

SHORT COMMUNICATION

A case of Dipteran parasitism in *Trachycephalus typhonius* (Anura: Hylidae), with a summary of myiasis parasitism in anurans

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Keywords: amphibians, infestation, larvae, Sarcophagidae.

Palavras-chave: anfíbios, infestação, larvas, Sarcophagidae.

Some species of Diptera cause myiasis in anurans, and infestations can occur in organs or other vertebrate tissues for varying lengths of time, depending on the species of parasite (Schell and Burgin 2001, Bolek and Coggins 2002). Larvae feed on tissues as they develop within or on the body of their host, which often results in the death of the host, although some individuals do survive and heal (Eaton *et al.* 2008, Souza-Pinto *et al.* 2015). Some parasitic dipteran species need living hosts to continue their life cycle (Kraus 2007). Dipteran infestations have been well documented in humans and domestic animals because their impacts concern public

health and economics (Hall and Wall 1995). Nevertheless, wild animals also host dipteran parasite larvae, but records are scarce and poorly documented (Travers and Townsend 2010, Pinto *et al.* 2017).

Dipteran families such as Calliphoridae, Chloropidae, Phoridae, and Sarcophagidae have been reported parasitizing anuran species around the world, e.g. *Bufo bufo* (Linnaeus, 1758) and *Hyla arborea* (Linnaeus, 1758) (Meisterhans and Heusser 1970, Eaton *et al.* 2008, López *et al.* 2016). In Brazil, documented occurrences are restricted to 10 species, distributed among the families Bufonidae, Hylidae, Leptodactylidae, and Ranidae (Lopes 1981, Souza Jr. *et al.* 1990, Eizemberg *et al.* 2008, Carvalho-Filho *et al.* 2010, Mello-Patiu and Luna-Dias 2010, Oliveira *et al.* 2012, Müller *et al.* 2015, Souza-Pinto *et al.* 2015, Pinto *et al.* 2017). Herein, we present the

Received 30 January 2019
Accepted 03 October 2019
Distributed December 2019

first record of a dipteran larva in *Trachycephalus typhonius* (Linnaeus, 1758) from the Pantanal region of Mato Grosso do Sul state, Brazil. In addition, we provide a summarized appendix of all records of dipteran larvae as myiasis in anurans.

Trachycephalus typhonius is a hyloid treefrog that is widely distributed in Argentina, Colombia, Paraguay, Peru, Venezuela, Trinidad Tobago and Brazil (Frost 2018). On 10 November 2017, during field work in the Environmental Protection Area (APA) Baía Negra, (19°01'6.27" S, 57°33'23.06" W; 89 m a.s.l.) in the municipality of Ladário, Mato Grosso do Sul state, Brazil, we captured an adult male *T. typhonius* (ZUFMS-AMP12463, CRC= 76.34 mm). The individual was taken to the laboratory, euthenized with 5% Xylocaine® that was distributed on the abdomen and absorbed into its skin, fixed in 10% formalin, and preserved in 70% alcohol. After fixation, we observed a sarcophagid larva (1.44 mm long, 0.45mm wide) in one of its nasal cavities (Figure 1). This is the first record of a sarcophagid parasite of *T. typhonius*.

Larvae of Sarcophagidae differ from those of other dipteran families by their size and the position of posterior spiracles, which are located inside a concavity (Mello-Patiu *et al.* 2009). Specific identification of the larva we observed was not possible owing to its immature stage; only adults of this dipteran family can be confidently identified (Mello-Patiu and Luna-Dias 2010). Sarcophagids are characterized by their diurnal habits, which contrast with the nocturnal activity of most anuran species (Hagman *et al.* 2005), including *T. typhonius* (Uetanabaro *et al.* 2008). The low occurrence of parasitism by these dipterans in anurans may reflect their discrete activity periods.

Trachycephalus typhonius is arboreal and active at night, but it perches on leaves and branches during the day and is easily spotted by human observers (Duré and Kehr 2006). Thus, the frogs are easily available for infestation by sarcophagids because infestation would occur by day, a period associated with low host activity



Figure 1. (A) Individual of *Trachycephalus typhonius* showing a Sarcophagidae larva in the nasal cavity. (B) Head details of a Sarcophagidae larva. Scale bar = 0.2 mm.


during time the frogs are less likely to eat the adult flies (Souza-Pinto *et al.* 2015).

Species of Sarcophagidae are known to cause myiasis in anurans (e.g., Crump and Pounds 1985, Travers and Townsend 2010). The general pattern of infestation begins when adult flies deposit their eggs on the skin of hosts, after which the eggs hatch and first instar larvae penetrate the skin, migrating to the final infestation site in the body of the host, where they develop (Crump and Pounds 1985, Kraus 2007). Egg deposition by dipterans on anurans usually occurs on healthy hosts (Medina *et al.* 2009), as we observed parasitism on an apparently healthy frog lacking skin lesions.

Worldwide, 63 anuran species, distributed in 15 families, were recorded as dipteran hosts, with the highest number of occurrences in Australia and Brazil (10 records each) (Appendix I). Among the four dipteran families that parasitize anurans, Sarcophagidae is most prevalent ($N = 24$), followed by Calliphoridae ($N = 19$), Chloropidae ($N = 18$), and Phoridae ($N = 1$). Three records included in Appendix I have not been identified.

Most of the anuran hosts documented in Appendix I are terrestrial ($N = 11$ families), and the most frequently parasitized families are Bufonidae ($N = 11$ records) and Myobatrachidae ($N = 9$ records). The terrestrial habits of these anurans may provide greater exposure to parasitic dipterans searching for potential hosts (Hagman *et al.* 2005). Contact with water, even briefly, can kill dipteran larvae (Ziser and Nettles 1979, Eaton *et al.* 2008); thus, if frogs frequent bodies of water, it would be difficult for parasitic larvae to survive. Among hylids, dipteran larvae have been documented as parasites in seven species, with five records in Brazilian species (Meisterhans and Heusser 1970, Eaton *et al.* 2008, Eizemberg *et al.* 2008, Mello-Patiu and Luna-Dias 2010, Oliveira *et al.* 2012, Souza-Pinto *et al.* 2015, Pinto *et al.* 2017). Most hylids are arboreal and, while some species have both terrestrial and aquatic habits, most are associated with terrestrial vegetation, perching on leaves and branches (Vitt and Caldwell 2013); this would allow adult dipterans to access these anuran hosts. Thus, habitat type of anuran hosts can influence their risk of being parasitized by dipterans, with arboreal and terrestrial species being the most likely to be affected. Conversely, species with aquatic or semi-aquatic habits may avoid being parasitized by dipteran larvae as water submersion can lead to mortality of parasitic larvae.

Acknowledgments.—We thank Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) for authorization to capture anurans (number 56729-3). ICOS and SSC thanks Coordenação de Aperfeiçoamento de Pessoal de

Nível Superior (CAPES), Finance Code 001. KC thanks Fundação de Apoio ao Desenvolvimento do Ensino, Ciência e Tecnologia do Estado de Mato Grosso do Sul (FUNDECT) for her scholarship. DJS thanks CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) for his research fellowship (311492/2017-7). 

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Editor: Jaime Bertoluci

Appendix I. Records of Dipteran larvae as myiasis parasites of anurans worldwide. Diptera families:¹ Calliphoridae, ²Sarcophagidae, ³Chloropidae, and ⁴Phoridae.

Host species	Diptera species	References
Alytidae		
<i>Alytes obstetricans</i> Laurenti, 1768	<i>Lucilia bufonivora</i> ¹	Brumpt 1934a
Bufoidea		
<i>Anaxyrus americanus</i> Holbrook, 1836	<i>Lucilia elongata</i> ¹	Briggs 1975
	<i>Lucilia silvarum</i> ¹	Anderson and Bennett 1963, Bleakney 1963, Bolek and Coggins 2002
<i>Anaxyrus boreas</i> Baird and Girard, 1852	<i>Lucilia elongata</i> ¹	James and Maslin 1947
	<i>Lucilia silvarum</i> ¹	Eaton <i>et al.</i> 2008
<i>Atelopus varius</i> Lichtenstein and Martens, 1856	<i>Lepidodexia bufonivora</i> ²	Crump and Pounds 1985, Pounds and Crump 1987
<i>Bufo</i> sp.	<i>Lucilia bufonivora</i> ¹	Spence 1954
	<i>Lucilia sericata</i> ¹	Stewart and Foote 1974
<i>Bufo bufo</i> Linnaeus, 1758	<i>Lucilia ampullacea</i> ¹	Glaw <i>et al.</i> 2014
	<i>Lucilia bufonivora</i> ¹	Brumpt 1934a,b, Hendriks 1974, Garanin and Shaldybin 1976, Strijbosch 1980, Nijss 1984, Spieler 1990, Albrecht <i>et al.</i> 1996, Zavadil 1997, Gosá <i>et al.</i> 2009, Salazar <i>et al.</i> 2012, Arias-Robledo <i>et al.</i> 2019
	<i>Lucilia silvarum</i> ¹	Duncker 1891, Stadler 1930, Heim de Balsac 1933, Sandner 1955, Eaton <i>et al.</i> 2008
	<i>Lucilia</i> sp. ¹	Gerber 1950, Janzen 1994
	<i>Wohlfahrtia vigil</i> ²	Cepelák 1952, Povolný and Verves 1997
<i>Bufo viridis</i> Laurenti, 1768	<i>Lucilia bufonivora</i> ¹	Garanin and Shaldybin 1976
<i>Duttaphrynus melanostictus</i> Schneider, 1799	<i>Lucilia porphyryna</i> ¹	Dasgupta 1962
	<i>Sarcophaga ruficornis</i> ²	Roy and Dasgupta 1977
<i>Epidalea calamita</i> Laurenti, 1768	<i>Lucilia bufonivora</i> ¹	Vestjens 1958, Zavadil 1997, Kordges 2000
<i>Rhinella diptycha</i> Cope, 1862	Undetermined ²	Souza-Pinto <i>et al.</i> 2015
<i>Rhinella nattereri</i> Bokermann, 1987	<i>Lepidodexia bufonivora</i> ²	Lopes and Vogelsang 1953

Appendix I - Continued.

Host species	Diptera species	References
<i>Rhinella margaritifera</i> Laurenti, 1768	Undetermined	Carvalho-Filho <i>et al.</i> 2010
Centrolenidae		
<i>Hyalinobatrachium fleischmanni</i> Boettger, 1893	Undetermined ²	Medina <i>et al.</i> 2009
Craugastoridae		
<i>Pristimantis thectopternus</i> Lynch, 1975	Undetermined ²	Gómez-Hoyos <i>et al.</i> 2012
<i>Craugastor rhodopis</i> Cope, 1867	<i>Lepidodexia</i> (<i>Notochaeta</i>) <i>bufonivora</i> ²	Vázquez-Corzas <i>et al.</i> 2018
Dendrobatidae		
<i>Ameerega bassleri</i> Melin, 1941	Undetermined ²	Hagman <i>et al.</i> 2005
<i>Ameerega cainarachi</i> Schulte, 1989	Undetermined ²	Hagman <i>et al.</i> 2005
<i>Ameerega peruviridis</i> Bauer, 1986	<i>Sarcodexia</i> <i>lambens</i> ²	Hagman <i>et al.</i> 2005
Eleutherodactylidae		
<i>Eleutherodactylus</i> sp.	<i>Lepidodexia</i> sp. ²	Dodge 1968
Hylidae		
<i>Aplastodiscus arildae</i> Cruz and Peixoto, 1987	<i>Lepidodexia</i> <i>bufonivora</i> ²	Eizemberg <i>et al.</i> 2008
<i>Boana atlantica</i> Caramaschi and Velosa, 1996	Undetermined ²	Oliveira <i>et al.</i> 2012
<i>Boana beckeri</i> Caramaschi and Cruz, 2004	<i>Lepidodexia</i> <i>centenaria</i> ²	Mello-Patiu and Luna-Dias 2010
<i>Boana caingua</i> Carrizo, 1991	<i>Megaselia</i> <i>scalaris</i> ⁴	López <i>et al.</i> 2016
<i>Boana polytaenia</i> Cope, 1870	Undetermined ¹	Gomes <i>et al.</i> 2018
<i>Boana stenocephala</i> Caramaschi and Cruz, 1999	Undetermined ¹	Gomes <i>et al.</i> 2018
<i>Dryaderces inframaculata</i> Boulenger, 1882	Undetermined ²	Pinto <i>et al.</i> 2017
<i>Hyla arborea</i> Linnaeus, 1758	<i>Lucilia silvarum</i> ¹	Anderson and Bennett 1963
<i>Pseudacris maculata</i> Agassiz, 1850	<i>Lucilia silvarum</i> ¹	Eaton <i>et al.</i> 2008
<i>Pseudacris triseriata</i> Wied-Neuwied, 1838	<i>Lucilia silvarum</i> ¹	Roberts 1998
<i>Scinax fuscovarius</i> Lutz, 1925	Undetermined ²	Souza-Pinto <i>et al.</i> 2015

Appendix I - Continued.

Host species	Diptera species	References
<i>Rheohyla miotympanum</i> Cope, 1863	<i>Lepidodexia</i> (<i>Notochaeta</i>) <i>bufonivora</i> ²	Vázquez-Corzas <i>et al.</i> 2018
Leptodactylidae		
<i>Adenomera diptyx</i> Boettger, 1885	<i>Lepidodexia</i> (<i>Notochaeta</i>) <i>adelina</i> ²	Mulieri <i>et al.</i> 2018
<i>Leptodactylus elenae</i> Heyer, 1978	<i>Lepidodexia</i> (<i>Notochaeta</i>) <i>adelina</i> ²	Mulieri <i>et al.</i> 2018
<i>Leptodactylus latrans</i> Steffen, 1815	Undetermined ²	Müller <i>et al.</i> 2015
<i>Physalaemus albonotatus</i> Steindachner, 1864	<i>Lepidodexia</i> (<i>Notochaeta</i>) <i>adelina</i> ²	Mulieri <i>et al.</i> 2018
Limnodynastidae		
<i>Heleioporus albopunctatus</i> Gray 1841	<i>Batrachomyia</i> sp. ³	McAlpine 1955, Elkan 1965
Myobatrachidae		
<i>Crinia signifera</i> Girard, 1853	<i>Batrachomyia</i> sp. ³	Krefft 1864, Elkan 1965, Lemckert 2000
<i>Geocrinia laevis</i> Günther, 1864	<i>Batrachomyia</i> sp. ³	McAlpine 1955, Elkan 1965
<i>Geocrinia victoriana</i> Boulenger, 1888	<i>Batrachomyia</i> sp. ³	McAlpine 1955
<i>Pseudophryne bibronii</i> Günther, 1859	<i>Batrachomyia</i> <i>quadrilineata</i> ³	McAlpine 1955, Elkan 1965
	<i>Batrachomyia</i> sp. ³	Krefft 1864, Pengilley 1992
<i>Pseudophryne corroborae</i> Moore, 1953	<i>Batrachomyia</i> sp. ³	Pengilley 1992
<i>Pseudophryne dendyi</i> Lucas, 1892	<i>Batrachomyia</i> sp. ³	McAlpine 1955, Elkan 1965, Pengilley 1992
<i>Pseudophryne pengilleyi</i> Wells and Wellington, 1985	<i>Batrachomyia</i> sp. ³	Lemckert 2000
<i>Uperoleia laevigata</i> Keferstein, 1867	<i>Batrachomyia</i> sp. ³	Lemckert 2000
	<i>Batrachomyia</i> <i>strigipes</i> ³	McAlpine 1955, Schell and Burgin 2001
<i>Uperoleia marmorata</i> Gray, 1841	<i>Batrachomyia</i> sp. ³	Krefft 1864
Odontophrynidae		
<i>Proceratophrys</i> sp.	<i>Lepidodexia</i> sp. ²	Gómez-Hoyos <i>et al.</i> 2012 <i>apud</i> Lopes 1981

Appendix I - Continued.

Host species	Diptera species	References
Pelobatidae		
<i>Pelobates fuscus</i> Laurenti, 1768	<i>Lucilia</i> sp. ¹	Gerber 1950
	<i>Lucilia</i> <i>bufonivora</i> ¹	Garanin and Shaldybin 1976
Pelodryadidae		
<i>Ranoidea caerulea</i> White, 1790	<i>Batrachomyia</i> <i>mertensi</i> ³	Lindner 1958, Elkan 1965, Vogelnest 1994
<i>Ranoidea citropa</i> Péron, 1807	<i>Batrachomyia</i> sp. ³	Krefft 1864, Elkan 1965
<i>Ranoidea genimaculata</i> Horst, 1883	<i>Batrachomyia</i> sp. ³	Hoskin and McCallum 2007
<i>Ranoidea jungguy</i> Donnellan and Mahony, 2004	<i>Batrachomyia</i> sp. ³	Hoskin and McCallum 2007
<i>Ranoidea myola</i> Hoskin, 2007	<i>Batrachomyia</i> sp. ³	Hoskin and McCallum 2007
<i>Ranoidea phyllochroa</i> Günther, 1863	<i>Batrachomyia</i> <i>nigritarsis</i> ³	Skuse 1889, McAlpine 1955, Elkan 1965
<i>Ranoidea wilcoxii</i> Günther, 1864	<i>Batrachomyia</i> sp. ³	Hoskin and McCallum 2007
Phyllomedusidae		
<i>Agalychnis saltator</i> Taylor, 1955	Undetermined	Travers and Townsend 2010
Ranidae		
<i>Lithobates berlandieri</i> Baird, 1859	<i>Lepidodexia</i> (<i>Notochaeta</i>) <i>bufonivora</i> ²	Vázquez-Corzas <i>et al.</i> 2018
<i>Lithobates catesbeianus</i> Shaw, 1802	<i>Lepidodexia</i> sp. ²	Souza Jr. <i>et al.</i> 1990
	<i>Lucilia</i> <i>bufonivora</i> ¹	Hall 1948
<i>Lithobates sylvaticus</i> LeConte, 1825	<i>Lucilia elongata</i> ¹	Bolek and Janovy Jr. 2004
	<i>Lucilia silvarum</i> ¹	Roberts 1998, Bolek and Janovy Jr. 2004, Eaton <i>et al.</i> 2008
<i>Papurana supragrisea</i> Menzies, 1987	<i>Batrachomyia</i> <i>krausi</i> ³	Evenhuis 2006, Kraus 2007
<i>Pelophylax perezii</i> López-Seoane, 1885	<i>Lucilia</i> <i>bufonivora</i> ¹	Gosá <i>et al.</i> 2009
<i>Rana arvalis</i> Nilsson, 1842	<i>Lucilia</i> <i>bufonivora</i> ¹	Brumpt 1934a, Zumpt 1965, Garanin and Shaldybin 1976
<i>Rana dybowskii</i> Günther, 1876	Undetermined ²	Povolný and Verves 1997
<i>Rana temporaria</i> Linnaeus, 1758	<i>Lucilia</i> <i>bufonivora</i> ¹	Brumpt 1934a,b, Zumpt 1965, Koskela <i>et al.</i> 1974, Albrecht <i>et al.</i> 1996, Kordges 2000
Not reported	<i>Lucilia</i> <i>bufonivora</i> ¹	Tantawi and Whitworth 2014