

Microhabitat selection and co-occurrence of *Pachistopelma rufonigrum* Pocock (Araneae, Theraphosidae) and *Nothroctenus fuxico* sp. nov. (Araneae, Ctenidae) in tank bromeliads from Serra de Itabaiana, Sergipe, Brazil

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ABSTRACT. Microhabitat selection and co-occurrence of *Pachistopelma rufonigrum* Pocock (Theraphosidae) and *Nothroctenus fuxico* sp. nov. (Ctenidae), in tank bromeliads were investigated. Thermal conditions, inside and outside the plants, were measured in order to verify if the temperature of the water that accumulates inside the plant affects the behavior of these species. Measurements of foliar parameters were taken in order to evaluate if and how plant structure affects spider abundance and microhabitat selection. Apparently, differences in plant structure do not affect either spider abundance or microhabitat selection. No microhabitat preference was observed and co-occurrence of both species was a random event. In addition, notes on the distribution range of *P. rufonigrum* and the description of *N. fuxico* sp. nov. from State of Sergipe, Brazil are presented.

KEY WORDS. Microhabitat preference, inter specific co-existence, spiders, terrestrial's bromeliads, thermal conditions.

RESUMO. Foram estudadas a seleção de microhabitat e co-ocorrência de *Pachistopelma rufonigrum* Pocock (Theraphosidae) e *Nothroctenus fuxico* sp. nov. (Ctenidae) em bromélias-tanque. A condição da temperatura dentro e fora das plantas foi medida para verificar se a temperatura da água acumulada dentro da bromélia afeta algum aspecto comportamental das aranhas que ali vivem. Medidas dos parâmetros foliares foram realizadas para avaliar se a estrutura das plantas chega a afetar a abundância ou a seleção de microhabitat dessas aranhas. Aparentemente, as diferenças na estrutura das duas espécies de bromélias estudadas não afetam nem a abundância, nem a seleção de microhabitat de *P. rufonigrum* e *N. fuxico* sp. nov. A preferência e co-ocorrência de ambas as espécies de aranhas parece ser um evento ao acaso. Adicionalmente, apresenta-se notas sobre os limites de distribuição de *P. rufonigrum* e descreve-se *N. fuxico* sp. nov. do Estado de Sergipe, Brasil.

PALAVRAS CHAVE. Aranhas, bromélias terrestres, condições termais, co-ocorrência interespecífica, preferência por microhabitat.

Spiders use bromeliads for several means. Some species use the plants as reproductive sites (BARTH *et al.* 1988, DIAS *et al.* 2000, ROSSA-FERES *et al.* 2000, DIAS & BRESCOVIT 2003), for foraging (DIAS & BRESCOVIT 2003) or even as a shelter against desiccation (BARTH *et al.* 1998). Although there are several papers that deal with the relationship between spiders and host plants, none present information on the co-occurrence and niche overlapping of large spiders. According to PIANKA (1994) niche overlapping occurs when two organisms use the same resources in a same habitat and this overlapping can result in a competition for resources. Several well-documented examples have been presented on tactics to avoid competition in niche overlapping species (ROBINSON 1981, SCHEIDLER 1990, PIANKA 1994). ROBINSON (1981), while studying the effects of habitat structure over spi-

der species composition, concluded that different species in a community show a preference towards different substrate structures as a means to prevent competition for resources.

In the Serra de Itabaiana, Sergipe, Brazil, two terrestrial tank bromeliad species of the genera *Aechmea* Ruiz & Pav. and *Hohenbergia* Schult, host large spiders of the families Theraphosidae (*Pachistopelma rufonigrum* Pocock, 1901) and Ctenidae (*Nothroctenus fuxico* sp. nov.). All stages of the life cycle of both species have been recorded inside the plants, confirming that the bromeliads are used as a reproduction site and that the spiders are probably associated exclusively to these plants throughout their entire life cycle (DIAS *et al.* 2000, DIAS & BRESCOVIT 2003). The aims of this study were to investigate the preference of these spiders towards any of the plant species,

the co-occurrence of species in a same plant, the effects of thermal conditions on their foraging behavior and of habitat structure on species abundance. In addition to the natural history data, the description of the new species of *Nothroctenus* Badcock, 1932 as well as notes on the northeastern distribution range of *P. rufonigrum* are presented.

MATERIAL AND METHODS

This study was carried out in the "Estação Ecológica Serra de Itabaiana", Areia Branca (10°40'S; 37°25'W), State of Sergipe, Brazil, between July and September 2002. The area is characterized by the presence of white sandy soil and vegetation composed mainly of shrubs, bushes, bromeliads and cactus (VICENTE *et al.* 1997). The data were collected between the "Água Fria" and "Coqueiro" streams and between "Água Fria" and "Negros" streams.

The data on co-occurrence and preference were based on the number of specimens recorded in 80 plants of each species. Since both spider species are nocturnal, plants were marked during the day and observations were made during the night. Temperature measurements were taken, inside and outside 20 tank bromeliads, at three different time spans: between 0700-0800 h, 1200-1300 h and 1730-1830 h. In order to determine the total leaf surface of the bromeliad species, the number of live leaves of 20 plants of each species was counted and the length and width of one leaf from the median layers of the plant was measured. All measurements were taken in centimeters.

Chi-square tests were used to determine if there was a preference towards a specific microhabitat and if there was co-occurrence of species (SIEGEL 1997). The *t*-test, used for independent samples, was used to compare the temperature between the inside and outside of the plants as well as to determine if there were differences between the average of foliar surface and the number of live leaves of the two bromeliad species (VANZOLINI 1993, ZAR 1996).

Systematic description format, leg spination and terminology follow HÖFER *et al.* (1994). All measurements are in millimeters. Abbreviations: (AME) anterior median eyes; (PME) posterior median eyes; (ALE) anterior lateral eyes; (PLE) posterior lateral eyes; (p) prolateral; (r) retrolateral; (d) dorsal. The epigynum was dissected and submerged in clove oil to study internal structures. Micrographs were obtained with a JEOL scanning electron microscope (JSM 840A) from the "Laboratório de Microscopia Eletrônica do Departamento de Física Geral do Instituto de Física da Universidade de São Paulo (USP)".

RESULTS

Microhabitat preference

Only two species of tank bromeliads are found in the Serra de Itabaiana region. The proportion of individuals of each species in the area is the same.

Thirty-two *P. rufonigrum* specimens were observed inhab-

iting bromeliads amongst 160 examined plants, 80 of each species. As shown on table I, there was no preference of this spider towards any of the bromeliad species ($\chi^2 = 0.0312$, $p > 0.05$).

In relation to *N. fuxico* **sp. nov.**, 32 specimens were observed amongst the 160 examined plants and no preference towards any of the species was observed, as shown on table I ($\chi^2 = 0.0192$, $p > 0.05$).

Co-occurrence of spiders

DIAS & BRESCOVIT (2003) observed that *P. rufonigrum* and *N. fuxico* **sp. nov.** are sometimes found inhabiting the same plant. According to the data obtained in this study, the co-occurrence of spiders occurs at random. For *Aechmea* sp. $\chi^2 = 0.0334$, $p > 0.05$ and for *Hohenbergia* sp. $\chi^2 = 0.0908$, $p > 0.05$.

Temperature

Since both species of plants accumulate pluvial water inside of their central tank, the temperature inside the plant is the same as that of the accumulated water and as such, directly influenced by the environmental temperature. Nevertheless, the temperature inside of the plants was lower or higher than that of the outside, on morning and night, respectively. table II, with the Student *t*-tests results, shows when there was a significant difference between the temperature inside and outside of the plant.

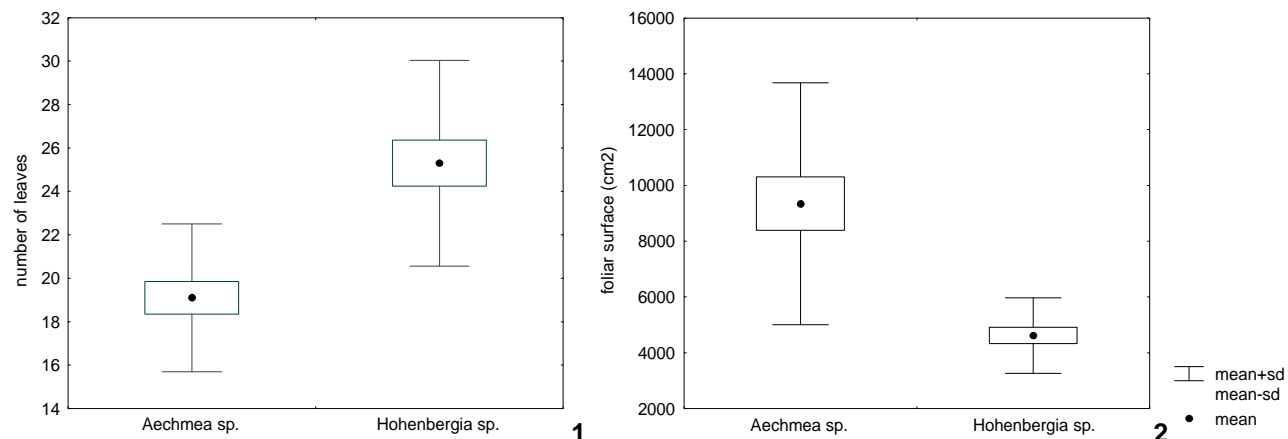
Foliar parameters

Although the tank bromeliad species found in the "Serra de Itabaiana" are very similar, both presenting central tanks and a spiraled leaf arrangement that accumulates rainwater, comparisons of the foliar parameter showed significant differences. *Hohenbergia* bromeliads present more leaves than *Aechmea* ($t = -4.75$, d.f. = 38, $p < 0.01$, Fig. 1). Nevertheless, *Aechmea* bromeliads present larger foliar surfaces than *Hohenbergia* ($t = 4.65$, d.f. = 38, $p < 0.01$, Fig. 2).

Systematics

The spider species dealt in this paper belong to two different orders. *P. rufonigrum* belongs to the order Mygalomorphae, amply distributed throughout the Brazilian Northeastern coastland and semi-arid regions. The genus *Pachistopelma* Pocock, 1901 includes only two species *P. concolor* Caporiacco, 1947, restricted to the Guyana, and the above-mentioned species (PLATNICK 2003). Notes on the behavior of the *P. rufonigrum* were presented by DIAS & BRESCOVIT (2003). In this paper data on the distribution range of *P. rufonigrum* is presented based on material from the collections of the Instituto Butantan, São Paulo (IBSP) and Museu Nacional do Rio de Janeiro, Rio de Janeiro (MNRJ).

The other species, belonging to the order Araneomorphae, is an undescribed species of the genus *Nothroctenus* Badcock, 1932. This genus includes, to date, eight Neotropical species, six of which are recorded from Brazil (PLATNICK 2003). This new species is probably the only one with morphological adaptations for living in bromeliads.



Figures 1-2. (1) Comparison between the average number of leaves in the two bromeliad species; (2) Comparison between the average foliar surface in the two bromeliads species.

Table I. Microhabitat preference for *P. rufonigrum* and *N. fuxico* sp. nov. (F) Observed frequency of spiders, (E) expected frequency.

Habitat	<i>P. rufonigrum</i>			<i>N. fuxico</i> sp. nov.		
	F	E	χ^2 (with Yates correction)	F	E	χ^2 (with Yates correction)
<i>Aechmea</i> (50%)	16	16	0.0156	25	26	0.0096
<i>Hohenbergia</i> (50%)	16	16	0.0156	27	26	0.0096
Total	32	32	$\chi^2 = 0.0312$	52	52	$\chi^2 = 0.0192$

Table II. Student t-tests comparing the average difference of temperature inside and outside of the tank bromeliads, at three different times during the day. (x) Average, (sd) standard deviation.

Specie	Period	x \pm sd T°C plant	x \pm sd T°C air	t values (d.f. = 38)	p
<i>Aechmea</i>	Morning	21.85 \pm 0.671	22.92 \pm 0.907	- 4.261	< 0.01
<i>Aechmea</i>	Midday	24.80 \pm 1.196	24.52 \pm 1.141	0.740	> 0.05
<i>Aechmea</i>	Night	23.32 \pm 1.029	21.77 \pm 0.617	5.774	< 0.01
<i>Hohenbergia</i>	Morning	22.22 \pm 0.638	24.42 \pm 0.892	- 8.968	< 0.01
<i>Hohenbergia</i>	Midday	26.42 \pm 1.238	25.67 \pm 1.290	1.875	> 0.05
<i>Hohenbergia</i>	Night	25.80 \pm 0.732	22.77 \pm 0.785	12.593	< 0.01

Pachistopelma rufonigrum Pocock, 1901

Fig. 3

Pachistopelma rufonigrum Pocock, 1901: 548 (2 males and 6 females paratypes from Igarassú, Pernambuco, Brazil, deposited in the The Natural History Museum, London, not examined); Mello-Leitão, 1923: 336; Brescovit *et al.*, 1999: 108; Rocha-Neto, 2001: 28; Platnick, 2003.

Distribution. Northeastern Brazil, living exclusively in bromeliads.

Records. BRAZIL, *Rio Grande do Norte*: Extremóz, Pitanguí (in ROCHA-NETO 2001); *Pernambuco*: Moreno, Bonança (MNRJ 13615); Paraíba: Mamanguape (IBSP 9756); *Sergipe*: Nossa Senhora da Glória (IBSP 7892; 7893); Brejo Grande (IBSP 8085);

Barra dos Coqueiros (IBSP 8086; 8087; 8088); Areia Branca, Estação Ecológica Serra de Itabaiana (IBSP 8525; 8599; 8716; 9147; 9789; 8698; 9832; 10010; 10011; 10035); Santa Luzia do Itanh, Mata do Crasto (in BRESCOVIT *et al.* 1999).

Nothroctenus fuxico sp. nov.

Figs 4-18

Types. Holotype male and allotype female from Estação Ecológica Serra de Itabaiana, Areia Branca, Sergipe, 09.IX.2000, S.C. Dias *leg.*, deposited in Instituto Butantan (IBSP 37834). Paratypes: 1 male, 1 female with the same data as holotype, N. Zyngier *leg.* (IBSP 37835); 1 female from Barra dos Coqueiros, Sergipe, 20.II.1995, E.C.G. Couto e L.T. dos Santos *leg.* (IBSP 24002).



Figures 3-4. (3) *Pachistopelma rufonigrum* on leaves of *Hohenbergia* sp. bromeliad, adult female; (4) *Nothroctenus fuxico* sp. nov. on leaves of *Aechmea* sp. bromeliad, adult female.

Etymology. Brazilian northeastern slang that means friendship, due to the fact that this species is commonly observed living together with *P. rufonigrum* in the tank bromeliads.

Diagnosis. *Nothroctenus fuxico* sp. nov. is easily distinguished from the other species of this genus by the flattened body (Figs 4 and 6) and modified eye area, where the PME are located almost between the AME and ALE (Figs 5-6).

Description. Male (Holotype). Carapace brown, with cephalic area and posterior third of carapace orange; black rings around the eyes; chelicerae orange; labium, endites and sternum yellowish. Legs brown with distal area of the articles gray, coxae ventrally yellow and femora gray. Abdomen dorsally yellowish, laterally gray and ventrally yellow to orange.

Total length 11.80. Carapace 6.20 long, 5.00 wide. Clypeus 0.04. Eye diameters and interdistances: AME 0.26, ALE 0.20, PME 0.56, located almost between the AME and ALE (Figs 5-6), PLE 0.62; AME-AME 0.10, AME-ALE 0.72, PME-PME 0.28, PME-PLE 0.56, AME-PLE 0.50, AME-PME 0.10. MOQ length 0.68, anterior width 0.64, posterior width 1.56. Chelicerae with 3 promarginal teeth, the median the largest, and 3 retromarginal denticles.

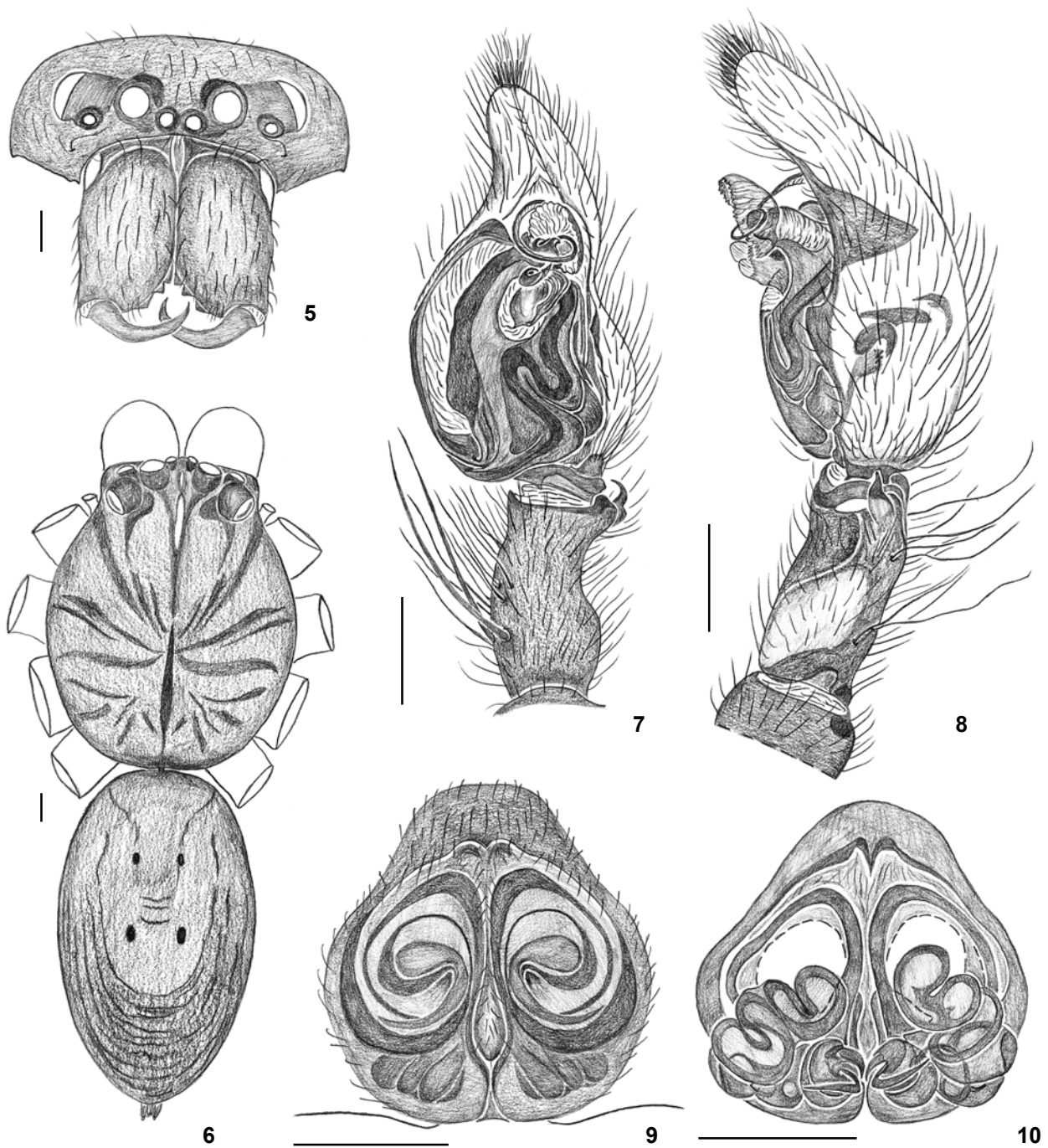
Leg measurements. I - femur 7.70/patella 3.00/tibia 8.20/metatarsus 8.80/tarsus 2.00/total 29.70/II - 7.40/2.80/7.10/7.70/1.80/26.80/III - 6.20/2.20/5.20/6.70/1.50/21.80/IV - 8.20/2.30/7.60/9.30/2.30/29.70. Leg spination: femur I p1-1-2-1-1, d1-1-1, r1-1-1; II - IV p1-1-1-1, d1-1-1, r1-1-1-1; trochanter I - II r0-1-0, III - IV r0-1-0; tibia I v2-2-2-2-2, p1-1-1-1-1, r0-1-1; II v2-2-2-2-2-2, p1-0-0, r1-1-1-1-1; III - IV v2-2-2, p1-1-0, r1-1-0; metatarsus I v2-2-2-2, p1-1-1-1, r1-1-1-1; II v2-2-2-2, p1-1-0, r1-1-1-1; III v2-2-2-2, p1-1-1, r1-1-1; IV v2-2-2-2, p1-1-1, r1-1-

1. Cribellum inconspicuous, not divided, calamistrum absent. Palpal spination: femur p1, d1-1, r1. Palp: tibia with retrolateral-basal enlargement and tibial retrolateral apophysis short, sinuous and curved at tip (Fig. 7); cymbium with median retrolateral projection (Fig. 8) and distal area with 13-15 very thick spines (Fig. 15); tegulum with sinuous and retrolateral reservoir, median apophysis short and curved at apex, conductor with long and very thick basis, distally with great number of short projections and presenting a hyaline area involving the tip of embolus, embolus very long, with large basis and narrow and sinuous distal area (Figs 7; 13-14).

Female (Allotype). Coloration as in male, except chelicera, endites, labium and sternum red-brown (Fig. 4).

Total length 12.80. Carapace 5.90 long, 4.90 wide. Clypeus 0.15 high. Eye diameters and interdistances: AME 0.25, ALE 0.25, PME 0.60, as in the male, PLE 0.70; AME-AME 0.20, AME-ALE 0.15, PME-PME 0.75, PME-PLE 0.75, ALE-PLE 0.40, AME-PME 0.06. MOQ length 1.30, anterior width 1.65, posterior width 1.95. Chelicerae as in male.

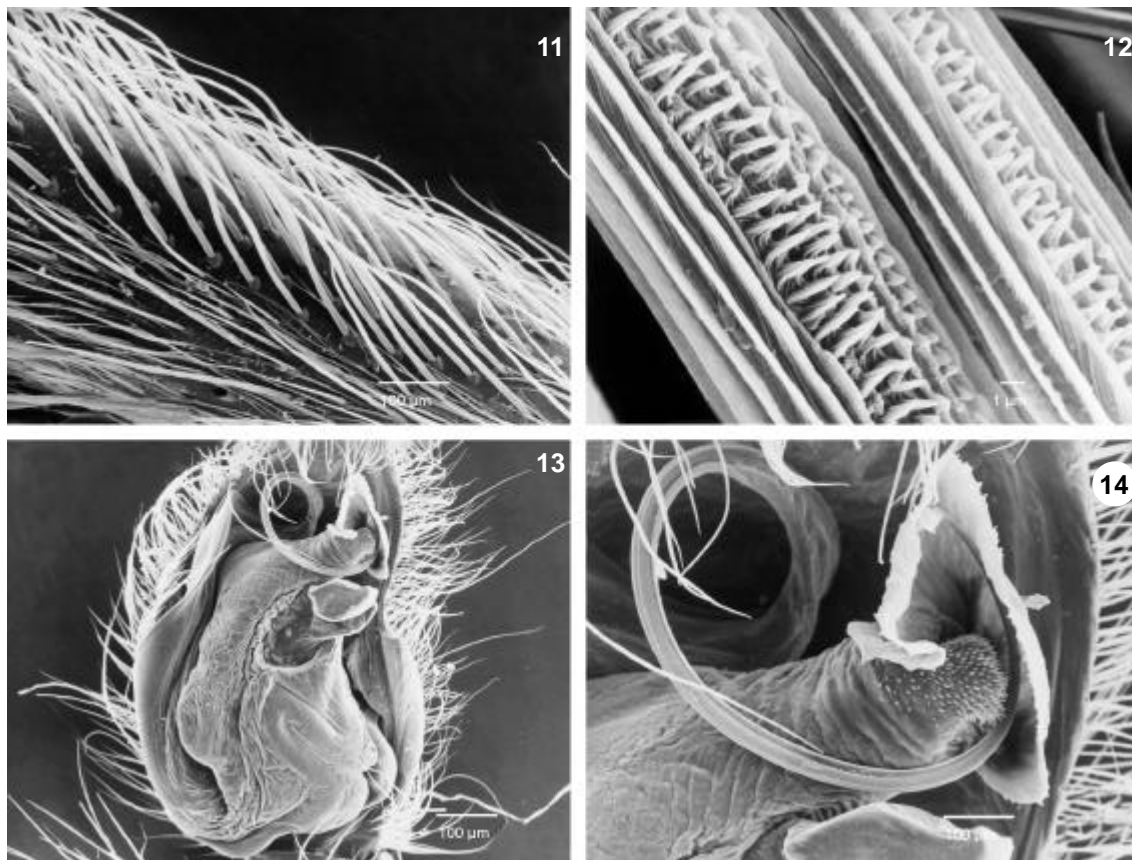
Leg measurements. I - femur 5.70/patella 2.80/tibia 5.80/metatarsus 5.40/tarsus 1.20/total 20.90/II - 5.80/2.60/5.20/5.20/1.10/19.90/III - 5.10/2.00/4.00/4.60/1.00/16.70/IV - 6.40/2.30/5.50/6.40/1.40/22.00. Leg spination: femur as in male; tibia I v2-2-2-2-2-2, p1-1-0, r1-1-1; II v2-2-2-2-2-2, p1-1-1-1, r1-1-1-1-1; III - IV v2-2-2, p1-1-0, r1-1-0; metatarsus I v2-2-2-2, p1-0-0, p1-0-0, II v2-2-2-1p, p1-0-0, r1-0-0, III v2-2-2, p1-2-2, r1-2-2, IV v2-2-2, p1-1-1-2, r1-1-1-2. Leg IV with long claws with only three small ventral teeth and developed claw tufts (Fig. 16). Trichobothria with long trichoma, bothrium with transverse and striated ring (Fig. 17). Tarsal organ capsulated with oval opening (Fig. 18). Cribellum not divided, calamistrum brush-



Figures 5-10. *Nothroctenus fuxico* sp. nov.: (5) carapace, female, frontal, (6) Habitus, female, dorsal, (7-8) male palp: (7) ventral, (8) retrolateral; (9-10) female epigynum: (9) ventral, (10) dorsal. Scale bars: 0,5 mm.

like, from base to top of tibia and presenting hairs with modified lateral surfaces (Figs 11-12). Epigynum with circular atrium divided by a median septum with a median, short and finger-

like scapus (Fig. 9). Internally with long and narrow copulatory ducts, large and coiled spermathecae and short, narrowed and basal fertilization ducts (Fig. 10).



Figures 11-14. *Nothroctenus fuxico* **sp. nov.** (11-12) female calamistrum, leg IV: (11) lateral, (12) detail of hairs, lateral; (13-14) male palp: (13) ventral, (14) detail of apex, conductor and embolus, ventral.

Variation. Three males: total length 10.80-12.00; carapace 5.30-6.20; femur I 6.80-7.70; six females: total length 12.60-15.80; carapace 5.60-6.80; femur I 5.60-6.80.

Distribution. Only known from the state of Sergipe, Brazil.

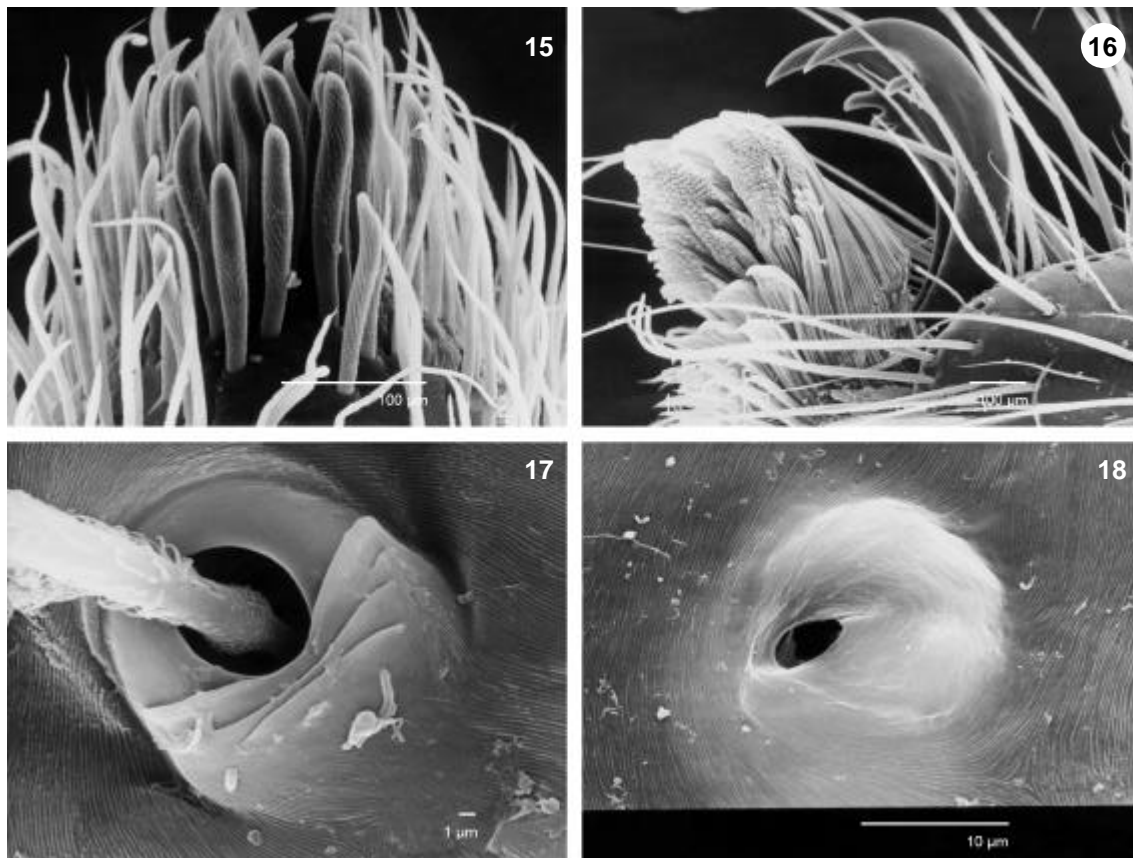
Other material examined: BRAZIL. Sergipe: Areia Branca, Estação Ecológica Serra de Itabaiana, 5 juveniles, VII-IX.2000, N. Zyngier & S.C. Dias *leg.* (IBSP 37386; 37837; 37838); Barra dos Coqueiros, 1 male and 3 females, XI.1994-X.1998, E.C.G. Couto & L.T. Santos *leg.* (IBSP 24001; 24005; 37839; 37840).

DISCUSSION

There was no preference of the spiders' towards any bromeliad species, even though there were significant differences in the number of leaves and foliar surface of the plants. Nevertheless, differences in foliar parameters could be a reason for the spiders' preference towards one bromeliad species. HATLEY & MACMAHON (1980) observed that the number of leaves of a shrub indicated the amount of available substrate for spiders and as such, shrubs with more leaves have more resident spiders than those with less foliage. PIANKA (1966) obtained the same results

while studying lizards. He showed that more the larger the volume of the dwelling plant, the higher the fauna diversity associated to it. Although *Hohenbergia* has more leaves than *Aechmea*, the latter has a larger foliar surface. As such, the quantity of available microhabitats that could be occupied in both plants is virtually the same, since the higher number of leaves is compensated by the larger foliar surface and vice-versa. This is probably the reason why no preference was observed in the studied spiders.

DIAS & BRESCOVIT (2003) state that, for *P. rufonigrum*, only one spider occurs in each plant. This is probably also the case for *N. fuxico* **sp. nov.**, since both species are quite large and the bromeliad has enough resources for only one spider. The data obtained in this study shows that *N. fuxico* **sp. nov.** and *P. rufonigrum* do not co-occur in the same plant. In other words, the spiders prefer inhabiting separate plants so that there is no niche overlapping. DIAS & BRESCOVIT (2003) found *P. rufonigrum* and *N. fuxico* **sp. nov.** in the same bromeliad in few cases. Nevertheless, no agonistic encounters between the species were recorded. One reason can be appointed to the competition excluded hypothesis between these two species of spi-



Figures 15-18. *Nothroctenus fuxico* sp. nov.: (15) male palp, cymbium, apex ventral; (16) female, leg IV, detail of claws and subungueal hairs; (17) Trichobothria, leg I, dorsal; (18) tarsal organ, leg I, dorsal.

ders that is the strategies foraging difference. While *P. rufonigrum* have a mode sit and wait of strategy foraging (DIAS & BRESCOVIT 2003), *N. fuxico* sp. nov. it can be, like the major of Ctenidae, active hunter and, therefore, must be feed it of different prey. Due to the fact that both species include large animals, it is believed that a single bromeliad does not have enough resources to enable two spiders to live in it. Several papers deal with the relation between population density and body size in many groups of animals (DAMUTH 1981, PETERS & WASSENBERG 1983, GUNARSSON 1992, MORSE *et al.* 1988, LAWTON 1989). DAMUTH (1981) states that there is an inverse relation between body size and local abundance and that two distinct patterns can be observed for population densities: a large number of small individuals or a small number of large individuals. The same conclusions were presented by GUNARSSON (1992) for spiders, PETERS & WASSENBERG (1983), while dealing with several studies of different authors on a variety of animal groups, and by MORSE *et al.* (1988), for beetles.

Tank bromeliads are important microhabitats for their associated biota. In addition to the protection against predators

offered by the bromeliad leaves, the water accumulated in the central tank acts as a thermoregulation mechanism, providing a microclimate different to that of the external environment. SCHEIDLER (1990) states that plant structure affects abiotic factors, such as temperature. BARTH *et al.* (1998) observed significant differences between temperature and humidity inside and outside the bromeliads, reporting higher humidity values inside the bromeliads. VRCIBRADIC & ROCHA (2002), while working with cactus in the Brazilian "restinga", verified that the temperature of the accumulated water inside the plants varies in relation to air temperature according to a physical component, known as specific heat. According to these authors, if the air temperature decreases, the water inside the plant remains warmer a little longer. This fact was also verified in this study, with significant differences between the temperature inside and outside the plant. This does not mean that the temperature of the water inside the plant was always lower than that of the outside. We believe that temperature is one of the main factors affecting the spiders' behavioral cycle. For the spiders it is best to remain inside the bromeliad during the morning, when the temperature

is lower than that of the outside. At nightfall, the spiders tend to leave the plants. This can be explained by the fact that the temperature is lower outside the plant and that both spider species' diet is composed of nocturnal animals. Both species prefer to remain inside the bromeliad during the day not only because the leaves provide protection against direct sun radiation but also because the high humidity, provided by the water accumulated inside the central tank, prevents desiccation, even if the temperatures inside and outside the plant are the same.

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