REPTILES & AMPHIBIANS

Bladder Snails (Physidae: *Physa*) as Ectosymbionts of the Endangered Houston Toad, *Bufo* [*Anaxyrus*] *houstonensis* Sanders 1953

Lawrence G. Bassett and Michael R. J. Forstner

Department of Biology, Texas State University, San Marcos, Texas 78666, USA (lawrencebassett@gmail.com)

Symbiosis is the close physical association of two species, often involving one species occurring inside or on another species (Begon et al. 1990; Starr and Taggart 2004). Such relationships can be mutually beneficial (mutualism), detrimental to one of the species but beneficial for the other (e.g., parasitism, predation), detrimental to both species (antagonism), beneficial to one species but harmless to the other (commensalism), neither good nor bad for either species (neutralism), or harmful for one species but neither harmful nor beneficial for the other (amensalism) (Martin and Schwab 2013). Symbionts can be broadly divided into two primary groups: ectosymbionts and endosymbionts. Ectosymbionts are organisms that occur on the exterior of a host species, whereas endosymbionts occur within the host species (Martin and Schwab 2013).

Anurans are known hosts to a variety of ectosymbionts, such as leeches (Ayres and Comesaña 2010; Rocha et al. 2012; Siddall and Bowerman 2006), arachnids (Guglielmone et al. 2014; Spieler and Linsenmair 1999), crustaceans (Watermolen 2019), gastropods (Kolenda et al. 2017), and bivalves (Kwet 1995). Herein we provide the first report of bladder snails (Genus *Physa*) as ectosymbionts of the federally endangered Houston Toad (*Bufo* [*Anaxyrus*] *houstonensis*). We prefer to retain the genus name *Bufo* over the newer use of *Anaxyrus* for the sake of taxonomic stability (Pauly et al. 2009), particularly given inconsistencies with generic stability in North American amphibians at present.

At 2332 h on 4 March 2021, while conducting an anuran survey on private property in Bastrop County, Texas, USA, we captured a male *B. houstonensis* with six *Physa* sp. attached to its body. More specifically, we found two *Physa* sp. on the dorsolateral portion of the toad's body, two *Physa* sp. on one of the toad's posterior limbs, and two *Physa* sp. on the ventral surface of the toad (Figs. 1–2). The toad was encountered partially submerged along the shallow margins of a small (ca. 1,000 m^2) pond within a second succession loblolly pine (*Pinus taeda*) woodland (30.1992°N, 97.2220°W; WGS 84). Weather conditions included clear skies, an ambient temperature of 19.1°C, relative humidity at 85.1%, barometric pressure at 762.762 mmHg, and a maximum windspeed of 8.37 km/h.

The gastropods were identified as belonging to the family Physidae by their sinistral (left coiled) shell morphology and absence of an operculum (Burch 1982). Identification to the genus *Physa* was based on the short-spired nature of the shells, a characteristic lacking in the confamilial genus *Aplexa* (Wethington 2004). Species-level identification of *Physa* spp. often requires examination of internal anatomy, particularly penial morphology (Te 1978; Taylor 2003; Wethington and Lydeard 2007). Because we did not collect any of the snails

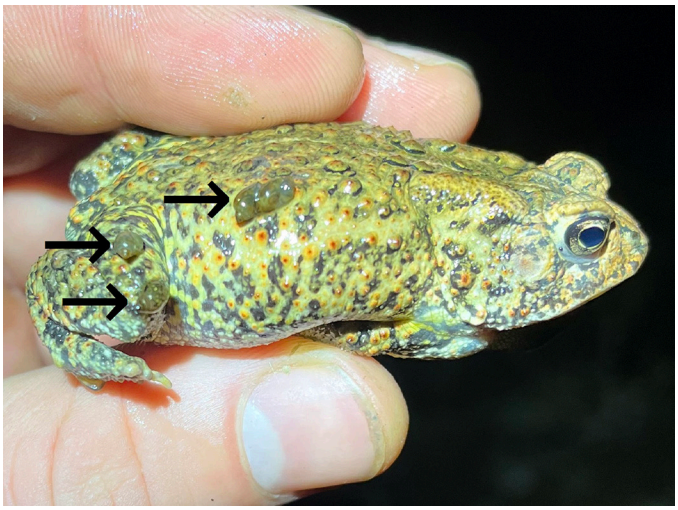

Fig. 1. Male Houston Toad (*Bufo* [*Anaxyrus*] *houstonensis*) from Bastrop County, Texas, USA captured on 4 March 2022. Bladder snails (Genus *Physa*) are attached to the right posterior hindlimb and the dorsolateral region of the body. Snails (N = 4) are demarcated with lines. Photograph by Lawrence G. Bassett.

Reptiles & Amphibians ISSN 2332-4961
https://doi.org/10.17161/randa.v29i1.17964

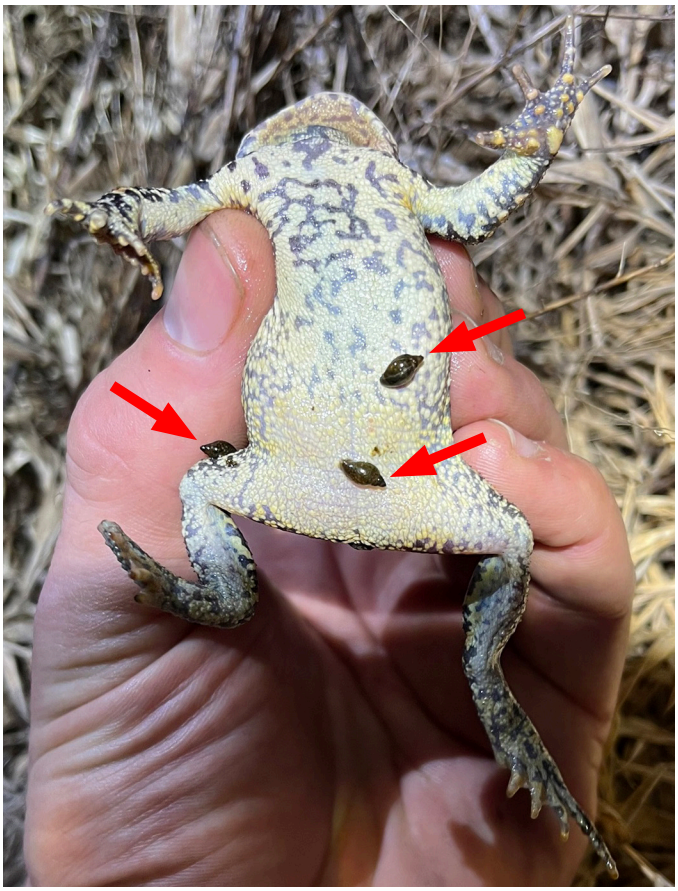

Fig. 2. Male Houston Toad (*Bufo* [*Anaxyrus*] *houstonensis*) from Bastrop County, Texas, USA captured on 4 March 2022. Bladder snails (Genus *Physa*) are attached to the right posterior hindlimb and the ventromedial region of the body. Snails (N = 3) are demarcated with lines. Photograph by Lawrence G. Bassett.

for dissection or molecular barcoding, we cannot provide a confident species-level identification.

Prior to this report, the only reported ectosymbiont of *B. houstonensis* was the glossiphoniid leech, *Helobdella austinensis* (Bassett et al. 2022). Similar to the association between *H. austinensis* and *B. houstonensis*, the association between *Physa* sp. and *B. houstonensis* appears to be rare. During the 2022 *B. houstonensis* breeding season, up to the time of writing, the lead author has examined 39 *B. houstonensis* at chorus locations in Bastrop County. Of those detections, this was the only instance where *Physa sp.* were found attached to a *B. houstonensis* (2.56%).

Although rare, the number of snails found on this toad would suggest that the observed association represents more than gastropods merely wandering onto a syntopic organism. Kolenda et al. (2017) observed 58 terrestrial gastropod eggs deposited on the skin of a *B. bufo* in Raszków, Poland and speculated that snails may utilize anurans as a vector for dispersal. Kwet (1995) likewise proposed that a phoretic relationship may exist between *B. bufo* and the bivalve *Sphaerium corneum*. Although *Physa* spp. are aquatic, they breathe air and are resistant to desiccation. Gulanicz et al. (2018) found that the LT_{90} for *P. acuta* in drying sand was 11 days. It has also been demonstrated with multiple bufonid species that some individuals will move between ponds during a single breeding season (Reading et al. 1991; Denton and Beebee 1993). Therefore, the potential exists for successful phoresy to occur, which in the present case would likely represent an instance of commensalism. An alternative possibility is that the *Physa* were grazing on the mucosal layer of the toad's skin. Amphibian skin mucosa can be rich in peptides and bacteria and may therefore be a worthwhile nutritional subsidy for *Physa* snails (Lazarus and Attila 1993; Rollins-Smith 2009; Xi et al. 2015). However, this hypothesis seems unlikely with bufonid hosts given the potential for consumption of bufadienolide toxins (Bókony et al. 2019). Reports of gastropods scavenging or predating on anurans exist in the literature (Carter et al. 2018; González-Guillén and López-Silvero 2021; Yadav et al. 2021; Ayres 2022), however, we saw no damage to the skin that would suggest consumption beyond the mucosal layer had occurred (Figs. 1–2). We encourage closer examination of snail-toad associations so that the frequency and nature of such symbioses can be further elucidated.

Acknowledgments

All work was authorized by a Texas Parks and Wildlife Department Scientific Permit for Research (SPR-0102-191) and a United States Fish and Wildlife Service Permit (TE039544-0) issued to Michael R.J. Forstner. This research was approved by the Texas State University Institutional Animal Care and Use Committee (protocol no. IACUC 7994). The Capitol Area Council of the Boy Scouts of America provided us with access to their private ranch where we made this observation, and we appreciate their continuing support of our research.

Literature Cited

Ayres, C. 2022. A road-killed Fire Salamander (*Salamandra salamandra*) scavenged by a Round-backed Slug (*Arion* sp.) in Galicia (Northwestern Spain). *Reptiles & Amphibians* 29: 121. https://doi.org/10.17161/randa.v29i1.16314.

Ayres, C. and J. Comesaña. 2010. Leech prevalence in *Rana iberica* populations from northwestern Spain. *North-Western Journal of Zoology* 6: 118–121.

Bassett, L.G., F.E. Zughaiyir, D.J. Richardson, C.I. Hammond, C.T. McAllister, and M.R.J. Forstner. 2022. Association of leeches with the endangered Houston toad. *Southeastern Naturalist* 21: 51–62. https://doi.org/10.1656/058.021.0109.

Begon, M., J.L. Harper, and C.R. Townsend. 1990. *Ecology: Individuals, Populations, and Communities*. 2nd ed. Blackwell Scientific Publications, Cambridge, Massachusetts, USA.

Bókony, V., B. Üveges, V. Verebélyi, N. Ujhegyi, and A.M. Móricz. 2019. Toads phenotypically adjust their chemical defenses to anthropogenic habitat change. *Scientific Reports* 9: 3163. https://doi.org/10.1038/s41598-019-39587-3.

Burch, J.B. 1982. North American freshwater snails. *Walkerana* 1: 217–365.

Carter, J., D. Johnson, and S. Merino. 2018. Exotic invasive *Pomacea maculata* (giant apple snail) will depredate eggs of frog and toad species of the southeastern US. *Southeastern Naturalist* 17: 470–475. https://doi.org/10.1656/058.017.0313.

Denton, J.S., and T.J.C. Beebee. 1993. Reproductive strategies in a female-biased population of natterjack toads, *Bufo calamita*. *Animal Behaviour* 46: 1169–1175. https://doi.org/10.1006/anbe.1993.1306.

González-Guillén, A. and R. López-Silvero. 2021. First record of *Oleacina cyanozoaria* (Gundlach in Pfeiffer, 1857) feeding on a *Eleutherodactylus* frog in Pico San Juan, Cumanayagua, Cienfuegos Province, Cuba. *The Festivus* 53: 293–297.

Guglielmone, A.A., R.G. Robbins, D.A. Apanaskevich, T.N. Petney, A. Estrada-Peña, and I. Horak. 2014. *The Hard Ticks of the World*. Springer, Dordrecht, The Netherlands.

Gulanicz, T., J. Kobak, and M. Poznańska-Kakareko. 2018. Effects of water level fluctuations and substratum drying on the survival and behaviour of the invasive freshwater snail *Physa acuta* Draparnaud, 1805. *Marine and Freshwater Research* 69: 1389–1396. https://doi.org/10.1071/MF17349.

Kolenda, K., A. Najbar, N. Kuśmierek, and T.K. Maltz. 2017. A possible phoretic relationship between snails and amphibians. *Folia Malacologica* 25: 281–285. https://doi.org/10.12657/folmal.025.019.

Kwet, A. 1995. Erdkröten (*Bufo bufo*) als Transportwirte von Kugelmuscheln (*Sphaerium corneum*). *Salamandra* 31: 61–64.

Lazarus, L.H. and M. Attila. 1993. The toad, ugly and venomous, wears yet a precious jewel in his skin. *Progress in Neurobiology* 41: 473–507. https://doi.org/10.1016/0301-0082(93)90027-P.

Martin, B.D. and E. Schwab. 2013. Current usage of symbiosis and associated terminology. *International Journal of Biology* 5: 32–45. https://doi.org/10.5539/ijb.v5n1p32.

Pauly, G.B., D.M. Hillis, and D.C. Cannatella. 2009. Taxonomic freedom and the role of official lists of species names. *Herpetologica* 65: 115–128. https://doi.org/10.1655/08-031R1.1.

Reading, C.J., J. Loman, and T. Madsen. 1991. Breeding pond fidelity in the common toad, *Bufo bufo*. *Journal of Zoology* 225: 201–211. https://doi.org/10.1111/j.1469-7998.1991.tb03811.x.

Rocha, R., E. Borda, F. Andreone, and G.M. Rosa. 2012. First reports of leech parasitism in Malagasy anurans. *Comparative Parasitology* 79: 352–356. https://doi.org/10.1654/4546.1.

Rollins-Smith, L.A. 2009. The role of amphibian antimicrobial peptides in protection of amphibians from pathogens linked to global amphibian declines. *Biochimica et Biophysica Acta (BBA) – Biomembranes* 1788: 1593–1599. https://doi.org/10.1016/j.bbamem.2009.03.008.

Siddall, M.E. and J. Bowerman. 2006. A new species of glossiphonid leech from *Rana pretiosa* (Amphibia: Ranidae) in Oregon. *Journal of Parasitology* 92: 855–857. https://doi.org/10.1645/GE-778R.1.

Spieler, M. and K.E. Linsenmair. 1999. The larval mite *Endotrombicula pillersi* (Acarina: Trombiculidae) as a species-specific parasite of a west African savannah frog (*Phrynobatrachus francisci*). *The American Midland Naturalist* 142: 152–161. https://doi.org/10.1674/0003-0031(1999)142[0152:TLMEPA]2.0.CO;2.

Starr, C. and R. Taggart. 2004. *Biology: The Unity and Diversity of Life*. 10th ed. Wadsworth Publishing Company, Belmont, California, USA.

Taylor, D.W. 2003. Introduction to Physidae (Gastropoda: Hygrophila); biogeography, classification, morphology. *Revista de Biología Tropical* 51: 1–287.

Te, G.A. 1978. The systematics of the family Physidae (Basommatophora: Pulmonata). Unpublished Ph.D. Dissertation, University of Michigan, Ann Arbor, Michigan, USA.

Watermolen, D.J. 2019. Crustacean ectoparasites of amphibians. *Bulletin of the Chicago Herpetological Society* 54: 85–91.

Wethington, A.R. 2004. Family Physidae. A supplement to the workbook accompanying the FMCS Freshwater Identification Workshop, University of Alabama, Tuscaloosa, Alabama, USA.

Wethington, A.R. and C. Lydeard. 2007. A molecular phylogeny of Physidae (Gastropoda: Basommatophora) based on mitochondrial DNA sequences. *Journal of Molluscan Studies* 73: 241–257. https://doi.org/10.1093/mollus/eym021.

Xi, X., B. Li, T. Chen, and H.F. Kwok. 2015. A review on bradykinin-related peptides isolated from amphibian skin secretion. *Toxins* 7: 951–970. https://doi.org/10.3390/toxins7030951.

Yadav, O., M. Jadhav, S. Kininge, P. Bajantri, and A. Bhosale. 2021. Land snails feeding on dead frogs. *Reptiles & Amphibians* 28: 546–547. https://doi.org/10.17161/randa.v28i3.15817.