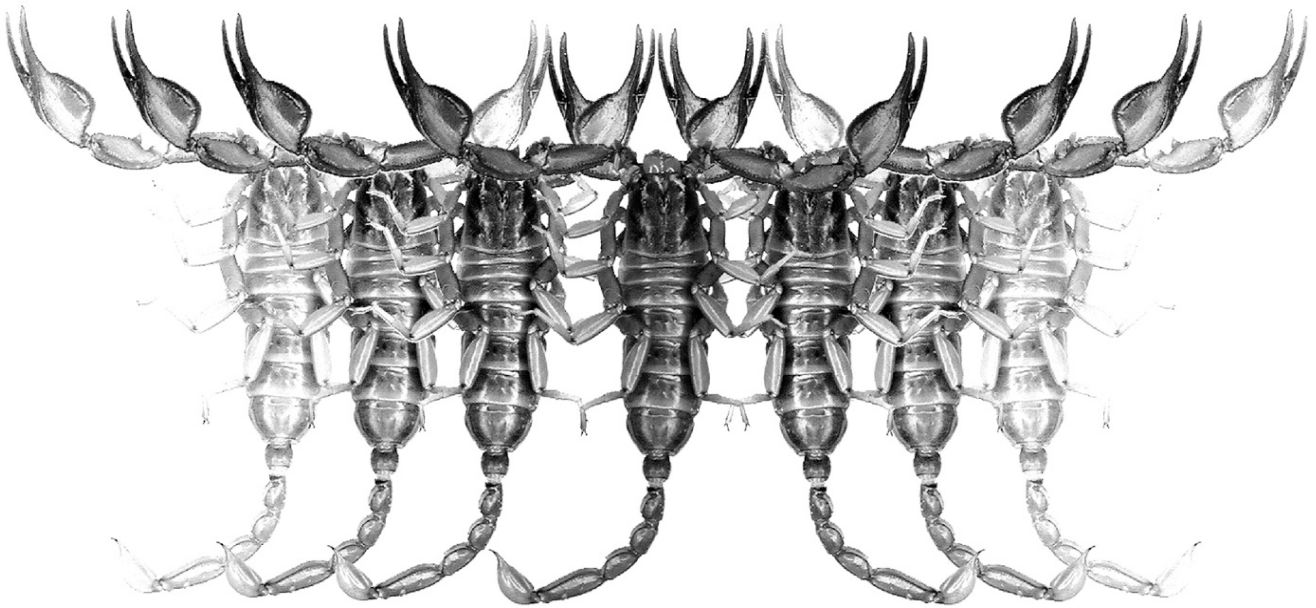


Euscorpius

Occasional Publications in Scorpiology



**Report of thanatosis in the Central American
scorpions *Tityus ocelote* and
Ananteris platnicki (Scorpiones: Buthidae)**

**Felipe Triana, Fabián Bonilla, Adriana Alfaro-Chinchilla,
Carlos Viquez, Cecilia Díaz and Mahmood Sasa**

October 2022 — No. 359

Euscorpius

Occasional Publications in Scorpiology

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

ASSOCIATE EDITOR: **Michael E. Soleglad**, ‘msoleglad@gmail.com’

TECHNICAL EDITOR: **František Kovařík**, ‘kovarik.scorpio@gmail.com’

Euscorpius is the first research publication completely devoted to scorpions (Arachnida: Scorpiones). *Euscorpius* takes advantage of the rapidly evolving medium of quick online publication, at the same time maintaining high research standards for the burgeoning field of scorpion science (scorpiology). *Euscorpius* is an expedient and viable medium for the publication of serious papers in scorpiology, including (but not limited to): systematics, evolution, ecology, biogeography, and general biology of scorpions. Review papers, descriptions of new taxa, faunistic surveys, lists of museum collections, and book reviews are welcome.

Derivatio Nominis

The name *Euscorpius* Thorell, 1876 refers to the most common genus of scorpions in the Mediterranean region and southern Europe (family Euscorpiidae).

Euscorpius is located at: <https://mds.marshall.edu/euscorpius/>
Archive of issues 1-270 see also at: <http://www.science.marshall.edu/fet/Euscorpius>

(Marshall University, Huntington, West Virginia 25755-2510, USA)

ICZN COMPLIANCE OF ELECTRONIC PUBLICATIONS:

Electronic (“e-only”) publications are fully compliant with ICZN (*International Code of Zoological Nomenclature*) (i.e. for the purposes of new names and new nomenclatural acts) when properly archived and registered. All *Euscorpius* issues starting from No. 156 (2013) are archived in two electronic archives:

- **Biotaxa**, <http://biotaxa.org/Euscorpius> (ICZN-approved and ZooBank-enabled)
- **Marshall Digital Scholar**, <http://mds.marshall.edu/euscorpius/>. (This website also archives all *Euscorpius* issues previously published on CD-ROMs.)

Between 2000 and 2013, ICZN *did not accept online texts* as “published work” (Article 9.8). At this time, *Euscorpius* was produced in two *identical* versions: online (*ISSN 1536-9307*) and CD-ROM (*ISSN 1536-9293*) (laser disk) in archive-quality, read-only format. Both versions had the identical date of publication, as well as identical page and figure numbers. **Only copies distributed on a CD-ROM** from *Euscorpius* in 2001-2012 represent published work in compliance with the ICZN, i.e. for the purposes of new names and new nomenclatural acts.

In September 2012, ICZN Article 8. What constitutes published work, has been amended and allowed for electronic publications, disallowing publication on optical discs. From January 2013, *Euscorpius* discontinued CD-ROM production; only online electronic version (*ISSN 1536-9307*) is published. For further details on the new ICZN amendment, see <http://www.pensoft.net/journals/zookeys/article/3944/>.

Publication date: 1 October 2022

<http://zoobank.org/urn:lsid:zoobank.org:pub:B023E1F9-C0A2-4DB2-95B9-90FFE8436EF0>

Report of thanatosis in the Central American scorpions *Tityus ocelote* and *Ananteris platnicki* (Scorpiones: Buthidae)

Felipe Triana^{1,2*}, Fabián Bonilla¹, Adriana Alfaro-Chinchilla¹, Carlos Víquez³, Cecilia Díaz^{1,4} and Mahmood Sasa^{1,2,5}

¹Instituto Clodomiro Picado, Facultad de Microbiología, Universidad de Costa Rica

²Escuela de Biología, Universidad de Costa Rica

³Oficina Subregional de Alajuela, Sistema Nacional de Áreas de Conservación, Ministerio de Ambiente y Energía

⁴Departamento de Bioquímica, Escuela de Medicina, Universidad de Costa Rica

⁵Museo de Zoología, Centro de Investigación de Biodiversidad y Ecología Tropical, Universidad de Costa Rica

* Correspondence author: felotriana19@gmail.com

<http://zoobank.org/urn:lsid:zoobank.org:pub:B023E1F9-C0A2-4DB2-95B9-90FFE8436EF0>

Summary

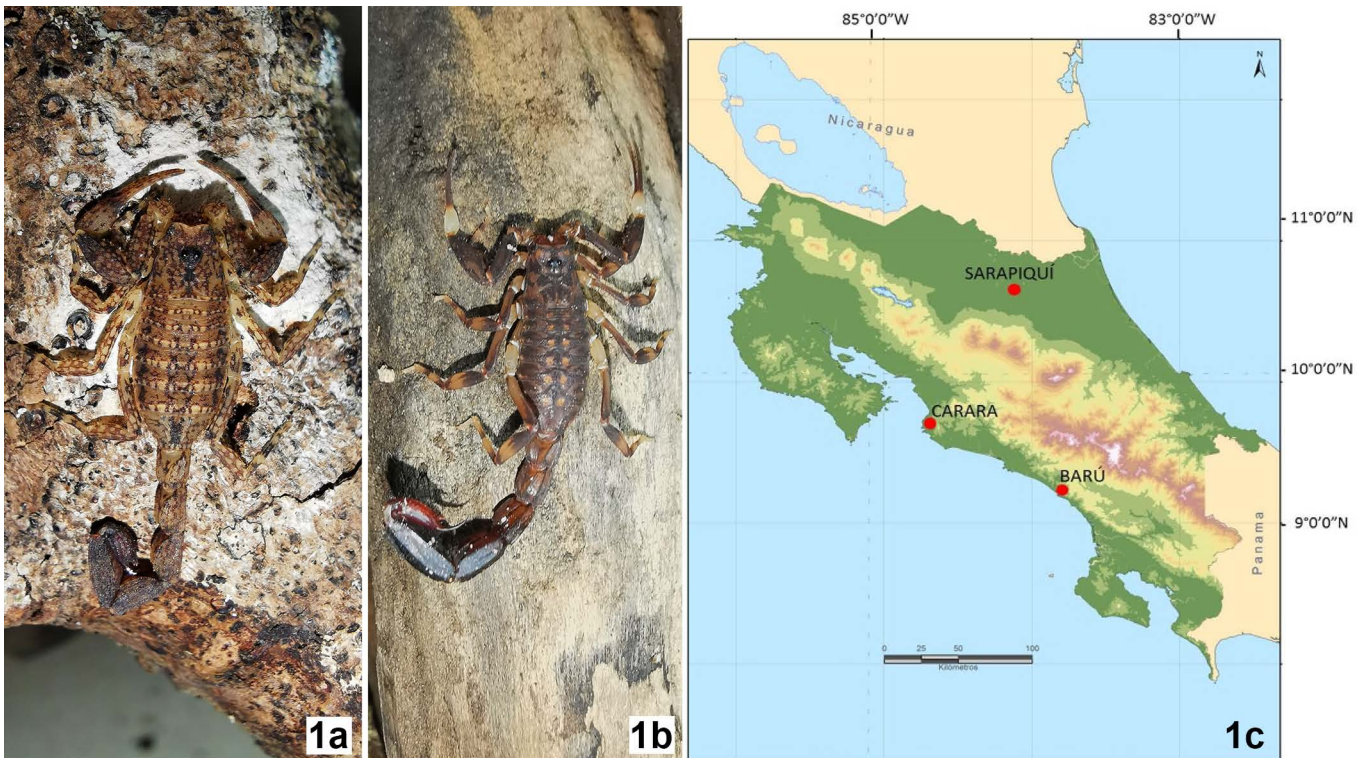
Thanatosis, or tonic immobility, is a behavior where animals adopt a motionless posture after a physical contact or very close proximity of a predator. This behavior has been described in a wide range of taxa, from invertebrates to vertebrates. For scorpions, tonic immobility has been reported in two buthids, *Tityus pusillus* and *Tityus cerroazul*, one hormurid, *Liocheles australasiae*, and one scorpionsid, *Scorpiops jendeki*. Here we report other cases of this thanatosis for two buthid scorpions from lower Central America: *Tityus ocelote* and *Ananteris platnicki*. Thanatosis in these species were observed in wild, but was better documented in the laboratory. After human handling, several individuals for both species rolled over and laid on their back, adopting a distinctive rigid position, where they did not respond to external mechanical stimuli. As tonic immobility might be associated with other defense strategies, such as cryptic colorations, it is hypothesized that this behavior is used as a strategy in both species only if there is physical contact that simulated by a predator. On the other hand, the observations of thanatosis we reported here and the ones reported in other *Tityus* scorpions suggest that this behavior may have a phylogenetic basis in American buthids and that it could be more widespread than initially thought. However, more observations of tonic immobility in buthids would allow the evaluation of this hypothesis.

Introduction

Thanatosis, commonly known as death-feigning and recently more appropriate as tonic immobility, is defined by Humphreys & Ruxton (2018) as an unlearned adoption of a motionless posture by a prey individual triggered by physical contact or very close proximity of a predator. Tonic immobility has been proven to be widely distributed among different animal taxa, from arthropods to vertebrates (Humphreys & Ruxton, 2018). Although this behavioral response is assumed to be mainly an antipredator strategy, it has been observed that in some cases, it occurs as a hunting strategy (McKaye, 1981; Tobler, 2005) and as sexual behavior (Lawrence, 1992; Kynaston et al., 1994; Bilde et al., 2006; Hansen et al., 2008). Humphreys & Ruxton (2018) hypothesized that tonic immobility may have evolved multiple times in different lineages, given its taxonomic distribution's simplicity and its widespread but sparse nature.

Specifically for arthropods, tonic immobility has been reported (at least) in Anomura (Coutinho et al., 2013), Phasmatodea (Farkas, 2016), Orthoptera (Honma et al., 2006),

Lepidoptera (Shreeve et al., 2006), Coleoptera (Krams et al., 2013), Hymenoptera (Neves & Pie, 2018), Araneae (Hansen et al., 2008), Opiliones (Cook et al., 2013), and Scorpiones. In the last group, feigning death is known from the Brazilian buthid scorpion *Tityus pusillus* (Lira et al., 2020). In this species, thanatosis is one of the five defensive behaviors displayed when predator attacks were simulated, along with fleeing, stinging, standing still, and tail wagging (Lira et al., 2020). The other three species of scorpions reported exhibiting tonic immobility are the Costa Rican species *Tityus cerroazul* (Buthidae) (Viquez et al., 2005; Quintero & Miranda, 2007) and the Chinese species *Liocheles australasiae* (Hormuridae) and *Scorpiops jendeki* (Scorpiopsidae) (Tang, 2022). Nonetheless, the details of how these species display thanatosis were not described, making the conditions under which these scorpions performed this behavior unclear. Although not reported, this behavior is often found in scorpions, being more obvious in scorpions of the genus *Neobuthus* from the Horn of Africa (František Kovařík, personal communication). Here we report other cases of thanatosis in buthid scorpions from Central America.



Figures 1a–1c: **Figure 1a.** *Tityus ocelote*, female from Hacienda Barú. **Figure 1b.** *Ananteris platnicki*, male from Hacienda Barú. **Figure 1c.** Collection localities.

Tityus ocelote is a small (body length ≤ 35 mm) spotted scorpion included in the subgenus *Tityus* (*Archaeotityus*) (Lourenço, 2006). As other members of the subgenus, it exhibits a yellowish to reddish-brown background covered with a mottled pattern of darker spots (Figure 1) (Francke & Stockwell, 1987; Víquez, 1999). It is distributed in the Pacific and Caribbean humid lowlands of Costa Rica and Bocas del Toro in western Panama (Víquez, 1999; Montoya & Armas, 2002; Teruel & Cozijn, 2011). *T. ocelote* is mainly arboreal, usually found in palms and trees with vines (Blasco-Aróstegui et al., 2020).

Ananteris platnicki is a buthid scorpion also distributed in the Caribbean slope's low and midlands and the South Pacific's lowlands in Costa Rica and western Panama, specifically in Bocas del Toro, Veraguas, and Coclé (Víquez, 1999; Teruel & Cozijn, 2011). It is more likely to find this species in the leaf litter and under logs (Víquez, 1999). It has light to medium greyish brown background colorations with a lighter lateral spotted pattern (Figure 1) (Lourenço, 1993; Víquez, 1999). *A. platnicki* is also a tiny scorpion, whose size does not exceed 30 mm (Víquez, 1999).

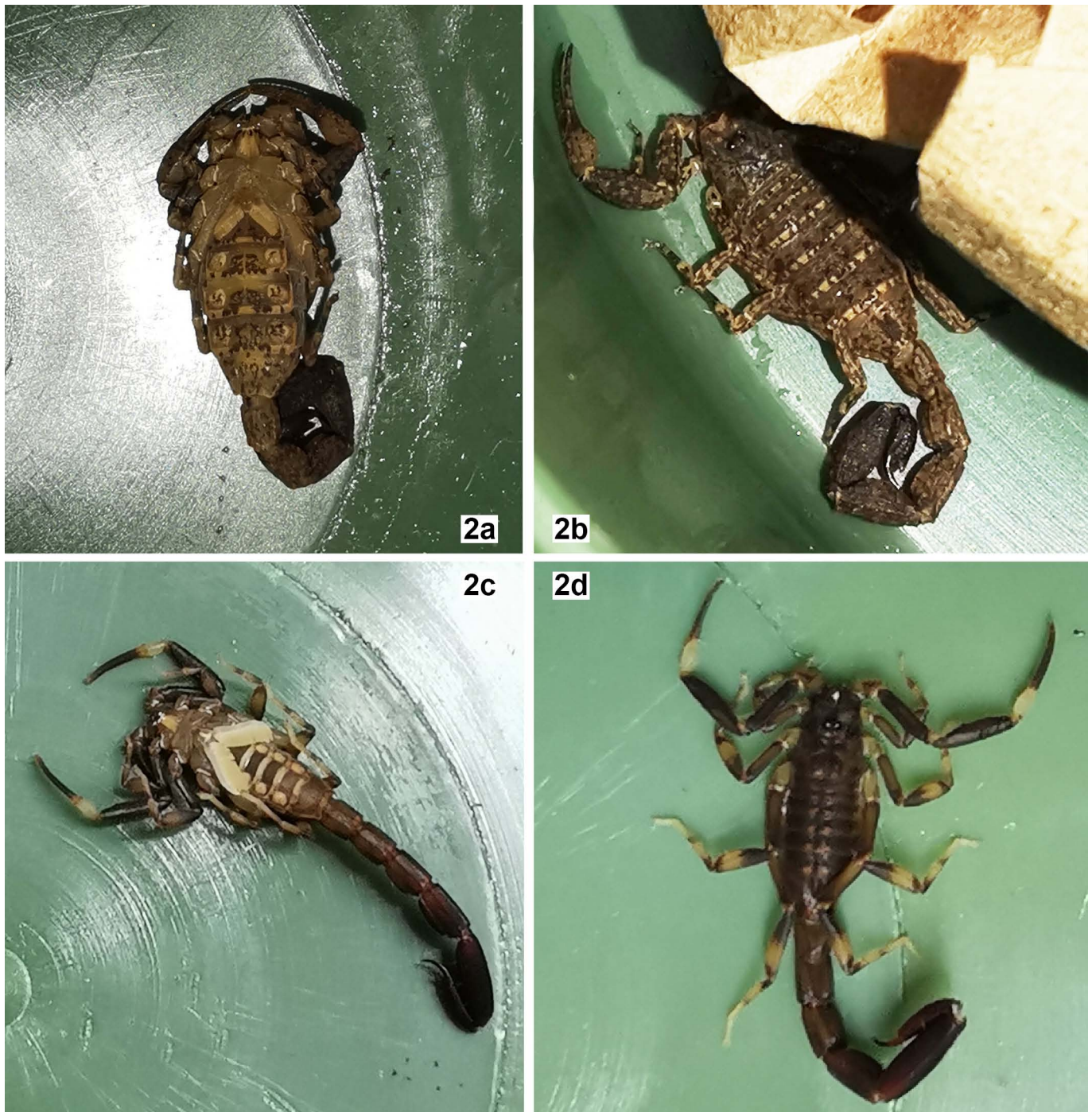
Results and Discussion

For an ongoing project focused on the venomics of Costa Rican buthid scorpions, we collected individuals of *T. ocelote* in three locations in Costa Rica: Carara National Park (9°46'53.04"N 84°36'16.09"W), Hacienda Barú (9°16'17.00"N 83°52'52.27"W) and Pueblo Nuevo de Sarapiquí (10°28'26.11"N 84°4'29.54"W) (Figure 1). *A.*

platnicki was only found in Hacienda Barú (Figure 1). The scorpions were transferred to the Instituto Clodomiro Picado in San José, Costa Rica, and kept individually in plastic boxes with two pieces of paper as a substrate. Mealworms and crickets were offered as prey weekly, and a soaked cotton swab provided water *ad libitum*.

During the collection of the scorpions in wild, it was observed that several individuals feign death. This behavior was better documented once the animals were in the laboratory. During our weekly revision of specimens, some individuals lying on the cotton had to be handled. On several occasions, after human handling, specimens of *T. ocelote* and *A. platnicki* performed tonic immobility as a behavioral response to the physical stimuli, as they did in wild. Here we show an example with an individual from *T. ocelote* of Pueblo Nuevo de Sarapiquí (Figure 2). Both species roll over and lay on their back, adopting a distinctive rigid position (Figure 2). For *T. ocelote*, the legs and the metasoma persist retracted near the body. In contrast, for *A. platnicki*, the legs remain relaxed but not completely extended, and the metasoma lays extended (Figure 2). Individuals of both species did not respond to external mechanical stimuli while displaying thanatosis. After a few minutes of not being disturbed, specimens spontaneously and quickly resumed activity, moving directly towards a refuge. In the case of *T. ocelote*, this behavior was observed in individuals from the three collection sites, so it is not a locality-specific condition.

Tonic immobility is associated with other defense strategies, such as cryptic colorations (Rogers & Simpson, 2014), although the idea has some detractors (Humphreys



Figures 2a–2d. Tonic immobility behavior in *Tityus ocelote* from Pueblo Nuevo de Sarapiquí (2a) and *Ananteris platnicki* (2c) under laboratory-controlled conditions in contrast to their normal behavior for *T. ocelote* (2b) and *A. platnicki* (2d).

& Ruxton, 2018). Both *T. ocelote* and *A. platnicki* have colorations that could help them blend in with their substrates. Humphreys & Ruxton (2018) hypothesized that tonic immobility should be seen as a last resort that requires not only that the individual has been detected but also that physical contact occurs. According to this hypothesis, the cryptic coloration and initial posture in *T. ocelote* and *A. platnicki* may represent a first defensive resource. In contrast, tonic immobility is used as a strategy in both species only if there is physical contact in the attack.

One of the other species of *Tityus* where tonic immobility has been reported, *T. pusillus* (Lira et al., 2020), also belongs to the subgenus *T. (Archaeotityus)*, suggesting an evolutive affinity with *T. ocelote*. In both species, the behavior of thanatosis observed was similar. In contrast, the other species of *Tityus* reported to display tonic immobility, *T. cerrozazul* (Viquez et al., 2005; Quintero & Miranda, 2007), is part of the subgenus *T. (Tityus)* inside the *Tityus bolivianus* complex. This subgenus is estimated to have diverged from the ancestor of *T. (Archaeotityus)* about 27 million years ago (Ojanguren-Affilastro et al., 2017). Moreover,

Ananteris belongs to a distant lineage of American buthids that is estimated to have diverged from the ancestor of *Tityus* about 40 million years ago (Ojanguren-Affilastro et al., 2017). Our observations in *A. platnicki* and the ones done by other authors in *T. cerroazul* suggest that tonic immobility in American buthids scorpions may have a phylogenetic basis and that this behavior is more widespread than initially thought. Nonetheless, observations in a more significant number of species of buthids is needed to evaluate this hypothesis.

Acknowledgments

We thank Vicerrectoría de Investigación (Universidad de Costa Rica) for partially financing this project by grant 741-C2-076. The permits for scorpions' research and collections are registered as SINAC-ACOPAC-D-RES-051-2021 and The Biodiversity Commission Resolution #293. We also thank the Laboratorio para la Investigación de Animales Peligrosos (LIAP) from Instituto Clodomiro Picado for the maintenance and management of the animals in captivity.

References

- BILDE, T., TUNI, C., ELSAYED, R., PEKÁR, S., & TOFT, S. 2006. Death feigning in the face of sexual cannibalism. *Biology Letters*, 2(1): 23–25. <https://doi.org/10.1098/rsbl.2005.0392>
- BLASCO-ARÓSTEGUI, J., GARCÍA-GILA, J., FRANCKE, O. F., BLASCO-ARÓSTEGUI, J., GARCÍA-GILA, J. & FRANCKE, O. F. 2020. Ecological aspects of the interactions between *Centruroides limbatus* and *Tityus ocelote* (Scorpiones: Buthidae) in a Caribbean forest of Costa Rica. *Revista Mexicana de Biodiversidad*, 91. <https://doi.org/10.22201/ib.20078706e.2020.91.3418>
- COOK, D. R., SMITH, A. T., PROUD, D. N., VÍQUEZ, C., & TOWNSEND, Jr., V. R. 2013. Defensive responses of neotropical harvestmen (Arachnida, Opiliones) to generalist invertebrate predators. *Caribbean Journal of Science*, 47(2–3): 325–334. <https://doi.org/10.18475/cjos.v47i3.a20>
- COUTINHO, C., AYRES-PERES, L., ARAUJO, P. B., JARA, C. G. & SANTOS, S. 2013. Thanatosis in freshwater anomurans (Decapoda: Aeglidae). *Journal of Natural History*, 47(41–42): 2623–2632. <https://doi.org/10.1080/00222933.2013.807949>
- FARKAS, T. E. 2016. Body size, not maladaptive gene flow, explains death-feigning behaviour in *Timema cristinae* stick insects. *Evolutionary Ecology*, 30(4): 623–634. <https://doi.org/10.1007/s10682-016-9832-9>
- FRANCKE, O. F. & STOCKWELL, S. A. 1987. *Scorpions (Arachnida) of Costa Rica*. Texas Tech University.
- HANSEN, L. S., GONZALES, S. F., TOFT, S. & BILDE, T. 2008. Thanatosis as an adaptive male mating strategy in the nuptial gift-giving spider *Pisaura mirabilis*. *Behavioral Ecology*, 19(3): 546–551. <https://doi.org/10.1093/beheco/arm165>
- HONMA, A., OKU, S. & NISHIDA, T. 2006. Adaptive significance of death feigning posture as a specialized inducible defence against gape-limited predators. *Proceedings of the Royal Society B: Biological Sciences*, 273(1594): 1631–1636. <https://doi.org/10.1098/rspb.2006.3501>
- HUMPHREYS, R. K. & RUXTON, G. D. 2018. A review of thanatosis (death feigning) as an anti-predator behaviour. *Behavioral Ecology and Sociobiology*, 72(2): 22. <https://doi.org/10.1007/s00265-017-2436-8>
- KRAMS, I., KIVLENIECE, I., KUUSIK, A., KRAMA, T., FREEBERG, T. M., MÄND, R., VRUBLEVSKA, J., RANTALA, M. J. & MÄND, M. 2013. Predation selects for low resting metabolic rate and consistent individual differences in anti-predator behavior in a beetle. *Acta Ethologica*, 16(3): 163–172. <https://doi.org/10.1007/s10211-013-0147-3>
- KYNASTON, S. E., MCERLAIN-WARD, P. & MILL, P. J. 1994. Courtship, mating behaviour and sexual cannibalism in the praying mantis, *Sphodromantis lineola*. *Animal Behaviour*, 47(3): 739–741. <https://doi.org/10.1006/anbe.1994.1103>
- LAWRENCE, S. E. 1992. Sexual cannibalism in the praying mantid, *Mantis religiosa*: A field study. *Animal Behaviour*, 43(4): 569–583. [https://doi.org/10.1016/S0003-3472\(05\)81017-6](https://doi.org/10.1016/S0003-3472(05)81017-6)
- LIRA, A. F., ALMEIDA, F. M. & ALBUQUERQUE, C. M. 2020. Reaction under the risk of predation: effects of age and sexual plasticity on defensive behavior in scorpion *Tityus pusillus* (Scorpiones: Buthidae). *Journal of Ethology*, 38(1): 13–19.
- LOURENÇO, W. R. 1993. A review of the geographical distribution of the genus *Ananteris* Thorell (Scorpiones: Buthidae), with description of a new species. *Revista de Biología Tropical*, 41(3A): 697–701.
- LOURENÇO, W. R. 2006. Nouvelle proposition de découpage sous-générique du genre *Tityus* C. L. Koch, 1836 (Scorpiones, Buthidae). *Boletín Sociedad Entomológica Aragonesa*, 39: 55–67.
- MCKAYE, K. R. 1981. Field observation on death feigning: a unique hunting behavior by the predatory cichlid, *Haplochromis livingstoni*, of Lake Malawi. *Environmental Biology of Fishes*, 6(3): 361–365. <https://doi.org/10.1007/BF00005766>

- MONTOYA, M. & ARMAS, L. F. 2002. Escorpiones (Arachnida) del Archipiélago de Bocas del Toro, Panamá. *Revista de Biología Tropical*, 50: 155-160.
- NEVES, F. M. & PIE, M. R. 2018. On the adult behavioral repertoire of the sawfly *Perreyia flavipes* Konow, 1899 (Hymenoptera: Pergidae): movement, mating, and thanatosis. *Neotropical Entomology*, 47(1): 46–52. <https://doi.org/10.1007/s13744-017-0509-z>
- OJANGUREN-AFFILASTRO, A. A., ADILARDI, R. S., MATTONI, C. I., RAMÍREZ, M. J. & CECCARELLI, F. S. 2017. Dated phylogenetic studies of the southernmost American buthids (Scorpiones: Buthidae). *Molecular Phylogenetics and Evolution*, 110:39-49. <http://dx.doi.org/10.1016/j.ympev.2017.02.018>
- QUINTERO, D. & MIRANDA, R. 2007. *Tityus cerroazul* Lourenço (Scorpiones: Buthidae): Nueva sinonimia, notas sobre su biología, nuevos registros de distribución en Panamá, descripción del macho previamente desconocido y picadura mortal de un niño. *Tecnociencia*, 9(2): 121-135.
- ROGERS, S. M. & SIMPSON, S. J. 2014. Thanatosis. *Current Biology*, 24(21): R1031–R1033. <https://doi.org/10.1016/j.cub.2014.08.051>
- SHREEVE, T. G., DENNIS, R. L. H. & WAKEHAM-DAWSON, A. 2006. Phylogenetic, habitat, and behavioural aspects of possum behaviour in European Lepidoptera. *Journal of Research on the Lepidoptera*, 39: 80–85. <https://doi.org/10.5962/p.266539>
- TANG, V. 2022. A new scorpion genus and species from China, *Qianxie solegladi* gen. et sp.n. (Scorpiones: Pseudochactidae). *Euscorpius*, 351:1–19.
- TERUEL, R., & COZIEN, M. 2011. A checklist of the scorpions (Arachnida: Scorpiones) of Panama, with two new records. *Euscorpius*, 133: 1–6. <https://doi.org/10.18590/euscorpius.2011.vol2011.iss133.1>
- TOBLER, M. 2005. Feigning death in the Central American cichlid *Parachromis friedrichsthalii*. *Journal of Fish Biology*, 66(3): 877–881. <https://doi.org/10.1111/j.0022-1112.2005.00648.x>
- VÍQUEZ, C. 1999. *Escorpiones de Costa Rica*. INBio.
- VÍQUEZ, C., DE ARMAS, L. & LOURENÇO, W. 2005. Presencia de *Tityus cerroazul* Lourenço, 1986 (Scorpiones:Buthidae) en Costa Rica y descripción del macho. *Boletín Sociedad Entomológica Aragonesa*, 36: 93–96.