

Substrate preferences, and the relationship between soil characteristics and the distribution of the giant whipscorpion, *Mastigoproctus giganteus* (Lucas) (Arachnida, Uropygi) in Big Bend National Park

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Summary

The distribution of the giant whipscorpion *Mastigoproctus giganteus* in Big Bend National Park is related to certain characteristics of the substrate, especially soil hardness as measured with a penetrometer. Adult males and females were most frequently associated with sand loam soils exhibiting a mean hardness value of 7.9 kg cm^{-2} , and least associated with hard, adobe soils ($37\text{--}41 \text{ kg cm}^{-2}$). There was no obvious relationship between specific capture or burrow sites and the type of plants found at these sites. In laboratory substrate selection experiments, *M. giganteus* showed a significant preference for the sand loam substrate as compared with loose sand and adobe substrates. These whipscorpions also spent a significantly greater period of time on the sand loam soil. Only 24% of females and 18% of males exhibited any digging behaviour in these experiments.

Introduction

The giant whipscorpion, *Mastigoproctus giganteus* (Lucas), is a common inhabitant of many areas of the Sonoran and Chihuahuan Deserts in the United States and Mexico (Crawford, 1981; Punzo, 2000a, b). It is a large (40–80 mm in length) and formidable-looking arachnid with heavy pedipalps that are formed into pincers (Marx, 1886; Kästner, 1932; Cloudsley-Thompson, 1968), and it is well known for its chemical defence system (Eisner *et al.*, 1961; Schmidt *et al.*, 2000). Although a considerable body of folklore and anecdotal information can be found (Marx, 1886, 1893; Pocock, 1895; Howard, 1919), few studies exist concerning the ecology and behaviour of this arachnid (Ahearn, 1970; Weygoldt, 1970, 1971; Levi, 1982; Punzo, 2000b).

Previous studies have established that in desert regions, *M. giganteus* is strongly nocturnal in its diel periodicity (Marx, 1886; Cloudsley-Thompson, 1968, 1975; Punzo, 2000b) and is a cursorial hunter that feeds on a wide variety of arthropod prey (Rowland & Cooke, 1973; Savory, 1977; Punzo, 2000a, b). Although it has been reported to inhabit a number of different microhabitats in desert regions (Banks, 1901; Cloudsley-Thompson, 1968), no detailed studies have been done concerning the distribution of this arachnid within a given area.

Soil characteristics such as hardness, particle size and organic content have been shown to be important edaphic factors influencing the distribution of various desert arthropods, including scorpions (Lamorale, 1978; Polis, 1990), theraphosid spiders (Baerg, 1958; Main, 1982; Punzo & Henderson, 1999), eresid spiders (Lubin & Henschel, 1990) trap-door spiders (Main, 1976, 1991),

burrowing wolf spiders (Richardson, 1990), and solifugids (Muma, 1966; Punzo, 1998). The purpose of the present study was to analyse the distribution of *M. giganteus* at a number of different locations in Big Bend National Park (Figs. 1 and 2) in relation to soil hardness, and to determine if this arachnid exhibits any preference for specific types of substrates in laboratory experiments.

Description of the general study area

Big Bend National Park (BBNP) ($28^{\circ}58'\text{--}29^{\circ}37'\text{N}$; $102^{\circ}55'\text{--}103^{\circ}45'\text{W}$) lies within the northern region of the Chihuahuan Desert (Brewster County, Texas) in the Trans Pecos region of Texas (Figs. 1 and 2). The climate of this region can range from semi-arid to arid (Wauer, 1980). Within the Park, annual rainfall is usually between 16.8–31.4 cm, depending on location and altitude, with 60–80% occurring from May through October (Medellín-Leal, 1982). Mean monthly air temperatures can range from 5.5°C (January) to 32.8°C (July), with low and high temperatures of -12.7 and

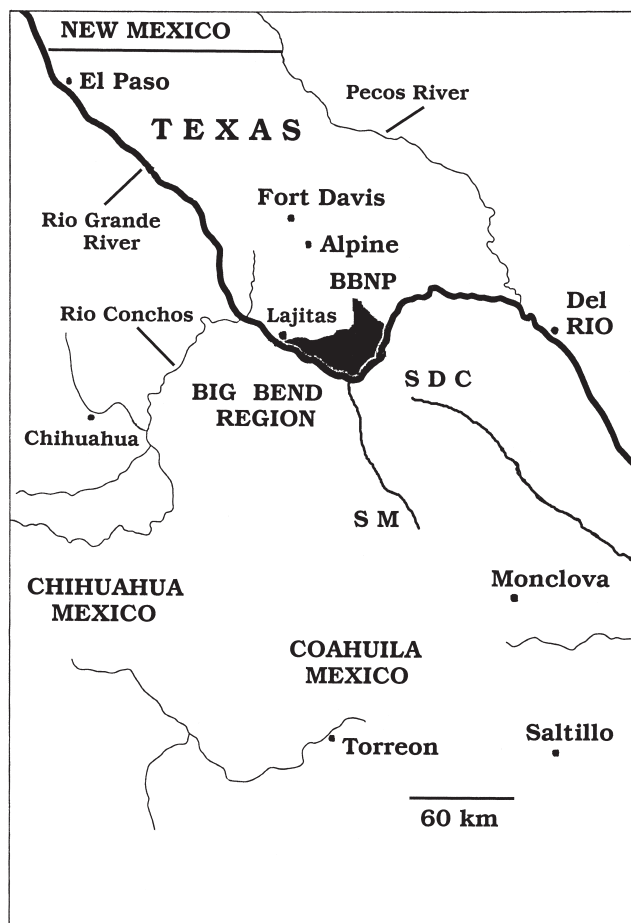


Fig. 1: The northern region of the Chihuahuan Desert including the Big Bend region of Trans Pecos Texas. The darkly shaded area shown near the centre of the map represents Big Bend National Park (BBNP) which is separated from Mexico by the Rio Grande River. The two large mountain ranges to the south of BBNP are the Sierra del Carmen (SDC) and Sierra Madre (SM) Mountains. Lajitas, Texas is located at $29^{\circ}16'\text{N}$, $103^{\circ}46'\text{W}$. Monclova, Mexico is located at $26^{\circ}55'\text{N}$, $101^{\circ}25'\text{W}$.

46.1°C, respectively (Tinkam, 1948; U.S. Dept. Interior, 1990).

There is a wide range of topographic diversity within BBNP, ranging from limestone deposits with internally draining basins, igneous rock, and gypsum formations, that provide a variety of substrates including mountain ridges, slopes, canyons, alluvial fans, fine-textured basins, saline playas, gypsum flats, siliceous and gypsum dunes, freshwater seeps, and springs (Jaeger, 1957; Maxwell *et al.*, 1967; Medellín-Leal, 1982). The Park is bordered on the south-east and south-west by the Rio Grande River. The vegetative zones of BBNP have been described by Cottle (1931), Tinkam (1948), Henrickson & Johnston (1983), and Powell (1988).

Soil hardness is determined by the cohesive forces holding soil particles together which, in turn, are related to the percent composition of clay, silt, and sand (Milford, 1991). The greater the cohesion, the harder a

soil will be, and more force will be required to penetrate its surface. Thus, soil hardness directly influences the ability of animals to excavate burrows. More specifically, hardness values at the surface of the ground may represent the most important proximate factor determining whether or not an animal will initiate burrow construction.

The terminology associated with the various types of soils found at the various study sites in BBNP follows the descriptions reported by Jenny (1941) and González-Cortés (1959). Aridisoles are silt loam soils that contain little humus, and are found in areas receiving little precipitation that contain an ochric epipedon and several additional horizons including cambic, argylic, calcic, salic, or gypsic, associated with duripans. They are typically red in colour when associated with the oxidation of iron-containing sediments. Adobe soils are compact and have a high clay content. Halomorphic

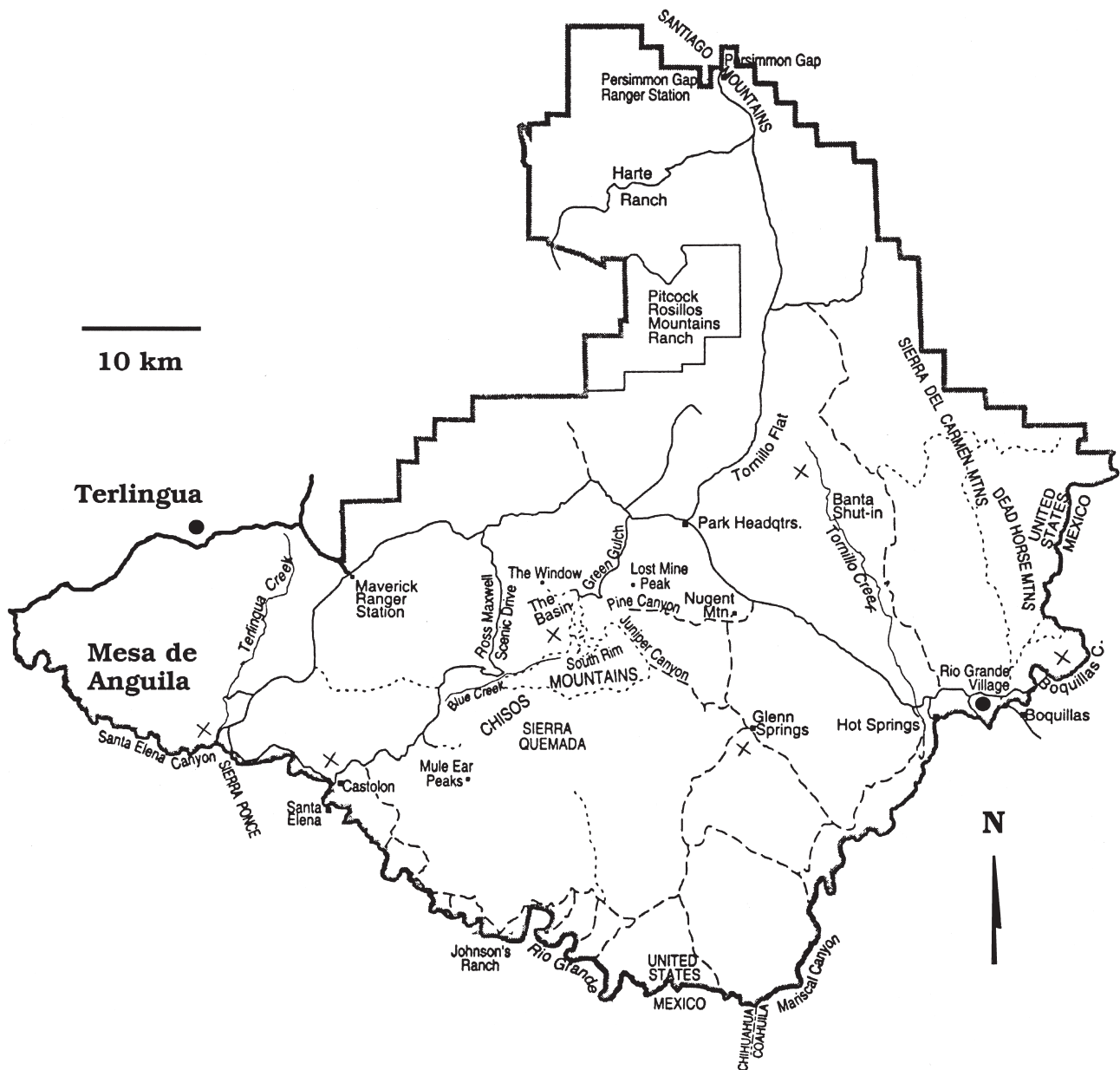


Fig. 2: Map of Big Bend National Park, Brewster County, Texas. The map coordinates for the Park Boundaries are: area near Persimmon Gap (northern boundary), 29°37'N, 103°04'W; Boquillas Canyon (eastern boundary), 29°12'N, 102°55'W; Santa Elena Canyon (western boundary), 29°11'N, 103°45'W; Mariscal Canyon (southern boundary), 28°58'N, 103°13'W). Positions of study sites marked by crosses.

(saline) soils are aridisoles that contain a high concentration of salts due to leaching processes. Fluvents are alluvial soils found on arid floodplains and other regions characterised by fluvio-lacustrine sedimentation adjacent to foothills. They contain a variable amount of sand and gravel. Molisoles contain a moderate amount of organic material and have a brown or walnut stain (Medellín-Leal, 1982). Lithic soils are thin, clay loam soils found in montane regions of BBNP and they contain an infertile (distric) phase and a fertile (eutric) phase. Each of these major soil types may exhibit a range of soil hardness values depending on a number of factors including variable degrees of compaction, presence or absence of particular inorganic compounds, and soil pH.

Methods

Field studies were conducted at six sites in BBNP from early May through August over a three-year period (1997–1999). The study sites were: the north end of Tornillo Creek (TNC; elevation 857 m), south end of Terlingua Creek (TGC; 704 m), Chisos Mountains Basin (CMB; 2340 m), Blue Creek (BC) at Castolon (1004 m), Glenn Springs (GS; 773 m), and Boquillas Canyon (BQ; 600 m) (see Fig. 2). I used wooden stakes to mark five 0.75 ha plots at each study site as described by Punzo (2000b), chosen at random from a topographical grid map of BBNP (U.S. Geological Survey).

Whipscorpions were collected manually at the surface of each plot, with the aid of a Coleman butane lamp, by walking over the study area between 2100–0500 h, or by using pitfall traps (1.0 litre plastic containers) that were checked at 3 h intervals over a 24 h period, for 20 days per month (starting at 0400 Central Standard Time, CST). Pitfall traps were positioned in a cross-shaped grid as previously described by Punzo (2000b). Since over 85% of all animals collected were adults, only data from this life cycle stage were used in subsequent analyses. Whenever possible, I recorded the following data for each animal collected: date, location and time of capture, body length (mm), width of carapace (mm), sex (based on the morphology of the genital sternite and pedipalps), weight (measured to the nearest 0.01 g with an Ohaus Model 31677 Port-O-Gram electronic balance), and soil hardness at the capture site. Four soil samples were also taken at each collection site in order to determine organic content and soil particle size.

All burrows within each plot were investigated in order to determine if any resident arachnid was present. Burrows whose entrances were covered by silk were assumed to be occupied by theraphosid spiders (Punzo & Henderson, 1999) and were therefore left alone. A mixture of clove oil (0.5 ml), acetone (2.0 ml), and water (97.5 ml) was shaken thoroughly and slowly poured down the entrances of other burrows. I have found that oil of cloves is a repellent that will cause fossorial arthropods to evacuate their burrows without causing any harm to the animal (unpubl. data). In this way, the number of burrows within each plot occupied by *M. giganteus* could be ascertained.

Soil hardness (penetrability) was measured from the surface of the ground with a Proctor pocket penetrometer (Model 77114; Forestry Suppliers, Inc., Jackson, Mississippi, USA) and expressed as kg cm^{-2} , using the procedure described by Schraer *et al.* (1998). The organic matter content and particle size of soil samples were determined using the wet oxidation method and the Bouyoucos hydrometer method, respectively (Milford, 1991).

I also conducted substrate selection experiments in the laboratory to determine if these whipscorpions showed any preference for soil surfaces differing in hardness. Selection experiments were conducted in a rectangular plastic chamber ($45 \times 30 \times 15$ cm). Three soil samples (10×10 cm), 5 cm in depth and differing in hardness (sand: 1.7 kg cm^{-2} ; sand loam: 8 kg cm^{-2} ; adobe: 38 kg cm^{-2}), were randomly positioned next to one another on the floor at one end of the chamber. Each soil sample was moistened and then allowed to dry before selection trials were initiated. The remainder of the floor of the chamber was covered with a medium grade sandpaper.

The experimental subjects consisted of 100 adult whipscorpions (50 males and 50 females) that were reared in the laboratory from birth. These whipscorpions were reared separately in plastic containers whose floors were covered with a synthetic turf grass matting. They were maintained at $21 \pm 2.0^\circ\text{C}$ and 60–70% RH, and fed on a diet of crickets, beetle larvae, long-horned grasshoppers, and cockroaches. For each trial, an individual whipscorpion was placed at the end of the chamber opposite the three soil samples and allowed to select one of the substrates at the opposite end. A trial (initiated when the animal first made contact with the substrate) lasted 30 min and each animal was tested only once. Data were recorded on which substrate was initially selected, how much time was spent on a particular substrate, and whether or not the animal initiated any type of burrowing activity.

Voucher specimens have been deposited in the University of Tampa Invertebrate Collection. All statistical procedures follow those described by Sokal & Rohlf (1995).

Results

The soil characteristics of each of the study sites are listed in Table 1. The soil at BQ (loose sand) contained the highest proportion of sand and no detectable clay particles, and had the lowest mean penetrometer recordings (1.7 kg cm^{-2}) and organic matter (1.07%). Conversely, the adobe soils at the TNC and TGC sites had the highest mean penetrometer recordings (37.2 and 41.2 kg cm^{-2} , respectively) with intermediate levels of organic matter (3.06–3.41%). At the study site characterised by the highest elevation (CMB; 2340 m), which receives more rainfall and has cooler temperatures, the clay loam soil had the highest organic content (6.71%) and a mean penetrometer recording of 10.6 kg cm^{-2} .

The number of occupied burrows and the number of adult whipscorpions collected at the surface at the

Site	Clay (%)	Silt (%)	Sand (%)	Organic matter (%)	Soil class	Mean hardness (kg cm ⁻²)
TNC	47.5	34.6	17.9	3.41	Adobe	37.2 (± 3.9)
TGC	54.7	31.6	13.7	3.06	Adobe	41.2 (± 4.4)
CMB	34.2	31.6	34.2	6.71	Clay loam	10.6 (± 0.9)
BC	9.6	11.5	78.9	2.45	Sand loam	7.9 (± 1.1)
GS	12.1	33.5	54.4	2.66	Silt loam	4.5 (± 0.7)
BQ	0	2.7	97.3	1.07	Sand	1.7 (± 0.3)

Table 1: Characteristics of soil samples taken at the various study sites in Big Bend National Park. Data include percent composition of clay, silt, and sand, organic matter (%), soil textural class, and mean soil hardness (penetrability) measured with a penetrometer and expressed in kg cm⁻² (± SD). Study sites: Tornillo Creek (TNC), Terlingua Creek (TGC), Chisos Mountains Basin (CMB), Blue Creek (BC), Glenn Springs (GS), and Boquillas Canyon (BQ). See text for details.

various study sites is shown in Fig. 3. Since no significant differences were found between the sexes ($z=1.7$, $p>0.5$), the data represent the sums for both sexes. There was a significant effect of soil hardness on the number of occupied burrows (ANOVA, $F=31.6$, $p<0.01$) and on the number of whipscorpions found at the ground surface ($F=48.3$, $p<0.001$). Twenty-one out of 55 burrows (38.2%), and 44 out of 105 adults (41.9%) collected at the surface, were associated with the sand loam soil of the BC site. This soil type had a mean surface hardness value of 7.9 kg cm⁻². The GS site (silt loam soil), with a lower hardness value (4.5 kg cm⁻²), contained 16.4% and 23.8% of the burrows and surface whipscorpions, respectively. The values for the CMB site (clay loam; 10.6 kg cm⁻²) were 27.3% and 13.3%, respectively. The BQ site, with sand soil (1.7 kg cm⁻²), contained significantly fewer occupied burrows (9.1%) and surface animals (8.6%), when compared with BC ($\chi^2=26.8$, $p<0.01$), GS ($\chi^2=16.3$, $p<0.01$), and CMB ($\chi^2=9.3$, $p<0.05$) sites. The TNC and TGC sites, characterised by the hardest adobe soils (37.2 and 41.2 kg cm⁻², respectively), contained the fewest whipscorpions. The results suggest that *M. giganteus* is found throughout the Park, although the hardness of the substrate may be a limiting factor.

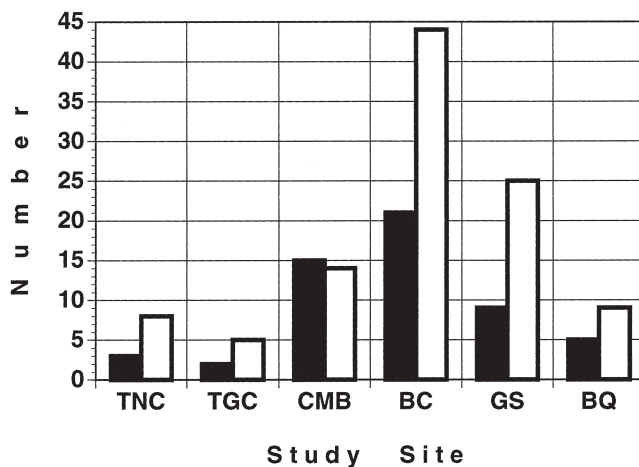


Fig. 3: The number of occupied burrows (black bars) and the number of adults of the giant whipscorpion *Mastigoproctus giganteus* collected at the ground surface (open bars) at various sites in Big Bend National Park. Study sites: Tornillo Creek (TNC), Terlingua Creek (TGC), Chisos Mountains Basin (CMB), Blue Creek (BC), Glenn Springs (GS), and Boquillas Canyon (BQ). See text for details.

There was no obvious relationship between the specific capture or burrow sites of these whipscorpions and amount or type of vegetative cover. Some whipscorpions were collected at locations completely devoid of vegetation, whereas others were found at locations with varying degrees of plant cover. Dominant plants at these locations included various combinations of velvet mesquite (*Prosopis juliflora*), screw bean mesquite (*P. pubescens*), saltbush (*Atriplex canescens*), prickly pear cactus (*Opuntia engelmanni*), creosote bush (*Larrea divaricata*), ocotillo (*Fouquieria splendens*), sotol (*Dasyliion leiophyllum*), lechuguilla (*Agave lechuguilla*), as well as several grasses (*Muhlenbergia* spp., *Bouteloua* spp.). At the higher CMB site, there was Emory oak (*Quercus emoryi*), gray oak (*Q. grisea*), red berry juniper (*Juniperus erythrocarpa*), Texas madrone (*Arbutus xalapensis*), and bigtooth maple (*Acer grandidentatum*).

In the laboratory substrate selection experiments, *M. giganteus* showed a significant initial preference ($\chi^2=11.7$, $p<0.01$) for sand loam soil as compared with sand and adobe substrates (Fig. 4), with no significant difference between the sexes ($p>0.5$). These whipscorpions also spent a significantly greater period of time on the sand loam soil (Table 2). Only 12 of the 50 females (24%) and nine of 50 males (18%) exhibited

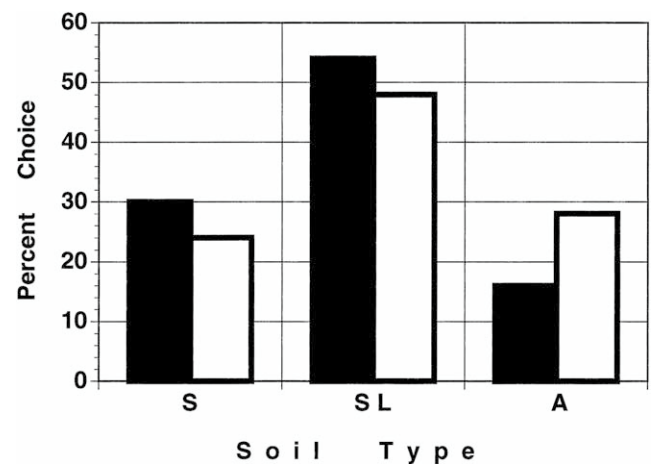


Fig. 4: Laboratory substrate selection experiments on *Mastigoproctus giganteus*. Data represent the percentages (percent choice) at which *M. giganteus* adult males ($n=50$; black bars) and females ($n=50$; white bars) selected soil types of varying hardness when exposed to a choice between three soil types. Soil types and hardness values: S (sand; 1.7 kg cm⁻²); SL (sand loam; 8.0 kg cm⁻²); A (adobe; 38.0 kg cm⁻²). See text for details.

Type of substrate	Time (min) spent on substrate	
	Males	Females
Sand	8.7 (\pm 1.1) ^a	6.2 (\pm 0.8) ^a
Sand loam	16.5 (\pm 3.8) ^b	20.1 (\pm 3.4) ^b
Adobe	4.8 (\pm 0.6) ^a	3.7 (\pm 0.3) ^a

Table 2: Substrate selection experiments (30 min trials) with *Mastigoproctus giganteus*. Data represent the amount of time (min) spent by adults (in individual 30 min trials) on various soil substrates differing in hardness. Soil types and corresponding hardness values (in kg cm^{-2}) were: sand (1.7), sand loam (8), and adobe (38). Data are expressed as means (\pm SD) for 50 males and 50 females. Values followed by different superscript letters are significantly different (Chi-Square contingency tests, $p < 0.01$). See text for details.

digging behaviour once a substrate had been selected. In all cases, digging was initiated using the pedipalps and was observed only on the sand loam substrate.

Discussion

The abundance of *M. giganteus* at any given locality is strongly influenced by the hardness (penetrability) of the soil surface, suggesting that soil hardness plays an important role in habitat selection in this species. Variables affecting soil hardness include moisture, particle size distribution (ratio of sand, silt, and clay), and organic content (Carter & Cory, 1930; Schraer *et al.*, 1998). Adobe soils with their high clay content have surfaces that are greatly compacted, which makes burrowing more difficult. Therefore, it is not surprising that low numbers of whipscorpions and burrows were found at sites with adobe soils. Even in the laboratory substrate selection experiments, *M. giganteus* exhibited a low preference for this soil type and spent the least amount of time on it.

However, hardness is not the only soil factor that influences habitat selection, since the site with the least compact soil (BQ, loose sand) also had low numbers of whipscorpions. This is interesting in the light of the fact that sand holds water to a greater degree than other types of desert soils (Medellín-Leal, 1982; Milford, 1991) and, as a result, is often characterised by more abundant vegetation and higher insect prey densities. This suggests that psammophilous arthropods possess specific adaptations for burrowing in loose sand (Polis, 1990). Although the BQ site had abundant vegetation, *M. giganteus* does not appear to be able to exploit the relatively high abundance of arthropod prey associated with this area. Thus, in addition to hardness, the combination of soil particles of various sizes in conjunction with organic content may also be important.

Previous research has indicated that soil hardness is an important factor in habitat selection by other desert arthropods. Lamoral (1978) showed that habitat selection, distribution, and the geographical ranges of the scorpions *Opisthophthalmus wahlbergi* and *O. carinatus* in South Africa are strongly associated with soil factors. Indeed, species-specific preferences for substrates of differing hardness serve as an isolating mechanism in these species, and Lamoral further suggested that soil

hardness is the most important ecological factor controlling competition for burrow sites. The burrows of *O. wahlbergi* were only found in soils whose hardness values ranged from 1.2–2.1 kg cm^{-2} , whereas *O. carinatus* was associated with soils having a higher degree of compactness (3.6–4.7 kg cm^{-2}). Soil hardness has been identified as an important edaphic factor affecting the distribution of other scorpions as well (Hadley, 1974; Polis, 1990; Cloudsley-Thompson, 1991; Punzo, 2000a). Lawrence (1969) has argued that species of scorpions burrowing in soft soils are usually restricted to a smaller range of soil hardness than those burrowing in harder soils.

Several species of eremobatid solifuges exhibit preferences for certain types of soils (Muma, 1966; Punzo, 1994). The solifuge *Eremobates palpisetulosus* prefers soils with a mixture of sand and gravel and can also be found on alluvial fans (Punzo, 1998). Soil hardness is also an important factor affecting the distribution of other desert arthropods, including some species of centipedes (Cloudsley-Thompson, 1968; Lewis, 1981), millipedes (Lewis, 1974; Crawford, 1981), isopods (Warburg *et al.*, 1978), theraphosid spiders (Main, 1982; Cloudsley-Thompson, 1975, 1983; Punzo & Henderson, 1999), and trapdoor spiders (Main, 1976, 1991).

Vegetation did not seem to influence the distribution of *M. giganteus* in BBNP. This is in agreement with studies on other desert arthropods. Koch (1981) stated that the distribution of Australian scorpions was not correlated with vegetation patterns. Analyses of scorpion-vegetation associations in North American deserts suggested that most scorpions inhabit areas with various different types of vegetation (Polis, 1990). This is also true for some species of spiders (Banks, 1901; Baerg, 1958; Cloudsley-Thompson, 1968; Main, 1982; Richardson, 1990; Punzo, 2000a), solifuges (Punzo, 1998), and centipedes (Crawford, 1981; Lewis, 1981).

In laboratory substrate selection experiments, only a relatively low percentage of adult males (18%) and females (24%) initiated any type of digging behaviour. Although there is anecdotal information, as well as several studies describing the burrowing behaviour of *M. giganteus* (Marx, 1886, 1893; Cloudsley-Thompson, 1968; Weygoldt, 1970, 1971), I have found that these animals seek shelter under surface debris, rocks, and within rock crevices more frequently than within burrows (pers. obs.). It seems that fossoriality in *M. giganteus* is less pronounced than in many scorpions and mygalomorph spiders.

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Relative tolerance and communication in agonistic behaviour between females of *Loxosceles gaucho* (Araneae, Sicariidae)

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Summary

We describe the agonistic behaviour of adult female pairs of the brown spider, *Loxosceles gaucho*, in a flow diagram based on the observation of 12 experimental contests. Three chronological phases were identified: perception, information exchange, and aggression. We provide evidence of a relative tolerance in the trials once the female pairs have shown intra-specific recognition, inhibition of aggression, and communication. The communicative behaviours included foreleg vibration on the silk, palpal drumming, and “contestants hugging”.

Introduction

Spiders of the genus *Loxosceles* Heineken & Lowe are of considerable medical and veterinary importance, and the study of their behaviour contributes to the understanding of factors that may influence the population growth of species of that group. However, the main studies concerning their natural history date back to the 1960s and 1970s and rarely report their behaviours. Some data on intra-specific interactions can be found in Hite *et al.* (1966) and Horner & Stewart (1967) for *Loxosceles reclusa* Gertsch & Mulaik; Ennik (1971) for *L. unicolor* Keyserling; and Levi & Spielman (1964), Galiano (1967), Galiano & Hall (1973), and Waldron *et al.* (1975) for *L. laeta* (Nicolet). Regarding *L. gaucho* Gertsch, only Rinaldi *et al.* (1997) and Rinaldi & Stropa (1998) dealt with their life cycle and sexual behaviour.

Although the agonistic behaviour of female spiders is less elaborate than that of males (Foelix, 1982), some studies have described communication and aggression between them, e.g. Riechert (1984) and Hodge & Uetz (1995).

In this study, the agonistic behavioural acts of pairs of *L. gaucho* adult females were recorded and quantified, and are described in a flow diagram and discussed in relation to intra-specific tolerance and communication.

Methods

Experimental animals

We used 24 adult females of *L. gaucho*, which had made at least one egg sac in the laboratory. These spiders were maintained individually in diet tubes (8.5 cm long × 2.5 cm internal diameter) from capture from nature or breeding from egg sacs produced in the laboratory. They were fed weekly with a varied diet of several types of insects obtained in the field by sweeping. The tests were performed in the Laboratory of Spiders of the Department of Zoology in the Institute of Bioscience of UNESP/Botucatu, SP, Brazil, under temperature and relative air humidity of 23°C and 70%.

Experimental model and specific procedures

We set up experimental arenas, each consisting of a transparent plastic cage (11.0 cm diameter × 7.0 cm high) connected to a transparent plastic tube (4.0 cm internal diameter × 6.0 cm long), called the escape valve. Each spider described as the owner was transferred from its diet tube to one of these arenas, where it was kept for at least one week before the experiments. That period was sufficient for the owners to spin a web. The spiders described as intruders were kept in their diet tubes until the time of the experiments.

The escape valve was sealed at one end with damp cotton. Before the experiments, the sealed end was connected to the cage, so that the owner could not enter the escape valve. For each trial, we disconnected the escape valve from the cage and placed the intruder inside the escape valve. We then reconnected it, so that the intruder could enter the cage.

We standardised the feeding of the owners and intruders, to prevent this variable interfering in their aggressiveness. Each spider was offered 10 *Musca domestica*. After two days, we randomly selected an owner and an intruder for each experimental contest. All the spiders were weighed on a Mettler H20T balance (Pmax. 160 g; d=0.01 mg), and food scraps were removed from the arenas and diet tubes to avoid the spiders consuming them after weighing. This procedure was carried out in such a way that the owners' silk was not damaged. We marked one female of each pair, sometimes the owner, and sometimes the intruder, to facilitate the recognition of the animals during the experiments. The