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Ocorrência de formigas cortadeiras em campos de altitude no sul do Brasil

Occurrence of the leaf-cutters ants in the high-altitude grasslands in the south Brazil

Ocurrencia de la hormiga cortadoras en los campos de altitud del sur de Brasil

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Resumo

Remanescentes do ecossistema Campos Altitude são encontrados na microrregião de "Campos de Lages", SC, sul do Brasil. O objetivo deste trabalho foi avaliar e identificar espécies de formigas cortadeiras que ocorrem em Campos de Altitude. O estudo foi realizado entre os meses de Agosto de 2012 e Dezembro de 2013, em 18 municípios da micro-região de "Campos de Lages", Santa Catarina, sul do Brasil. No total, 75 formigueiros de cortadeiras foram localizados, medidos e georreferenciados, apresentando 16 formigueiros pertencentes ao gênero *Atta* e 59 do gênero *Acromyrmex*. Amostras de formigas de diferentes castas foram recolhidas de cada formigueiro para identificação adequada. Uma espécie foi identificada no gênero *Atta*, *A. sexdens piriventris* e oito no gênero *Acromyrmex*, *A. laticeps*, *A. heyeri*, *A. Iundii*, *A. crassispinus*, *A. ambiguus*, *A. aspersus*, *A. coronatus*. As espécies *Atta sexdens*

piriventris, *Ac. laticeps* e *Ac. heyeri* foram as mais frequentes. Espécies pertencentes ao gênero *Acromyrmex* foram localizadas em altitudes acima dos 1000 metros, e tamanho médio de formigueiros de 1,04 ± 0,93 m^2. Formigueiros do gênero Atta foram localizados em altitudes de até 850 metros, e apresentaram um tamanho médio 132,75 ± 12,96 m^2 de área total de superfície, considerando à área dos olheiros.

Palavras-chave: Formigas; Campos de Lages; Biodiversidade; *Atta*; *Acromyrmex*.

Abstract

Remnants of the Campos Altitude ecosystem are found in the "Campos de Lages" micro-region, SC, southern Brazil. The objective of this work was to evaluate and identify species of leaf-cutter ants that occur in Campos de Altitude. The study was conducted between the months of August 2012 and December 2013, in 18 municipalities of the micro-region of "Campos de Lages", Santa Catarina, southern Brazil. In total, 75 cutter anthills were located, measured and georeferenced, which presented 16 anthills belonging to the genus Atta and 59 to the genus Acromyrmex. Samples of ants from different castes were collected from each anthill for proper identification. One species has been identified in the genus *Atta*, *A. sexdens piriventris* and eight in the genus *Acromyrmex*, *Ac. laticeps*, *Ac. heyeri*, *Ac. Iundii*, *Ac. crassispinus*, *Ac. ambiguus*, *Ac. aspersus*, *Ac. coronatus*. The species *Atta sexdens piriventris*, *Ac. laticeps* and *Ac. heyeri*, were the most frequent. Species belonging to the genus *Acromyrmex* were located at altitudes above 1000 meters, and average anthills size of 1.04 ± 0.93 m2. Atta anthills were located at altitudes of up to 850 meters, and had an average size of 132.75 ± 12.96 m2 of total surface area, considering the area of entrance roles.

Keywords: Ants; Campos de Lages; Biodiversity; *Atta*; *Acromyrmex*.

Resumen

Remanentes del ecosistema de los Campos de Altitud se encuentran en la microrregión de los "Campos de Lages", SC, en el sur de Brasil. El objetivo de este trabajo fue evaluar e identificar las especies de hormigas cortadoras que ocurren en Campos de Altitud. El estudio se realizó entre los meses de Agosto de 2012 y Diciembre de 2013 en 18 municipios de la microrregión de "Campos de Lages", Santa Catarina, en el sur del Brasil. En total, se localizaron, midieron y georeferenciaron 75 hormigueros cortadores, que presentaron 16 hormigueros pertenecientes al género *Atta* y 59 al género *Acromyrmex*. En cada hormiguero se recogieron muestras de hormigas de diferentes castas para su adecuada identificación. Se ha identificado una especie en el género *Atta*, *A. sexdens piriventris* y ocho en el género

Acromyrmex, *Ac. laticeps*, *Ac. heyeri*, *Ac. Iundii*, *Ac. crassispinus*, *Ac. ambiguus*, *Ac. aspersus*, *Ac. coronatus*. Las especies *Atta sexdens piriventris*, *Ac. laticeps* y *Ac. heyeri*, fueron las más frecuentes. Las especies del género *Acromyrmex* fueram localizados en altitudes superiores a los 1000 metros, y un tamaño medio de hormiguero de 1,04 ± 0,93 m^2. Los Hormigueros *Atta* se encontraban en altitudes de hasta 850 metros, y tenían un tamaño medio de 132,75 ± 12,96 m2 de superficie total, considerando el área de los exploradores.

Palabras clave: Hormigas; Campos de Lages; Biodiversidad; *Atta*; *Acromyrmex*.

1. Introduction

The leaf-cutter ants, *Atta* and *Acromyrmex*, are among the best-known ants in the Americas (Mueller et al., 2017). Its taxon's is distributed from the northern United States (40° "N"), to the far south of the Americas, in Argentine Patagonia (41° "S") (Rabeling et al., 2007). Its importance is due to the damage caused to agriculture, since it needs to cut down vegetative material to cultivate its symbiotic fungus, which represents the real food source of these ants (Lazzari et al., 2019). Practicing an "advanced agriculture", comparable only to that practiced by man (Della lucia et al., 2011).

The leaf-Cutter ants perform important ecological functions in different natural ecosystems and even in agroecosystems, contributing to the secondary dispersion of seeds, combined with the breaking of dormancy of several plant species, mainly native ones (Swanson et al., 2019). They also promote an increase in the concentrations of nutrients in the soil, generating improvements in its fertility (Leal et al., 2014). According to Mehdiabadi and Schultz (2010) the leaf-cutting ants are widely adapted to various environments, ranging from native forests to areas of intensive agricultural use. Studies on the leaf-cutter ants show that there are differences in the behavior between genera, species and even within the ant species itself, located in different environments (Giesel et al., 2013). The geographical distribution of leaf-cutter ant species can be influenced by several factors, from the soil and climate characteristics of a region to the availability of plants in a given location (Meyer et al., 2006).

According to Toledo et al. (2016), leaf-cutting ants are adapted to various environments, from native forests, natural fields and areas of intensive agricultural use, thus showing the influence of environmental factors, such as phytogeographic changes, on their mode of survival.

Regional phytogeographic formations determine, for the most part, the rich diversity of Brazilian flora and fauna intrinsic to the biomes (Costa-Coutinho et al., 2019). In the south

of Brazil, the Atlantic Forest biome presents differences in relation to the Southeast and Northeast regions, due to the predominance of phytogeographic formations that shelter singular ecosystems of the Atlantic Forest and high-altitude grasslands (Longhi-Wagner et al., 2012).

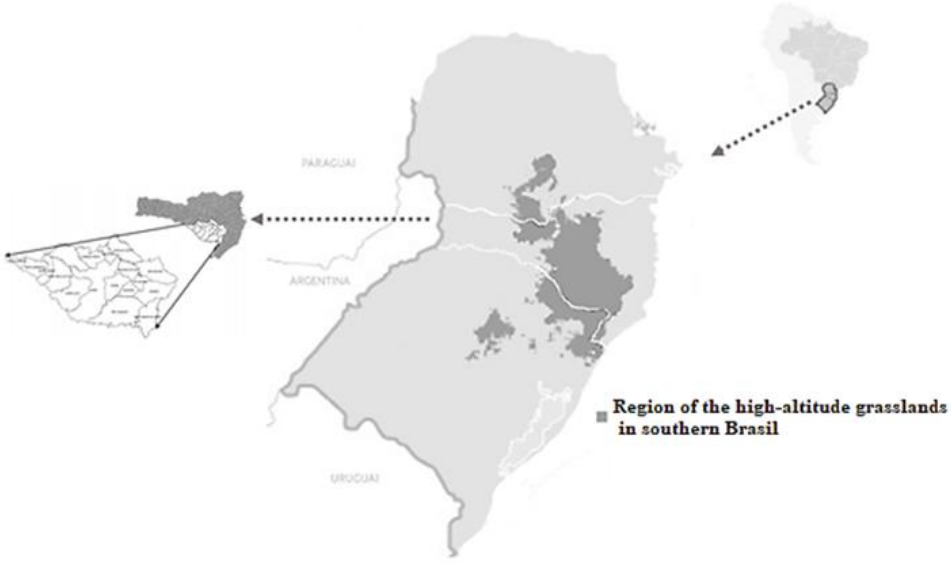
The ecosystems of high-altitude grasslands, in southern Brazil, are recognized as important centers of endemism of the world's Neotropical flora and fauna (Iganci et al., 2011). The soil condition of the high-altitude in southern Brazil, are characterized by the low depth of the soil profile, and the low natural fertility, with rupture in the natural sequence of plant species present in the surrounding physiognomic formations (Lopes et al., 2010). The high-altitude grasslands are formed by a singular biodiversity with marked presence of plant and animal species endemic to these ecosystems (Iganci et al., 2011). However, in recent years, has been observed a rapid and growing substitution of grasslands by agricultural activities, mainly forestry, by the introduction of exotic species such as *Pinus* ssp., annual crops and orchards, which threaten the biodiversity of high-altitude grasslands in southern Brazil (Lopes et al., 2010).

These landscape changes directly influence the population dynamics of numerous animals (Vibrans et al., 2011), acting directly on the distribution, wealth and diversity of numerous species, including leaf-cutter ants. Due to the ecological role played by leaf-cutter ants, they can serve as indicator tools of environmental conservation, thus needing to make the recognition of different species present in a given environment. Thus, this work aimed to study the diversity of *Atta* and *Acromyrmex* cutter ants, and the relationship of this diversity with the environment, in the Microregion of Campos de Lages, SC.

2. Methodology

The survey was conducted during the period from August 2012 to December 2013, in the “Campos de Lages” Region, Santa Catarina State, southern Brazil. This region comprises 18 municipalities with total area of 15.725 km2 (IBGE 2019), with particular phyto-geographic formation, called High-altitude grasslands (Fig. 1).

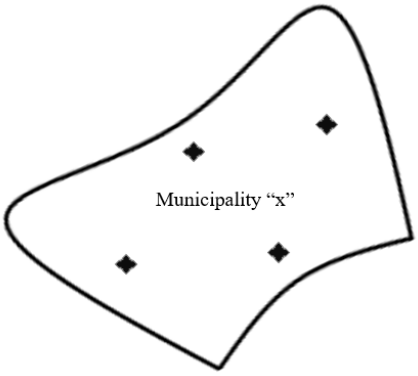
Figure 1 - Geographic map of the South Region of Brazil showing the ecosystem of high-altitude grasslands. Having indicated micro-region of "Campos de Lages", Santa Catarina state, Brazil.



Source: Authors.

In each municipality, 4 equally distributed collection locations were established, in this way, we tried to cover the variations in the environmental gradient existing in each municipality (Fig. 2). In each location a single sample was collected, the latter being individualized in bottles containing 70% alcohol, with at least 10 individuals. At the time of collection, we tried to select the largest individuals present in the anthills or in the tracks if the anthill was not found.

Figure 2 - Collection scheme and sampling points in each municipality the ecosystem of high-altitude grasslands in "Campos de Lages" region, Santa Catarina State, Brazil.



Source: Authors.

The anthills were located by means of the observation of tracks with the presence of ants performing foraging activity and / or by the direct observation of the ants of both genera Atta and Acromyrmex, throughout the particular external anatomy characteristics (Della Lucia et al., 2011). The ants were located through the observation of tracks with the presence of ants performing foraging activity and/or through direct observation of the ants of both *Atta* and *Acromyrmex* genera. They were considered to belong to the genus *Acromyrmex*, ants that presented 4 pairs of thorn in the back, and anthill covered with a mixture of straw and earth in unique formation. Ants that had 3 pairs of thorns on the back, with anthill with the appearance of ploughed earth, generally occupying a large area, with innumerable outlets, were considered belonging to the genus *Atta* (Della Lucia et al., 2011).

Once the anthills were identified, they were geo-referenced with manual GPS (Garmin Etrex®). The superficial measurement of the area of each anthill was performed by the method of evaluation of the largest diameter by the smallest, using a 50-meter topographic tape measure (Lukfin®). In each anthill, sampling of ants was performed with the collection of one hundred (100) individuals with the aid of entomological tweezers. The identification of the species was performed in the laboratory by observation the morphological characterization throughout stereoscopic microscope with magnification of 40x. For identification of the species, a systematic key described by Della Lucia et al. (2011), Sub-samples were sent to the taxonomist Dionisio Link of the Federal University of Santa Maria (UFSM) for species confirmation.

Once the results were obtained, they were submitted to faunistic analysis, based on the works of Silveira Neto et al. (1976) and Loeck et al. (2003). Estimating the following parameters:

a) Frequency: represents the proportion of individuals of a species in relation to the total number of individuals in the sample: $p_i = \frac{n_i}{N}$ where n_i: number of individuals of species i and N: total individuals of the sample.

b) Constance: Percentage of samples in which a certain species was present.

$C = \frac{p.100}{N}$ Where p: number of samples with the species and N: total number of samples taken.

Classification of species in terms of constancy:

- Constant species: present in more than 50% of samples;
- Species ancillary: present in 25-50% of samples;
- Accidental species: present in less than 25% of the samples.

c) Richness (S): Total number of species observed in the community.

d) Number of dominant species: dominant species is one with a frequency above 1/S, where S is the total number of species in the community.

e) Simpson index: It is an index of dominance and reflects the probability of two randomly chosen individuals in the community belonging to the same species. Varies from 0 to 1 and the higher it is, the greater the likelihood that individuals be of the same species, i.e. greater dominance and less diversity.

f) Shannon index: Measures the degree of uncertainty in predicting to which species a randomly chosen sample with S species and N individuals will belong. The lower the value of the Shannon index, the lower the degree of uncertainty and, therefore, the diversity of the sample is low. The diversity tends to be higher the higher the value of the index. It is calculated using the formula: $\lambda = \sum_{1}^{S} p_i^2$

Were p_i: proportion of each species, for i ranging 1 to S (Richness), and p_i: frequency of the species i.

3. Results and Discussion

In total, 75 anthills of both *Atta* and *Acromyrmex* genera were sampled, presenting a relatively high specific value of richness for the high-altitude grasslands in "Campos de Lages" region (Table 1).

Table 1 - Faunistic analysis of leaf-cutter ants species sampled from the ecosystem of high-altitude grasslands in "Campos de Lages" region, Santa Catarina State, Brazil, 2011.

Parameters	**Value**
Richness (S)	9
Simpson index	0,30
Shannon index	1,49
Number of species	
dominance	2
no-dominance	7
Number of species	
constancy	1
accessory	2
accidental	6

Source: Authors.

The Diversity Indexes showed that there is not a kind of leaf-cutting ant dominant in the region, because we have a low Simpson index (0.30) and a high Shannon index (1.49) (Table 1). This can be proved by the low number of species classified as dominant (2), in relation to non-dominant (7) (Table1). And also, in relation to the constancy of species, where only one species was classified as constant, the others being considered accessory (2) and accidental (6) (Table 1). In a study by Ricalde et al. (2012) in the campaign region in the State of Rio Grande do Sul, the occurrence of ants cut in the area with the presence of vineyards was verified. In this work, the occurrence of 8 species was identified, all belonging to the genus *Acromyrmex*. According to the authors, the dominance of 3 species was verified, *A. ambiguus*, *A. heyeri*, *A. lundii*, differing from the present study, in which there was dominance of 2 species, *Atta sexdens piriventris* e *Acromyrmex laticeps* (Table 1 and 2). Such differences may be related to environmental factors that characterize the different environments, with emphasis on the relief, altitude and temperature, which may favor the occurrence of certain species over others.

In the areas with some small field crops and plantation of *Pinus* sp. it was observed the occurrence of eight species of leaf-cutting ants of the genus *Acromyrmex*: *Ac. laticeps* (Emery), *Ac. heyeri* (Forel), *Ac. lundii* (Guerin-Meneville), *Ac. crassispinus* (Forel), *Ac.*

ambiguus (Emery), *Ac. aspersus* (F. Smith), *Ac. coronatus* (Fabricius), *Ac. lobicornis* (Santschi) and only one species of the genus *Atta: A. sexdens piriventris* (Santschi) (Table 2).

Table 2 - Frequency, dominance and constancy the leaf-cutter ants species sampled from the ecosystem of high-altitude grasslands in "Campos de Lages" region, Santa Catarina State, Brazil, 2011.

Species	N[1]	Frequency (%)	Dominance[2]	Constancy[3]
Atta sexdens piriventris	17	22.66	d	y
Acromyrmex laticeps	36	48.00	d	w
Acromyrmex heyeri	11	14.68	n	y
Acromyrmex lundii	4	5.35	n	z
Acromyrmex crassispinus	2	2.66	n	z
Acromyrmex ambiguus	2	2.66	n	z
Acromyrmex aspersus	1	1.33	n	z
Acromyrmex coronatus	1	1.33	n	z
Acromyrmex lobicornis	1	1.33	n	z
Total	75	100		

[1]number of anthills; [2]d: dominance, n: no-dominance; [3]w: constancy, y: accessory, z: accidental.
Source: Authors.

The species of leaf-cutting ants with larger dominance were *Ac. laticeps* (48,00 %), *A. sexdens piriventris* (22.66%) and *Ac. heyeri* (14.68%) (Table 2). The species *Ac. Laticeps* was the most frequent leaf-cutter ant species and also the larger abundant (Table 2). The species *Ac. coronatus*, *Ac. asperses*, *Ac. lobicornis* and *Ac. Ambiuus*, were the species with the lowest frequency and abundance for the high-altitude grasslands, In the work conducted by Grurzmacher *et al*., (2002), in the Central Region of Rio Grande do Sul, were identified 6 predominant species, *Ac. lundii* Guerin (23.91%), *A. sexdens piriventris* (22.89%), *Ac. ambiguus* (16.86%), *Ac. heyeri* (14.04%), *Ac. striatus* (6.85%) and *Ac. laticeps* (6.7%), *Ac. lundii* Guerin (23.91%), *A. sexdens piriventris* (22.89%), *Ac. ambiguus* (16.86%), *Ac. heyeri* (14.04%), *Ac. striatus* (6.85%) and *Ac. laticeps* (6.7%). Comparing the occurrence of leaf-cutter ant species between the Central Region of Rio Grande do Sul and the high-altitude grasslands of Santa Catarina State, species of *A. sexdens piriventris* and *Ac. Heyeri* were dominant in both regions. Considering the geographic distribution of leaf-cutting ants in the Southern Region of Rio Grande do Sul, Gusmão *et al*., (2002) identified 7 species of leaf-cutting ants with predominance of *Ac. lundii*, *Ac. ambiguous* and *Ac. striatus*. The results

obtained in the survey in the micro-region of "Campos de Lages" showed a difference in the predominance of the species *Ac. laticeps.*

Although the species *A. sexdens piriventris* was considered frequent (Table 1 and 2), because it was present in 17 of the 75 foraged plants sampled, this species was found in only seven of the 18 municipalities that comprise the region of the high-altitude grasslands in Santa Catarina State (Table 1 and 2). The dominance index presented by the species *A. sexdens piriventris* (22.67%), (Table 1) was similar to that observed by Grutzmacher *et al*., (2002) from the Central Region of Rio Grande do Sul where the species *Ac. lundii* and *A. sexdens piriventris*, presented dominance of 23.91 and 22.89%, respectively. The occurrence of a single species of the genus *Atta* in the region of high-altitude grasslands in Santa Catarina State (Table 3), corroborates with Della Lucia *et al*., (2011), who consider the species as one of the most frequent in the southern region of Brazil. According to Loeck *et al*., (2001), *A. sexdens piriventris* predominates in the Northern regions of Rio Grande do Sul State nearby Santa Catarina State.

The Table 3 shows that in the municipality of Capão Alto, ants from four different species of the genus *Acromyrmex* were identified: *Ac. laticeps*, Ac. *heyeri*, *Ac. ambiguus* and *Ac. lobicornis*. The species *Ac. coronatus*, *Ac. asperses*, *Ac. lobicornis* and *Ac. ambiguus* were the species that presented low frequency and low abundance in the geographical region of the study, with a dominance of 1.33%, with species classified as rare according to the index of abundance (Table 1). In a study carried out by Loeck *et al*., (2005) in Rio Grande do Sul, the species *Ac. ambiguus, Ac aspersus* and *Ac coronatus*, showed also low frequency and rare abundance. Whereas the species *Ac. lobicornis* proved to be common for the geographical region of the study, a similar result to that found in our study, being classified as rare for the region of the study differentiating itself from our study. In studies by Solomon *et al*., (2008), he describes that the regional groupings of cutting ant species are associated with the existing differentiation in the soil-biogeographic conditions existing in each region. According to Vibrans *et al*., (2011), some species of leaf-cutting ants may be widely distributed in different tropical and temperate regions. Whereas other species may be considered as endemic to a given ecosystem.

The occurrence of the species *Ac. coronatus*, *Ac. asperses*, *Ac. lobicornis* and *Ac. ambiuus*, considered rare in the micro-region high-altitude grassland (Campos Naturais de Altitude). It may be associated with the migration of leaf-cutting ants from other surrounding regions, due to the availability of food generated by the increase in cultivated areas with monocultures of *Pinnus* spp. and *Eucalyptus* spp.. In this way, the gradual replacement of

areas of native vegetation and natural fields by commercial forests has altered the floristic and faunal composition of the high-altitude grasslands, micro-region of "Campos de Lages" and has favored the immigration and establishment of previously non-existent species of leaf-cutting ants.

The epidemic proliferation of insects is directly related to symptoms of environmental imbalances existing in the agro-ecosystem (Gliessman, 2000). One example is the leaf-cutting ants that, in a condition of change in floristic composition, show themselves to be opportunistic insects increasing their behavioral activities causing damage to agriculture (Giesel *et al*., 2013). The dominance of leaf-cutting ants, *A. sexdens piriventris* and *Ac. laticeps*, in the high-altitude grasslands, Catarina State, may be correlated to the reduction of areas of forest remnants and mainly due to the advance in agricultural and forest monoculture areas. This is confirmed by the work carried out by Delabie *et al*., (2011) where the species *A. sexdens piriventris* and *Ac. laticeps* are reported to be widely distributed throughout the country, with a higher frequency in the southern states of Brazil, especially in Rio Grande do Sul state, which has large areas with commercial reforestation and agricultural monocultures.

Another example of these particularities is the survey carried out by Rando and Forti (2005), in 10 Brazilian states, they recorded for the first time the occurrence of the species *Ac. rugosus* (Smith), in Santa Catarina state in the municipalities of Chapecó, Xanxerê and Campos Novos. In the same work, the species *Ac. balzani*, *Ac. disciger* and *Ac. subterraneus* were also described as occurring in the Santa Catarina state, in the municipalities of Curitibanos, Blumenau and Pouso Redondo. However, these species were not observed in any of the micro-region municipalities of the high-altitude grasslands, where we have been studying. The results of the above-mentioned surveys confirm that the influence of physiognomic changes in a given region favors the occurrence of species of leaf-cutting ants, since the municipalities covered by the study of Rando and Forti (2005), present different agricultural characteristics from the high-altitude grasslands, micro-region of "Campos de Lages".

Tropical ecosystems are highly biomass-producing, so they can host a greater number of animal species, including leaf-cutting ants (Baccaro *et al*., 2015). The subtropical climate of the micro-region of the high-altitude grasslands, accompanied by harsh winters it is certainly a determining factor in the diversity of species of leaf-cutting ants raised. This climate of subtropical regions, such as the high-altitude grasslands, the largest richness of cut ant species that anthill in the ground or in open, unshaded areas such as field areas, with their formulators exposed to sun or outside temperatures, where the temperature can be controlled

by the ant population (Nickele et al., 2016). This may be related to the fact that leaf-cutting ants are thermophilic insects. Regions with low temperatures associated with dark environments have a stressful effect on leaf-cutting ants (Bollazzi et al., 2008). On the other hand, micro-regions with cold environments, but high incidence of sunlight can favor the diversity of species of leaf-cutting ants such as those collected in our survey (Table 1).

Therefore, the different plant physiognomics presented in the high-altitude grasslands, micro-region of "Campos de Lages", associated with the remnants of araucaria forest, contributed to the diversity of species of leaf-cutting ants by providing habitats conducive to colonization, survival and multiplication. According to Albuquerque and Diehl (2009), the structural complexity of the vegetation of a given region is reflected by the diversity of species of animals that are dispersed in this habitat.

The predominance of *Ac. laticeps* may be correlated to distinct characteristics among regions such as geographical relief differences, climate vegetation, among others. The species *Ac. laticeps* also had a higher occurrence, since it was collected in 37 of the 75 sampled ant nests, being present in most of the municipalities of high-altitude grassland (Table 3).

Table 3 - Distribution and characterization of ants and cutter ant species sampled in the different municipalities of the high-altitude grasslands, micro-region of "Campos de Lages", Santa Catarina state, Brazil, 2011.

Species	Municipalities	Coordinates				Geographic Altitude (meter)	Anthill area (meter^2)
		X[1]	x[2]	Y[1]	y[2]		
Acromyrmex laticeps	Anita Garibaldi; Bocaína do Sul; Bom Jardim da Serra; Bom Retiro; Campo Belo do Sul; Capão Alto; Celso Ramos; Correia pinto; Lages; Otacílio Costa; Painel; Palmeira; Rio Rufino; São Joaquim; Urubici; Urupema.	-27.43	-28.26	-49.51	51.89	1000.34±221.47	1.01±0.42
Atta sexdens piriventris	Anita Garibaldi; Campo Belo do Sul; Capão Alto; Celso Ramos; Cerro Negro; Correia Pinto; Lages; Painel.	-27.62	-27.99	-50.46	51.35	859.75±98.92	126.22±37.08
Acromyrmex heyeri	Bocaina do Sul; Bom Jardim da Serra; Campo Belo do Sul; Capão Alto; Cerro Negro; Correia Pinto; Lages; Otacílio Costa; Painel; Palmeira; Rio Rufino.	-27.46	-28.35	-49.62	50.88	1000.63±142.97	1.01±0.45
Acromyrmex *lundii*	Bocaína do Sul; Otacílio Costa; Palmeira	-27.48	-27.73	-49.43	50.17	865.75±13.57	0.63±0.51
Acromyrmex crassispinus	Bom Retiro; Urubici.	-27.81	-28.05	-49.54	49.43	921.50±58.68	0.37±0.23
Acromyrmex ambiguus	Capão Alto; Cerro Negro.	-27.89	-27.93	-49.34	50.54	960.01±52.32	0.51±0.04
Acromyrmex lobicornis	Capão Alto.	-27.73	-	-49.05	-	890	0.68
Acromyrmex aspersus	Correia Pinto.	-27.59	-	-50.38	-	879	1.32
Acromyrmex coronatus	Lages.	-27.90	-	-50.32	-	967	1.23

[1]Minimum limit and [2]Maximum limit. Source: Authors.

The leaf-cutting ants of the genus *Atta* were located between the coordinates, -27.62 to -27.78 (x) and -50.92 to -51.22 (y) (Table 3). The ants of the genus *Acromyrmex* were located at the coordinates -27.41 to -28.38 (x) and -49.43 to -51.89 (y) (Table 3).

Another aspect observed in our study was the relationship between altitude and the size of the anthills. The anthills of the species *A. sexdens piriventris* had an average diameter

of 132.75 ± 12.96 m^2, located at an average altitude of 856.37 m. *Acromyrmex* anthills had an average diameter of 1.04 ± 0.93 m^2, located at an average altitude of 992.87 m. There was no correlation between anthills size and altitude for both *Atta* (r = 0.3; p > 0.05) and Acromyrmex (r = 0.4; p > 0.05) genera. Anthills of the species *A. sexdens piriventris* were located at a maximum altitude of 972.85 m in the municipality of Campo Belo do Sul. *Acromyrmex* spp. anthills were found at a maximum altitude of 1.467 m in the municipality of Urupema. The altitude influenced the presence of anthills of both species studied, mainly the presence of *A. sexdens piriventris* which was limited to altitudes below 972.85 m.

Similar results were observed by Grandeza et al. (1999) on behavioral aspects of ants *A. sexdens rubropilosa* Forel and *A. laevigata* F. Smith in the Northwest Region of Minas Gerais, because the anthills of these species were located in an average altitude of 830 m. The smaller size of *Acromyrmex* anthill is related to the smaller internal volume of anthill, which ranges from 0.3 to 1.5 L, with the presence of a maximum of 3 chambers (Fort et al., 2011). On the other hand, anthill of *A. sexdens piriventris* may present dozens of internal chambers (Fort et al., 2011).

According to Della Lucia *et al*., (2011), these differences in the size and location of anthill beds may be related to co-evolutionary aspects of adaptation of the species to the different available environments and also to their survival strategies. According to Moreira *et al*., (2002), the shape of ants is one of the characteristics initially observed in the field for identification of species, but small or large variations may occur, depending on the species of leaf-cutter ant that occurs. Despite the small peculiarities of each species in relation to the shape of the anthill and the choice of nesting site in different regions of the country, there may be serious errors of species identification when only this factor is observed in the field (Moreira *et al*., 2002).

Thus, the characterization of species is of fundamental importance, especially in relation to species as a great ecological and economic value as in the case of leaf-cutting ants (do Nascimento et al., 2020). According to Baccaro *et al*., (2015), Brazil has the second largest diversity of ants in the world. In the case of leaf-cutting ants, several species have a wide distribution and abundance in the Brazilian territory, but many of them are endemic. Thus, the correct recognition of the different genera and species in the different regions of Brazil is essential to verify their behavioral habits, which will facilitate their management and the very ecological conservation of the species.

Another important factor is the elaboration of species recognition materials that are practical in the field since the existing systematic keys for the identification of species of leaf-

cutting ants require monitoring in entomological laboratories, which in many cases brings the slowness of species recognition and can thus compromise the proper management of the target species.

4. Conclusion

In the high-altitude grasslands. “Campos de Lages” region. Southern Brazil, there are eight species of ant genus *Acromyrmex: Ac. laticeps*, *Ac. heyeri*, *Ac. lundii*, *Ac. crassispinus*, *Ac. ambiguus*, *Ac. asperses*, *Ac. coronatus* and *Ac. lobicornis*. *Atta* genus has only one species, *A. sexdens piriventris*. The most frequent species is *Ac. laticeps* and the least frequent were *Ac. crassispinus*, *Ac. ambiguus*, *Ac. asperses*, *Ac. coronatus* and *Ac. lobicornis*. The species *A. sexdens piriventris* is present in 8 of the 18 municipalities comprising the region we studied. *Acromyrmex* spp. tingles are located at an elevation higher than those observed for *A. sexdens piriventris* species, which may be a limiting factor for the distribution of the species.

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