Conjoined twins in a Brazilian litter dwelling scorpion, *Tityus pusillus* (Scorpiones, Buthidae)

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Abstract: Teratologies have been recurrently reported in scorpions over the years, and can be seen in different cases affecting different body parts. Herein we report a special case of teratology, the duplication of parts of the longitudinal axis of the body that leads to the occurrence of conjoined twins. Two juvenile individuals of *Tityus pusillus* Pocock, 1893, showed fusion in the metasoma and the absence of a telson. In addition, one of the subjects showed regular mobility, while another performed weak movements of the appendages. However, both animals died a few days after birth without performing the first ecdysis. Cases of teratologies reported in the literature are also compiled, with species belonging to the Buthidae being the most frequently involved, probably correlated with the great diversity and wide distribution of this family.
Key words: Scorpiones, Buthidae, *Tityus pusillus*, malformation, Brazil.

Gemelos unidos en un escorpión brasileño que vive en la hojarasca, *Tityus pusillus* (Scorpiones, Buthidae)
Resumen: Se han reportado teratologías recurrentemente en escorpiones a lo largo de los años, y pueden verse en diferentes casos localizados en diferentes partes del cuerpo. Aquí reportamos un caso especial de teratología, la duplicación de partes del eje longitudinal del cuerpo que conduce a la aparición de gemelos unidos. Los dos individuos juveniles de *Tityus pusillus* Pocock, 1893 mostraban fusión en el metasoma y ausencia de telson. Además, uno de los especímenes mostró movilidad regular, mientras que el otro realizó movimientos débiles de sus apéndices; sin embargo, ambos fallecieron a los pocos días de nacer, sin realizar la primera ecdisis. En el presente estudio también se recopilan los casos de teratologías reportados en la literatura, la mayoría pertenecientes a especies de Buthidae, probablemente correlacionado con la gran diversidad y amplia distribución geográfica de esta familia.
Palabras clave: Scorpiones, Buthidae, *Tityus pusillus*, malformación, Brasil.

Teratology is a structural malformation or abnormality in leaving organisms (Clegg, 1971). Despite these morphological anomalies are common in invertebrates, their records are fragmented in the literature (e.g., Armas, 1977; Jansen *et al*., 2013, Salmelin *et al*., 2015, Napiorkowska *et al*., 2015). In scorpions, teratologies has been recurrently recorded along the years (reviewed in Dupre & Legangneux, 1999). In these arachnids, most teratologies occur on the pedipalp, such as the duplication or deletion of segments, which may alter the functionality of the structure (Graham, 2006). In smaller amounts, they can also be found in other parts of the body, such as the prosoma, legs and metasoma (e.g., Berland, 1913; Vanchon, 1972; Karataş & Kürtüllü, 2006; De Souza *et al*., 2009; Teruel & Baldazo-Monsivaiz, 2015; Alqahtani & Badry, 2021).

A special case of malformation is the duplication of parts of the longitudinal body axis that leads to the occurrence of conjoined twins (Spencer, 2000). This type of teratology generally results on individual mortality (Kulawik *et al*., 2017). Conjoined twins are a common malformation in vertebrates (Hynd *et al*., 2013; Spitz *et al*., 2018) may also occur in invertebrates, principally in crustaceans (Jara & Palacios, 2011; Scholtz, 2020). Therefore, at best of our knowledge, in the present study we reported a first case of conjoined twins in scorpions. In addition, we provide a compiled list of published records of teratology on these arachnids.

Conjoined twins are herein recorded in *Tityus pusillus* Pocock, 1893 juveniles from a pregnant female collected during a nocturnal field study conducted in the ´Campo de Instrução Marechal Newton Cavalcanti' (07° 49' 52" S, 35° 06' 12" W) an Atlantic Forest fragment with 7,000 ha. The list of published records of teratology in scorpions was compiled by searching the keywords "teratology", "malformation", and "scorpion" in Google Scholar. The conjoined twins' individuals were found in floor of terrarium after female parturition. These scorpions were united by metasoma, exhibited an absence of telson (Figure 1). One of these individuals shows a regular mobility and other performed weak movements of his appendages (Video S1; www.sea-entomologia.org/ ria40videoS1). Both animals died a few days after birth.

The specimens described in this work showed a duplication in the longitudinal axis of their bodies, thus being able to be classified as conjoined twins according to Spencer (2000). Consequently, to this teratology, the individuals were not able to perform the ecdysis for the next instar, later causing the death of both individuals. In conjoined twins, it is common for one individual to be more developed than the other, as is the case reported for *T. pusillus*. For example, conjoined twins of crustaceans of the genus *Aegla* Leach, 1820, it was reported that the larger specimen carried the smaller individual (Jara & Palacios, 2011). In addition, a high mortality rate is expected for individuals with this malformation (Nowosad *et al*., 2018; Vaishnavi, 2020), which could result in the death of both or only one individual (Benirschke, 1995).

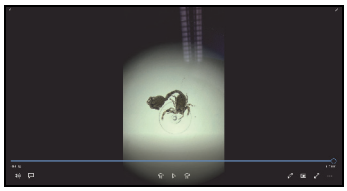
A total of 60 studies reporting teratologies in scorpions were compiled for 109 species from 13 families (Table I). Of these, Buthidae correspond to 51% of species recorded followed by Chactidae with 15%. Others scorpion families ranged from 1 to 8 species records (Table I). Considering that buthids correspond to about half of the total species described for the order Scorpiones (Rein, 2022). In addition, these scorpions are distributed in practically all regions of the planet (Polis ,1990; Brandão & Françoso, 2010, Brazil & Porto, 2011). Thus, the greater number of teratologies reported in the literature for this family may be a reflection of the greater representativeness of this taxon.

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Fig. 1. Conjoined twins individuals of the scorpion *Tityus pusillus* Pocock, 1893.



Video S1. Conjoined twins individuals showing different levels of mobility. www.sea-entomologia.org/ria40videoS1

Table I. Scorpion species with teratology records from scientific literature.

Species	Reference
Buthidae	
Alayotityus juraguaensis Armas,1973	Teruel (2003)
Alayotityus nanus Armas, 1973	Teruel (2003)
Androctonus amoreuxi (Audouin, 1826)	Sadine (2021)
Androctonus australis (Linnaeus, 1758)	Sergent (1942); Sergent (1946)
Androctonus crassicauda (Olivier, 1807)	Millot & Vachon (1949); Vachon (1951); Karataş & Kürtüllü (2006); Teruel (2003)
Buthacus leptochelys (Ehrenberg, 1829)	Sergent (1946); Vachon (1952)
Buthus occitanus (Amoreux, 1789)	Zarrouk *et al*. (1980); Crucitti & Chine (1994)
Centruroides anchorellus Armas, 1976	Armas (1977); Teruel (2003)
Centruroides baracoae (Armas, 1976)	Teruel (2003)
Centruroides gracilis (Latreille, 1804)	Armas (1977); Armas (1995); González-Sponga (2004); Teruel (2003)
Centruroides guanensis Franganillo, 1930	Armas (1977); Armas (1989)
Centruroides infamatus (C. L. Koch, 1844)	Berland (1913)
Centruroides margaritatus (Gervais, 1841)	Campos (1918); Teruel (2003)
Centruroides nitidus (Thorell, 1876)	Seiter & Teruel (2014)
Centruroides noxius Wood, 1863	Briseño (1963)
Centruroides sculpturatus Ewing, 1928	Williams (1971)
Centrudoides thorelli (Kraepelin, 1891)	Armas (1977)
Centruroides vittatus (Say, 1821)	Sissom & Shelley (1995)
Centruroides sp. Marx, 1890	Santiago Blay (1986)
Heteroctenus garridoi (Armas, 1974)	Teruel (2003)
Heteroctenus junceus (Herbst, 1800)	Armas (1977); Teruel (2003)
Hottentotta alticola (Pocock, 1895)	Vachon & Serfaty (1950)
Hottentotta franzwerneri (Birula, 1914)	Teruel (2003)
Hottentotta socotrensis (Pocock, 1898)	Teruel (2003)
Hottentotta trilineata Dupré & Balliet, 1997	Teruel (2003)
Hottentotta zagrosensis Kovarik, 2018	Salabi *et al*. (2021)
Isometrus maculatus (DeGeer, 1778)	Pawlowsky (1917); Vachon (1972)
Jaguajir rochae (Borelli, 1910)	Matthiesen (1989)
Leiurus quinquestriatus (Ehrenberg, 1828)	Shulov *et al*. (1955); Karatas & Çolak (2005)
Lychas mucronatus (Fabricius, 1798)	Teruel (2003)
Lychas obsti Kraepelin, 1913	Teruel (2003)
Mesobuthus eupeus (C. L. Koch, 1839)	Teruel (2003)
Mesobuthus gibbosus (Brullé, 1832)	Teruel (2003)
Microtityus jaumei Armas, 1974	Teruel (2003)
Orthochirus innessi Simon, 1910	Teruel (2003)
Orthochirus sp. Karsch, 1891	Jahanifard *et al*. (2008)
Parabuthus liosoma (Ehrenberg, 1828)	Alqahtani & Badry (2021)
Parabuthus pallidus Pocock, 1895	Teruel (2003)
Paraorthochirus sp. Lourenço & Vachon, 1997	Jahanifard *et al*. (2008)
Rhopalurus laticauda Thorell, 1876	González-Sponga (2004)
Tityopsis inexpectata (Moreno, 1940)	Armas (1990)

Species	Reference
Tityus bahiensis (Perty, 1833)	Armas (1977); Matthiesen (1989)
Tityus carabobensis Gonzalez-Sponga, 1987	González-Sponga (2004)
Tityus clathratus C. L. Koch, 1844	González-Sponga (2004)
Tityus discrepans (Karsch, 1879)	González-Sponga (2004); Teruel (2003)
Tityus fasciolatus Pessoa, 1935	Lourenço (1984)
Tityus pusillus Pocock, 1893	*This study*
Tityus quirogae De Sousa, Manzanilla & Parrilla-Alvarez, 2006	De Souza *et al*. (2009)
Tityus mattogrossensis Borelli, 1901	Lourenço (1984)
Tityus metuendus Pocock, 1897	Lourenço (1984)
Tityus neoespartanus Gonzalez-Sponga, 1996	González-Sponga (2004)
Tityus obscurus Gervais, 1843)	Matthiesen (1980); Seiter & Teruel (2014)
Tityus riocaurensis Gonzalez-Sponga, 1996	González-Sponga (2004)
Tityus sp. C. L. Koch, 1836	González-Sponga (2004); Santiago Blay (1986)
Tityus serrulatus Lutz & Mello, 1922	Matthiesen (1978); Matthiesen (1981); Matthiesen (1989)
Tityus stigmurus (Thorell, 1876)	Matthiesen (1989)
Bothriuridae	
Bothriurus coriaceus Pocock, 1893	Mattoni (2005)
Bothriurus noa Maury, 1984	Mattoni (2005)
Brachistosternus pentheri Mello-Leitão, 1931	Maury (1983)
Brachistosternus roigalsinai Ojaguren-Affilastro, 2002	Mattoni (2005)
Centromachetes pococki (Kraepelin, 1894)	Teruel (2003)
Urophonius granulatus Pocock, 1898	Teruel (2003)
Chactidae	
Brotheas camposi Gonzalez-Sponga, 1972	GonzálezSponga (2004)
Brotheas libinallyi Gonzalez-Sponga, 1978	GonzálezSponga (2004)
Brotheas perezramirezi Gonzalez-Sponga, 1996	González-Sponga (2004)
Brotheas sp. C. L. Koch, 1837	González-Sponga (2004)
Neochactas bilbaoi (Gonzalez-Sponga, 1978)	González-Sponga (2004)
Neochactas garciai (Gonzalez-Sponga, 1978)	González-Sponga (2004)
Neochactas leoneli (Gonzalez-Sponga, 1978)	González-Sponga (2004)
Neochactas neblinensis (Gonzalez-Sponga, 1991)	González-Sponga (2004)
Neochactas santanai (Gonzalez-Sponga, 1978)	González-Sponga (2004)
Neochactas sp. Soleglad & Fet, 2003	González-Sponga (2004)
Brotheas gervaisii Pocock, 1893	Teruel (2003)
Broteochactas venezuelensis (Gonzalez-Sponga, 1996)	González-Sponga (2004)
Chactas barbacoensis Gonzalez-Sponga, 1987	González-Sponga (2004)
Chactas gansi Gonzalez-Sponga, 1974	González-Sponga (2004)
Chactas laevipes (Karsch, 1879)	González-Sponga (2004)
Broteochactas vestigialis Gonzalez-Sponga, 1978	González-Sponga (2004)
Teuthraustes reticulatus Gonzalez-Sponga, 1991	González-Sponga (2004)
Chaerilidae	
Chaerilus truncatus Karsch, 1879	Teruel (2003)
Diplocentridae	
Bioculus comondae Stahnke, 1968	Williams & Lee (1975)
Cazierius gundlachii (Karsch, 1880)	Francke (1978); Teruel (2003)
Cazierius parvus Armas, 1984	Teruel (2003)
Didymocentrus krausi Francke, 1978	Teruel (2003)
Didymocentrus sp. Kraepelin, 1905	Armas (1976)
Heteronebo sp. Pocock, 1899	Santiago Blay (1986)
Tarsoporosus kugleri (Schenkel, 1932)	González-Sponga (2004)
Tarsoporosus flavus (Gonzalez-Sponga, 1984)	González-Sponga (2004)
Euscorpiidae	
Euscorpius carpathicus (Linnaeus, 1767)	Brauer (1917); Šarić & Tomić (2016)
Scorpiops luridus Qi, Zhu & Lourenço, 2005	Di *et al*. (2018)
Tetratrichobothrius flavicaudis (DeGeer, 1778)	Dupré & Legangneux (1999); Lourenço & Hypolite (2010); Teruel (2003)
Alpiscorpius germanus (C. L. Koch, 1837)	Pavesi (1881)
Megacormus gertschi Díaz Najera, 1966	Teruel (2003)
Hemiscorpiidae	
Hemiscorpius lepturus Peters, 1861	Teruel (2003)
Hemiscourpius sp. Peters, 1861	Jahanifard *et al*. (2008)
Hormuridae	
Opisthacanthus sp. Peters, 1861	González-Sponga (2004); Galvis & Flórez (2016)
Liocheles australasiae (Fabricius, 1775)	Teruel (2003)
Caraboctonidae	
Caraboctonus keyserlingi Pocock, 1893	Teruel (2003)
Hadruroides lunatus (C. L. Koch, 1867)	Teruel (2003)
Scorpionidae	
Chersonometrus fulvipes (C. L. Koch, 1837)	Naidu (1977)
Javanimetrus cyaneus (C. L. Koch, 1836)	Teruel (2003)
Scorpio fuscus (Ehrenberg, 1829)	David (2012)
Pandinus imperator (C. L. Koch, 1841)	Teruel (2003)
Scorpio maurus Linnaeus, 1758	Vachon (1953)
Scorpio kruglovi Birula, 1910	Yağmur *et al*. (2021)
Superstitioniidae	
Superstitionia donensis Stanhke, 1940	Graham (2006)
Vaejovidae	
Mesomexovis punctatus (Karsch, 1879)	Teruel & Baldazo-Monsivaiz (2015)
Vaejovis lapídicola Stanhke, 1940	Ayrey (2011)
Without species identification	Campos (1930); Berland (1945); Vachon (1946); Vachon (1950); Lewis (1954); Hjelle (1990)

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*Reference available at www.sea-entomologia.org