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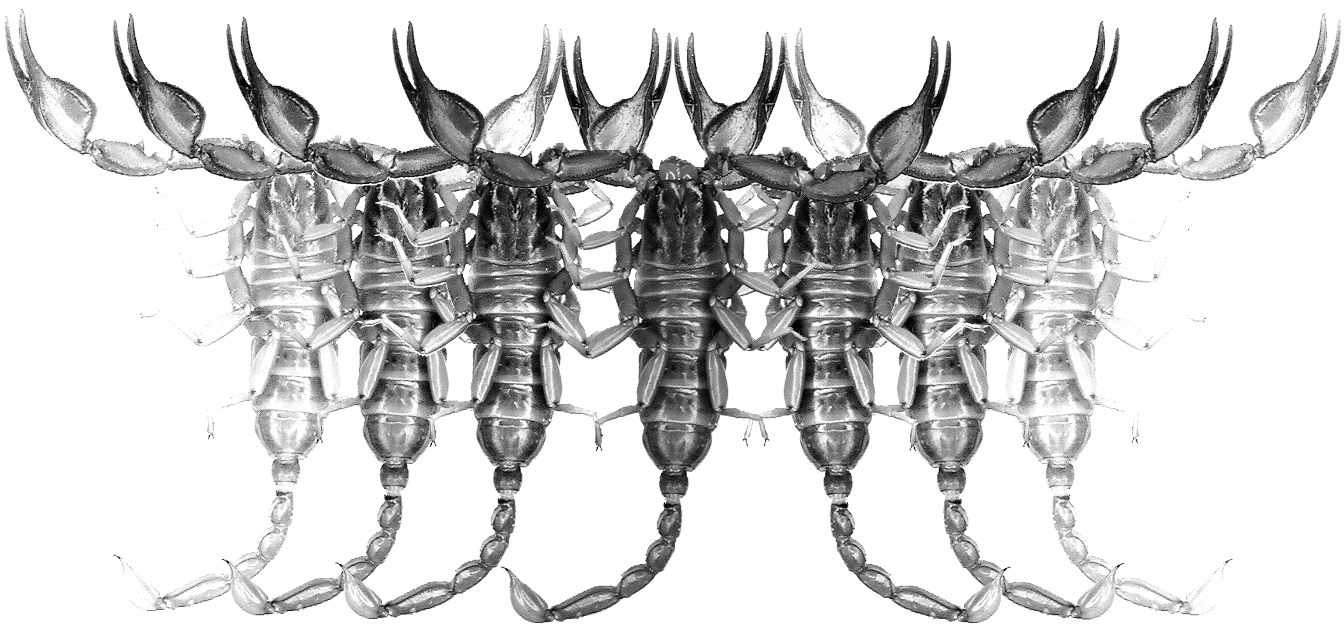

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Polymorphism and Hybridization in Species of *Hottentotta* Birula, 1908 (Scorpiones: Buthidae)

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EDITOR: **Victor Fet**, Marshall University, **‘fet@marshall.edu’**

ASSOCIATE EDITOR: **Michael E. Soleglad, ‘soleglad@la.znet.com’**

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Polymorphism and hybridization in species of *Hottentotta* Birula, 1908 (Scorpiones: Buthidae)

Wilson R. Lourenço [1], Eric Ythier [2], Mark Stockmann [3] & John L. Cloudsley-Thompson [4]

[1] Muséum national d'Histoire naturelle, Département Systématique et Evolution, UMR7205, CP 053, 57 rue Cuvier 75005 Paris, France: e-mail: arachne@mnhn.fr
[2] SynTech Research, 613 route du Bois de Loyse, 71570 La Chapelle de Guinchay, France, e-mail: eythier@syntechresearch.com
[3] Poststraße 69, 49477 Ibbenbüren, Germany
[4] 10 Battishill Street, Islington, London N1 1TE, United Kingdom

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 $\mathbf{F_0}$ males and females, but also from $\mathbf{F_1}$ males and females, thereby attesting to the fact that the first generation obtained ($\mathbf{F_1}$), was completely fertile. Both $\mathbf{F_1}$ and $\mathbf{F_2}$ 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 3th instar, no elements of the second generation ($\mathbf{F_1}$) 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 $\mathbf{F_0}$ male and female, but also from $\mathbf{F_1}$ male and female, attesting thereby that the first generation ($\mathbf{F_1}$) 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.

Figures 1−6: 1. F_0 female of *Hottentotta salei* (pale morph). **2. F_0** male of *Hottentotta jayakari* (dark morph). **3.** Courtship and mating between **F_0** male (dark morph) and **F_0** female (pale morph). **4. F_1** brood, on instar I. **5. F_1** brood, on instar II. **6. F_1** adult female (dark morph).

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

Figures 7–11: 7. F_1 adult male (pale morph). **8.** Courtship and mating between F_1 male (pale morph) and F_1 female (dark morph). **9.** F_2 brood, on instar II. **10.** F_2 juvenile of second instar (dark morph). **11.** F_2 juvenile of second instar (pale morph).

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 $\mathbf{F_0}$ 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 $\mathbf{F_1}$ 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 $\mathbf{F_1}$ 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 $\mathbf{F_1}$ generation, one male (pale morph) and four females (dark morph), were selected for further experiment. The male reached adulthood at the sixth molt (7^{th} instar) after 783 days: the females at the seventh molt (8^{th} instar) at ages varying from 611 to 783 days.

The courtship and mating behaviour of another pair of these scorpions was observed on the 30 November 2009 (Fig. 8). This $\mathbf{F_1}$ pair was composed of a male (pale morph) and a female (dark morph). This female gave birth on 7 July 2010, to an $\mathbf{F_2}$ 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 scorpions 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 $\mathbf{F_2}$ 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 provided any evidence of sperm uptake or fecundation. In the case, reported by Le Pape & Goyffon (1975), of mating between two *Androctonus* species, effective fecundation 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 margaritatus* (Lourenço, 1991), suggest that these two "species" might only represent "morphs" of a widespread polymorphic species. However, since no members of the $\mathbf{F_1}$ 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 $\mathbf{F_0}$, but also between those of $\mathbf{F_1}$, which demonstrated that the first generation obtained ($\mathbf{F_1}$), was globally fertile;

(b) $\mathbf{F_1}$ and $\mathbf{F_2}$ 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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