, resulting in significant reductions of production, in some cases. Up to now, there are records of this disease only in Brazil (Saraiva et al. 2010). None of the studies conducted have confirmed a connection between this disorder and these mites. It is known that most of oribatid species exhibit mycophagous and saprophagous feeding, i.e., they can ingest dead plant material, spores or fungal fragments (Schneider et al. 2005; Norton & Behan-Pelletier 2009; Oliveira 2010). This characteristic, at least, suggests that a direct connection between oribatid mites and the new disorder would be improbable. Although there are some references to oribatid mites feeding on cultivated plants, these reports are isolated and rare. Thus, no oribatid species has reached pest status (A. R. Oliveira, Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, personal communication).

Considering only the data attained from the samplings under this study, Phytoseiidae and Tarsonemidae presented the largest richness. However, almost 50 % of the Phytoseiidae were found exclusively in spontaneous soybean. According to the farmers' statements, their crops were treated with several pesticides. Some chemical defensives can suppress populations of non-target species present in the field, i.e., predatory mites (Degrande et al. 2002; Guedes et al. 2007). So, it is possible that the lower diversity of Phytoseiidae, recorded in cultivated soybean, might be related to pesticide application. Anyway, the occurrence of certain phytoseiid species in the field, i.e. *E. alatus*, *G. annectens*, *I. zuluagui*, *N. anonymus*, *P. fragariae* and *T. aripo* must be highlighted because these mites can contribute effectively to the pest mite control (De Vis et al. 2006; Gerson et al. 2003; Ferla & Moraes 2003; McMurtry & Croft 1997; Melo et al. 2009; Reis et al. 2003; Vasconcelos et al. 2003). As for the Tarsonemidae, in contrast to the results of Phytoseiidae, all the species have been recorded exclusively in cultivated soybean. Most of them belong to *Tarsonemus* genus, which is comprised of fungivorous species (Lindquist 1986).

The results attained from several surveys carried out indicate that *M. planki* was the mite spe-

cies most frequently found on soybean in Brazil, until the present date, considering the numbers of crops on which it has been recorded. Bolland et al. (1998) mentioned that *M. planki* is broadly distributed, extended throughout the American continent. In addition, this mite has been recorded on 64 other host plants species (Migeon & Dorkeld 2011). Some works report populations of *M. planki* as harmful to several crops in Brazil, e.g., cotton, peanut, beans and okra (Flechtmann 1981; Moraes & Flechtmann 2008). Thus, there is no doubt that this mite has relevance for Brazil's national agriculture. Therefore studies about control and biological aspects of *M. planki* are needed in Brazil.

Polyphagotarsonemus latus (Tarsonemidae) can be considered as another species with potential of being a pest for soybean production in Brazil. This mite species was recorded both in the Cerrado areas and in the surveys carried out by Guedes et al. (2007) and Leite et al. (2003). It is known that this species is present on a large number of host crops (Lindquist 1986). Other potential pests species included in the presented list are mites of the *Tetranychus* genus. It should be highlighted that none of these species were recorded in the samplings carried out in crops from the country's central region, and that they have been found only in prior surveys carried out in Rio Grande do Sul. According to Moraes & Flechtmann (2008), all such species are seen as pest mites in certain crops. Guedes et al. (2007) asserted that some of these species were recorded in localized infestations in Rio Grande do Sul state. Furthermore, *T. urticae* is cited as an important pest mite in soybean in several parts of the world (Abraham 2000; Carlson 1969; Hoda et al. 1986; Shabalta et al. 1992; Singh 1988). Such facts certainly add to the importance of *T. urticae* as an agricultural pest.

Finally, although the mite densities observed in the samplings did not indicate risks of economic damage, it is necessary to take into account the potential these species to cause economic damage. Hence, the mere occurrence of their populations should be periodically monitored so that infestation of those mites can be properly handled in the future, without great losses in the soybean production chain.

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REFERENCES CITED

- ABRAHAM, R. 2000. Mite and thrips populations of soybean varieties of different ripening groups. *Növényvédelem* 36: 583-589.
- BELLINI, M. R., ARAÚJO, R. V. DE, SILVA, E. S., MORAES, G. J. DE, AND BERTI FILHO, E. 2010. Ciclo de Vida de *Proproseiusopsis cannaensis* (Muma) (Acari: Phytoseiidae) com Diferentes Tipos de Alimentos. *Neotropical Entomology* 39: 360-364.
- BOLLAND, H. H., GUTIERREZ, J., AND FLECHTMANN, C. W. H. 1998. World catalogue of spider mite family (Acari: Tetranychidae). Brill Academic Publishers, Leiden, Zuid-Holland, Netherlands. 392 pp.
- CARLSON, E. C. 1969. Spider mites on soybeans: injury and control. *California Agric.* 23: 16-18.
- CONAB. 2010. Séries históricas das safras 1976/77 a 2009/2010 de área plantada e produtividade. www.conab.gov.br/conteudos.php?a=1252&t=&Pagina_objemsconteudos=3#A_objemsconteudos/ accessed 10th October, 2010.
- CORRÊA-FERREIRA, B. S., DOMIT, L. A., MORALES, L., AND GUIMARÃES, R. C. 2000. Integrated soybean pest management in micro river basins in Brazil. *Integ. Pest Manag. Rev.* 5: 75-80.
- CORRÊA-FERREIRA, B. S., ALEXANDRE, T. M., PELLIZZARRO, E. C., MOSCARDI, F., AND FREITAS BUENO, A. 2010. Circular Técnica 78: Práticas do manejo de pragas usado em soja e seus impactos na agricultura. Embrapa Soja, Londrina, Paraná, Brazil.
- DEGRANDE, P. E., REIS, P. R., CARVALHO, G. A., AND BELARMINO, L. E. 2002. Metodologia para avaliar o impacto de pesticidas sobre inimigos naturais, pp. 71-93 *In* J. P. R. Parra, P. S. M. Botelho, B. S. C. Ferreira and J. M. S. Bento [eds.], *Controle biológico no Brasil: parasitóides e predadores*. Editora Manole, São Paulo, São Paulo, Brazil.
- DE LEON, D. 1967. Some Mites of the Caribbean Area. Part I. Acarina on Plants in Trinidad, West Indies. Allen Press Inc., Lawrence, Kansas, USA. 66 pp.
- DE VIS, R. M. J., MORAES, G. J. DE, AND BELLINI, M. R. 2006. Initial screening of little known predatory mites in Brazil as potential pest control agents. *Exp. Appl. Acarol.* 39: 115-125.
- DURIGAN, G., SIQUEIRA, M. F. DE, AND FRANCO, G. A. D. C. 2007. Threats to the Cerrado remnants of the state of São Paulo, Brazil. *Sci. Agric.* 64: 355-363.
- EMBRAPA. 2000. Recomendações técnicas para lavouras de soja no estado do Paraná 2000/2001. Embrapa Soja, Londrina, Paraná, Brazil. 225 pp.
- EMBRAPA. 2008. Tecnologias da produção de soja: região central do Brasil 2009 e 2010. Embrapa Soja, Londrina, Paraná, Brazil. 263 pp.
- FERLA, N. J., AND MORAES, G. J. DE 2003. Oviposition rates of the predatory mites *Agistemus floridanus* Gonzalez, *Euseius concordis* (Chant) and *Neoseiulus anomymus* (Chant & Baker) (Acari) with different types of food. *Rev. Brasileira de Zool.* 20: 153-155.

- FLECHTMANN, C. H. W. 1981. Ácaros de importância agrícola. Editora Nobel, São Paulo, São Paulo, Brazil. 189 pp.
- GERSON, U., SMILEY, R. L., AND OCHOA, R. 2003. Mites (Acari) for pest control. Blackwell Publishing Company, Oxford, Oxfordshire, UK. 539 pp.
- GNANVOSSOU, D., YANINEK, J. S., HANNA, R., AND DICKE, M. 2003. Effects of prey mite species on life history of the phytoseiid predators *Typhlodromalus manihoti* and *Typhlodromalus aripo*. Exp. Appl. Acarol. 30: 265-278.
- GUEDES, J. V. C., NÁVIA, D., LOFEGO, A. C., AND DEQUECH, S. T. B. 2007. Mites associated to soybean crops in Rio Grande do Sul State, Brazil. Neotrop. Entomol. 36: 288-293.
- HODA, F. M., HASSAN, A. A., SAWIRES, Z. R., TAHA, H. A., AND IBRAHIM, G. A. 1986. Effect of some acaricides on the number of spider mites infesting soybean plants in lower and upper Egypt. Bull. Entomol. Soc. Egypt, Econ. Series 15: 253-262.
- KRANTZ, G. W. 2009 Habits and Habitats, pp. 64-82 In G. W. Krantz and D. E. Walter [eds.], A manual of Acarology. 3rd edition. Texas Tech Univ. Press, Lubbock, Texas, USA.
- LEITE, G. L. D., ALMEIDA, C. I. M., ROCHA, S. L., COSTA, C. A., AND VELOSO, R. V. S. 2003. Insects, mites and spiders associated to soybean vegetable, in four spacings between plants, in Montes Claros-MG. Unimontes Científica 5: 1-5.
- LINDQUIST, E. E. 1986. The world genera of Tarsonemidae (Acari: Heterostigmata): A morphological, phylogenetic and systematic revision, with reclassification of family group taxa in Heterostigmata. Mem. Entomol. Soc. Canada, Ottawa, ON, Canada. 517 pp.
- LINDQUIST, E. E., KRANTZ, G. W., AND WALTER, D. E. 2009a. Classification, pp. 97-103 In G. W. Krantz and D. E. Walter [eds.], A Manual of Acarology. 3 ed. Texas Tech Univ. Press, Lubbock, Texas, USA.
- LINDQUIST, E. E., KRANTZ, G. W., AND WALTER, D. E. 2009b. pp. 124-232. Order Mesostigmata. In G. W. Krantz and D. E. Walter [eds.], A manual of Acarology. 3 ed. Texas Tech University Press, Lubbock, Texas, USA.
- LUH, H.-K., AND CROFT, B. A. 2001. Quantitative classification of life-style types in predaceous phytoseiid mites. Exp. & Appl. Acarol. 25: 403-424.
- MCMURTRY, J. A., AND CROFT, B. A. 1997. Life-styles of phytoseiid mites and their roles in biological control. Annu. Rev. Entomol. 42: 291-321.
- MELO, J. W. DA S., DOMINGOS, C. A., GONDIM JR., M. G. C., AND MORAES, G. J. DE 2009. Can *Euseius alatus* De Leon (Acari: Phytoseiidae) preys *Aceria guerreronis* Keifer (Acari: Eriophyidae) in coconut trees? Neotrop. Entomol. 38: 139-143.
- MIGEON, A., AND DORKELD, F. 2011. Spider mites web: a comprehensive database for the Tetranychidae. <http://www1.montpellier.inra.fr/CBGP/spmweb>. Accessed 26 Oct 2011.
- MORAES, G. J. DE, AND FLECHTMANN, C. H. W. 2008. Manual de Acarologia: Acarologia básica de ácaros em plantas cultivadas no Brasil. Holos Editora, Ribeirão Preto, São Paulo, Brazil. 288 pp.
- MOUTIA, L. A. 1958. Contribution to the study of some phytophagous acarina and their predators in Mauritius. Bull. Entomol. Res. 49: 59-75.
- MUMA, M. H. 1962. New Phytoseiidae (Acarina: Mesostigmata) from Florida. Florida Entomol. 45: 1-10.
- NÁVIA, D., AND FLECHTMANN, C. H. W. 2004. Rediscovery and redescription of *Tetranychus gigas* (Acari, Prostigmata, Tetranychidae). Zootaxa 547: 1-8.
- NORTON, R. A., AND BEHAN-PELLETIER, V. M. 2008. Suborder Oribatida, pp. 430-564 In G. W. Krantz and D. E. Walter [eds.], A Manual of Acarology. 3 ed. Texas Tech Univ. Press, Lubbock, Texas, USA.
- O'DOWD, D. J., AND WILSON, M. F. 1997. Leaf domatia and the distribution and abundance of foliar mites in broadleaf deciduous forest in Wisconsin. Am. Midl. Nat. 137: 337-348.
- OLIVEIRA, C. M. DE, NÁVIA, D., AND FRIZZAS, M. R. 2007. First record of *Tyrophagus putrescentiae* (Schrank) (Acari: Acaridae) in soybean plants under no tillage in Minas Gerais, Brazil. Ciência Rural 37: 876-877.
- OLIVEIRA, A. R. 2010. Oribatid mites X soja louca II, p. 64-70 In O. F. Saraiva, R. M. V. B. de C. Leite and R. M. Soares [eds.], Documentos 324: Ata da XXXI reunião de pesquisa de soja da região central do Brasil. 1 ed. Embrapa Soja, Londrina, Paraná, Brazil. 321 pp.
- REIS, P. R., AND ALVES, E. B. 1997. Criação do ácaro predador *Iphiseiodes zuluagai* Denmark & Muma (Acari: Phytoseiidae) em laboratório. An. Soc. Entomol. Brasil 26: 565-568.
- REIS, P. R., SOUSA, E. O., TEODORO, A. V., AND NETO, M. P. 2003. Effect of prey density on the functional and numerical responses of 2 species of predaceous mites (Acari: Phytoseiidae). Neotrop. Entomol. 32: 461-467.
- REZENDE, A. V., SANQUETTA, C. R., AND FIGUEIREDO FILHO, A. 2005. Efeito do desmatamento no estabelecimento de espécies lenhosas em um cerrado *sensu stricto*. Floresta. 35: 69-88.
- ROGGIA, S., GUEDES, J. V. C., KUSS, R. C. R., ARNEMANN, J. A., AND NÁVIA, D. 2008. Spider mites associated to soybean in Rio Grande do Sul, Brazil. Pesqui. Agropecu. Bras. 43: 295-301.
- ROGGIA, S., GUEDES, J. V. C., KUSS-ROGGIA, R. C. R., VASCONCELOS, G. J. N. DE, NÁVIA, D., AND DELALIBERA JR, I. 2009. Ácaros predadores e o fungo *Neozygites floridana* associados a tetraniquídeos em soja no Rio Grande do Sul. Pesqui. Agropecu. Brasileira. 44: 107-110.
- SALVADORI, J. R., PEREIRA, P. R. V. S., AND CORRÊA-FERREIRA, B. S. 2007. Documentos 91: Pragas ocasionais de lavouras de soja no estado do Rio Grande do Sul. Embrapa Trigo, Passo Fundo, Rio Grande do Sul, Brazil. 19 pp.
- SARAIVA, O. F., LEITE, R. M. V. B. DE C., AND SOARES, R. M. 2010. Documentos 324: Ata da XXXI Reunião de Pesquisa de Soja da Região Central do Brasil. Embrapa Soja, Londrina, Paraná, Brazil. 325 pp.
- SCHNEIDER, K., RENKER, K., SCHEU, S., AND MARAUN, M. 2005. Feeding biology of oribatid mites: a minireview. Phytophaga 14: 247-256.
- SHABALTA, O. M., NGUEN, T. M., AND SHYRINIAN, O. M. 1992. Injuriousness of spider mites to soybean in relation to the mineral nutrition of plants. Agrokhimiya 8: 125-126.
- SINGH, O. P. 1988. Assessment of losses to soybean by red spider mite in Madhya Pradesh. Agric. Sci. Dig. 8: 129-130.
- VASCONCELOS, G. J. N. DE, MORAES, G. J. DE, DELALIBERA JR., I., AND KNAPP, M. 2008. Life history of the predatory mite *Phytoseiulus fragariae* on *Tetranychus evansi* and *Tetranychus urticae* (Acari: Phyto-

- seiidae, Tetranychidae) at five temperatures. *Exp. Appl. Acarol.* 44: 27-36.
- VIVAN, L., FRANCISCO, E. A. B., MAGRI, J., AND OLIVEIRA, A. R. 2011. Searching for answers. *Revista Cultivar* 13: 20-21.
- WALTER, D. E., LINDQUIST, E. E., SMITH, I. M., COOK, D. R., AND KRANTZ, G. W. 2009. Order Trombidiformes, pp. 233-420 *In* Krantz, G. W. and D. E. Walter [eds.], *A manual of Acarology*. 3rd edition. Texas Tech University Press, Lubbock, Texas, USA.