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White grubs (Coleoptera, Melolonthidae) in the "Planalto Region", Rio Grande do Sul state, Brazil: Key for identification, species richness and distribution

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ABSTRACT. White grubs (Coleoptera, Melolonthidae) in the "Planalto Region", Rio Grande do Sul state, Brazil: Key for identification, species richness and distribution. The objective of this study was to survey the occurrence and geographic distribution of white grub species (Coleoptera, Melolonthidae) in cultivated and non-cultivated fields of the "Planalto Region", Rio Grande do Sul state, Brazil and develop a key at genus-level. Twenty-eight species from 15 genera and three subfamilies were recorded: Dynastinae, Melolonthinae and Rutelinae. The species or genera recorded for the first time in the state are: *Cyclocephala metrica*, *C. tucumana*, *Isonychus albicinctus*, *Liogenys bidenticeps*, *L. fusca*, *L. obesa* and *L. sinuaticeps*, *Paranomala violacea*, as well as unidentified species of *Amononyx*, *Dicrania*, *Leucothyreus*, *Macrodactylus*, *Plectris* and *Rhizogeniates*. Among the species recorded, 23 were associated with winter crops. Only *Cyclocephala metrica*, *Dyscinetus rugifrons*, two species of *Leucothyreus* and one species of the tribe Sericini were not present in cultivated crop fields. C*yclocephala flavipennis* and *Diloboderus abderus* occurred in most of the municipalities sampled, often associated with *Plectris* sp., *C. modesta* and *C. putrida*. The highest richness of melolonthids was concentrated in the northeast of the Planalto region.

KEYWORDS: grain crops, Insecta, rhizophagous larvae, species assemblages, taxonomy.

The "Planalto region" is one of the most important grain producing areas of Rio Grande do Sul state and is among the most important in Brazil. The most common crops are soybeans, corn and wheat, and to a lesser extent oats. These crops, together with rice, form the agricultural economic basis of the state (IBGE 2010). With the introduction of no-till methods after the 1980s, various problems associated with white grubs appeared in winter crops in the state. White grubs are beetle larvae belonging to Melolonthidae, that feed on the roots and seeds of various plants (Pereira & Salvadori 2006). Although these melolonthid species damage various crops, there is a lack of knowledge about their biology and identification in South America compared to Central and North America (Morón 1997). Several causes limit the number of specialists who study this topic. White grubs go unnoticed in the soil until they produce some disequilibrium in the agrosystem, which results in more intensive research since economic interests are affected, such as crop yield losses. Also, there are various difficulties in studying the biology and behavior of soil dwelling insects without disturbing their natural development (Morón 2004). Due to the poor knowledge on the richness of this group, people believe that all species can be controlled in the same way. Together with monitoring, controlling is expensive and time-consuming and can lead to an incorrect pest management. Taxonomic characters used to differentiate among Melolonthidae larvae are mainly present in mouth parts and ventral part of the last abdominal segment (raster). The raster has bristles (pali) distributed in various ways according to the species and these can form one or more rows called palidia (Morón *et al.* 1997). Even so, identifications should be confirmed by breeding individuals to the adult stage in the laboratory, because larvae are very similar to each other (Pardo-Locarno *et al.* 2005). In Brazil, Melolonthidae have 1,008 species with soil-inhabiting larvae (Morón 2004). Species assemblages differ in composition and richness from one region to another, depending on the orography, weather and different crops of each locality (Pardo-Locarno *et al.* 2003). Surveys about regional species assemblages is important for developing suitable pest management programs, since the strategies adopted in one region may not necessarily be appropriate in another. The objective of the present study was to identify melolonthid larvae found in cultivated and non-cultivated fields of the Planalto region of Rio Grande do Sul, bring species records up-to-date, develop an identification key and determine their geographic distribution.

MATERIAL AND METHODS

A survey of melolonthid species (Coleoptera, Scarabaeoidea) was carried out in the Planalto region of Rio Grande do Sul, in southern Brazil. The mean annual temperature is 18.0°C, varying from 16.0 to 19.4°C. Higher temperatures are observed in the west of the Planalto and the lowest ones in the northeast. The mean average temperature varies from 9.9 to 13.6°C in July and from 22.3 to 26.1°C in January. Values of normal rainfall in the state vary from 1,186 (eastern Planalto) to 2,468 mm/year (western Planalto) (Brasil 1973). The altitude varies from 140 m (Manoel Viana) in the east to 770 m (Caseiros) in the northeast. Latosol is the predominant soil type in the region, but also occur Argisol in the west (Streck *et al*. 2008). The Planalto is represented by the combination of two floristic ecoregions, the Brazilian Araucaria moist forests and "Campos" moist grasslands, both with secondary vegetation and agricultural activities (Duarte *et al*. 2006). The Brazilian Araucaria moist forests have a predominance of *Araucaria angustifolia*, *Podocarpus lambertii* and *Ilex paraguariensis*. "Campos" grasslands is composed mainly by *Paspalum notatum* and *Aristida pollens*, as well as species of *Stipa*, *Andropogon* and *Erianthus* undergrowth vegetation. Other important elements are the gallery forests, with representative species of seasonal and rainforests. They belong to different genera of Asteraceae, Cyperaceae, Poaceae, Fabaceae, Pteridophytae and Verbenaceae (Leite 2002).

Larvae were collected from 23 representative agricultural municipalities with occurrence of white grubs, as informed by farmers and extension specialists (Table I). Samples were collected during the period of highest larval populations, from July to September in both years 2009 and 2010. At each municipality, a cultivated area (CA) and a non-cultivated area (NA) were chosen, with 800 to 2000 m distance from each other. The cultivated area varied from wheat, oats to Italian ryegrass, while non-cultivated area was always open wild field. In each area, trenches of 50 cm long x 25 cm wide x 30 cm deep were opened. The number of sample points depended on the size of the sampled area, varying from 20 to 40 points. Larvae from 2nd and 3rd instar were collected individually, placed in plastic containers containing soil from the area and transported to the Entomology Laboratory of the Federal University of Santa Maria (UFSM). The specimens were identified using taxonomic keys and larval descriptions of Melolonthidae elaborated by Frana (2003), Pereira & Salvadori (2006) and Neita-Moreno *et al*. (2012). Besides the general aspects of the body, morphological characteristics used to differentiate the larvae were: color and size of the cephalic capsule, number and form of dorsal sensorial maculae of the last antennomere, distribution of bristles on the labrum and epipharynx and details of stridulatory structures in the maxilla and mandible. On the abdomen, shape of the anal opening, bristle type and organization on the ventral part of the extreme portion of the abdomen (raster), shape and size of the respiratory plates, proportions of each pair of legs and tarsungulus size. The terms utilized for each diagnostic structure are based in Böving (1936) and Ritcher (1966). All larval morphotypes collected were separated into two lots. In one lot, larvae were boiled and preserved in 70% alcohol to be used later as vouchers and for comparing with identified species. Larvae of the other lot were bred in the laboratory under controlled conditions (25 ºC temperature, 70% relative humidity and 12 hour photophase), to obtain adults for later taxonomic identification. The larvae were

Table I. Municipalities sampled, coordinates, previous and actual vegetation or cultivated crops, sampling date, area sampled (in hectares) and number of dug trenches (n) for cultivated and non-cultivated areas in the Planalto region of Rio Grande do Sul, southern Brazil, in 2009 and 2010.

	Cultivated crop fields							Non-cultivated sites (mix of moist forests and open native grasslands)				
	Municipality	Coordinates	Previous crop	Crop at time of sampling	Date	Area (ha)	n	Municipality	Coordinates	Date	Area (ha)	n
Caseiros	28°15'S	51°40'W	corn	fallow	5/Aug/2010	3	25	28°15'S	51°41'W	5/Aug/2010	5	25
Chapada	28°15'S	53°4'W	soybeans	Italian ryegrass	10/Sep/2010	4	25	28°15'S	53°5'W	10/Sep/2010	1	25
Coxilha	28°11'S	52°20'W	soybeans	oats	10/Sep/2010	2	25	28°11'S	52°20'W	10/Sep/2010	2	25
Cruz Alta	28°31'S	53°41'W	soybeans	oats	27/Aug/2009	21	43	28°32'S	53°42'W	27/Aug/2009	7	20
Dois Irmãos das Missões	27°38'S	53°25'W	soybeans	oats + Italian ryegrass	18/Sep/2010	8	25	27°39'S	53°25'W	18/Sep/2010	3	25
Fortaleza dos Valos	28°41'S	53°26'W	soybeans	oats	9/Sep/2010	5	25	28°40'S	53°27'W	9/Sep/2010	3	25
Guabiju	28°33'S	51°38'W	soybeans	Italian ryegrass	6/Aug/2010	9	25	28°33'S	51°39'W	6/Aug/2010	2	25
Ijuí	28°30'S	53°48'W	soybeans	fallow	13/Aug/2009	13	31	28°31'S	53°47'W	14/Aug/2009	2	25
Itaara	29°32'S	53°45'W	soybeans	wheat	26/Aug/2009	9	20	29°32'S	53°46'W	26/Aug/2009	9	20
Lagoa Vermelha	28°38'S	51°37'W	soybeans	oats	30/Jul/2009	15	30	28°29'S	51°33'W	30/Jul/2009	9	25
Manoel Viana	29°13'S	55°31'W	sorghum	oats + Italian ryegrass	13/Aug/2010	8	25	29°13'S	55°31'W	13/Aug/2010	4	25
Nonoai	27°16'S	52°43'W	soybeans	fallow	21/Aug/2010	8	25	27°15'S	52°43'W	21/Aug/2009	2	25
Nova Palma	29°17'S	53°28'W	soybeans	wheat	25/Aug/2010	6	25	29°17'S	53°28'W	25/Aug/2010	6	25
Panambi	28°9'S	53°27'W	soybeans	turnip + oats	21/Aug/2009	15	30	28° 9'S	53°27'W	21/Aug/2009	2	25
Porto Lucena	27°50"S	54°55"W	soybeans	wheat	21/Aug/2010	6	25	27°49'S	54°54'W	21/Aug/2010	5	25
Santa Rosa	27°56'S	54°32'W	soybeans	oats	14/Aug/2009	6	20	27°57'S	54°32'W	14/Aug/2009	1.5	20
São Francisco de Assis	29°18'S	55°17'W	soybeans	oats	11/Jul/2009	23	43	29°18'S	55°10'W	11/Jul/2009	4	28
São Luiz Gonzaga	28º24'S	54º56'W	soybeans	oats	14/Aug/2010	7	25	28º24'S	54º56'W	14/Aug/2010	5	25
Tapejara	29°04'S	52°07'W	soybeans	fallow	28/Jul/2009	5	39	28°3'S	52°7'W	28/Jul/2009	3	21
Três Palmeiras	27°38'S	52°50'W	soybeans	oats	11/Sep/2010	3	25	27°38'S	52°49'W	11/Sep/2010	3	25
Tupanciretã	28°54'S	53°39'W	sorghum	oats + Italian ryegrass	14/Aug/2010	7	25	28°56'S	53°41'W	14/Aug/2010	6	25
Vacaria	28°15'S	51°17'W	corn	wheat	31/Jul/2009	9	35	28°15'S	51°16'W	31/Jul/2009	6	25
Vila Maria	28°34'S	52°7'W	soybeans	Italian ryegrass	29/Jul/2009	5	36	28°34'S	52°7'W	29/Jul/2009	2	20

reared in plastic containers with a substrate of soil from the area they were collected from. The soil in each container was moistened weekly during larval rearing to the adult stage. The adults obtained were killed in 70% alcohol after 15 days and mounted on entomological pins. Adult body measurements were made using a stereoscopic microscope (up to 5x) and adults were identified using keys and diagnostic descriptions for Melolonthidae in Endrödi (1985), Frey (1969), Katovich (2008) and Smith (2008). Unidentified larvae and adults were sent to Dr. Miguel Angel Morón (*Instituto de Ecologia*, A. C., Xalapa, Veracruz, Mexico) for identification. Vouchers were deposited in the *Departamento de Defesa Fitossanitária*, Federal University of Santa Maria, Rio Grande do Sul and in the *Instituto de Ecología*, A.C. Xalapa, Mexico. An identification key was elaborated based on the results of larvae identifications from the 23 studied municipalities.

RESULTS AND DISCUSSION

Occurrence of Melolonthidae in the Planalto region of Rio Grande do Sul

The occurrence of 28 melolonthid species were recorded from 15 genera belonging to the subfamilies Dynastinae, Melolonthinae and Rutelinae (Table II). Five of the 28 species belong to *Liogenys* Guerín-Meneville, 1838 (*L. fusca* Blanchard, 1850 (Fig. 1A), *L. bidenticeps* Moser, 1919; *L. sinuaticeps* Moser, 1918; *Liogenys obesa* Burmeister, 1855 and *Liogenys* sp.); five belong to *Cyclocephala* Dejean 1821 (*C. flavipennis* Arrow, 1914, *C. modesta* Burmeister, 1855, *C. putrida* Burmeister, 1847; *C. tucumana* Brèthes, 1904 (Fig. 1B) and *C. metrica* Steinheil, 1874(Fig. 1C)); four belong to *Leucothyreus* MacLeay, 1819 (*Leucothyreus* sp.1, *Leucothyreus* sp.2 (Fig. 1D), *Leucothyreus* sp.3 and *Leucothyreus* sp.4); two to *Dyscinetus* Harold, 1869 (*D. rugifrons* Burmeister, 1847 (Fig. 1E) and *D. gagates* Burmeister, 1847) and one species belongs to each of the genera *Geniates* Kirby, 1808 (*Geniates* sp. aff. *cylindricus* (Fig. 1F)); *Rhizogeniates* Ohaus, 1909 (*Rhizogeniates* sp. (Fig. 1G)); *Dicrania* Le Peletier and Audinet-Serville, 1828 (*Dicrania* sp. (Fig. 1H)); *Demodema* Blanchard, 1850 (*D. brevitarsis* (Blanchard, 1850), *Macrodactylus* Dejean, 1821 (*Macrodactylus* sp. (Fig. 1I)), *Plectris* Le Peletier and Audinet-Serville, 1828 (*Plectris* sp.), *Isonychus* Mannerheim, 1829 (*I. albicinctus* (Mannerheim, 1829) (Fig. 1J)); *Amononyx* Saylor, 1940 (*Anomonyx* sp. (Fig. 1K)); *Paranomala* Casey, 1915 (*P. violacea* Burmeister 1844 (Fig. 1L)); *Diloboderus* Reiche, 1859 (*D. abderus* Burmeister, 1826) and *Phyllophaga* Harris, 1827 (*P. triticophaga* Salvadori & Morón, 1998). One species was identified only to tribal level, being included in the tribe Sericini (Melolonthinae).

Only 12 of the 28 species were identified in the larval stage, demonstrating the lack of descriptions and keys for the identification of immature Melolonthidae. Six of the species identified in this study have already been recorded from Brazil associated with economically important crops.

Table II. Taxonomic composition of Melolonthidae (Coleoptera) and occurrence in cultivated and non-cultivated areas of the Planalto Region of Rio Grande do Sul, southern Brazil, in 2009 and 2010. Taxa marked with an asterisk were not found in areas under agriculture.

Dynastinae (3 genera/8 species)	
Cyclocephalini	*Cyclocephala flavipennis*
	C. modesta
	C. putrida
	C. tucumana
	*C. metrica**
	*Dyscinetus rugifrons**
	D. gagates
Pentodontini	*Diloboderus. abderus*
Melolonthinae (8 genera/13 species)	
Diplotaxini	*Liogenys fusca*
	L. bidenticeps
	L. sinuaticeps
	L. obesa
	Liogenys sp.
Macrodactylini	*Demodema brevitarsis*
	Isonychus albicinctus
	Macrodactylus sp.
	Plectris sp.
	Anomonyx sp.
	Dicrania sp.
Melolonthini	*Phyllophaga triticophaga*
Sericini	unidentified genus*
Rutelinae (4 genera/7 species)	
Anomalini	*Paranomala violacea*
Geniatini	*Geniates aff. cylindricus*
	Rhizogeniates sp.
	Leucothyreus sp. 1
	Leucothyreus sp. 2*
	Leucothyreus sp. 3*
	Leucothyreus sp. 4

Cyclocephala flavipennis, *Diloboderus abderus*, *Demodema brevitarsis* and *Phyllophaga triticophaga* were recorded from winter crops in different localities of Rio Grande do Sul (Salvadori & Silva 2004). *Isonychus albicinctus* was recorded from Minas Gerais in eucalyptus plantations by Freitas *et al*. (2002). *Liogenys fusca* occurs in the western region of central Brazil and attacks corn and soybeans (Santos *et al*. 2008; Costa *et al*. 2009).

All 28 species were found in non-cultivated areas whereas 23 of them also occurred in cultivated areas (Table II). The predominant subfamilies in South America are Melolonthinae and Dynastinae, principally due to the richness of *Plectris* and *Cyclocephala*, respectively (Morón 1996). However, Melolonthinae was predominant in this study, with 8 genera and 13 species, with *Liogenys* being the richest genus (Table II). Since no adults of *Plectris* were collected, it is uncertain if the larvae found belong to the same species or not. Most species of the Melolonthinae are rhizophagous, with *Phyllophaga* being the most economically important in agriculture (King 1984).

Cyclocephala had the major richness among the Dynastinae and *Leucothyreus* was the richest among the Rutelinae collected. The high specific richness of a genus suggests that at local and regional levels there might be a delicate equilibrium in the rhizosphere, which permits interspecific coexistence. If one of these species becomes a pest, it is almost certainly due to the slow or sudden elimination of this underground richness, probably caused by monoculture or by indiscriminate application of toxic products, among other factors (Morón 1996).

Key to the genera of Melolonthidae present in Rio Grande do Sul, Brazil, based on 3rd instar larvae

1. Anal opening transverse (Fig. 2N), straight or slightly curved. Last antennomere with one or more dorsal maculae. Raster with or without defined palidia. Mandibles with a ventral stridulatory area 9
1'. Anal opening "V-shaped" or "Y-shaped" (Fig. 2O). Raster always with defined palidia. Last antennomere with only one dorsal macula. Mandibles without ventral stridulatory area .... Melolonthinae 2

2. Raster without a defined septula. Oblique palidia, which converge to the midline (Fig. 2P) .... *Liogenys* Guérin-Méneville
2'. Raster with a defined septula between straight or curved, longitudinal palidia (Fig. 2Q-W) 3

3. Palidia with simple pali, clearly separated from the base. Respiratory plates completely or incompletely surrounding the bulla (Fig. 2C, D) 4
3'. Palidia with pali strongly close together, sometimes double and united at their base (Fig 2R, S). Respiratory plates incompletely surrounding the bulla 6

4. Maximum body length greater than 8 mm. Palidia long with more than five pali (Fig. 2Q). Respiratory plates completely surrounding the bulla 5
4'. Maximum body length less than 8 mm. Palidia short with two to five pali, septula narrow. Respiratory plates incompletely surrounding the bulla ..... *Macrodactylus* Dejean

5. Epipharynx's haptomerum with four strong, well-differentiated heli (spines on the surface). Tarsungulus of all legs with claws of the same length (Fig. 2M) .... *Isonychus* Mannerheim
5'. Epipharynx's haptomerum with five or more heli. Claws of meso- and metatarsungulus shorter than the protarsungulus (Fig. 2L) .... *Phyllophaga* Harris

6. Respiratory plates with the same diameter in all segments (Fig. 2B). Haptomerum roundish with five heli. Claws of protarsungulus more developed than in the other pairs of legs .... *Demodema* Blanchard
6'. Respiratory plates becoming progressively smaller in the posterior segments (Fig. 2A). Claws of all the tarsungulus poorly developed 7

7. Palidia recurved, convergent at ends, pali closed together (Fig. 2R) .... *Dicrania* Serville
7'. Palidia parallel in the anterior half and very divergent in the posterior half (Fig. 2S-U) 8

8. Palidia with more than one palus united at their base, divergent with the pali nearby and do not continuing to the ventral, anal labium (Fig. 2S) .... *Plectris* Serville
8'. Palidia with simple pali, divergent in the posterior half, at the edge of the ventral, anal labium (Fig. 2U) .... *Anomonyx* Saylor

9. Epipharinx's plegmatia (lateral sides grooved) absent (Fig. 2J, K), heli absent, without palidia, bristles disposed in regular or irregular manner .... Dynastinae 10
9'. Epipharinx's plegmatia present (Fig. 2H, I), two to four heli, frequently with palidia formed by two rows of longitudinal, parallel pali .... Rutelinae 12

10. Haptomerum prominent, entire (Fig. 2K). Without palidia 11
10'. Haptomerum prominent, with a cleft (Fig. 2J). With or without palidia .... *Cyclocephala* Dejean

11. Last antennomere with two sensorial macula (Fig. 2E) .... *Dyscinetus* Harold
11'. Last antennomere with eight dorsal, sensorial macula (Fig. 2F) .... *Diloboderus* Reiche

12. Haptomerum angled without row of heli (Fig. 2I) 13
12'. Haptomerum rounded with row of four heli (Fig. 2H) .... *Paranomala* Casey

13. Palidia present, parallel, bristles around the palidia present or absent 14
13'. Palidia absent (Fig 1N), bristles present, short and thick, disposed regularly on raster .... *Rhizogeniates* Ohaus

14. Haptomerum cleft. Palidia formed by eight to nine pali (Fig. 2W) .... *Leucothyreus* MacLeay
14'. Haptomerum entire. Palidia formed by four to five pali (Fig. 2V) .... *Geniates* Kirby

Distribution of species of Melolonthidae in the Planalto Region of Rio Grande do Sul

Melolonthidae larvae were found at all the municipalities sampled. Among the 28 species of white grubs recorded, *Cyclocephala flavipennis*, *Diloboderus abderus, Plectris* sp., *C. modesta* and *C. putrida* were collected in the majority of municipalities sampled, occurring in 18, 17, 10, 9 and 8 localities, respectively (Fig. 3). A second assemblage of species occurred in four to seven localities. It is represented by *Macrodactylus* sp., *Dyscinetus gagates* (four localities), *Phyllophaga triticophaga*, *Leucothyreus* sp.1 (five localities), *Isonychus albicinctus*, *C. tucumana* (six localities) *Paranomala violacea* and *Geniates* sp. (seven localities). Only two species were recorded in three localities, *Rhizogeniates* sp. and *Anomonyx* sp. The species *Leucothyreus* sp.2, *Liogenys* sp., *L. fusca*, *L. bidenticeps*, *Dicrania* sp., and *C. metrica* occurred only in two localities. *Dyscinetus rugifrons, Demodema brevitarsis*, *Liogenys obesa*, *L. sinuaticeps*, *Leucothyreus* sp.3, *Leucothyreus* sp.4 and the unidentified species of Sericini were each one recorded only at a single locality: Tapejara, Santa Rosa, São

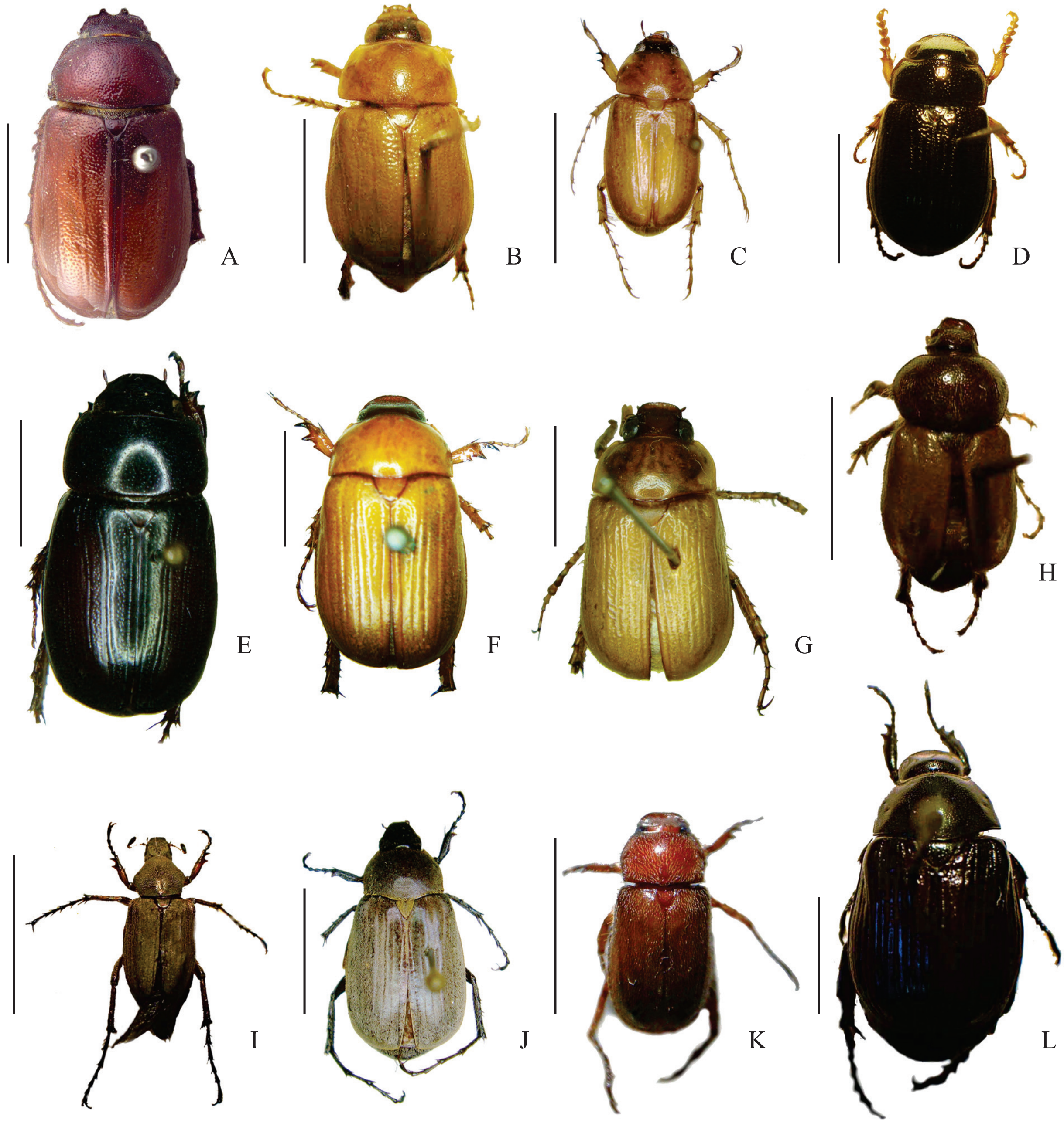

Fig. 1. Adults of species reared in the laboratory. *Liogenys fusca* (A), *Cyclocephala tucumana* (B), *C. metrica* (C), *Leucothyreus* sp.2 (D); *Dyscinetus rugifrons* (E), *Geniates* sp. (F), *Rhizogeniates* sp. (G), *Dicrania* sp. (H), *Macrodactylus* sp. (I), *Isonychus albicinctus*. (J), *Anomonyx* sp. (K), *Paranomala violacea* (L). Scale bar, 5 mm.

Luiz Gonzaga, Manoel Viana, Caseiros, Porto Lucena and Chapada, respectively.

The occurrence of a species in a higher number of localities could indicate a greater capacity to adapt to soil and climate conditions, as verified for *Cyclocephala flavipennis* and *Diloboderus abderus* (Pereira & Salvadori 2006). Salvadori and Pereira (2006) reported that *D. abderus* is widely distributed in Rio Grande do Sul, but *P. triticophaga* only occurs in some areas of the northeastern and northern Planalto. Municipalities with major richness of melolonthid species were Caseiros with 13, Vila Maria with 10, Guabiju and Três Palmeiras with nine and Nova Palma with seven species. Most municipalities showed an intermediate richness: Ijuí, Manoel Viana, Panambi, Tapejara and Vacaria with six species each and Coxilha, Cruz Alta, Dois Irmãos das Missões, Itaara, Lagoa Vermelha, São Luiz Gonzaga and Tupanciretã with five species each. The lowest richness (two species) was registered in Nonoai, followed by Chapada, Porto Lucena and Santa Rosa, with three species each. The regional richness is heterogeneous since the localities sampled varied in number of species and composition, with larger assemblages in the northeast, corresponding to *Campos de Cima da Serra* sub-division and the

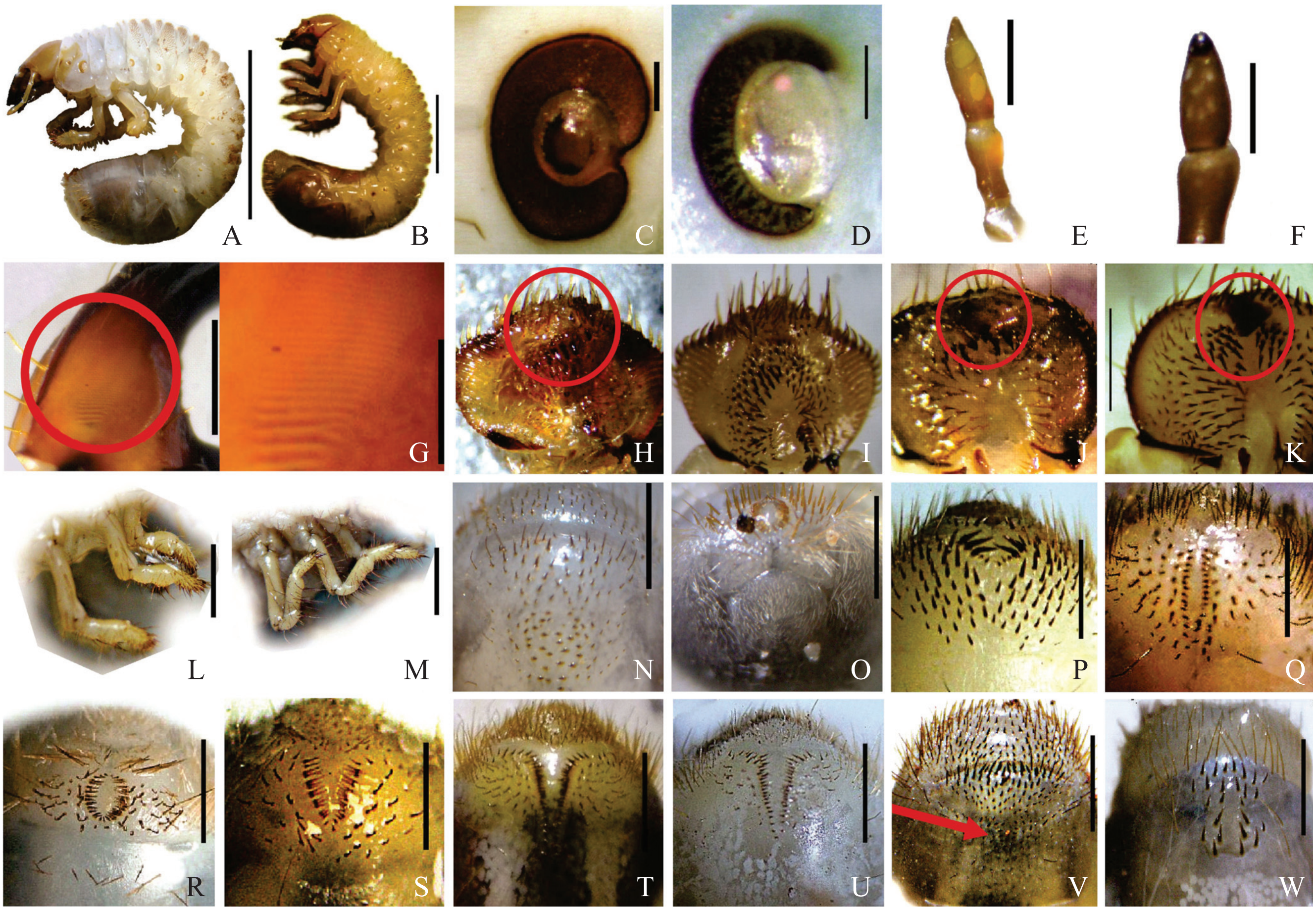

Fig. 2. Diagnostic structures used in the identification key. Size of respiratory plates of *Dicrania* (A) and *Demodema* (B). Bulla of the spiracles, complete (C) and incomplete (D). Sensorial macula of the last antennomere (E, F). Mandibula with stridulatory area (G). Epipharynx showing haptomerum (H-K) and plegmatia (H, I). Tarsal claws (L,M). Anal opening transverse (N) and V or Y-shaped (O). Raster with different types of palidia (P-W). Scale bars: (A-B) 10 mm, (C-D) 0.5 mm, (G-K) 1 mm, (P-W) 3 mm.

southern and eastern *Planalto Médio* sub-division. The northwest was the poorest sub-region in number of species. According to Morón (2001), who evaluated melolonthid diversity in Mexico, the regional richness pattern depends on the soil type, mean temperature and rainfall of each region.

The present study showed a trend to find a higher number of species in wetter and colder sub-regions of the state. These species would be adapted to a lower climatic variability and, therefore, would clearly prefer moist soil conditions for oviposition compared to endemic species adapted to variable regimes, which would be able to oviposit in soil areas with more variable water content (Ward & Rogers 2007). Latosols occupy most of Rio Grande do Sul (Streck *et al.* 2008) and, thus, species diversity would not be conditioned by this variable. In Australia, some species of the sugarcane white grub complex (Coleoptera, Melolonthinae), for example, *Dermolepida albohirtum* Waterhouse, *Holotrichia reynaudi* Blanchard and *H. serrata* (F.) are found preferentially in soils in the same geographic region with different levels of clay. These distribution patterns are, therefore, dependent on limiting environmental factors for oviposition and/or mortality of eggs and larvae (Ward & Rogers 2007). In the Planalto of Rio Grande do Sul, besides the clay content, other variables need to be investigated, such as host plants, cultivation systems, concentrations of organic matter, altitude, competition, and natural enemies, among others.

In this survey, the composition of species assemblages varied from one municipality to another. The five most common species, as showed in Fig. 3 (*Cyclocephala flavipennis*, *Diloboderus abderus, Plectris* sp., *C. modesta* and *C. putrida*), were only recorded together in Caseiros municipality, whereas species combinations varied in the other municipalities. *Cyclocephala flavipennis* and *Diloboderus abderus* occurred together at 12 localities, confirming their wide geographic and ecological distribution in the state, and consequently, the capacity to adapt to changes caused by agriculture and deforestation. Therefore, their occurrence together demands correct larval identification during monitoring to avoid inadequate management and crop infestations, since *Cyclocephala flavipennis* do not cause economic loses even with 100 larvae per square meter (Pereira & Salvadori 2006). Although *Phyllophaga triticophaga* is one of the most important pest species in Rio Grande do Sul (Salvadori & Pereira 2006), it was not widely distributed and occurred in

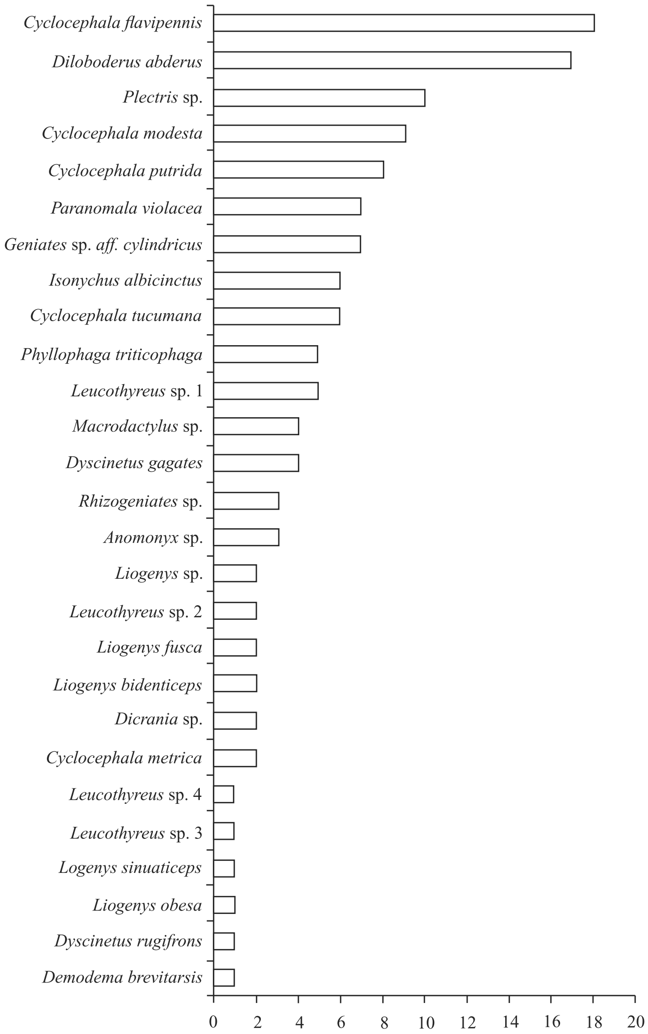

Fig. 3. Melolonthid species and number of municipalities that each one occurs in Rio Grande do Sul Planalto region, in 2009 and 2010.

only five localities. *Isonychus albicinctus,* collected from six localities, could be easily confused with *Phyllophaga* in the larval stage, but its occurrence in Rio Grande do Sul is poorly documented. Therefore, a correct identification of the larva during the monitoring of an area is indispensable for avoiding unnecessary white grub control.

The five species of *Liogenys* were distributed between Caseiros, Chapada, Cruz Alta, Ijuí, Manoel Viana, São Francisco de Assis and São Luiz Gonzaga municipalities. The only species known as an important pest is *L. fusca* (Santos *et al*. 2008; Costa *et al*. 2009) but it supposedly does not cause damage to crops in the Planalto region (Cherman *et al*. 2011). Thus, high richness of *Liogenys* observed in the present survey means that studies on biology and feeding habits of this group is necessary, to avoid an increase in the population of rhizophagous species which could be potential pests. The distribution and ecology of the species recorded from one to four localities is poorly described in the literature, except for *Demodema brevitarsis.* Although this species was found only in the Tapejara municipality, it is known to cause damage to both winter and summer grain crops, apparently due to its irregular biological cycle, currently under study by the EMBRAPA Wheat Centre (Morón & Salvadori 2006).

In view of the results discussed, it is recommended that the methods for breeding and studying the biology of species, especially of *Plectris*, *Macrodactylus* and *Liogenys*, the most diverse genus, should be improved, considering the rhizophagous habits of their larvae. The similarity between larvae of *Isonychus* and *Phyllophaga* in the studied area demands more detailed taxonomic and biological studies since the former genus has become a pest in Minas Gerais, in southeastern Brazil.

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