ARE ASSOCIATIONS OF ENDOPHAGOUS INSECTS AND CAPITULA OF ASTERACEAE SPECIES ENHANCED BY RESOURCE AVAILABILITY?
A CASE STUDY OF COASTAL DUNES ENVIRONMENT

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INTRODUCTION

The Asteraceae family is one of the greatest groups of flowering plants which occur in temperate, subtropical and tropical regions, predominantly in grasslands and mountains when compared to forested areas (7; 13). The inflorescence of Asteraceae species-the capitulum-is composed of numerous florets sharing a single receptacle, which is surrounded by bracts. Capitula are an evident attribute of Asteraceae species, and its unique morphology act as food resource and microhabitat, attracting a diverse and rich fauna of endophagous insects (1; 24). Endophagous insects feed on internal parts of its host plants and can be gall makers, borers or miners, and are especially diverse and frequent in Asteracean flower heads (1). Endophagous insects associated to Asteraceae capitula in Brazil account at least 120 species and belong mainly to three distinct Diptera families (Agromyzidae, Cecidomyiidae and Tephritidae) and four Lepidoptera families (Gelechiidae, Pterophoridae, Pyralidae and Tortricidae) (15).

Endophagous insects show high host fidelity (10) and consequently are likely to be strongly influenced by changes in host - plant abundance (29). Resource abundance, measured as the abundance of individual plants or as plant biomass, for instance, represents an important feature affecting herbivores insect community structure (11). Therefore, host plants with greater biomass can attract and support more species and greater abundances of individuals. Plant species that occur in higher densities-resource concentration hypothesis-are more likely to be found by insect herbivores (24). Nonetheless, species richness is not always correlated to plant density (18). Attributes such as plant size and architecture also influence the number of associated herbivores (26), such as endophagous insects. The plant species of more complex architecture and larger sizes might support more species of insects than do smaller, architecturally simple ones (8). However, the possible effects of size upon diversity are hard to evaluate once other factors such as life stage, phenology, architecture and density correlate with size (17). Moreover, records of endophagous insects associated to their host plants are important once they represent community biodiversity (16; 17) as well as trophic structure (1). Thus, investigations of herbivores, such as endophagous insect species, are a key to our understanding of trophic relations of insects and plant communities.

The Asteraceae species Noticastrum malmei Zardini and Senecio crassiflorus (Poir.) occur in the investigated restinga vegetation and previous field surveys indicated the potential use of these species by endophagous insects. S. Crassiflorus is an herbaceous perennial, prostrate species restricted to coastal sand dunes and beaches of the Southwestern Atlantic coastline, from Santa Catarina, Brazil to Argentina (3). It is distributed along the sea - continent gradient (5), especially concentrated the foredune (11). The species N. Malmei also presents herbaceous prostrate species, with higher abundance on interior dunes and dry slacks (11).

OBJECTIVES

Our intentions were: (1) to assess the existence of en-
dophagous insects associated to these co - occurring Asteraceae species from Joaquina beach rearing; (2) identify the emergent insect families from rearing; (3) investigate if endophagous fauna abundance and richness are correlated to resource availability (measured as biomass and capitulum size of N. Malmei and S. Crassiflorus) and (4) discuss the possible differences of endophagous insect abundance in relation to plant species distribution pattern at the investigated site.

**MATERIAL AND METHODS**

Field sampling and insect rearing. In the southwestern part of Santa Catarina Island lies Joaquina beach (27° 36′ 40″ S, 48° 27′ 10″ W) where our surveys for Notocactus trum malmei e Senecio crassiflorus capitula were conducted. The coastline of Joaquina beach is 3km long and comprises sand hills covered by herbaceous and arborescent vegetation-trees, shrubs-as well as permanent lakes surrounded by small dunes (4). Climate in the area is categorized as humid mesotermic, with no drier season and mean annual precipitation of 1521mm (23). Monthly mean temperature in the summer is 24°C and in the winter 17°C. Winds blow predominantly from the south and north quadrants.

Field trips for N. Malmei and S. crassiflorus heads sampling were conducted from September to November (2008), the main flowering period of Asteraceae in Santa Catarina region. Moreover, the species S. crassiflorus presents a very short flowering period (6) that requested concentrated field work. Sampling of S. crassiflorus covered mainly the foredune of the shore (15-20m), where this species is more frequent (11). However, N. malmei individuals seem to be spatially separated from S. crassiflorus, and were sampled in a distance from the seashore (20-40m), mainly on interior dunes where the species is apparently numerous protected from the ocean wind and water dynamics.

For the present purpose, we define a sample as a group of flowerheads sampled from a population-N. Malmei and S. Crassiflorus-in each sampling period. Capitulum were sampled in two different periods (September 22nd and November 6th), adding up 80 capitula of each species (30 from our first sample, 50 from the second). Flower heads were allocated into plastic bags and transferred to our laboratory facilities. In the laboratory, inflorescences were separately kept in plastic containers of 25 ml, covered by a mesh lid in order to allow the air flow and to prevent endophagous fauna from escaping. Samples were checked every two days for the presence of adult emerging insects. Emerged adults were sedated with ether to facilitate manipulation and kept individually in ethanol (70%) for further identification.

**Species identification.** Emerged adults were identified using descriptions of (2) and (19). Specimens were deposited in Laboratório de Ecologia de Águas Continentais, Departamento de Ecologia e Zoologia, Universidade Federal de Santa Catarina. All specimens could not readily be identified to more than family level.

**Resource measurement.** Once inflorescences were accounted as a resource available to endophagous insects, flowerheads diameter was used as a measurement of resource offered. A digital paquimeter (Digimess, 150mm) was applied to measure capitulum size briefly following field sampling. After insect emerging, N. Malmei e S. Crassiflorus flowers-except the bracts enclosing the inflorescence and the receptacle disc-were dehydrated in a greenhouse (60°C) for 48hrs. Afterwards, flowers dry weight values were determined through an electronic balance (AL500 MARTe). These values were utilized as a biomass measurement of each sampled inflorescence.

**Data analyses.** Shapiro - Wilk test was conducted to test for data normality. We applied the Student’s T - test (p < 0,05), for parametric distributed data, in comparisons of resource availability-biomass and inflorescence diameter-and abundance of emerged adults between both Asteraceae species. Comparisons were also performed for different samples of the same species. In order to test our hypothesis of the possible association between endophagous insect number/richness and resource availability, we performed a Pearson correlation test. Data utilized to correlation testing were flowerheads diameter and number of emerged adults. Data statistical analyses were conducted with Statistica (versão 7.0) software.

**RESULTS AND DISCUSSION**

A total of 322 individuals were reared from 160 flowerheads of N. malmei (80 capitula) e S. crassiflorus (80 capitula). Among insects reared, those from the family Ulidiidae (Diptera) were the most abundant (63.4%), followed by Cecidomyiidae (Diptera) (36.6%). The picture - winged flies (Ulidiidae) are a diverse and large cosmopolitan family, which larvae are typically scavengers. Though, a few are phytophagous larvae and some (Ottitae) have been found associated to inflorescences (25).

This new record of Ulidiidae endophages associated to Asteraceae flowerheads represents the addition of data to this field of research, once Diptera species associated to Brazilian Asteraceae inflorescences are mainly those from Agromyzidae, Cecidomyiidae and Tephritidae families (16). The family Cecidomyiidae is one of the largest of the Diptera. Many larvae are gall makers, inducing galls on various plants, whilst some live free in flower heads or in the stems of plants without forming galls (27). The greatest mean of insects emerged from S. crassiflorus flowerheads reared (mean ± standard deviation) (x=3.45 ±3.05 individuals) while N. malmei endophage per capitulum average was 0.35 (x=0.35 ±0.76) individuals. This difference of endophagous insects/flowerhead between species is significant (t=7,1; p=0,0001). The higher occurrence of endophages associated to S. crassiflorus inflorescences could be explained by greater resource availability-biomass and capitulum diameter-of this Asteraceae species. Biomass (g) and diameter (mm) of S. crassiflorus flower heads were higher when compared to N. Malmei inflorescences. Mean biomass for S. crassiflorus was 0.153g (±0.051) against 0.047g (±0.018) for N. malmei flower heads (t=15,3; p=0,0003). Capitulum mean diameter was also greater in S. crassiflorus (x=10,93 ±1.68mm) than for N. malmei inflorescences (x=7.21 ±0.76mm), and this difference is also significant (t=12.9; p=0,0001).
Endophage abundance relationship with Asteraceae species studied are moderately correlated to flowerheads size (mm) \((n=100, r=0.42; p=0.0001)\), and biomass \((g) (n=160, r=0.45; p=0.0001)\), i.e., larger, of greater biomass capitula may have the potential to support greater insect abundance. The obtained \(r\) (Pearson correlation) value could be a result of undersized field sampling. Herbivore insect’s abundance and richness in their host plants vary frequently (13) and this variability is usually assigned to host plant phenotypical distinctions (28). The factors influencing on the abundance of herbivore insects have been the core of herbivore - plant theories (21). A frequent pattern correlates higher herbivory to larger and denser host plant populations (22). The plant architecture Hypothesis (14; 15) suggests that larger and more complex plants sustain greater herbivore populations, especially due to its structural complexity. Moreover, capitula have been regarded as an advance and key ecological feature behind the diversification success of the Asteraceae family (7). A tri-trophic approach to plant and herbivorous interactions (flowerheads-endophages-parasitoids) revealed that defense against parasites might be another pressure of endophagous insects upon larger capitula (9).

The Asteraceae species studied, \(N.\) malmei and \(S.\) crassiflorus, have distinct distribution pattern at the investigated coastal dune site. \(S.\) crassiflorus population is mostly concentrated in the frontal dunes whilst \(N.\) malmei presents higher abundance on interior dunes (11). In addition to inflorescence size and biomass, host plant distribution pattern (isolated or aggregated) could be affecting endophagous abundance on this Asteraceae species, leading to greater oviposition in \(S.\) crassiflorus instead of \(N.\) malmei. Patch size and its influence upon the colonization of \(Praezelis clematidea\) (Asteraceae) by flies has also been investigated (20) and the abundance of Tephritidae, for instance, increased with experimental patch size.

**CONCLUSION**

A number of theories have been developed on attempts to explain the possible laws that guide herbivore and its host plants associations such as resource availability, plant architecture, host plant distribution pattern Hypothesis. We conducted to allow our understanding of this plant-herbivore interaction.

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