2022. Journal of Arachnology 50:27–29

## SHORT COMMUNICATION

# New records of the not-so-rare males of the parthenogenetic scorpion *Tityus stigmurus* (Thorell, 1876) (Scorpiones: Buthidae)

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**Abstract.** Parthenogenesis and sex-ratio bias may lead to erroneous assumptions concerning the natural history of some arachnids. To help address this issue, this study provides new data on the sex ratio and geographic distribution of sexual populations of the scorpion *Tityus stigmurus* (Thorell, 1876). Ultraviolet light lanterns were used to detect specimens during nocturnal searches performed in both urban and non-urban environments scattered thorough northeastern Brazil. Males of *T. stigmurus* were reported for 10 new localities, and although we did not find males in urban environments, non-urban populations presented near symmetrical sex ratios. Such results suggest that reproductive strategies in this species may be modulated by environmental conditions. Also, the general tendency of less biased sex ratios in non-urban environments reported here is in accordance with previous studies that indicated the occurrence of geographical parthenogenesis in this species. Thereby, we propose that sexual populations of *T. stigmurus* are less rare than previously reported.

**Keywords:** Reproductive biology, geographic parthenogenesis, sexual populations

https://doi.org/10.1636/JoA-S-21-009

Reproductive strategies adopted by animals typically seek to optimize the use of resources in a particular environment, as well as to minimize the risks to the parents and their offspring (Lourenço 2002; Scharf et al. 2013). In such a context, many arachnids can reproduce by parthenogenesis – an asexual reproduction mode that does not involve the genetic contribution of males (Francke 2008; Korenko et al. 2009; Seiter et al. 2016). The first report of parthenogenesis in scorpions was documented by Matthiesen (1962), who observed that, under laboratory conditions, females of *Tityus serrulatus* Lutz & Mello, 1922 were able to reproduce in the absence of males. Since then, parthenogenesis has been observed in other congeneric species (Francke 2008; Lourenço 2008; Ross 2010). Males of these parthenogenetic species are considered rare, and their occurrence is often restricted to undisturbed environments (Lourenço & Cloudsley-Thompson 1999; Santos et al. 2014). This argument has been made for the scorpion *Tityus stigmurus* (Thorell, 1876), yet knowledge on the geographic distribution of its sexual populations is poor (e.g., Lourenço & Cloudsley-Thompson 1999; Souza et al. 2009; Santos et al. 2014). To examine these previous claims, we aim to provide new records of sexual populations of *T. stigmurus* in northeastern Brazil, discussing the potential association of reproductive strategies in this species with specific environmental conditions.

Specimens were obtained from field collections performed in 12 localities in northeastern Brazil (Table 1, Fig. 1). We used ultraviolet light lanterns to detect scorpions at night (Gaffin et al. 2012). In each site, scorpions were sampled by at least two collectors who searched for scorpions during random walks limited by time (20h00min – 23h00min); fieldwork was performed between October and November 2019. Sample localities were classified as "urban" when specimens were collected within the dependencies of urban centers (e.g., residences, cemeteries, universities, etc.), or "non-urban", when specimens were found in undisturbed environments outside urban centers. Sexual characterization was performed based on the morphological characters detailed by Souza et al. (2009). Specimens were stored in glass vials containing 70% alcohol and deposited at the arachnological collections of the Federal University of Pernambuco (Recife, Brazil; curator: Dr. Luciana Iannuzzi).

A total of 89 adult specimens were collected (21 males and 68 females). Sexual populations of *T. stigmurus* were reported for 10 new non-urban localities in northeastern Brazil, distributed in the states of Ceará and Pernambuco (Table 1, Fig. 1). Males were absent in urban environments, but populations from non-urban habitats presented near symmetrical sex ratios (Table 1).

Here, we have expanded the geographic range of sexual populations for 10 new localities in northeastern Brazil, beyond the 11 localities previously known from the literature (Lourenço & Cloudsley-Thompson 1999; Souza et al. 2009; Santos et al. 2014). In addition, we provided sex ratio parameters for sexual populations of *T. stigmurus* from non-urban environments, information that is currently absent in previous studies (e.g., Lourenço & Cloudsley-Thompson 1999; Santos et al. 2014). The exclusive presence of females in populations from urban areas (Table 1), suggests that parthenogenesis might be the reproductive strategy adopted for this species in such environments, as proposed by Lourenço & Cloudsley-Thompson (1999). Indeed, the population sex ratio provides information on reproductive dynamics (Chahartaghi et al. 2006) and has been used to infer parthenogenesis in scorpions (e.g., Lourenço 1991, 2002; Lourenço & Cuellar 1999; Warburg 2011; Ayrey 2017; Seiter & Stockmann 2017).

The potential correspondence between undisturbed environments and nearly equal sex ratios (female:male) was previously reported for natural populations of other congeneric species, such as *T. bahiensis* (Perty, 1833) (3:1), *T. fasciolatus* Pessôa, 1935 (3:1), *T. metuendus* Pocock, 1897 (1:1), *T. pusillus* Pocock 1893 (2.67:1), and *T. serrulatus*

Table 1.—Sex ratio (females:males), and number of specimens of *Tityus stigmurus* collected in Northeastern Brazil. All localities listed in this table correspond to new records of sexual populations of *T. stigmurus* in northeastern Brazil.

| | | | | Number of specimens ($n = 89$) | | |
|---|---|---|---|---|---|---|
| Location | Longitude | Latitude | Environment type | Females | Males | Sex ratio |
| Buíque | −37.16 | −8.67 | Non-urban | 1 | 1 | 1:1 |
| Caetés | −36.72 | −8.78 | Non-urban | 2 | 1 | 2:1 |
| Crato | −39.52 | −7.36 | Non-urban | 3 | 2 | 1.5:1 |
| Floresta | −38.73 | −8.47 | Non-urban | 1 | 1 | 1:1 |
| Gravatá | −35.55 | −8.25 | Non-urban | 1 | 1 | 1:1 |
| Ipojuca | −35.07 | −8.41 | Non-urban | 2 | 1 | 2:1 |
| Recife | −34.94 | −8.07 | Urban | 17 | 0 | - |
| São Bento do Una | −36.49 | −8.54 | Non-urban | 1 | 1 | 1:1 |
| São Caetano | −36.16 | −8.29 | Non-urban | 4 | 2 | 2:1 |
| Sirinhaém | −35.12 | −8.60 | Non-urban | 2 | 2 | 1:1 |
| Triunfo | −38.12 | −7.87 | Non-urban | 9 | 5 | 1.8:1 |
| Vitória de Santo Antão | −35.29 | −8.14 | Urban | 29 | 0 | - |
| Total | - | - | - | 68 | 21 | - |

(2.25:1) (Bücherl 1956; Lourenço & Cuellar 1995, 1999; Lourenço & Cloudsley-Thompson 1999; Dionisio-da-Silva et al. 2018). In fact, there is a tendency for sexual populations of scorpions to occupy a greater coverage of habitats in natural environments, whereas the parthenogenetic populations (or subpopulations) are expected to be distributed in the peripheries (Sridhara et al. 2016), or newly created environments (Cuellar 1977), such as urban centers (Lourenço & Cuellar 1995). In such environments, the rate of demographic expansion per generation in these all-female parthenogenetic populations is expected to be twice that observed in the sexual counterparts because every individual generated as an offspring is a female that can reproduce by itself (Cuellar 1977). Naturally, as parthenogenic populations grow demographically, the sex ratio becomes increasingly skewed in favor of females (Russell & Stouthamer 2011). Thereby, the large difference in sex ratio between populations of urban and natural areas presented in our results may indicate that *T. stigmurus* is a good example of geographical parthenogenesis as proposed by Lourenço & Cloudsley-Thompson (1999), and Lourenço (2002).

Since parthenogenetic populations are expected to be more dispersive and proliferative, in part due to density-independent demographic processes (Lourenço 2008), it is extremely important to understand the reproductive biology of these organisms. This is especially true for medically important species, such as *T. stigmurus*, which is one of the most harmful scorpions in South America. Thus, we advocate that the acquisition of new data on the reproductive biology of different scorpion species may improve the theoretical

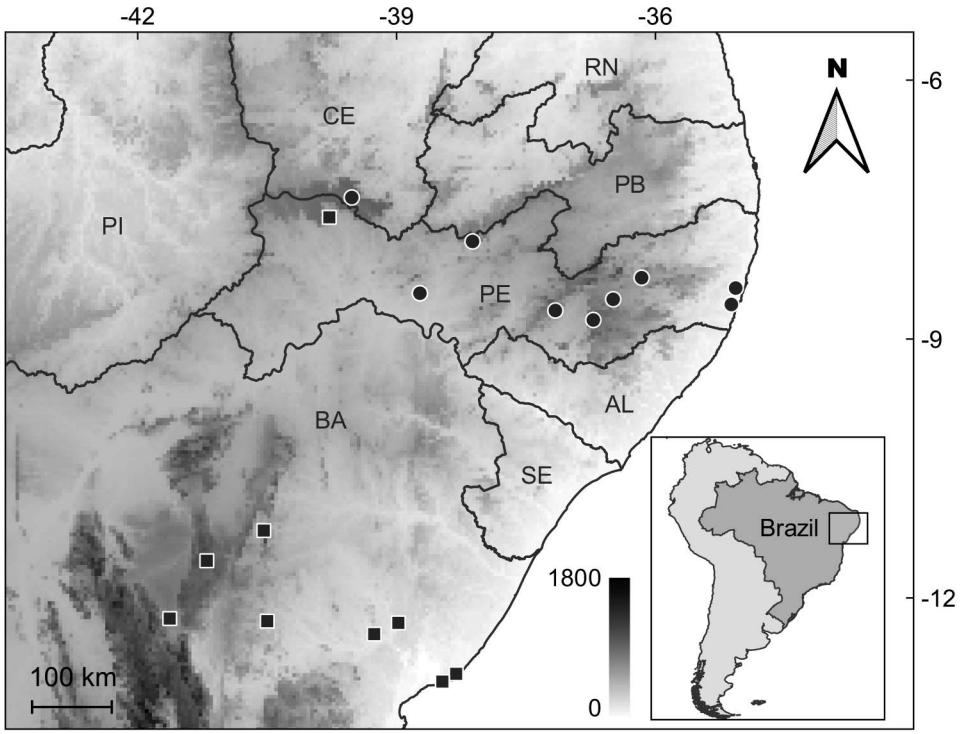


Figure 1.—Geographic distribution of sexual populations of *Tityus stigmurus* (Thorell, 1876) in northeastern Brazil. New records provided in this study are represented by black circles; black squares represent previous records from literature. Inset scale gives elevation in meters.

background required to both understand the evolutionary process shaping the natural history of the species, as well as to the development of public health strategies aimed to overcome the issues related to scorpion envenomation.

## ACKNOWLEDGMENTS

We cordially thank Conselho Nacional de Desenvolvimento Científico e Tecnológico for a master scholarship granted to SIA Foerster (CNPq 130756/2018-0). We are grateful to Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE) for a postdoctoral scholarship (BFP-0121-2.05/20) awarded to AFA Lira, as well as to Fundação de Apoio à Pesquisa do Estado da Paraíba (FAPESQ) for granting a doctoral scholarship (519/18) to W Dionisio-da-Silva. This study was financially supported by the Estonian Research Council (grant PRG741). Finally, we thank Dr. John Clarke (University of Tartu) for his valuable contribution to the readability of this manuscript.

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*Manuscript received 30 January 2021, accepted 11 February 2021.*