

ECOLOGY, BEHAVIOR AND BIONOMICS

Diversity and Community Structure of Social Wasps (Hymenoptera: Vespidae) in Three Ecosystems in Itaparica Island, Bahia State, Brazil

GILBERTO M. DE M. SANTOS¹, CARLOS C. BICHARA FILHO¹, JANETE J. RESENDE¹, JUCELHO D. DA CRUZ¹
AND OTON M. MARQUES²

¹Depto. Ciências Biológicas, Univ. Estadual de Feira de Santana, 44.031-460, Feira de Santana, BA, gmms@uefs.br

²Depto. Fitotecnia, Centro de Ciências Agrárias e Ambientais - UFBA, 44380-000, Cruz das Almas, BA

Neotropical Entomology 36(2):180-185 (2007)

Diversidade e Estrutura de Comunidade de Vespas Sociais (Hymenoptera: Vespidae) em Três Ecossistemas da Ilha de Itaparica, BA

RESUMO - A estrutura e a composição de comunidades de vespas sociais associadas a três ecossistemas insulares com fisionomias distintas: Manguezal, Mata Atlântica e Restinga foram analisadas. Foram coletados 391 ninhos de 21 espécies de vespas sociais. A diversidade de vespas encontrada em cada ecossistema está significativamente correlacionada à diversidade de formas de vida vegetal encontrada em cada ambiente estudado ($r^2 = 0,85$; $F(1.16) = 93,85$; $P < 0, 01$). A floresta tropical Atlântica foi o ecossistema com maior riqueza de vespas (18 espécies), seguida pela Restinga (16 espécies) e pelo Manguezal (8 espécies).

PALAVRAS-CHAVE: Ecologia, Polistinae, manguezal, restinga, Mata Atlântica

ABSTRACT - We studied the structure and composition of communities of social wasps associated with the three insular ecosystems: mangrove swamp, the Atlantic Rain Forest and the 'restinga' - lowland sandy ecosystems located between the mountain range and the sea. Three hundred and ninety-one nests of 21 social wasp species were collected. The diversity of wasps found in each ecosystem was significantly correlated to the diversity of vegetation in each of the three physiognomies, ($r^2 = 0.85$; $F(1.16) = 93.85$; $P < 0. 01$). The Tropical Atlantic Forest physiognomy had higher species richness (18 species), followed by the restinga (16 species) and the mangrove (8 species) ecosystems.

KEY WORDS: Ecology, Polistinae, mangrove swamp, restinga, Atlantic Forest

Biotic and abiotic factors are thought to influence community structure (Majer *et al.* 1994). The structure of social hymenopteran communities is usually characterized by simple ecological indices (Santos & Marques 1996, Aguiar & Martins 1997, Castro & Viana 1997), community ordination (Della Lucia *et al.* 1982), guild structure (Pleasants 1983, Santos *et al.* 1998), and nesting behavior (Gess 1981, Diniz & Kitayama 1994, Mechi 1996).

The variety of ecological and climatic conditions in tropical South America, allows the same social wasp species to have different nesting habits (Rodrigues 1968). Santos & Gobbi (1998) found distinct nesting habits among populations of *Polistes canadensis* (L.) living under different climatic conditions.

The Brazilian seacoast is a heterogeneous geomorphologic complex with lowlands and a mountain range that roughly follows the sea line (Ab'Saber 1966). The natural environment diversity on the coast and its ecological zones also house distinct biological communities. Mangroves (marine transitional ecosystems) are harbor life forms that live under the saline stress caused by tidal movements.

Restingas are lowland sandy ecosystems located between the mountain range and the sea; they can be closer or farther from the sea. The largest formation in the Brazilian eastern seacoast is the Atlantic Rain Forest, an arboreal ecosystem characterized by high biodiversity and significant altitudinal gradients.

Life forms associated with coastal and insular environments are highly influenced by harsh environmental conditions. According to Begon *et al.* (1996), one of the main factors affecting population distribution in coastal environments is the ability to explore different zonations and live under adverse ecological conditions.

Social wasps build nests and are foragers (Spradbery 1973). For these reasons, social wasps can be considered semi-sessile organisms with some fidelity to their environments, which makes them highly appropriate for community structure studies (Heithaus 1979, Santos 2000).

In this study, we compare wasp communities living in three insular ecosystems located on Itaparica Island, Bahia State, Northeastern Brazil: the mangrove, the restinga, and the Atlantic Rain Forest.

Material and Methods

The study was conducted in three ecosystems on Itaparica Island, Baía de Todos os Santos (12°53'S; 38°40'W), Bahia State, Brazil. The sites were the mangrove, the restinga, and the Atlantic Rain Forest. Three transects from each ecosystem were sampled (2 km x 10 m = 20,000 m²). Samples were collected from January 2000 to January 2003, with nine sampling periods per environment and a total of 27 collections in 216h of field work (72h per ecosystem).

Each collection lasted 8h; meanwhile, we estimated the vegetation structural complexity and wasp diversity in each environment. The presence of social wasps in each ecosystem was registered after collecting the specimens directly on the nests found *in loco*.

Species richness, Shannon's diversity (H'), evenness (J'), and Sorensen communities' similarity were analyzed. The abundance data were based on the number of nests with active colonies in each environment, following the methodology described in Silveira Neto *et al.* (1976) and Ludwig & Reynolds (1988).

The structural complexity of the vegetation was estimated after classifying plant communities according to Raunkiaer (1934). The plants were characterized as Epiphytes (Ep), Phanerophytes (Fn), Chamaephytes (Ch), Hemicyptophytes (Hm), Cryptophytes (Cp), or Therophytes (Tr). All plants found in the transects were sampled.

The effect of plant structural diversity on social wasp diversity was assessed by a regression analysis that considered the diversity (H') of plant life forms as an estimator of social wasp diversity (H') in each transect.

Results and Discussion

We collected 21 wasp species from 391 nests (Table 1). The Atlantic Rain Forest had the highest species richness (18 species) (S'), and was followed by the restinga (16) and the mangrove (8 species) (Table 2).

The tribe Mischocyttarini (genus *Mischocyttarus*) was the least representative in all three environments, with 3.3% of the nests. These were followed by the Polistini tribe (genus *Polistes*) (29.4%), and the Epiponini tribe (all other genera encompassing), with 67.3% of the nests sampled. The Epiponini colonies also were the far more abundant tribe and had the highest wasp population. Colonies of Mischocyttarini and Polistini had had a few dozens of individuals, whereas an Epiponini colony could have millions of individuals (Richards 1978, Ross & Matheus 1991, Sakagami *et al.* 1996) (Table 1). The abundance of Epiponini nests and individuals in the colonies indicates the importance of this tribe for the environments under study.

The physiognomic differences among the mangrove, the restinga, and the Atlantic Rain Forest corresponded to differences in the composition of social wasp communities. Mangrove vegetation was almost exclusively formed by three Phanerophytes plants species (77% of all vegetation), with little variation in nesting substrate. The restinga physiognomy was somewhat heterogeneous, with areas of low bushes (predominantly Chamaephytes) and open scrub. The Atlantic

Rain Forest was relatively more complex and had a wider variety of plant life forms (Fig. 1).

We found a significant relationship between diversity of plant life-forms (H') and diversity of wasp species (H') ($r^2 = 0.85$; $F(1.16) = 93.85$; $P < 0.01$) (Fig. 2). The high number of species in the Atlantic Rain Forest can be explained by its environmental heterogeneity and more realized niches. On the other hand, mangroves were structurally more homogeneous and presented lower wasp diversity and higher dominance. The similarity analysis suggests that wasp communities in the restinga and the Atlantic Rain Forest are more similar to each other than they are to wasp communities in the mangrove habitat (Table 1, Fig. 3).

Besides the lower vegetation diversity, the mangrove and the restinga areas are under strong pressure of the harsh ecological factors (air humidity, salinity, temperature, and aridity) that makes the settling of most species difficult and favors the dominance of opportunistic species. We found several differences in the range of ecological factors in the three areas. In the Atlantic Rain Forest, the ecological factors remained stable throughout the study, with low variations in temperature and air humidity. The range of variation in ecological factors in restingas and mangroves varied at a wider range (Fig. 4).

Although some wasp species build nests in only one environment, their foraging area includes neighboring ecosystems. *Polistes carnifex* (Fabricius) and *Synoea cyanea* (Fabricius), for instance, whose nests were restricted to the restinga and the Atlantic Rain Forest, were also found foraging in mangrove areas.

Some of the main factors affecting island diversity of species are: the relationship between migration and extinction rates (McArthur & Wilson 1967), island size (Lack 1969), and habitat heterogeneity (Simberloff & Abele 1976). Begon *et al.* (1996) argue that the analysis of habitat effect on diversity should focus on habitat structure instead of only on the effects of area on diversity. Plant life diversity is closely related to habitat complexity.

In general, vegetation is the main substrate for founding social wasp colonies. Heterogeneous substrates may enhance the coexistence of a larger number of species. Species such as *Angiopolybia pallens* (Lepelletier) and *S. cyanea* can only be found in environments with specific nesting conditions (Marques 1996, Santos 2000). On the other hand, *Polistes canadensis* (L.) and *Polybia ignobilis* (Haliday) can change their nesting habits according to environmental conditions and the available substrata (Santos & Gobbi 1998, Santos 2000). Lawton (1983) and Santos *et al.* (2000) have shown that structurally complex environments have more realized niches for the settling and survival of a larger number of species.

The number of species in a community is highly influenced by the number of realized niches, which reflect the environmental structural heterogeneity. However, species diversity is ultimately determined by species tolerance to physical conditions (the fundamental niche) and by species interactions with other organisms (the realized niche). Hence, if communities are organized by such interactions, then the manner and degree of organization lead to differences in size and shape of the realized and fundamental niches (Giller 1984).

Table 1. Number of social wasp nests found in each Raunkiaer's plant life forms in three insular ecosystems. Itaparica Island, Bahia - Brazil, January 2000 - January 2003. (Raunkiaer's plant life forms, Ep= Epiphytes, Fn= Phanerophytes, Ch= Chamaephytes, Hm= Hemiepiphytes, Cp= Cryptophytes, Tr= Therophytes).

Species of social wasp	Mangrove						Restinga						Rain forest						
	Fn	Ch	Hm	Cp	Tr	Ep	Fn	Ch	Hm	Cp	Tr	Ep	Fn	Ch	Hm	Cp	Tr	Ep	
<i>Angiopolybia palens</i> (Lepeletier)	-	-	-	-	-	-	-	-	-	-	-	-	12	5	-	-	-	-	12
<i>Apoica pallens</i> (Fabricius)	1	-	-	-	-	-	-	4	1	-	-	-	-	2	-	-	-	-	-
<i>Brachigastra lecheguana</i> (Latreille)	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-
<i>Metapolybia cingulata</i> (Fabricius)	-	-	-	-	-	-	1	-	-	-	-	-	4	-	-	-	-	-	-
<i>Mischocyttarus</i> sp. 1	-	-	-	-	-	-	-	-	-	-	-	-	1	4	1	-	-	-	2
<i>Mischocyttarus</i> sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-	-	-
<i>Parachartergus pseudoapicalis</i> Willink	-	-	-	-	-	-	1	-	-	-	-	-	5	2	-	-	-	-	-
<i>Polistes billiardieri</i> Fabricius	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1
<i>Polistes canadensis</i> (L.)	-	-	-	-	-	1	11	20	-	-	-	3	6	12	1	2	1	3	-
<i>Polistes carnifex</i> (Fabricius)	-	-	-	-	-	-	1	13	-	-	-	-	-	-	-	-	-	-	-
<i>Polistes cinerascens</i> Saussure	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
<i>Polistes versicolor</i> (Olivier)	-	-	-	-	-	-	-	5	-	-	-	-	23	-	-	-	-	-	-
<i>Polybia flavitincta</i> Fox	3	-	-	-	-	-	1	-	-	-	-	-	26	-	-	-	-	-	-
<i>Polybia ignobilis</i> (Haliday)	-	-	-	-	-	-	-	5	-	-	-	-	-	6	2	-	-	-	-
<i>Polybia occidentalis</i> (Olivier)	4	-	-	-	-	1	8	9	-	-	-	-	7	3	-	-	-	-	-
<i>Polybia paulista</i> Ihering	7	-	-	-	-	-	3	15	-	-	4	12	-	-	-	-	-	-	-
<i>Polybia rejecta</i> (Fabricius)	8	-	-	-	-	1	2	-	-	-	-	14	-	-	-	-	-	-	-
<i>Polybia sericea</i> (Olivier)	1	-	-	-	-	-	-	10	-	-	-	3	-	-	-	-	-	-	-
<i>Protonectarina sylveirae</i> (Saussure)	17	2	-	-	-	-	8	3	-	-	-	-	-	1	-	-	-	-	-
<i>Protopolybia exigua</i> (Saussure)	-	-	-	-	-	-	1	-	-	-	-	-	15	-	-	-	-	-	-
<i>Synoecca cyanea</i> (Fabricius)	-	-	-	-	-	-	-	-	-	-	-	-	17	-	-	-	-	-	-
Total	41	2	0	0	0	3	37	86	2	1	0	7	149	38	4	2	2	17	212
							46					133							

Table 2. Species richness (S), Pielou's Evenness index (J'), and Shannon's diversity index (H') of social wasps in three insular ecosystems. Itaparica Island, Bahia, Brazil. January 2000 - January 2003. Analyses based on the number of colonies found.

Ecosystem	Richness (S)	Equitability (J')	Diversity (H')
Mangrove	8	0.79	1.64
Restinga	16	0.81	2.25
Rain forest	18	0.90	2.61

The vegetation structure influences directly both fundamental and realized niches of communities of social wasp. Besides providing support for nesting, glucidic resources, resources to build nests, and for the hunting area, vegetation can influence the amount of shading, temperature,

and air humidity, thus affecting social wasp communities. Some communities will only nestle under certain structural conditions, selecting the open or closed shapes and the kinds of vegetation structure (such as shape and arrangement of leaves) (Nauman 1975, Dejean *et al.* 1998, Santos *et al.* 1998).

In our study, differences in local wasp diversity were related to differences in habitat structure. Still another important factor to be considered is the ecological tolerance of different species of wasps: populations with wider ecological tolerances and under stronger pressure by harsh ecological factors (salinity, temperature and aridity), could quickly colonize the area and impose strong dominance on communities in which they participated.

Our data are consistent with results from studies on the structure of communities of social wasps conducted in the 'caatinga' (dry scrub), the 'cerrado' (bush land), and the Continental Rain Forest. Santos (2000) has shown that

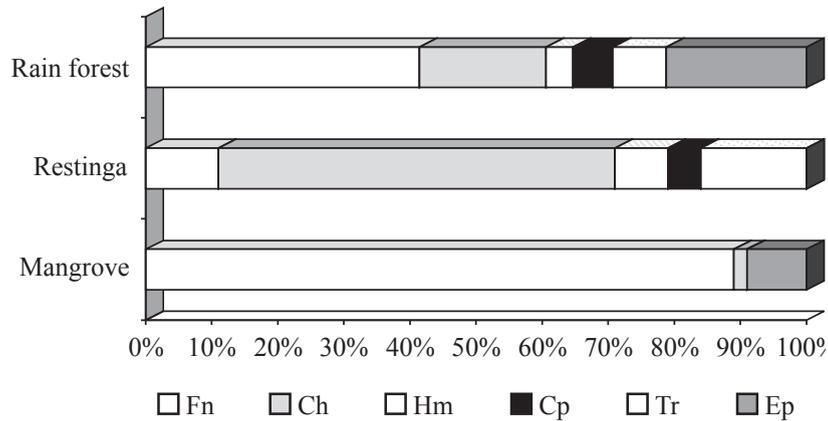


Fig. 1. Spectrum of plant life-forms found in three insular ecosystems, Itaparica Island, Bahia, Brazil. January 2000 – January 2003. (Raunkiaer's Method, Ep = Epiphytes, Fn = Phanerophytes, Ch = Chamaephytes, Hm = Hemicryptophytes, Cp = Cryptophytes, Tr = Therophytes).

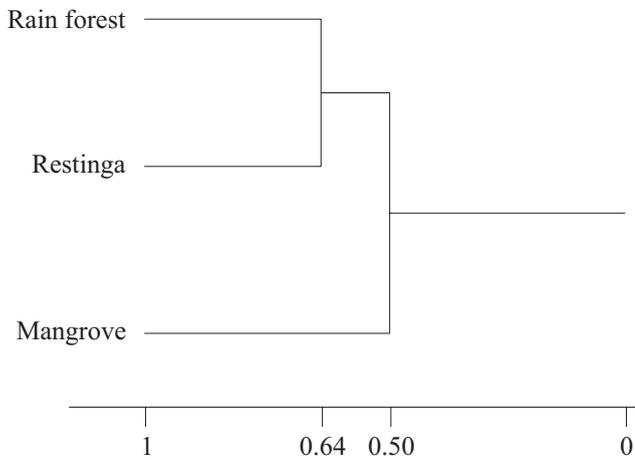


Fig. 2. Similarity dendrogram of species among communities of social wasps in three ecosystems. Itaparica Island, Bahia, Brazil. January 2000 - January 2003. Analyses based on the number of colonies found.

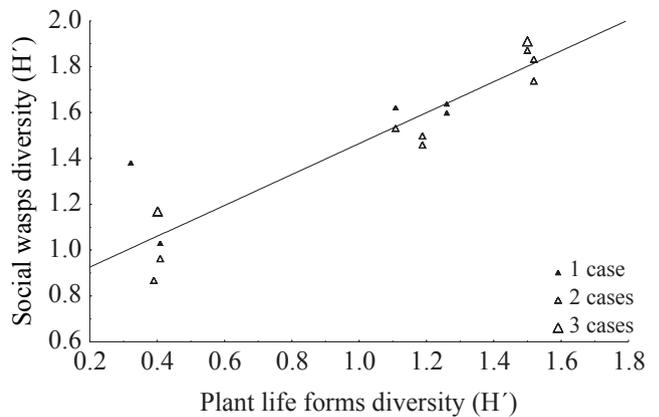


Fig. 3. Relationship between plant structural diversity and diversity of social wasps in insular ecosystems. Itaparica Island, Bahia, Brazil. January 2001 - January 2003. Analyses based on number of colonies found. Twelve of twenty-seven points are not seen in the graph due to data overlap.

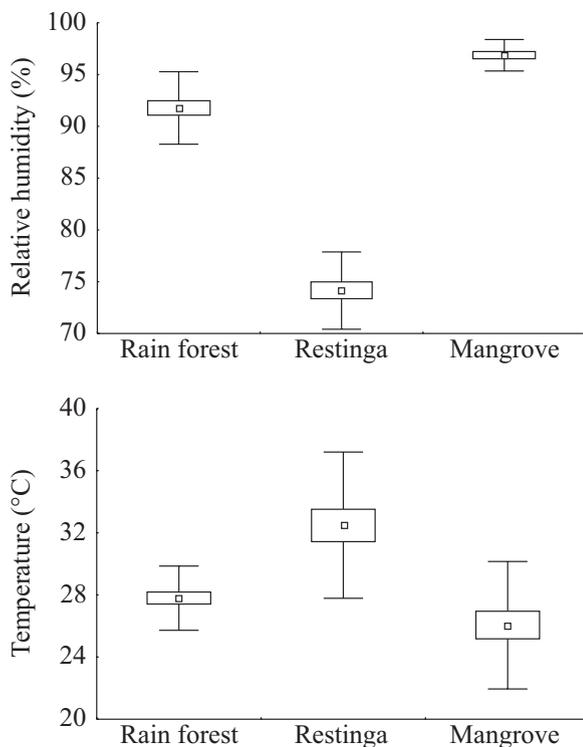


Fig. 4. Temperature and air relative humidity variations in three insular ecosystems. Itaparica Island, Bahia, Brazil. January 2001 - January 2003.

species such as *Apoica pallens* (Fabricius), *Brachygastra lecheguana* (Latreille), *P. canadensis*, *P. ignobilis*, *Polybia occidentalis* (Olivier), *Polybia paulista* Ihering, *Polybia sericea* (Olivier), and *Protonectarina sylveirae* (Saussure) have wide ecological tolerance and are generally dominant in open ecosystems and under harsh environmental conditions such as the dry scrub. Thus, these species are highly important in the structure of simpler communities or under harsh ecological conditions.

Acknowledgments

We thank Mr. Antonio Gigliotti, Hotel Pousada Porto Calado, for providing the lodging and means to accomplish this study.

References

- Ab'Saber, A.N. 1966. O domínio de mares de morros no Brasil. *Geomorfologia* 2: 1-65.
- Aguiar, C.M.L. & C.F. Martins. 1997. Abundância relativa, diversidade e fenologia de abelhas (Hymenoptera, Apoidea) na caatinga, São João do Cariri, Paraíba, Brasil. *Iheringia* 83:151-163.
- Begon, M., J.L. Harper & C.R. Townsend. 1996. *Ecology - individuals, populations and communities*. 3^a ed. Oxford, Blackwell Science, 1068p.
- Castro, M.S. & B.F.Viana. 1997. Bees visiting coconut inflorescences in Bahia, Northeast Brazil. *J. Apic. Res.* 36: 180-181.
- Dejean, A., B. Corbara & J.M. Carpenter. 1998. Nesting site selection by wasps in the Guianese Rain Forest. *Insectes Soc.* 45: 33-41.
- Della Lucia, T.M.C., M.C. Loureiro, L. Chandler, J.A. Freire, J.D. Galvão & B. Fernandes. 1982. Ordenação de comunidades de Formicidae em quatro agroecossistemas em Viçosa, Minas Gerais. *Experientiae* 28: 67-94.
- Diniz, I.R. & K. Kitayama. 1994. Colony densities and preferences for nest habitats of some wasps in Mato Grosso State, Brazil (Hymenoptera: Vespidae). *J. Hym. Res.* 3: 133-143.
- Gess, F.W. 1981. Some aspects of an ethological study of the aculeate wasps and the bees of a Karroid area in the Vicinity of Grahamstown, South Africa. *Ann. Cape Provincial Museum (Natural History)* 14: 1-80.
- Giller, P.S. 1984. *Community structure and the niche*. Chapman and Hall, London, 176p.
- Heithaus, E.R. 1979. Community structure of neotropical flower visiting bees and wasps: Diversity and phenology. *Ecology* 60: 190-202.
- Lack, D. 1969. The numbers of bird species an island. *Bird Study* 16: 193-209.
- Lawton, J.H. 1983. Plant architecture and the diversity of phytophagous insects. *Annu. Rev. Entomol.* 28: 23-39.
- Ludwig, J.A. & J.F. Reynolds. 1988. *Statistical ecology - a primer on methods and computing*. New York, John Wiley & Sons, 337p.
- Majer, J.D., J.H.C. Delabie & M.R.B. Smith. 1994. Arboreal ant community patterns in Brazilian cocoa farms. *Biotropica* 26: 73-83.
- Marques, O.M. 1996. *Vespas sociais (Hymenoptera, Vespidae): Características e importância em agroecossistemas*. *Insecta* 3: 18-39.
- McArthur, R. & E.O. Wilson. 1967. *The theory of Island Biogeography*. Princeton, Princeton University Press, 203p.
- Naumann, M.G. 1975. Swarming behavior: Evidence for communication in social wasps. *Science*, 189: 642-644.
- Pleasants, J.M. 1983. Structure of plant and pollinator communities, p.375-393. In G.E. Jones & R.J. Little (eds.), *Handbook of experimental and pollination biology*. New York, Van Nostrand Reinhold, 558p.
- Raunkiaer, C. 1934. *The life forms of plants and statistical plant geography*. Oxford, Clarendon Press, 632 p.
- Richards, O.W. 1978. *The social wasps of the Americas (excluding the Vespinae)*. London, British Museum (Natural History), 580p.

- Ross, K.G. & R.W. Matheus. 1991. The social biology of wasp, Cornell University Press, 678p.
- Sakagami, S.F., R. Zucchi., S. Yamane., F.B. Noll, & J.M.P. Camargo. 1996. Morphological caste differences in *Agelaia vicina*, the Neotropical Swarm-founding Polistine wasp with the largest colony size among social wasps (Hymenoptera: Vespidae). *Sociobiology* 28: 208-223.
- Santos, G.M. de M. 2000. Comunidades de vespas sociais (Hymenoptera-Polistinae) em três ecossistemas do estado da Bahia, com ênfase na estrutura da guilda de vespas visitantes de flores de Caatinga. Tese de doutorado, Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto/USP, 129p.
- Santos, G.M. de M. & N. Gobbi. 1998. Nesting habits and colonial productivity of *Polistes canadensis canadensis* (L.) (Hymenoptera - Vespidae) in a caatinga area, Bahia State - Brazil. *J. Adv. Zool.* 19: 63-69.
- Santos, G.M. de M. & O.M. Marques. 1996. Análise faunística de comunidades de formigas epigéias (Hymenoptera - Formicidae) em dois agroecossistemas em Cruz das Almas - Bahia. *Insecta* 5: 1-17.
- Santos, G.M. de M., S.O.C. Silva, C.C. Bichara Filho & N. Gobbi. 1998. Influencia del tamaño del cuerpo em el forrajeo de avisvas sociales (Hymenoptera - Politinae) visitantes de *Syagrus coronata* (Martius) (Arecaceae). *Rev. Gayana Zool.* 62: 167-170.
- Santos, G. M. de M., V.P.G. Santana-Reis, J. J. Resende, P. De Marco & C.C. Bichara Filho. 2000. Flying capacity of swarm-founding wasp *Polybia occidentalis occidentalis* Olivier, 1971 (Hymenoptera, Vespidae). *Rev. Bras. Zoociên.* 2: 33-39.
- Silveira-Neto, S., O. Nakano, D. Barbin & N.A.V. Nova. 1976. Manual de ecologia dos insetos. Piracicaba, Ceres, 419p.
- Simberloff, D. & L.G. Abele. 1976. Island biogeography theory and conservation practice. *Science* 191: 285-286.
- Spradbery, J.P. 1973. Wasps. An account of the biology and natural history of social and solitary wasps. Seattle, University Washington Press, 408p.

Received 01/VII/05. Accepted 01/VIII/06.
