1999. The Journal of Arachnology 27:149–153

A NEW ALL-FEMALE SCORPION AND THE FIRST PROBABLE CASE OF ARRHENOTOKY IN SCORPIONS

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ABSTRACT. A new parthenogenetic species of scorpion, *Ananteris coineaui* Lourenço, is reported from French Guyana. Parthenogenesis is based on the production of an all-female brood (thelytoky) by a wild virgin female. Conversely, the first probable case of male parthenogenesis (arrehnotoky) in scorpions is reported based on the production of two successive all-male broods by a wild caught virgin female of *Tityus metuendus* Pocock from Peru. Both species were found in isolated palm trees within the rain forest, conforming with the insular theory of parthenogenesis.

With the exception of mites, all-female reproduction is quite rare within the order Arachnida (Taberly 1987; Palmer & Norton 1991; Norton & Palmer 1991; Nagelkerke & Sabelis 1991), but has also been demonstrated in a few species of harvestmen (Tsurusaki 1986), spiders (Lake 1986; Deelman-Reinhold 1986; Camacho 1994) and scorpions (Lourenço & Cuellar 1994). Among the almost 1500 species of scorpions throughout the world, only five are known to be parthenogenetic (Lourenço & Cuellar 1994). The first case was reported by Matthiesen (1962) in the Brazilian species *Tityus serrulatus* Lutz & Mello. Wild pregnant females were collected and their all-female progeny reared individually, giving virgin birth to a second all-female generation several months later. Matthiesen's findings were later confirmed by San Martin & Gambardella (1966). Since then, *T. serrulatus* has been relegated to *Tityus stigmurus* (Thorell) (Lourenço & Cloudsley-Thompson 1996) a parthenogenetic species consisting of at least four distinct all-female morphs (Lourenço & Cloudsley-Thompson this volume) of which the original *T. serrulatus* is one. The other four parthenogenetic species are *Tityus uruguayensis* Borelli from Uruguay and Brazil, *Tityus columbianus* (Thorell) from Colombia, *Hottentota hottentota* (Fabricius) from West Africa, and *Liochelis australasiae* (Fabricius) from the South Pacific (Lourenço & Cuellar 1994). *Tityus trivittatus* Kraepelin from Argentina is also suspected of parthenogenesis (Peretti 1994; Maury 1997). In this paper, we report an additional parthenogenetic scorpion (*Ananteris coineaui* Lourenço from French Guyana), and the first observation of all-male broods in scorpions (*Tityus metuendus* Pocock from Peru).

METHODS

Scorpions were raised individually in plastic boxes terraria, with different sizes ranging from 6/5/4 to 36/14/24 cm. The botton of each terrarium was covered with a soil layer and water was supplied in Petri dishes. Food, consisting on crickets and spiders of the genus *Pardosa*, was supplied once a week. The terraria were placed in a room where temperature was maintained at 25 °C ±2 °C. Humidity ranged from 60–70%.

The sex of individuals was determined by the examination of the size and sexual dimorphism of the pectines. For details and illustrations see Farzanpay & Vachon (1979) and Lourenço (1983).

When life cycles are completed, voucher material will be deposited in the Natural History Museum, Paris (*A. coineaui*) and in the Zoologisches Museum of the University of Hamburg (*T. metuendus*).

RESULTS

***Ananteris coineaui* Lourenço.**—*Ananteris coineaui* was described from a rain forest near

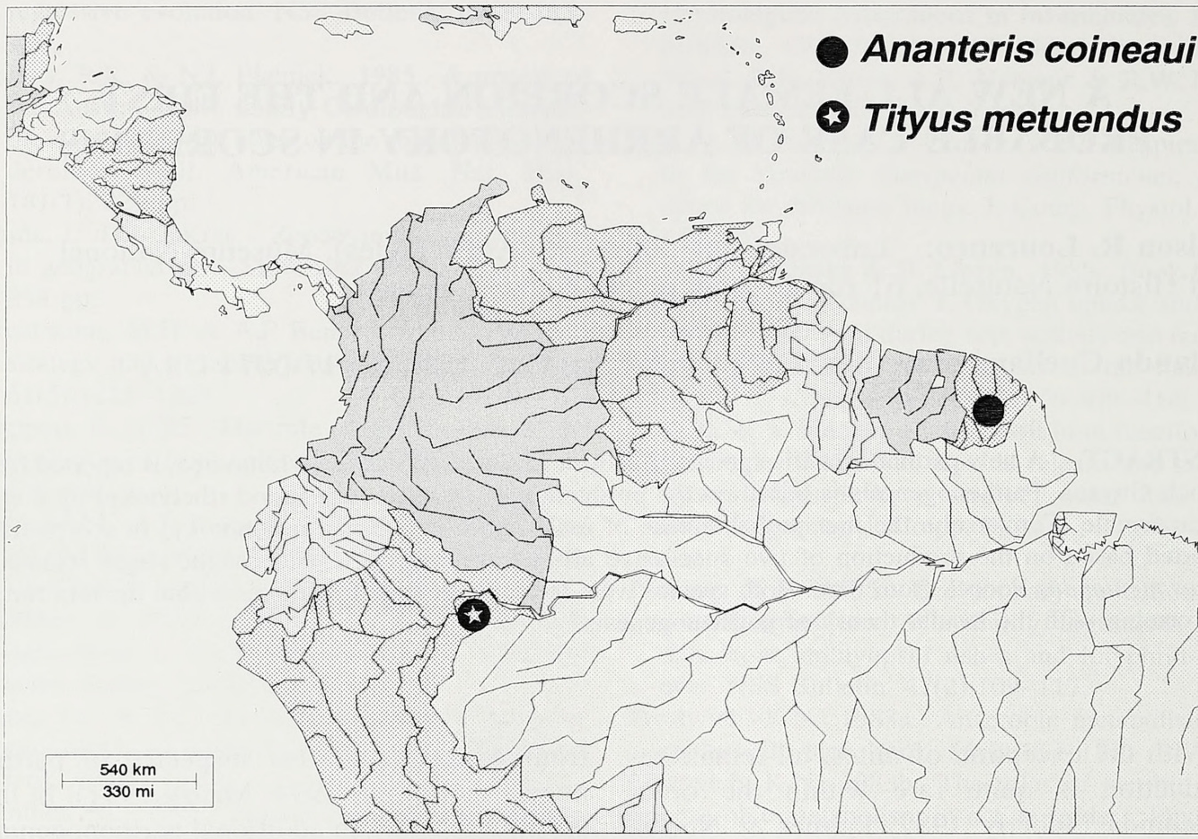

Figure 1.—Map showing the areas where the parthenogenetic females of *Ananteris coineaui* and *Tityus metuendus* have been collected.

the Arataye river in French Guyana, based on three adult females collected in a palm tree of the species *Astrocaryum paramaca* Martius (Lourenço 1982; Kahn 1997). Since then, only one additional specimen was collected from Saül (close to the original locality), also in a palm tree. Within about two weeks, the female molted; by March 30, she gave birth to 16

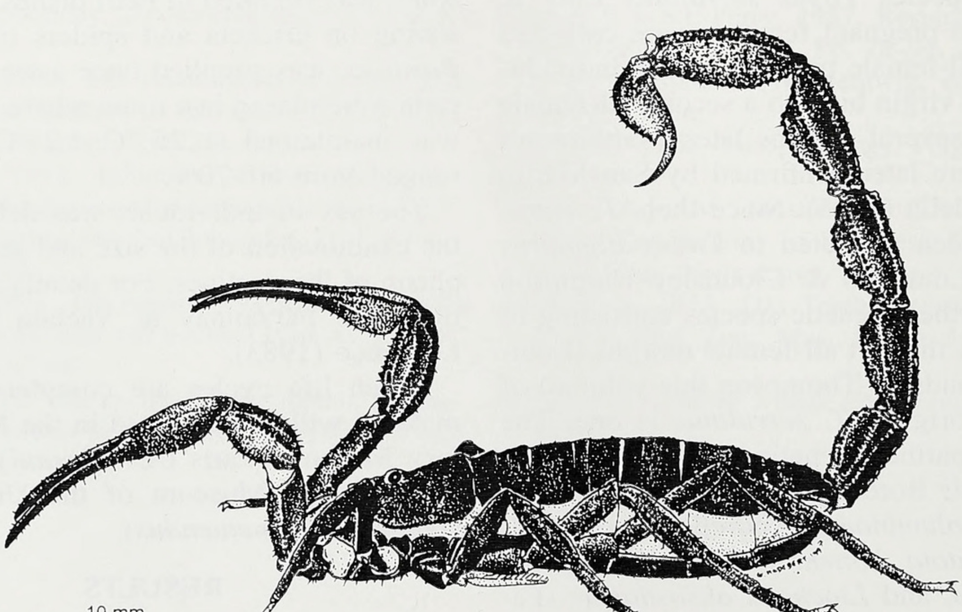

Figure 2.—The parthenogenetic female of *Tityus metuendus*.

young, which remained on her back until April 6 when they all died before molting. An examination of the size and sexual dimorphism of the pectines revealed that the entire brood consisted of females, suggesting parthenogenesis. *Ananteris coineaui* is probably endemic to the central region of French Guyana, and based on the rarity of field specimens, probably has a very low population density. Since this genus was created by Thorell in 1891, the number of species described is now 20 (Lourenço 1997a). The number of specimens representing these species remains very small (less than 200), suggesting that most species are rare. Only the original species described by Thorell, *A. balzani*, seems abundant and has a much larger range of distribution (Lourenço 1993). Nearly 50 specimens of *A. balzani* were collected since 1975, with a sex ratio of approximately 1♂:2♀. Of the remaining 19 species, 12 are represented by less than 5 specimens each, and 4 by only a single specimen. Males are rare, having been found in only 10 of the 19 species.

As noted by Camacho (1994) for spiders, female-biased sex ratios may be taken as evidence of parthenogenesis. This could also be true for the genus *Ananteris* and other microscorpions in which males are rare or absent. With the exception of a recent study on reproductive effort between sexual and parthenogenetic populations of *Tityus columbianus* (Lourenço et al. 1996), virtually nothing is published on the life history and behavior of parthenogenetic scorpions.

The occupancy of isolated palm trees within vast areas of rain forest or savanna conforms with the concept of insular parthenogenesis proposed by Cuellar (1977, 1994). Most well studied parthenogenetic animals occur in insular habitats such as isolated caves, spring heads, bogs, termite nests, rotting logs, tree trunks, hibernacula and oceanic islands (Cuellar 1994). Most parthenogens are also characterized by small size, low mobility, and low population density (Cuellar 1994). The rarity of *A. coineaui*, its occurrence on isolated palm trees, and the absence of males all suggest a parthenogenetic mode of reproduction. This may hold as a rule for other species in this genus.

***Tityus metuendus* Pocock.**—*Tityus metuendus* is a rain-forest species distributed mainly in western Amazonia between Brazil and Peru. In the vicinity of Manaus, Brazil, specifically the Ducke Reserve, the populations of *T. metuendus* are strictly sexual with a sex ratio of 1/1 (Lourenço 1983, 1997b). During some recent collections (1996) in the Amazonian region of Peru, near Iquitos (town of Jenaro Herrera), a single pre-adult female of *Tityus metuendus* was collected by Dr. G. Couturier (Orstom-Muséum) from a palm tree of the species *Astrocaryum chambira* (Kahn 1997) and brought to one of us (WRL). On 18 October 1996, about seven months after the last molt, this female gave birth to a brood of 21 neonates, of which only three survived to the adult stage, all males. An examination of the pectines of the remaining preserved immatures revealed that the entire brood was male. On 29 September 1997, the same female produced a second brood of 32 neonates, of which three did not complete embryological development and 29 were normal. The normal ones all died a few days later after the first molt. As with the previous brood, examination of the pectines revealed only males. A third all-male brood was observed on the 30 April 1998.

The production of three consecutive all-male broods by this virgin female may well represent the first case of arrehnotoky in scorpions, and possibly among Arachnida other than Acari (Nagelkerke & Sabelis 1991). No data are presently available in scorpions either to explain the meiotic mechanisms of arrhenotoky or its evolutionary significance (Bull 1983), as exist for other groups such as the Hymenoptera (Waage 1986; Cuellar 1987) and mites. According to Taylor & Sauer (1980), a major selective advantage of arrhenotoky compared to diploidy is that mothers can precisely determine sex ratio by controlling the fertilization of each egg. This is particularly advantageous in species with finite mating groups, in which the probablity is high that some clutches may contain no males (Nagelkerke & Sabelis 1991), or that the sex ratio may be biased in favor of females (Charnov 1982). Precise sex ratios have been documented in several arrhenotokous species of parasitic wasps (Waage 1986), which lay their eggs either in a single host or a clumped group of hosts. In phytoseiid mites, pseudo-arrhenotoky has apparently arisen as a consequence of low mobility and a subdivided population structure. Their dominant prey form patchy infestations which are probably invaded by only a few females, leading to very small mating groups (Nagelkerke & Sabelis 1991). Similar mating conditions may exist for *T. metuendus*, but extensive field work is needed to understand its life history and behavior.

ACKNOWLEDGMENTS

We are most grateful to Dr. G. Couturier, ORSTOM-Muséum for the use of Fig. 2.

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Manuscript received 3 April 1998, revised 6 September 1998.