

Variation in energy spent on reproduction between forest and savanna populations of *Pandinus imperator* (Koch) (Scorpiones, Scorpionidae) in the Ivory Coast

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Summary

Among tropical forest populations of *Pandinus imperator* (Koch) on the Ivory Coast, females are significantly larger and their litters contain more embryos than those of populations in the adjacent savanna. It is suggested that this may be the result of environmental differences in primary productivity, coupled with lower expenditure of energy on locomotory activity by the forest scorpions.

Introduction

Variations between the reproductive expenditure of different populations of scorpions have seldom been studied. In a recent publication Lourenço *et al.* (1996) demonstrated that such differences, observed in two distinct populations of the buthid scorpion *Tityus columbianus* (Thorell), could be explained on the basis of differences between the primary productivity of the environments of the two populations.

Pandinus imperator (Koch) (family Scorpionidae), along with *Pandinus dictator* Pocock, is one of the largest and heaviest species of scorpion in the world. With *Pandinus gambiensis* Pocock, these are the only scorpion species at present included in Annex II of the Washington Convention and consequently protected. The geographical distribution of all three species is located in West Africa, that of *P. imperator* more precisely from Guinea and Liberia to Nigeria (see Lourenço & Cloudsley-Thompson, 1996). The Sudan savanna and Eritrean species *Pandinus exitialis* (Pocock) is markedly smaller than the tropical forest and Guinea savanna species mentioned above.

Since the early 1960s, with the creation of the Ecological Station at Lamto in the Ivory Coast (Lamotte, 1967), several specimens of *P. imperator* have been collected and brought to Paris, both to the Zoology Laboratory of the "Ecole Normale Supérieure" and to the Zoology (Arthropods) Laboratory in the Natural History Museum. Preliminary observations seemed to indicate the presence of adult individuals of quite different sizes among these specimens. In the early 1980s more precise research was undertaken by Lourenço with the aim of describing the fauna of Lamto (Lourenço, 1986). During this work, several females of *P. imperator* from both forest and savanna environments were measured and

their respective broods counted. Since very few data are available about the reproduction of *Pandinus* species (Vachon *et al.*, 1970; Larrouy *et al.*, 1973), differences observed in the reproductive traits of the two populations of *P. imperator* may be important for understanding the life history strategies of this species.

Material and methods

Adult specimens were collected alive from two sites in the Ivory Coast, namely Banco forest, near Abidjan, and the Ecological Station at Lamto situated more to the north. The two locations are separated by approximately 190 km (Fig. 1). A total of 30 females were taken from Banco forest and 36 females from the savannas of the Lamto Ecological Station (but only 25 of each group produced broods). Banco forest has been classified as a dense wet forest (Vuattoux, 1968; Bernhard-Reversat *et al.*, 1980), whereas Lamto Ecological Station is composed mainly of Guinea savanna with patchy forests near rivers such as the Bandama. The savanna vegetation is composed mainly of grasses, e.g. *Loudetia* sp. and *Hypparrehenia* sp., with "Rônier" palm trees, *Borassus aethiopicum*, present in significant numbers.

Annual precipitation at Banco forest and Lamto Ecological Station averages 2,095 and 1,252 mm respectively (see Fig. 2), whereas average ambient temperatures are remarkably similar in both localities, with an annual average of 26.20°C in Banco forest and 26.75°C at the Lamto Ecological Station (Lamotte, 1967; Bernhard-Reversat *et al.*, 1980). Scorpions were collected during the day at both sites. In Banco forest they were found under logs and dead trees and in the Lamto savanna under dead "Rônier" palms. The scorpions were brought to the laboratory where they were maintained in separate terraria. Immediately after parturition, the body length (prosoma+mesosoma) of each female was measured (to the nearest mm), and the number of embryos in the litter was noted (see Table 1).

Results

The females from Banco forest were significantly longer than the females from the Lamto Ecological

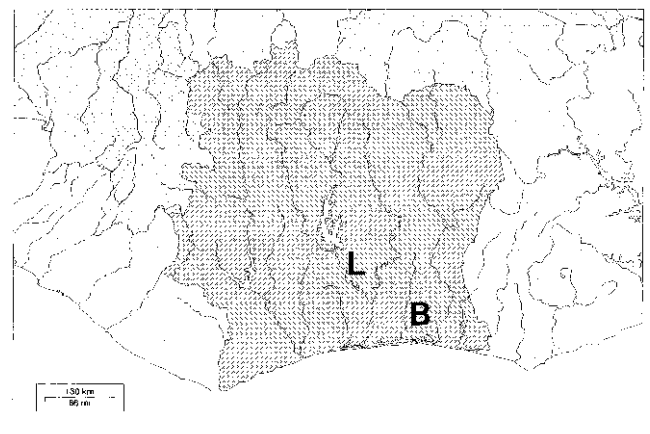


Fig. 1: Location of Banco forest (B) and Lamto Ecological Station (L) in Ivory Coast.

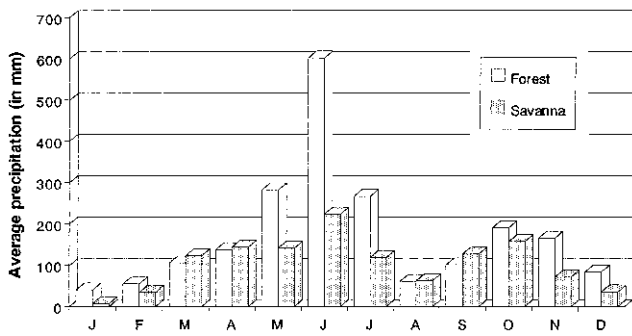


Fig. 2: Average precipitation (in mm) in Banco forest (1935–1973) (after Bernhard-Reversat *et al.*, 1980) and Lamto Ecological Station savanna (1962–1964) (after Vuattoux, 1968).

Station savanna (76.56 mm versus 58.00 mm, $t=17.73$, see Table 1 and Fig. 3), and had significantly more embryos per litter (34.80 versus 15.24, $t=16.6$, see Table 1 and Fig. 3). In the two populations combined, litter size was positively correlated with female body size (see Fig. 3). The average length of the embryos (26–28 mm) was very similar in both populations; they were not weighed.

Discussion

The relative humidity of the soil remains close to saturation at all times in Banco forest (i.e. 100% RH at 27°C). Fluctuations during both the daily and annual cycles are very slight (less than 10%). Soil temperature is close to 26°C at depths of 1–5 cm. In consequence of these conditions, primary productivity is continuous throughout the year and the scorpions have abundant prey at all times (Couturier & Gillon, 1988).

In the savanna of the Lamto Ecological Station, the relative humidity may reach saturation during the night, but in the dry season (which occurs from December to February) it may fall by 20–35% during the day. During this period, the savanna experiences drought conditions. Free water is available only in the form of dew on the grass in the early morning. Faced with these conditions, primary productivity is reduced and prey is much less abundant (Gillon & Gillon, 1967).

The larger body sizes and number of embryos per litter of the Banco forest females may therefore be due to environmental differences in primary productivity. Similar studies of reproductive output in both the Colombian scorpion *Tityus columbianus* (Lourenço

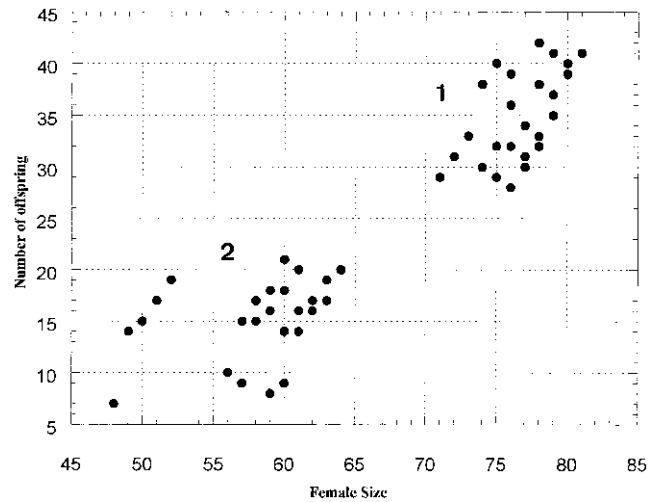


Fig. 3: Distribution of the number of offspring versus female size (prosoma+mesosoma length, in mm) in two populations of *Pandinus imperator*. **1** Banco forest; **2** Lamto Ecological Station savanna.

et al., 1996) and in the Mexican viviparous lizard *Sceloporus torquatus* (Méndez de la Cruz *et al.*, 1992), revealed essentially the same relationship of body to litter size as that reported in the present study. Méndez de la Cruz *et al.* (1992) concluded that the larger litters, and possibly heavier weights of one population of the Mexican lizards, were due to greater food availability resulting from richer soil and greater primary productivity. The differences observed in the case of the Colombian scorpion were probably also due to the availability of more food during the growing season. In this case it results from greater precipitation. The differences observed in the present study could also be due to greater precipitation in the Banco forest compared with the Lamto savannas.

Another factor that may also be involved is that tropical forest and woodland scorpions (as well as tarantula spiders and scolopendromorph centipedes) are much less active than desert and also, presumably, savanna forms. They often spend several days completely motionless, and what movement they do show is far less rhythmic than that of desert species (Cloudsley-Thompson, 1981). The energy saved as a result of reduced locomotion in tropical forest scorpions could well be directed towards greater size and larger litters. Of course, as productivity is greater in forests, there is less need for predators to go in search of their prey. More of them adopt a sit-and-wait strategy.

Scorpions also seem to conform to Congdon's (1989) optimal egg size theory. This was originally proposed for lizards and postulates that variation in reproductive output results from variation in the number of offspring rather than from differences in egg size. As in lizards (Cuéllar, 1984; Congdon, 1989), the clutch size of scorpions apparently increases with increasing body size. Additional studies of relative clutch size in scorpions are necessary for the reproductive effort of populations of species which live in different environments to be compared.

	Mean	t	Range	n
Banco forest population:				
Female size	76.56	17.73	71–81	25
Number of offspring	34.80	16.60	28–42	25
Lamto Ecological Station savanna:				
Female size	58.00	17.73	48–64	25
Number of offspring	15.24	16.60	7–21	25

Table 1: Female size (prosoma+mesosoma length, in mm) and number of offspring in two populations of *Pandinus imperator*.

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