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SHORT COMMUNICATION

First report of arm-span competition in buthid scorpions: male-male contest in *Tityus* cf. *rosenbergi* Pocock, 1898

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Abstract. Although courtship and mating behaviors have been described for nearly all scorpion lineages, intrasexual interactions in scorpions remain understudied. Recently, a novel ritualized behavioral unit, termed "arm-span competition," in which individuals face off and extend their pedipalps laterally, was described from analyses of male-male contests in several scorpionid species. Here, we present the first documented observation of arm-span competition in a buthid scorpion, *Tityus* cf. *rosenbergi* Pocock, 1898. Interestingly, both *T.* cf. *rosenbergi* and most scorpionid species known to engage in arm-span competition exhibit a similar sexual dimorphism: males have markedly longer and more slender pedipalps than females. We suggest that the elongated pedipalps in males of these species might be the result of selective pressure related to ritualized arm-span competition. We also highlight the potential for citizen science to contribute rare observations to scientific literature.

Resumen. Aunque se han descrito comportamientos de apareamiento para casi todos los linajes de escorpiones, las interacciones intrasexuales siguen poco estudiadas. Recientemente, a partir del análisis de luchas macho-macho en algunos escorpiónidos, se describió una nueva unidad de comportamiento ritualizado denominada "competencia por extensión de pedipalpos" en que los individuos se enfrentan extendiendo sus pedipalpos lateralmente. En este trabajo, presentamos la primera observación documentada de este comportamiento en un bútido, *Tityus* cf. *rosenbergi* Pocock, 1898. Tanto *T.* cf. *rosenbergi* como la mayoría de las especies de escorpionidos en que se describió este comportamiento, exhiben un dimorfismo sexual similar: los machos tienen pedipalpos notablemente más elongados y delgados que las hembras. Con esta observación, sugerimos que los pedipalpos de los machos en estas especies sean el resultado de la presión selectiva relacionada con la competencia ritualizada por extensión de pedipalpos. Además, enfatizamos el potencial de la ciencia ciudadana para contribuir con observaciones raras a la literatura científica.

Keywords: Agonistic behavior, Citizen science, Intrasexual combat, Neotropical scorpions, Sexual selection

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Scorpions (Order: Scorpiones; Koch, 1837) comprise over 2,700 species (Rein 2017). They range across six continents and have successfully colonized most biomes, from arid deserts to humid rainforests, because of their high capability to adapt to even the most extreme environments (Polis 1990). Scorpions are generally abundant and frequently encountered, especially in tropical and sub-tropical areas (Polis & Yamashita 1991; Lighton et al. 2001; Stockmann 2013); nevertheless, much about their natural history remains poorly understood. In particular, some sex-linked behaviors are remarkably understudied. While courtship and mating have been described in nearly all scorpion families (Polis 1990; Lourenço 2002), accounts of intrasexual aggression are scarce in the current literature. Benton (1992) reported a high frequency of intrasexual aggression in a population of *Tetratrichobothrius flavicaudis* (De Geer, 1778) (Euscorpiidae), but did not provide further behavioral details. Tallarovic (2000) provided the first detailed descriptions of intrasexual aggression in scorpions based on the observation of multiple contests involving both male-male and female-female pairs of captive *Hadrurus arizonensis* Ewing, 1928 (Hadruridae). In these interactions, scorpions grabbed each other with their pedipalps and occasionally grasped their opponent's metasoma or attempted to flip their opponent. The author observed no stinging, suggesting that this combat may be ritualized.

While *H. arizonensis* presents only very subtle sexual dimorphism (Fox et al. 2015), many other scorpion species can be remarkably dimorphic. The most common sexually dimorphic traits include stinger, metasoma, pectines, body size, and pedipalps (McLean 2018; Simone & van der Meijden 2021). In particular, pedipalps and their pincer-like ends (chelae) may present different degrees of sexual dimorphism in scorpions. Possibly, as observed in many other arthropods (Rico-Guevara & Hurme 2019), the shape of these sexually dimorphic traits could be the result of specialized fighting styles used in male-male contests.

Recently, Tang (2023) described a distinct form of apparently ritualized combat between captive males of several species of Heterometrinae (Scorpionidae) scorpions. In most of the species analyzed, males tend to have narrower, longer pedipalps than females. In the new proposed behavioral unit, termed "arm-span competition," both contenders faced off and with their pedipalps extended laterally. The author suggested that this type of sexual dimorphism may be related to this particular form of intrasexual contest.

Interestingly, several distantly related scorpion lineages can present similar sexual dimorphism. The Neotropical buthid genus *Tityus* CL Koch, 1836 is taxonomically complex, comprising over 200 species (Brito & Borges 2015). Almost all of the *Tityus* species within the subgenus *Atreus* present extreme sexual dimorphism,

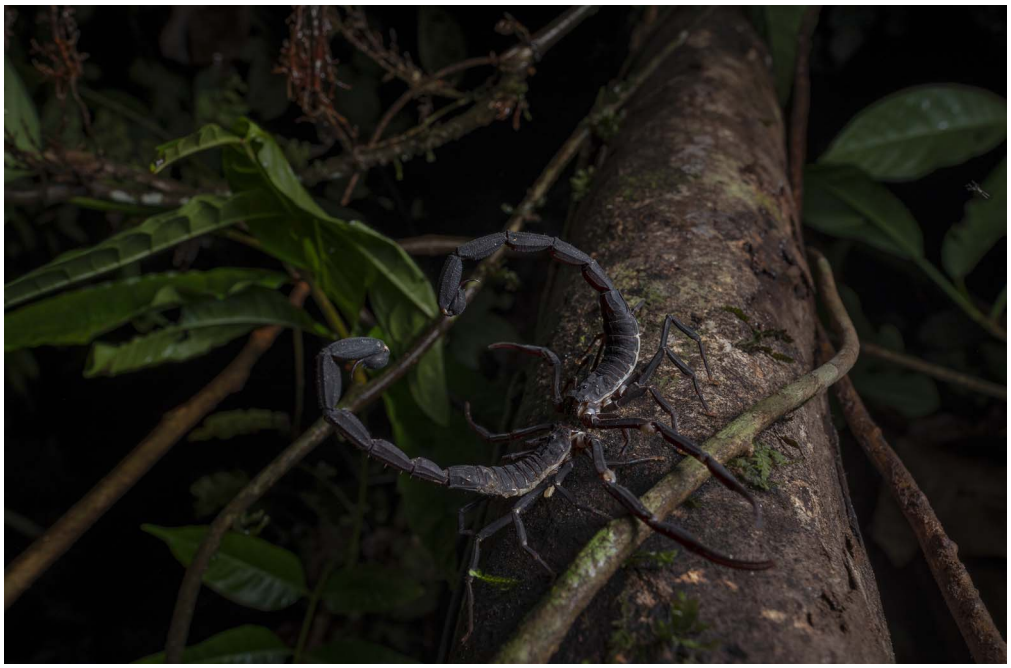

Figure 1.—Two *Tityus* cf. *rosenbergi* males engaged in arm-span competition. At this stage, both scorpions were mostly motionless.

especially in the pedipalps (Lourenço 2011). As in some Heterometrinae and other scorpionids (e.g., *Opistophthalmus* CL Koch, 1837 (Scorpionidae); Visser & Geerts 2021), as well as members of at least one other scorpion family (i.e., Chactidae; González-Gomez et al. 2020), males of *Tityus (Atreus) rosenbergi* Pocock, 1898 have significantly more elongated and slender pedipalps than females (Lourenço & Flórez 2018). Here, based on an observation of wild individuals, we describe the first recorded instance of intrasexual contest in *Tityus* cf. *rosenbergi,* and the first instance of arm-span competition in a buthid scorpion. The documentation of such a rare event in the field by a group of non-arachnologists, and its subsequent dissemination through social media platforms, provides a remarkable example of the power of citizen science to shed light on infrequent yet important ecological processes.

On 17 August 2022 at 2124h (UTC-5), we observed two *Tityus* individuals, identified as *T*. cf. *rosenbergi* based on the authors' photographic material and a recent re-classification of trans-Andean *Atreus* (Lourenço & Ythier 2017; Lourenço & Flórez 2018), in combat in Canandé Reserve, an 8,500-hectare reserve within the Chocó lowland forest in Esmeraldas, Ecuador (0.52540° N, 79.21030° W; WGS84; 323m asl). At the time of our observation, local air temperature was approximately 21°C and relative humidity was near 100%. The two *T*. cf. *rosenbergi* individuals were of approximately the same size and were found on an *Inga* sp. trunk (diameter approximately 15 cm) in a secondary forest patch with over 20 years of regeneration. We identified both scorpions as males based on their slender and elongated pedipalps (Lourenço & Flórez 2018). They were facing each other with their metasomas held vertically and pedipalps extended laterally (Fig. 1; Supplemental Videos S1–S3, online at https://doi.org/10.1636/JoA-S-23-009.s1 through https://doi.org/10.1636/JoA-S-23-009.s3). They periodically engaged in intense clashes. During these clashes, they mirrored each other's movements, rapidly knocking together their metasomas (with telsons tucked), sometimes gently grasping each other's chelae, and jockeying for position (Fig. 2; Video S2, online at https://doi.org/10.1636/JoA-S-23-009.s2). They traveled up and down the trunk while maintaining close contact and switched positions at least once. Throughout the interaction, both scorpions maintained their pedipalps laterally extended. They sometimes made prolonged contact with their chelicerae, both during and between periods of activity (Video S3, https://doi.org/10.1636/JoA-S-23-009.s3). Although not recorded, we observed both scorpions rapidly shaking their bodies (i.e., "juddering"; Alexander 1957) multiple times. We took many photographs and videos, and as far as we could tell, the scorpions were undisturbed by our presence. There was no clear winner after approximately twenty minutes of observation, and we did not witness the conclusion of the contest.

This observation represents the first recorded instance of intrasexual contest in *Tityus* cf. *rosenbergi* and the first evidence of the "arm-span competition" behavior in buthids. The interaction was more similar to that described by Tang (2023) for male *Srilankametrus yaleensis* (Kovařík et al., 2019) and other Heterometrinae scorpions than that described by Tallarovic (2000) for both sexes of *Hadrurus arizonensis*. As described for *S. yaleensis* and relatives, we noted that the *T*. cf. *rosenbergi* engaged in "arm-span competition" throughout much of the contest, and grasped each other's chelae only lightly, in marked contrast to the grappling and periodic head-to-tail alignment described for *H. arizonensis* as well as for other species of buthids by Tang (2023). Other similarities included cheliceral and metasomal contact (only the latter was observed in *Hadrurus* intrasexual combat), although the reasons for these behaviors remain unknown. It is worth noting that the absence of intentional stinging between males is shared across other observations of arm-span competition (Tang 2023), further suggesting the ritualized nature of the contests. With the present report, we suggest that the elongation of the male pedipalps of some scorpion species might be related to their "arm span competition" behavior. The length of the pedipalp is used in males to size

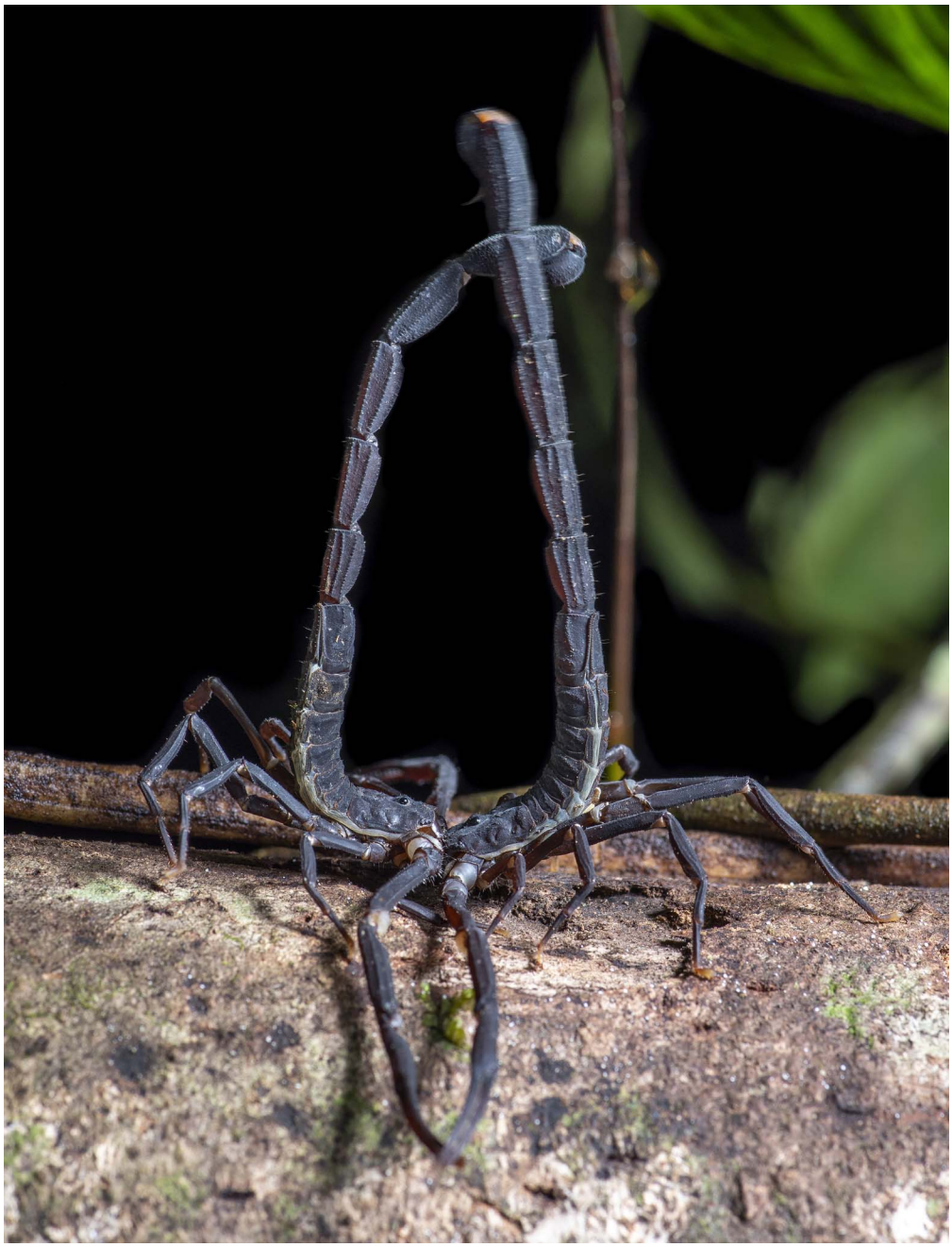

Figure 2.—Two *Tityus* cf. *rosenbergi* males engaged in arm-span competition. At this stage, both scorpions were pushing toward one another, while rapidly knocking together their metasomas and periodically gently grasping each other's chelae.

each other up by means of the lateral extension of the pedipalps. Validating this hypothesis requires additional data. First, it must be proven that this behavior is primarily performed by sexually dimorphic species in which males bear narrower and more elongated pedipalps than females. To further suggest that this behavior has evolved independently in multiple scorpion lineages, it would be necessary to document the occurrence of arm-span competition in other families of scorpions which present similar sexual dimorphism in the pedipalps.

Our observation also highlights the importance of scientific observations of rare species or behaviors contributed through citizen science. Citizen science has already produced terrestrial invertebrate datasets of great spatial and temporal scale, allowing for the discovery of unknown behaviors and species (Campbell & Engelbrecht 2018; Gardiner & Roy 2022). The present observations were made serendipitously by co-authors WJT, W-UJ, AQ and CI, who recorded the unusual behavior during a herpetological field trip. The videos, posted on Instagram by WJT, were seen by YS and served as the basis for this note. We urge citizen scientists to document observations of interesting behaviors and/or species and make these observations publicly available for scientific studies and potential conservation efforts.

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SUPPLEMENTAL MATERIALS

Two males of *Tityus* cf. *rosenbergi* engaged in combat in Canandé Reserve in the Chocó lowland forest in Esmeraldas, Ecuador.

Supplemental Video S1.—Males face each other with metasomas held vertically and pedipalps extended laterally; online at https://doi.org/10.1636/JoA-S-23-009.s1

Supplemental Video S2.—Males mirror each other's movements, rapidly knocking together their metasomas, grasping each other's chelae, and jockeying for position; online at https://doi.org/10.1636/JoA-S-23-009.s2

Supplemental Video S3.—Males make contact with their chelicerae; online at https://doi.org/10.1636/JoA-S-23-009.s3

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