Resting site choice depends on age in *Opisthacanthus madagascariensis* (Scorpiones: Hormuridae) in dry deciduous forest, western Madagascar

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Abstract

During the dry season, between 17 and 24 of November 2016, in the Kirindy (CNFREF) Forest, Central Menabe Region, western Madagascar, night searches for scorpions were conducted. In total, 22 individuals of Opisthacanthus madagascariensis were found and captured. No other species was present in the area. Majority of individuals (91%) were found in their retreat sites, mostly located in burrows or under objects such as bark, debris, and rocks. There was a significant difference in retreat site choice based on the different age class. Adults frequently used unconcealed burrows, while juveniles used exclusively hideouts located under objects. The results suggest the existence of age-related niche partitioning in O. madagascariensis in terms of retreat site choice. Possible reasons are briefly discussed.

Keywords: Kirindy CNFREF, retreat sites, age-niche partitioning, *Opisthacanthus madagascariensis*

Résumé détaillé

La partition de niche liée à l'âge consiste en la répartition d'individus d'une même espèce dans des niches écologiques différentes en fonction de leur âge. Il s'agit d'un phénomène relativement bien documenté chez les scorpions. Les niches écologiques des scorpions peuvent différer sur plusieurs aspects, l'un des plus importants étant le choix du site de repos.

Lors de la saison sèche de 2016, la forêt de Kirindy CNFEREF, située dans la région du Menabe Central dans l'Ouest de Madagascar, a été prospectée de nuit pour la recherche de scorpions. Au total, 22 individus de l'espèce *Opisthacanthus madagascariensis* ont été capturés. L'âge de chaque individu a été estimé à l'aide de la mesure morphométrique de la longueur du doigt mobile. Les individus ont été classés en tant que juvénile ou adulte, en fonction de leur âge et de leur sexe. Le même nombre de juvéniles et d'adultes a été récolté.

Mis à part deux individus, tous les scorpions capturés ont été trouvés à l'intérieur de leur site de repos. Ceux-ci ont été catégorisés en trois types : terriers, cachette sous débris (de bois ou de roche) et fissures d'arbres. Les individus adultes utilisent de manière significative des sites de repos différents de ceux des juvéniles. Ce résultat supporte l'hypothèse d'une partition de niche liée à l'âge chez *O. madagascariensis*. La principale différence entre les classes d'âge concerne l'utilisation de terriers : aucun juvénile n'a été trouvé dans un tel site de repos, alors qu'il était le type le plus utilisé des adultes.

L'existence d'une partition de niche liée à l'âge chez les scorpions est généralement associée au cannibalisme, qui inciterait les jeunes individus à éviter leurs congénères de plus grande taille. Toutefois, aucun comportement cannibale n'a jamais été confirmé dans les populations d'O. *madagascariensis*, que ce soit dans la nature ou en captivité. Cela suggère que d'autres facteurs soient impliqués dans la partition de niche liée à l'âge chez cette espèce, tels que, par exemple, des différences dans les capacités à creuser, la préférence de taille des proies ou encore le risque de prédation interspécifique.

Mots clés : Kirindy CNFREF, site de repos, partition de niche liée à l'âge, *Opisthacanthus madagascariensis*

Introduction

In most scorpion species, the majority of activity is restricted to their retreat site and immediate surroundings (Polis, 1980a; Polis *et al.*, 1986). Yet factors influencing retreat site choice remain poorly known. Researchers list thermal properties, food abundance, and predation risk among others (Baggett, 2016; Becker & Brown, 2016), and how these aspects are related to age class may be an important factor. In some species, animals of different age classes vary in terms of microhabitat choices, and therefore retreat site choices (Polis,

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1984; McReynolds, 2012; Lira *et al.*, 2013). This phenomenon is known as age-related niche partitioning. It is thought mainly to serve as a mean to reduce intraspecific competition. Juvenile scorpions often choose microhabitats with limited access to adults to reduce the risk of cannibalism (Polis, 1980b, 1984; McReynolds, 2012; Lira *et al.*, 2013; Nime *et al.*, 2016). The aim of the study was to determine if this phenomenon occurs in a common Madagascar scorpion species, *Opisthacanthus madagascariensis* (Kraeplin, 1894).

Materials & methods Study site

The research took place in the concession of Centre National de Formation, d'Etudes et de Recherche en Environnement et Forester (CNFEREF). The study took place in the Kirindy Forest, Menabe Region, 60 km north from Morondava (Figure 1). Kirindy Forest covers about 10,000 ha of dry deciduous forest, an ecosystem formerly widely distributed in western Madagascar, now endangered at a global scale. The rainy season normally spans the period between November and April with precipitation peaks in January and February. Mean annual rainfall is 770 mm (Ganzhorn *et al.*, 1990). Daily temperature amplitudes are high, with mean daily minimum of 19°C and maximum of 36°C (Chouteau, 2004).

Portions of the forests of CNFEREF were selectively logged from 1978-1991, leading to a mosaic of vegetation patches with different levels of disturbance. Logging was done in selective way in terms of tree diameter (only trees larger than 37 cm were cut) and the extracted amount of wood (less than 10 m³ per ha). My study area spanned between three patches: CS5 and CS6, which were the subject of logging (in 1978 and 1980, respectively), and CS7, which was left undisturbed. Study area was about 125 ha in total. Patches differed in some habitat aspects such as number of stems per m², litter structure, dead stem cover, and canopy cover (Chouteau, 2004). The CNFEREF field station is located in CS5. The ephemeral Kirindy River flows through all three patches. During the study period, the river was dry with only small and isolated pools of water.

Study object

Opisthacanthus madagascariensis is an endemic scorpion species of Madagascar. It is one of largest members of *Opisthacanthus* genus with adults growing up to 65-75 mm body length. Its activity is mostly restricted to the areas around its retreat site, where it employs a sit-and-wait foraging strategy. The ecology of this species in the wild is practically unknown (Lourenço *et al.*, 2010). Some other



Figure 1. Study area in the dry forest of Kirindy CNFEREF (represented with slanted bars) and its location on the map of Madagascar (bottom-right corner).

members of the genus show social behavior, and young remain with their mother and other adults throughout their lives (Lourenço, 2002), but this is not documented in *O. madagascariensis*. Cannibalism is unknown in any *Opisthacanthus* species (Ross, 2010).

Data collection

Field search took place from 17 to 24 of November 2016. During the course of six nights, a total length of 25 hours were conducted to searching for this scorpion. Walks started the earliest at 21 h 00 (3 hours after sunset) ending latest at 4 h 00 (1 hour before sunrise). During each night walk, scorpions were actively searched for in the forest and the riverbed using both UV and visible light. Objects such as bark, debris, and rocks were lifted to identify retreat sites. Tree crevices were investigated. Riverbanks were searched for burrows. Any potential burrow in the riverbank was investigated using UV light. Once a scorpion was located, the GPS coordinates of the site were recorded and the specimen was collected, weighed alive, and preserved in 96% ethanol. Movable finger length was measured with a calipers to determine the age class of each individual. Each scorpion was classified as adult or juvenile according to their instar stage and sex following Lourenço et al. (2010). The types of retreat sites of juveniles and adults were compared using Fisher's exact test.

Results

In total, 22 scorpions were found. All individuals were identified as *Opisthacanthus madagascariensis* (Figure 2). They varied in size and age. The youngest individuals (instar II) weighted less than 0.5 g, while the heaviest captured female was more than 8 g (instar VII). Eleven captured individuals were classified as juveniles, 11 as adults (Figure 3). Scorpions were captured in two zones, CS6 and CS7, more frequently in CS7 (Figure 4). However, most of the scorpions found alongside the riverbed were in CS6 area. No individual was found in CS5. All 22 animals were located less than 200 m from Kirindy riverbed.

Two scorpions (males of instar IV and VI) were captured actively moving on the ground. The remaining 20 individuals were found inside their retreat sites, which were located in burrows, under rocks, under debris, under bark, and inside trunk fissures (Figures 5 & 6). Adult scorpions used retreat sites different than juveniles (Fisher's exact test, P = 0.003). They most frequently used burrows as retreat sites (60%, n = 10). Such burrows were always located in sturdy, dry, sandy soil along river banks or abandoned termite nests. Each burrow had a clear entrance, followed by a corridor. Adults in burrows were found engaged in sit-and-wait foraging strategy, with pincers being easily recognized from outside. Juvenile scorpions were found resting exclusively under objects – bark, debris, and rocks (n = 10) were spotted after their cover was removed. All scorpions



Figure 2. Opisthacanthus madagascariensis, adult male actively moving on the ground.



Figure 3. Age distribution of all captured individuals of Opisthacanthus madagascariensis (n = 22).



Figure 4. Distribution of *Opisthacanthus madagascariensis* captures in forest patches of different logging regime (n = 22).



Figure 5. Different resting site types of *Opisthacanthus madagascariensis*: A) burrow, B) under rock, C) under bark, D) under debris, and E) inside tree trunk.



Figure 6. Retreat site distribution in *Opisthacanthus madagascariensis* (n = 20).

inhabited their retreat sites as single individuals, except for two adult males sharing a burrow.

Discussion

During the night searches, individuals of one scorpion species, Opisthacanthus madagascariensis, were located. The species showed some variation in terms of microhabitat choice, with individuals found under objects on the ground, in burrows, on litter, and even in tree fissures (1.5 m above the ground). Thus, O. madagascariensis seems to be a common scorpion species in the Kirindy Forest. The majority of scorpions were found in the unlogged forest patch (CS7), which might be associated with differences in habitat structure between different forest patches, following different exploitation histories (Chouteau, 2004). However, the sample size consisted of 22 individuals and search time was unequal between patches, thus the causes of observed differences remain unknown.

Despite low sample size, a significant difference in retreat sites between age classes was observed. Juvenile individuals tended to hide under objects, which are more cryptic compared to exposed burrows often chosen by adults. There are different possible reasons to explain the observed differences. One of them is predation risk. Many groups of animals prey on scorpions: other scorpions, mammals, lizards, birds, and centipedes among others. Many predators hunt scorpions regardless of their age and size (Polis *et al.*, 1981, Botero-Trujillo, 2006; Holderied *et al.*, 2011). Nevertheless cannibalism decreases with increasing age and size of the scorpion, and is believed to be one of the main factors driving ageniche partitioning (Polis *et al.*, 1981; Polis, 1984). In *O. madagascariensis* however, cannibalism is apparently rare and was never observed in captivity (Lourenço *et al.*, 2010; Ross, 2010). There is one known case of possible cannibalism within the species, with the remains of pincers found in the burrow of an intact individual *O. madagascariensis* (Walesiak, personal obs.).

Another explanation of age differences in retreat sites might be related to food availability. Various age classes of scorpions prey upon different prey size categories and their distribution might be unequal between microhabitats (Polis, 1984; Kaltsas et al., 2008; Lira et al., 2013). With the sit-and-wait foraging strategy employed by O. madagascariensis, it is important to choose a retreat site where prey of a certain size is abundant. However, the diet of this species remain practically unknown (Lourenço et al., 2010) and further interpretation of these patterns is not possible to interpret. Another third explanation is that juvenile scorpions may have limited digging capacity to open burrows in relatively dense soils, as is known for Heterometrus fulvipes (Shivashankar, 1994). As previously mentioned, the Kirindy River does not have permanent flowing water and during periods of being filled this would alter soil characteristics of the river banks, the zone where most of the burrows were found. Individuals born later during dry season, may find the soil impenetrable and therefore be forced to move to other retreat sites.

Conclusion

Opisthacanthus madagascariensis is a common scorpion species of the Kirindy Forest. The species shows variation in terms of microhabitat choice, with retreat sites located in burrows, under logs, rocks, bark, and inside tree trunks. Adult individuals choose significantly different retreat sites often using burrows dug in riverbanks or old termite nests and juveniles were found exclusively hidden under objects.

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