Polymorphism and Hybridization in Species of *Hottentotta* Birula, 1908 (Scorpiones: Buthidae)

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Summary

A new and well documented case of hybridization among scorpions is presented. It was obtained under laboratory conditions between *Hottentotta jayakari* (Pocock) and *Hottentotta salei* (Vachon) specimens of which had been collected in the northern and southern regions of Oman. Hybrids were successfully produced not only from F₀ males and females, but also from F₁ males and females, thereby attesting to the fact that the first generation obtained (F₁), was completely fertile. Both F₁ and F₂ broods were composed of dark and pale morphs, indicating that the juveniles could inherit either one or the other parental phenotype. This report brings new evidence about the true genetic relationship between these two “species”, suggesting that they may correspond only to “morphs” (=phenotypes) of a single polymorphic species.

Introduction

Very few examples of hybridization between different species of scorpions have been reported. Polis & Sissom (1990) dedicate a short section to this question in their chapter on “life history” of scorpions. These authors defined the reported cases as “mistakes” which occasionally occur in the identification of mates, and listed from the literature seven pairs of different species that engage in “promenades” and courtship behaviour. These included four pairs of species from different genera (Auber, 1963; Matthiesen, 1968; Probst, 1972; Le Pape & Goyffon, 1975). Spermatophore deposition and presumably sperm uptake was only observed, however, between congeneric species of *Euscorpius* Thorell (Auber, 1963) and *Androctonus* Ehrenberg (Le Pape & Goyffon, 1975). In the case of mating between a male of *Androctonus australis* (Linnaeus) and a female *Androctonus mauritanicus* (Pocock), 42 supposedly hybrid young were produced.

Several of these observations, however, were extremely empirical and provide no valid evidence of sperm uptake and consequent fecundation (Auber, 1963; Matthiesen, 1968; Probst, 1972). Even in the case of mating between two *Androctonus* species, effective fecundation was not demonstrated (Le Pape & Goyffon, 1975). We will return to this point in the discussion.

More recently, three cases of hybridization between female *Centruroides gracilis* (Latreille) from Mexico and male *Centruroides margaritatus* (Gervais) from Colombia have been observed (Lourenço, 1991). These results suggested strongly that the two species of *Centruroides* may constitute only “morphs” of a widespread polymorphic species. However, since all the offspring were lost before reaching the 3rd instar, no elements of the second generation (F₂) could be crossed. Consequently, little could be stated about the true interspecific relationships between these two species (or ‘morphs”).

In this note we present a new and better documented case of hybridization between two “species” of the genus *Hottentotta*. In this case, “hybrids” were successfully produced not only from F₀ male and female, but also from F₁ male and female, attesting thereby that the first generation (F₁) was completely fertile.

Material Used in the Observations

Scorpions of the species *Hottentotta jayakari* (Pocock, 1895) and *Hottentotta salei* (Vachon, 1980) were received by E.Y. The specimens had been collected respectively in the northern and southern regions of Oman. These are large species which may reach 75–80 mm in total length.
**Hottentotta jayakari** was described by Pocock (1895), as *Buthus jayakari*, from Muscat in the northern range of Oman. Subsequently, Vachon (1980) described a subspecies of *H. jayakari*, as *Buthotus jayakari salei*, from the Province of Dhofar in the South of Oman. The diagnostic characters defined by Vachon (1980) were mainly based on the patterns of pigmentation presented by the two populations. In a recent revision of the genus *Hottentotta* by Kovařík (2007), *H. jayakari salei* was raised to the rank of species. Kovařík (2007) argued as
follows: “This species was originally described as a subspecies of *H. jayakari*, however the distribution of the two taxons overlap and the species are easily separated by color” (An overlapping distribution with a zone of parapatry does not exclude the possibility of subspeciation). Even more recently, in a paper about the
Hottentotta of Oman, Lowe (2010) confirmed the validity of both H. jayakari and H. salei as distinct species.

Methods

The scorpions were reared by standard methods in plastic terraria of different sizes. These contained layers of soil and sand, 2–3 cm in depth, as well as a few pieces of bark and a small Petri dish containing water. Food, consisting of Acheta domestica L. and Tenebrio molitor L. larvae, was provided once every 7 to 10 days. Temperatures ranged from 30 to 32°C during the day and 22 to 24°C at night. Humidity was around at 40–50% (R.H.).

Laboratory Observations

Males and females of both species were collected alive, brought to the laboratory and maintained as described above. The courtship and mating behavior of one pair of scorpions was observed on the 30 June 2006. This F₀ pair consisted of one male H. jayakari (dark morph) and one female H. salei (pale morph) (Figs. 1–3). The female gave birth on 15 July 2007, to an F₁ brood composed of 25 neonates.

Embryonic development in this female lasted for 380 days. After they were carried on their mother’s back for 6 days, the first molt of the young scorpions took place on 20 July 2007 (Figs. 4–5). Juveniles began to leave their mother’s back at the age of 8 days. Subsequent molts took place at differing ages. The F₁ brood was composed of both dark and pale morphs, attesting to the fact that the juveniles could inherit one or other parental phenotypes (Figs. 6–7).

Five individuals of the F₁ generation, one male (pale morph) and four females (dark morph), were selected for further experiment. The male reached adulthood at the sixth molt (7th instar) after 783 days: the females at the seventh molt (8th instar) at ages varying from 611 to 783 days.

The courtship and mating behavior of another pair of these scorpions was observed on the 30 November 2009 (Fig. 8). This F₁ pair was composed of a male (pale morph) and a female (dark morph). This female gave birth on 7 July 2010, to an F₂ brood consisting of 18 neonates (Fig. 9).

Embryonic development in this female lasted for 220 days. After they were carried on their mother’s back for 5 days, the first molt of the offspring took place on 11 July 2010. Juveniles began to leave their mother’s back at the age of 8 days. Subsequent molts took place, but most of these juveniles are still under observation. The F₂ brood was composed of both dark and pale morphs, attesting once again that juveniles could inherit one of two parental phenotypes (Figs. 10–11).

Discussion

Previous observations of hybridization reported by Auber (1963), Matthiesen (1968) and Probst (1972) were poorly documented, exclusively empirical and did not provide any evidence of sperm uptake or fertilization. In the case, reported by Le Pape & Goyffon (1975), of mating between two Androctonus species, effective fertilization was not demonstrated. The two Androctonus species used in the experiment occupy totally distinct ranges of distribution (Lourenço, 2005). Le Pape & Goyffon (1975) stated that their chromosomal patterns were totally distinct: 16 for A. australis and 24 for A. mauritanicus. The suggestion of parthenogenetic reproduction activated by the male spermatozoa is irrelevant because this process has never been observed in the studied cases of parthenogenetic reproduction in scorpions (Lourenço, 2008).

The reported cases of hybridization between Centruroides gracilis and Centruroides marginatus (Lourenço, 1991), suggest that these two “species” might only represent “morphs” of a widespread polymorphic species. However, since no members of the F₁ generation could be crossed, it is impossible to determine the relationship between the two species.

The example of hybridization obtained between Hottentotta jayakari and Hottentotta salei suggests the existence of distinct “morphs” of a polymorphic species:

(a) Hybrids were successfully produced not only between members of F₀, but also between those of F₁, which demonstrated that the first generation obtained (F₁), was globally fertile;

(b) F₁ and F₂ broods were composed of dark and pale morphs, showing that the juveniles could inherit one or other parental phenotypes.

Hybridization can take place between closely related subpopulations under laboratory conditions since ecological barriers that separate them in nature do not exist in the laboratory. The different “morphs” observed in nature are very close to one another genetically and, polymorphism can be observed among scorpions in which temporary reproductive isolation does not give rise to genetic incompatibility. However, some minor morphological changes may take place during temporary isolation and, when the subpopulations disperse again the observed variability may no longer be correlated geographically. Such a biogeographical pattern seems to correspond well with certain “complex” populations observed in buthid scorpions (Williams, 1980; Lourenço, 1986, 1988). The species concerned show high vagility, dispersal capacity, ecological plasticity and, in general, have a large geographical distribution. Examples are well known in the genera Tityus Koch, Centruroides Marx, and could certainly be found among species of the genus Hottentotta (Lourenço, 1992).
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