Effect of Attractiveness of Protein and Glucose Baits in Estuarine Ant Communities in Southern Brazil

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Abstract

Salt marshes are intertidal coastal ecosystems flooded irregularly by salt water. Ants (Hymenoptera: Formicidae) are important predators of invertebrates in most ecosystems and are prominent herbivores in many Neotropical communities, including salt marshes. The aims of this study are to quantify the feeding preference of ant communities and to estimate the diversity and similarity along the Lagoa dos Patos Estuary salt marshes. We chose three salt marshes in Lagoa dos Patos Estuary along a salinity gradient: Low Estuary (32°10′65″S; 052°08′52″W), Middle Estuary (32°02′01′′S; 052°10′45″W) and Upper Estuary (31°53′33″S; 052°14′33″W). We used transections with protein and glucose baits. We found 25 ant species. Most of them was attracted by the two types of bait, being considered omnivores. We recorded the largest catch at the closest point to the sea, the Low Estuary, on both baits. We did the smallest catches in the Upper Estuary (K = 5.204; df = 2; P < 0.05). We found that Low and Middle Estuary showed proximate values of the quotient (Protein/Glucose +1), indicating that ant's eating habits were the same in these portions of Lagoa dos Patos Estuary. However, there was a tendency for ants preferring the Glucose baits in the Upper Estuary.

Kewords: Feeding preference; Formicidae; Salinity gradient; Salt marshes.

Introduction

Salt marshes are intertidal coastal ecosystems flooded irregularly by salt water, occupied by herbaceous vegetation and small shrubs [1]. These ecosystems occur in protected areas of estuaries, bays, and lagoons in tropical and subtropical regions. They are considered highly productive organic matter ecosystems, offering shelter and habitat for various animal species [2]. High productivity in salt marshes creates an attractive resource base for terrestrial consumers, but tidal inundation creates a harsh environment [3,4]. The inhabitant organisms exhibit adaptations, including synchronism of activity with the tidal cycles, great mobility to escape the floods, and physiological tolerance to submersion [3,5,6]. Ants (Hymenoptera: Formicidae) are the world's most successful group of eusocial insects [7,8]. They are important predators of invertebrates in most ecosystems and are also prominent herbivores in many Neotropical communities, including salt marshes [9-11].

Formicidae is a great model for food web studies [12,13]. Ants are common inhabitants in terrestrial ecosystems [7,14]. Moreover, ants are tropically diverse, with herbivores that feed on sugary exudates common in food webs with abundant vegetation, such as forest canopies and grasslands, and predators that feed on the consumers of decomposer microbes, common in litter food webs [15-17]. The aims of this study are (1) to quantify the feeding preference of ant communities and (2) to estimate the diversity and similarity of ant community along the Lagoa dos Patos Estuary salt marshes.

Materials and Methods

We chose three salt marshes in Lagoa dos Patos Estuary along a salinity gradient: Low Estuary (32°10′65″S; 052°08′52″W), highly influenced by salinity, 2 km from Atlantic Ocean; Middle Estuary (32°02′01′′S; 052°10′45″W), that receives fresh and salt water input, constituting a brackish environment, 17 km from the sea; and Upper Estuary (31°53′33″S; 052°14′33″W), subject to major influence of freshwater, 54 km from the sea. The dominant plant species are *Spartina densiflora*, *Spartina alterniflora*, *Scirpus olneyi*, *Scirpus maritimus*, *Juncus krausii* and the shrub *Myrsine parvifolia* [18]. We sampled ant communities in nine points (three

at each collection station), during a year, totalizing 108 samples per bait. We used transections with alternate baits. Protein baits were sardine baits, simulating the most common kind of protein in this environment. Glucose baits were honey baits. The traps were exposed for 60 minutes [19].

The analysis of ant abundances data was based on the species occurrence in samples, which is recommended for quantifying abundances of social insects [20,21]. We recorded the ants by the kind of bait. Censuses were repeated for each of three stations. We transformed data in a logarithm scale ($Log_{10} x+1$). We identified the ants according to Fernández [22] and we sent the specimens to Museu de Zoologia da Universidade de São Paulo (MZ- USP) to deposit in the scientific collection of MZ – USP. The specialists of MZ-USP also confirmed the ant's identification. We considered only the species that occurred in the three areas to perform the analysis of food preference. We chose the quotient Protein/Glucose +1 (the denominator cannot be zero) to perform the statistical analysis [17]. A Tukey's HSD test following an analysis of variance [23] was used to evaluate the null hypothesis of no differences among sites in the dissimilarity of assemblages along the gradient of Estuary. The similarity between areas was verified through the Jaccard and Morisita indexes [24].

Results

We found 25 ant species (12 genera, 4 subfamilies). Most of them was attracted by the two types of bait, being considered omnivores. Four species were exclusive of Low Estuary and one was exclusive of Middle Estuary. Two species of *Nylanderia* were attracted only by protein bait (Table 1). The values of ant occurrence in each collection station by bait attraction are shown in Figure 1 in logarithmic scale. We highlight the presence of seven species of the genus *Pheidole* in which the species number 4, 5, 6 and 7 were more associated to protein baits. *Solenopsis invicta, Wasmannia auropunctata, Camponotus punctulatus, Linepithema humile* and *Pseudomyrmex phillophylus* were representative along the salt marshes' Estuary. We recorded the largest catch at the closest point to the sea, the Low Estuary, on both baits. We did the smallest catches in the Upper Estuary, about 50 km from the sea ($K = 5.204$; $df = 2$; $P < 0.05$).
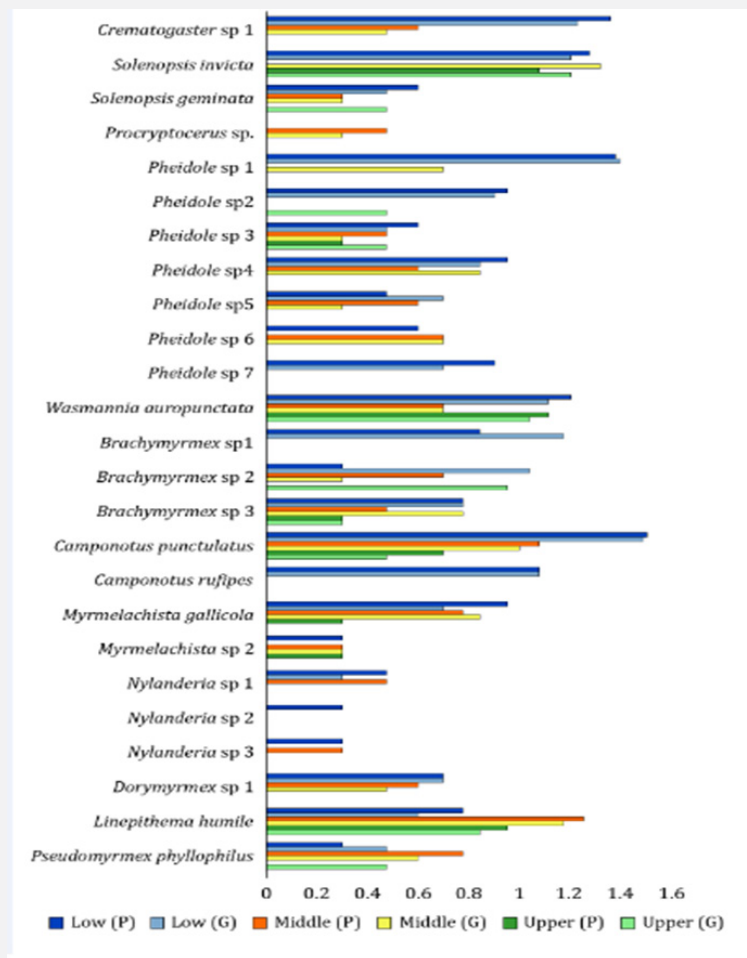

Figure 1: Ant visitation to Protein (P) and Glucose (G) baits in three points in Lagoa dos Patos Estuary: Low, Middle and Upper Estuary – in reference to the distance from the sea: 2 km, 17 km and 54 km, respectively. The frequency is the number of samples in which the species occurred.

Table 1: Three ant communities: Low Estuary, Middle Estuary and Upper Estuary sampled for Protein (P) and Glucose (G) use.

Ant species	Low	Middle	Upper
MYRMICINAE			
Crematogaster sp 1	P, G	P,G	
Solenopsis invicta	P,G	G	P,G
Solenopsis geminata	P,G	P,G	G
Procryptocerus sp.		P,G	
Pheidole sp1	P,G	G	
Pheidole sp 2	P,G		G
Pheidole sp 3	P,G	P,G	P,G
Pheidole sp 4	P,G	P,G	
Pheidole sp 5	P,G	P,G	
Pheidole sp 6	P	P,G	
Pheidole sp 7	P,G		
Wasmannia auropunctata	P,G	P,G	P,G
FORMICINAE			
Brachymyrmex sp 1	P,G		
Brachymyrmex sp 2	P,G	P,G	G
Brachymyrmex sp 3	P,G	P,G	P,G
Camponotus punctulatus	P,G	P,G	P,G
Camponotus rufipes	P,G		
Myrmelachista gallicola	P,G	P,G	P
Myrmelachista sp 2	P	P,G	P
Nylanderia sp 1	P,G	P	
Nylanderia sp 2	P		
Nylanderia sp 3	P	P	
DOLICHODERINAE			
Dorymyrmex sp 1	P,G	P,G	
Linepithema humile	P,G	P,G	P,G
PSEUDOMYRMICINAE			
Pseudomyrmex phyllophilus	P,G	P,G	G

We found that Low and Middle Estuary showed proximate values of quotient, indicating that ant's eating habits were the same in these portions of Lagoa dos Patos Estuary. However, there was a tendency for ants preferring the Glucose baits in the Upper Estuary, decreasing the quotient, being significantly lower than the other sampled sites (Figure 2). The richness of ant species showed a significant interaction with the marine gradient (Low Estuary = 24; Middle Estuary = 20; Upper Estuary = 12 species; K = 7.155; df = 2; P < 0.05). The richness of ants associated with salt marshes has gradually decreased as we moved away from marine influence. As consequence, the cluster analysis indicated that Upper Estuary is the dissimilar area (Figure 3, Table 2).

Table 2: Morisita's distance index in three sampling sites in the Lagoa dos Patos, Brazil, estuarine zone, considering ant communities.

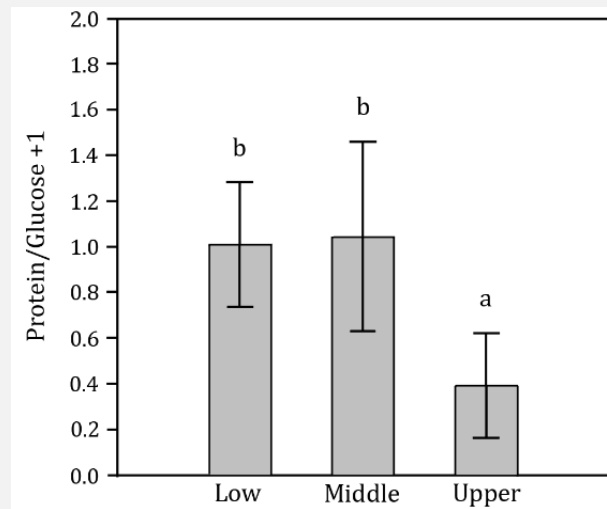|	Low	Middle	Upper
Low	1		
Middle	0.66	1	
Upper	0.48	0.61	1

Figure 2: The ratio of Protein baits and Glucose baits is compared among three ant communities: Low Estuary, Middle Estuary and High Estuary. Letters above bars signify significant difference using Tukey's HSD with P < 0.05.
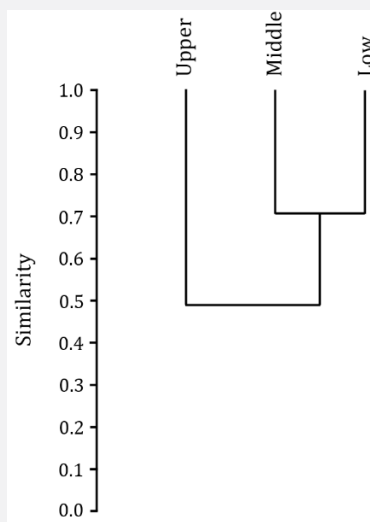

Figure 3: Cluster analysis based on the ant community's diversity matrix in three estuarine zones, using Jaccard Similarity Index (UPGMA; Cophenetic correlation = 0.967).

Discussion

Pheidole was the genus with the major number of species collected. They can play an important role in the Lagoa dos Patos salt marshes because many of these ants are predators and diggers [25], helping in the remobilization of fine sediments and in the plant root oxygenation. Another key species could be *Camponotus punctulatus.* It forms colonies with an association of macroinvertebrates, fungi and bacteria acting on the decomposition of organic matter [26,27]. The presence of *Solenopsis invicta, Wasmannia auropunctata,* and *Linepithema humile* may have influenced locally the diversity of ants. In common, these species are aggressive and form large colonies [28-30]. We have not tested the effect of competition, but previous studies have shown that

mainly *Solenopsis invicta* is a better forager and it displace less efficient species [31,32]. *Pseudomyrmex phillophilus* is associated with small shrubs or trees present in the study area, since species of *Pseudomyrmex* are usually arboreal [33].

We found an anomalous behavior for *Nylanderia* species. According to Cook et al. [34], this genus prefers diets rich in carbohydrates. Therefore, they would be expected to select the glucose bait. In salt marshes, many arthropods are linked to decomposition of carcasses, including ants [35]. Small carcasses, such as cockroaches, crabs, terrestrial isopods, are more available resources than the salt marshes own plants, because most of them have a physical structure and secondary chemistry of unpalatable plants and produce an unpalatable litter too [36-38].

So, we expected a large assemblage of carnivorous ants, with a low incidence of capture in the glucose baits. Within the limits of reasonable statistical power (3 sites, 3 substations, 108 samples), we showed that two communities (Low and Middle Estuary) consistently increased protein use relative to glucose, but one community do not (Upper Estuary).

Formicidae is a group of eusocial organisms that have a high demand for carbohydrates [39]. Ants on protein-rich, carbohydrate poor foods fulfill their carbohydrate requirements collecting large quantities of this food. However, these colonies experienced significantly elevated worker mortality [40,41], possibly because of "food stress" [42]. This explains why most species were found in both kind of bait. Glucose would serve to balance the demand for carbohydrates, which can be a limiting factor in salt marshes. In the Upper Estuary perhaps the resource could be more limited, which would explain the greater attractiveness of glucose baits compared to Middle and Low Estuary.

Analyzing the richness, we found that the major richness of ants was proportional to the marine influence in the Lagoa dos Patos Estuary. Kaspari et al., [17] also found that the species richness of ants increased with increasing salinity, in contrast with the negative effect of salinity on ants occurring in other coastal environments. This apparently contradictory result could arise, in part, because of the salinity gradient could operate as an environmental filter, allowing different ant species along the gradient depending on their tolerance to salt stress [43]. In fact, plant diversity also increases with salinity in these marshes [44], which also indicates an increase in niche availability for ants [44]. Low and Middle Estuary showed exclusive species, Upper Estuary did not, which could confirm this tendency.

However, we propose studies focusing on taxonomic patterns (subfamilies, tribes, and genera) and ant autecology to understand better the mechanisms of foraging and diversity along the estuarine gradients and take definite conclusions.

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