DIVERSITY OF GALL - INDUCING INSECTS OF PERNAMBUCO, NORTHEASTERN BRAZIL

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INTRODUCTION

Gall - inducing insects are very rich in species around the word and the latest global richness estimates the existence between 21,000 to 211,000 species, with an average of 132,930 species (Espírito - Santo & Fernandes 2007). In Brazil, studies addressing the richness of galling insects have been increasing in several ecosystems, such as Atlantic forest (e.g., Fernandes *et al.*, 2001; Mendonça 2007; Moreira *et al.*, 2007), restinga (Atlantic Coast restingas) (see Oliveira & Maia 2005), wetlands (Pantanal) (Julião *et al.*, 2002; Julião *et al.*, 2004), Amazon rain forest (Julião *et al.*, 2005), but most studies were done in the cerrado (savanna) (e.g., Fernandes *et al.*, 1997; Gonçalves - Alvim & Fernandes 2001ab; Lara *et al.*, 2002; Urso - Guimarães *et al.*, 2003; Maia & Fernandes 2004; Urso - Guimarães & Scarelli - Santos 2006, Carneiro *et al.*, 2009a). In these ecosystems, the highest species richness of galling insects is concentrated in the rupestrian fields and in the cerrado (savanna) vegetation of southeastern Brazil (Fernandes & Price 1988; Lara & Fernandes 1996). Up to date, the knowledge on the other many tropical vegetations of Brazil is scanty, such as in the seasonally dry tropical forests (caatinga) of northeastern region.

OBJECTIVES

Despite its great biological importance of ecosystems of northeast Brazil, there are exceedingly few ecological studies on insects in these ecosystems located north of the River São Francisco. For the first time, we report on the richness of galling insects of caatinga, altitudinal wet forests "brejos de altitude"and Atlantic forests of Pernambuco in an attempt to broaden our knowledge of Northeastern and Brazilian galling species diversity.

MATERIAL AND METHODS

Study site. In the caatinga, this study was conducted in seven private areas (municipalities: Alagoinha, Custódia, Pombos, Bodocó, Serrita, Pesqueira, Salgueiro and Parnamirim); in one national park (Parque Nacional Vale do Catimbau-Buíque); in one ecological university station of Universidade Federal Rural de Pernambuco (Serra Talhada), and in one ecological station of Instituto Agronômico de Pernambuco (Caruaru). To Atlantic forests, we chose six fragments: Reserva Ecológica de Saltinho (Tamandaré), Parque Dois Irmãos (Recife), Reserva Ecológica de Carnijó - Reserva Particular do Patrimônio Natural (RPPN) de Carnijó (Moreno), Reserva de Dois Lagos (Cabo de Santo Agostinho), Refúgio Ecológico Charles Darwin (Igarassu), and Engenho Monjolo (Abreu e Lima). Finally, we selected seven altitudinal wet forests: Reserva Municipal de Bonito - Brejo de Bonito (Bonito), Brejo de Bituri Grande - Brejo da Madre de Deus (Brejo Madre de Deus), Reserva Biológica de Serra Negra - Brejo de Serra Negra (Bezerros), Brejo de Taquaritinga do Norte (Taquaritinga do Norte), Brejo de Triunfo (Trunfo), Parque Municipal João Vasconcelos Sobrinho - Brejo dos Cavalos e Brejo da Serra Água Doce (Caruaru). All areas were located in Pernambuco state, Brazil. These areas were chosen to cover the maximum of the longitudinal variability of the vegetation in the state of Pernambuco and to avoid pseudo - replication between the areas.

Sampling galling insects richness. All ecosystems were investigated for galls over a period of seven months from February to August of 2008. In each site, galling insect richness were sampled by two people following the adapted methodology of random walking (see Julião *et al.*, 2002; Fernandes & Negreiros 2006), where instead of an hour, we spent three hours in each area. To maximize the sampling of richness, a distance of at least 500 meters was established among the sites sampled inside the areas (Fernandes & Price 1988). All plant organs were investigated, and each gall and host plants (up to 3 me-

ters height) found were collected, packed in plastic bags, and then taken to a laboratory for photographic registration and description of the external morphology. Host plants were classified into morphospecies in the field, and later at the species level by specialist before included in the Herbarium UFPE (Universidade Federal de Pernambuco). The classification of species of host plants followed the system proposed by Angiosperm Phylogeny Group II (APG II 2003), and the authors and scientific host plant names were checked in Missouri Botanical Garden website "http://mobot.mobot.org/W3T/Search/classicvast.html". In general, 95% species of insect induce a gall on a specific tissue of a certain plant species (Carneiro *et al.*, 2009b). Therefore, galls were characterized as reported by Fernandes & Price (1988): host plant species, number of types of galls by host plant, type of host tissue attacked, shape of galls, color of galls, presence or absence of pubescence, and number of chambers in the gall, occurrence on the galled organ: isolated or grouped/coaslescent. We chose to present only a list with the probable inducers of gall maker because many galls were naturally damaged, or without the presence of the inductor or with inductor parasited. The use of morphospecies to represent the galling species richness has been used in several studies in different ecosystems (e.g., Price *et al.*, 1998; Cuevas - Reyes *et al.*, 2004; Fernandes & Negreiros 2006; Moreira *et al.*, 2007).

RESULTS AND DISCUSSION

Caatinga. We found 64 morphologically distinct types of insect galls in the caatinga. These galls were found in 48 species of host plants from 17 families and 31 genera. The richness of galling insects was greater in the Vale do Catimbau (33 morphotypes) followed by Serra Talhada (11 morphotypes), Parnamirim (nine morphotypes), Caruaru (eight morphotypes), Alagoinhas, Custódia, Pombos and Bodocó each with six morphotypes, Serrita (five morphotypes), Pesqueira (three morphotypes) and Salgueiro with two morphotypes. The majority of galls induced by insects belonges to the family Cecidomyiidae (89%) followed by Coleoptera (5%), Heteroptera (2%) and five percent were undetermined. The host plant families that had a greater number of species of galls were: Fabaceae (23.44%), Euphorbiaceae (14.06%), and Boraginaceae, Malpighiaceae and Myrtaceae with 6.25% each. When we consider the host plant species by family, we found almost the same pattern: Fabaceae (16.67%), Euphorbiaceae (16.67%), and Sapindaceae, Malpighiaceae and Myrtaceae with 8.33% each. The genera with the greatest number of species of galls were: *Croton* (four species), *Cnidoscolus* (three species), and, *Bauhinia* and *Byrsonima* with two species each. Most galls were induced on the leaves (73.44%), stems (20.31%), and on apical buds (6.25%). The most frequent shape of galls was spheroid (32.81%), followed by discoid (25.00%). Seventy - seven percent of galls were glabrous, 78.13% were predominantly green, while 73.44% did not form clusters.
A comparison with the data from another Brazilian ecosystems (Atlantic rain forest, cerrado, Amazon rain forest), indicates that the richness of the insect galls in the caatinga is comparatively smaller. Different hypotheses have been proposed to explain variation in abundance and diversity of galling species. According to Fernandes & Price (1992), the harsh environment hypothesis predicts that galling species richness will be higher in dry and hygrothermically stressed environments. Preliminary, our results not corroborated this hypothesis because that the caatinga was poorer in species of galling insects; however, this hypothesis must be tested further.

Atlantic forest. We found 136 morphologically distinct types of insect galls in the Atlantic forests. These galls were found in 79 species of host plants from 35 families and 53 genera. The richness of galling insects was greater in the Reserva Ecológica de Saltinho (59 morphotypes) followed by Parque Dois Irmãos (50 morphotypes), Reserva Particular de Carnijó (46 morphotypes), Reserva Dois Lagos (Xáreu) (17 morphotypes), Refúgio Ecológico Charles Darwin (15 morphotypes), and Engenho Monjolo with 13 morphotypes. The majority of galls induced by insects belonges to the family Cecidomyiidae (94.85%) followed by Lepidoptera (1.47%), Coleoptera (0.74%), and 2.94%% were undetermined. The host plant families that had a greater number of species of galls were: Clusiaceae (8.09%), Lecythidaceae, Myrtaceae and Nyctaginaceae respectively with 6.62% each, and Burseraceae (5.88%). But if we consider the host plant species, families change: Myrtaceae (8.86%), Polygonaceae (7.59%) and Melastomataceae (6.33%). The genera with the greatest number of species of galls were: *Guapira* (nine species), *Protium* (seven species), and *Coccoloba, Miconia, Ocotea* and *Eschweilera* with six species each. Most galls were induced on the leaves (74.26%) and stems (19.85%). The most frequent shape of galls were globoid (29.41%) followed by elliptical (20.59%). Ninety - one percent of galls were glabrous, 66.18% were predominantly green, while 69.12% did not form clusters.

Some studies on insect gall richness conducted in Atlantic forest are concentrated in the south and southeast of Brazil. Comparing our results with the data from other Brazilian Atlantic forests indicates that the richness of the insect galls in the Atlantic forest of Pernambuco (136 morphospecies) is relatively intermediary. The highest diversity (282 morphospecies) was reported by Mendoça (2007) in the Atlantic forest and Pampas of South Brazil; following by Fernandes *et al.*, (2001) which reported on 273 galling species in an Atlantic forests of Southeast Brazil.

Altitudinal wet forests. We found 80 morphologically distinct types of insect galls in the altitudinal wet forests. These galls were found on 49 species of host plants belonging to 28 families and 35 genera. The richness of galling insects was greater in the Brejo dos Cavalos (32 species) followed by Brejo de Bonito (27 species), Brejo da Madre de Deus (15 morphotypes), Brejo de Serra Negra (eight species), Brejo de Taquaritinga do Norte (five species), Brejo de Triunfo (three species), and Brejo da Serra Água Doce with two species. The majority of insect galls were induced by species of the family Cecidomyiidae (81.25%) followed by Heteroptera (5%), Lepidoptera (1.25%), while we could not identify the remaining 12.50% (undetermined). The host plant families that supported the greater number of species of galls were: Nyctaginaceae (18.99%), Fabaceae (12.66%), Meliaceae (10.13%), Sapindaceae and Myrtaceae

with 8.86% each. The genera with the greatest number of species of galls were: *Guapira* (Nyctaginaceae) (15 species), *Guarea* (Meliaceae) (eight species), *Myrcia* (Myrtaceae) (six species), and *Paullinia* (Sapindaceae) with five species. Most galls were induced on the leaves (72.5%), followed by stems (10.0%), simultaneously on leaves and stems (6.25%), and on apical buds (5.0%). The most frequent shape of galls was spheroid (27.50%), followed by globoid (21.25%). Eighty - one percent of galls were glabrous; 53.75% were predominantly green, while 81.25% did not form clusters.

Our study represents the first contribution to the understanding on this herbivore guild distribution and diversity in the upland tropical wet forest ecosystems. A comparison with the data from other Brazilian Atlantic rain forests indicates that the richness of the insect galls in the upland forest of Pernambuco (80 species) is comparatively smaller. However, we need more sampling of local and regional diversity to build a concise pattern or generalizations on the differences between northern and southern forests. Moreover, these comparisons between studies should be viewed with some caution because of differences in methodology, sampling size and time.

CONCLUSION

Most studies conducted in Brazil with description of insect galls are concentrated in the cerrado (savanna) and this one represents the first contribution o the understanding on this guild distribution and diversity in the caatinga (64 species), upland tropical wet forest (80 species) and Atlantic forest of northeast Brazil (136 species). However, other ecosystems, in other Brazilian states should be sampled in order to reach a better understanding of the distribution of galling insects and their host plants.(We thank Mr. Gilcean, C. Magalhães, C. Tavares, M. Honorato, F. Alcântara, A. Ferreira for field work. We thank DCR - FACEPE/CNPq - DCR - 0087 - 2.05/06, APQ - 0008 - 2.05/07).

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