



Description of *Gastrophryne elegans* (Boulenger, 1882) tadpole from the rainforest of Los Tuxtlas, Veracruz, Mexico

VÍCTOR H. JIMÉNEZ-ARCOS^{1,2*}, RAFAEL ALEJANDRO CALZADA-ARCINIEGA³, BRUNO CORTÉS-ORTIZ^{1,6}, C. MARISOL GÓMEZ-HURTADO^{2,7} & CHRISTOPHER BLAIR^{4,5}

¹Laboratorio de Herpetología Vivario, FES Iztacala, Universidad Nacional Autónoma de México, AP 314, CP 54090. Tlalnepantla, México.

²Naturam Sequi AC, 16 de Septiembre 43, CP 53450. Naucalpan, México.

³Departamento de Zoología, Instituto de Biología, Universidad Nacional Autónoma de México, Apartado postal 70515, 04510 Cd. de México, México.

⁴<https://orcid.org/0000-0002-8467-252X>

⁵Department of Biological Sciences, New York City College of Technology, The City University of New York, 285 Jay Street, Brooklyn, NY, 11201, USA.

⁶<https://orcid.org/0000-0002-4782-6788>

⁷Biology PhD Program, Graduate Center, 365 5th Ave., New York, NY, 10016, USA.

⁸<https://orcid.org/0009-0006-2073-998X>

⁹<https://orcid.org/0009-0001-2830-4052>

*Corresponding author: victorhja@iztacala.unam.mx; <https://orcid.org/0000-0001-6948-0071>

The microhylid genus *Gastrophryne* Fitzinger comprises four species with a distribution in low to medium elevations in the southeastern and central USA to Honduras. Three of the four species are present in Mexico. *Gastrophryne elegans* (Boulenger) is distributed from northeastern Mexico, in the State of Tamaulipas, along the Atlantic coast to the Yucatan peninsula and north-central Honduras. It is a small toad, with snout-vent length in adult males ranging from 21.3 to 25.8 mm, and in adult females from 26.2 to 28.9 mm (Nelson & Altig 1972). Despite its wide distribution, few aspects of its natural history, biology, and ecology are known. Mating call characteristics in Sebol, Alta Verapaz, Guatemala are known, and some data are available pertaining to adult morphology and mating call microhabitat (Nelson 1966). Regarding the tadpoles, Nelson & Altig (1972) describes *G. elegans* and *G. usta* (Cope) (currently *Hypopachus ustus*; Greenbaum *et al.* 2011; de Sá *et al.* 2012). The *G. elegans* tadpole described corresponds to a developmental Stage close to 30 (Gosner 1960). However, because only one tadpole was collected and some morphological characteristics were not concordant with other *Gastrophryne* tadpoles, the author comments that “this assignment must be considered tentative” (p. 382).

The region of Los Tuxtlas, Veracruz, Mexico, is one of the most studied tropical areas in the country, but highly threatened by the conversion of rainforest to agricultural landscapes (Castillo *et al.* 2021). It concentrates the greatest diversity of amphibians and reptiles in Mexico weighted by its surface area (Lopez-Luna 2017). In this region, *G. elegans* is considered a common species, but difficult to observe after the first heavy rain of the year due to its fossorial habit (Vogt *et al.* 1997). In this study, we present a description of the *G. elegans* tadpole based on individuals collected from a pool in a temporary stream that flows to Laguna Zacatal, San Andres Tuxtla, Veracruz (18.5818°N, 95.0886°W, 203 m. a.s.l.; collectors V.H. Jiménez, A. Calzada and B. Cortés, 18 December 2021; IBH 33711-1 to IBH 33711-20).

Twenty tadpoles at Gosner (1960) Stages 26, 30, and 35–40 were exposed to an overdose of xylocaine and subsequently fixed in 10% formalin, stored in 70% alcohol, and deposited in the Colección Nacional de Anfibios y Reptiles, Universidad Nacional Autónoma de México (CNAR). Terminology of external larval features follows Altig (1970) and Altig & McDiarmid (1999). Measurements were made with digital calipers (Mitutoyo, Mod. CD-6”AX; 0.01mm precision) under a binocular microscope. To confirm the identity of the species, two tadpoles were kept until metamorphosis. The absence of metatarsal tubercles and the ventral coloration pattern confirmed the identity of *G. elegans*.

Tadpole description (Fig. 1 and Table 1). The tadpoles of *Gastrophryne elegans* are exotrophic, lentic, and suspension feeder (guild IIB7; Altig & McDiarmid 1999). In dorsal view, oval body; at Stage 40 the body tends to take a quadrangular form (Fig. 1A); in lateral view, body depressed dorsoventrally (Fig. 1B). Dorsum straight and rostrum triangular, widening towards the back of the body, reaching its maximum depth at the beginning of the spiracle (Fig. 1B). Eyes lateral and pupils oriented laterally. Nostrils closed in nine specimens, evidenced as small slightly dark pigmented

protuberances; nostrils opened in one individual at Stage 35, three at 36, two at 37, three at 39, and two at 40; nasolacrimal grooves indistinguishable. Spiracle ventral, medial, tube-shaped extending slightly beyond the body (Fig. 1C). Vent tube medial, curved, opening located at the ventral edge of the ventral fin (Fig. 1C). Tail relatively long, in average 1.6 times the body length, tip acute (Fig. 1B). Tail musculature weakly developed, representing about 15–30% of the maximum body width. Tail fins unequal, the ventral fin slightly deeper, with maximum height close to the middle portion. Dorsal fin originating approximately on the first fifth of the tail. Oral disc terminal, without keratinized elements. Upper labium arched, concave in dorsal view; a pair of smooth flaps pends from the upper lip. The flaps are not parallel but diverging ventrally, in the proximal first quarter are slightly extended towards the front; overall flaps forming an inverted “V” (Fig. 1D). Lower lip spatulate with medial labial prominence aligned with medial notch of upper lip.

Coloration. In dorsal view, the color ranges from faint reddish brown to dark brown almost black, with black and yellow to brown very fine reticulations (Fig. 1A). The two specimens at Stage 40 exhibit a blotch like a “sandglass” on the dorsum and hindlimbs with black stripes (Fig. 1A). The middle ventral body area is dark brown to black, towards the flanks a yellow to white line and pale-yellow blotches towards the central and terminal proportion of the belly. The middle and posterior region contains contrasting black and white reticulations, more contrasting in advanced developmental stages—at Stage 40, the lines, yellow blotches, and contrasting reticulate pattern are more developed. The tail shows a contrasting yellow to orange-pink irregular dorsal stripe extending about 30% over tail in lateral view (Fig. 1B). From the middle to the tip, the tail is black with gray blotches with fine black reticulations, the last quarter of the tail, including the fin, almost completely black. Fin with pale orange to pale yellow, gray, and black irregular small blotches; the ventral part of fin with a numerous black spots from the middle towards the end of the tail. In early stages, the proportion of blotches and black color is less on the fin (Fig. 1B). Spiracle with black margins and central zone yellow to pale yellow (Fig. 1A). Iris black with a thin golden ring bordering the pupil (Fig. 1B). In preservative, body dark gray to black, with a distinct white to yellowish stripe clearly visible on the tail.

Natural history. The Zacatal is a temporary lagoon that is filled during the rainy season by the contribution of several temporary streams. This lagoon has an average surface area of 76,453 m², a maximum depth of 13 m (average of 7 m), and an annual average oxygen saturation in surface waters of 149% (Torres-Orozco *et al.* 1994). On July 11, 2022, we observed a large number (possibly hundreds of thousands) of tadpoles when the lagoon was at approximately 50% of its capacity. We were able to identify tadpoles of *Smilisca baudinii* (the most abundant), *Leptodactylus melanonotus*, *Lithobates brownorum*, *L. vaillanti*, *Rhinella horribilis*, and *G. elegans*, but it was not possible collect tadpoles. The *G. elegans* tadpoles were the less abundant, we see them floating on the surface and submerged to hide among the flooded vegetation before the slightest disturbance. We observed foraging behavior on the surface and submerged plant leaves. In December 2022, when the lagoon was completely full, we recorded *G. elegans* tadpoles in a temporary pool (2.1 m wide and 0.32 m deep) with a water temperature of 20.1 °C. Although the pool was in the stream, the lagoon’s water surface comprised part of the stream where the tadpoles were observed. During the night, we recorded *G. elegans* tadpoles submerged and hidden among litter inside the pool, and the substrate was silty. In this month, we also observed some *S. baudinii* and *L. brownorum* tadpoles.

Tadpoles of two other species of *Gastrophryne* are known, *G. carolinensis* (Donnelly *et al.* 1990) and *G. olivacea* (Altig & McDiarmid 2015). Overall, they share many of the typical microhylid-like features, such as a small size, depressed body, medial spiracle opening close to the vent tube, tail fins almost equal, lateral eyes, nostrils mostly closed, keratinized mouthparts lacking, pending oral flaps, and spatulate lower lip. Some features differ among species, with *G. olivacea* being distinct because of their olive-gray to brown dorsum, white or coppery venter, and lateral tail stripe faint to absent (Altig & McDiarmid 2015), and *G. elegans* distinguishable from *G. carolinensis* by the comparatively smaller eyes and shorter dorsal fin.

Formerly, *Hypopachus ustus* and *H. pictiventris* (Cope) were placed within the genus *Gastrophryne*. Similarities among tadpoles are documented in these two related genera (Donnelly *et al.* 1990), and intraspecific variations can complicate species distinction based on larval morphology (e.g., papillated oral flaps are reported in *H. variolosus* and *H. ustus*; Taylor 1942; Nelson & Altig 1972). The inverted V-shape of flaps on the mouth (vs. U-shaped), shorter (vs. along the entire tail) dorsal fin slightly lower than ventral, tail tip pointed, and the body coloration not uniformly black along all developmental stages in our specimens are the main differences with respect to the tadpole described by Nelson & Altig (1972). We consider these authors were correct in their doubtful species assignment, and the specimen they described corresponds more closely to *H. ustus*. Alternatively, *G. elegans* could present also wide interpopulation variations. Given their fossorial habits that make them inconspicuous adults, understanding larval morphological variations in *G. elegans* and other species of *Gastrophryne* and *Hypopachus* is a highly valuable tool that can be used to monitor microhylid populations in natural and disturbed areas.

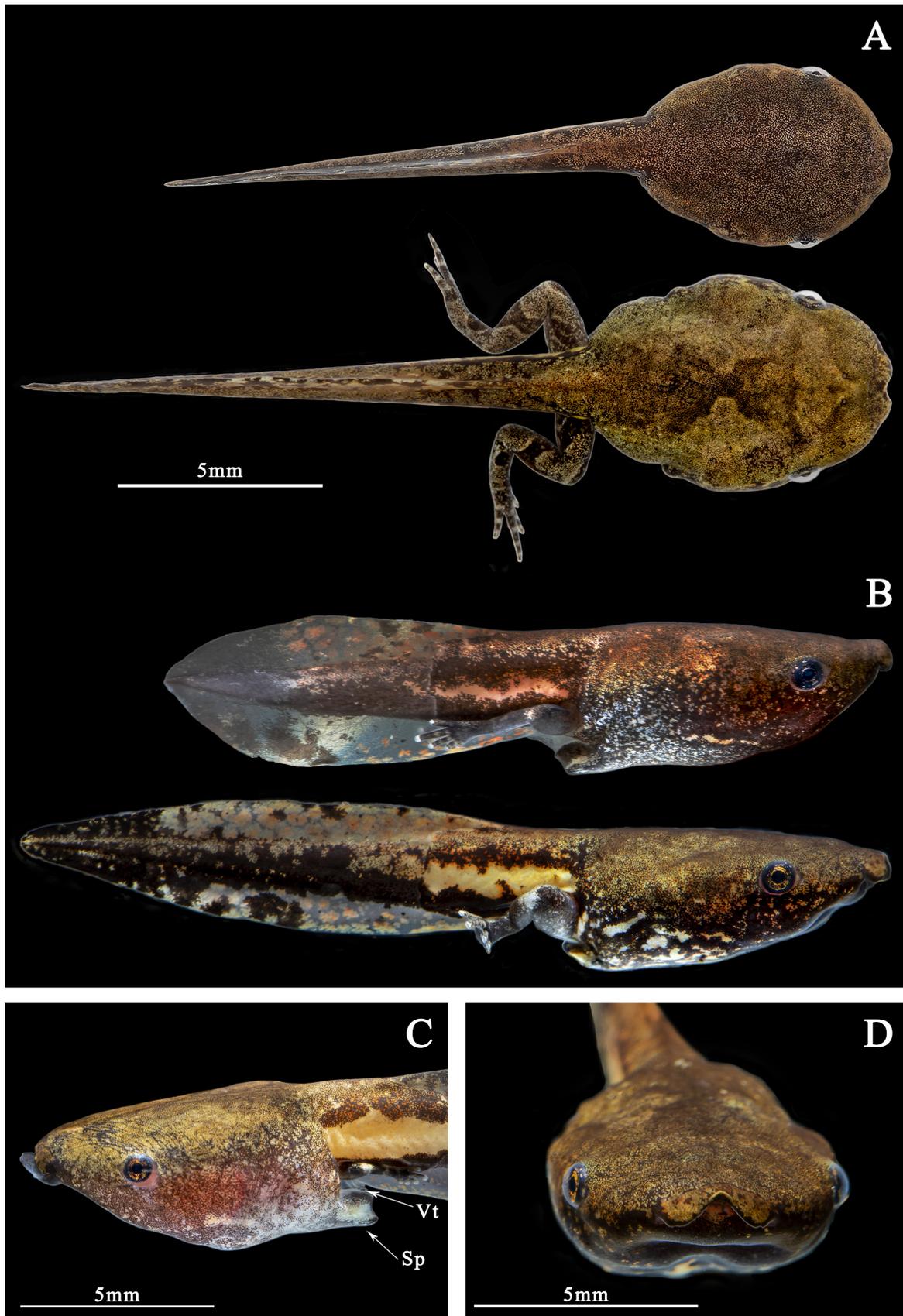


FIGURE 1. External morphology of *Gastrophryne elegans* tadpoles from Zacatal Lagoon, Los Tuxtlas, Veracruz, Mexico. Dorsal (A) and lateral (B) views of Stages 35 (above) and 40 (below; IBH 33711-7 and IBH 33711-1, respectively). (C) A close-up of the location of the spiracle (Sp) and vent tube (Vt) on an individual at Stage 37 (IBH 33711-11), and (D) a front view showing the shape of the oral flaps in a Stage 40 tadpole (IBH 33711-1).

TABLE 1. Measured morphological characters (average \pm SD; range in parentheses) by developmental stage in *Gastrophryne elegans*. NV indicates that the character was not visible.

	Development Stage							
	26	30	35	36	37	38	39	40
	n = 1	n = 1	n = 5	n = 3	n = 3	n = 1	n = 4	n = 2
Body Length	7.84	8.75	9.47 \pm 0.37 (8.43–10.46)	10.36 \pm 0.08 (10.20–10.46)	10.04 \pm 0.24 (9.77–10.52)	11.08	10.14 \pm 0.25 (9.45–10.27)	10.27 \pm 0.29 (9.97–10.56)
Internarial distance	NV	NV	1.09 ^a	1.48 \pm 0.26 (0.96–1.77)	1.20 \pm 0.28 ^a (0.92–1.48)	NV	1.07 \pm 0.17 ^a (0.84–1.41)	0.91 \pm 0.03 (0.87–0.94)
Interorbital distance	4.44	5.90	6.02 \pm 0.13 (5.59–6.26)	6.65 \pm 0.20 (6.25–6.91)	6.34 \pm 0.07 (6.22–6.45)	7.97	6.35 \pm 0.24 (5.88–7.03)	5.46 \pm 0.06 (5.40–5.52)
Tail Length	10.73	8.20	15.33 \pm 1.31 (10.23–17.44)	15.51 \pm 1.23 (13.99–17.95)	15.99 \pm 2.05 (12.50–19.59)	15.92	18.09 \pm 1.44 (13.92–20.47)	19.73 \pm 0.75 (18.98–20.48)
Maximum Tail Height	2.46	2.93	3.18 \pm 0.09 (2.95–3.41)	3.59 \pm 0.26 (3.12–4.03)	3.80 \pm 0.27 (3.47–4.33)	4.60	3.89 \pm 0.31 (3.17–4.69)	3.24 \pm 0.57 (2.67–3.81)
Tail Muscle Height	2.10	2.55	2.27 \pm 0.15 (1.89–2.65)	2.27 \pm 0.18 (1.92–2.55)	2.25 \pm 0.27 (1.88–2.77)	3.03	2.49 \pm 0.15 (2.14–2.82)	3.21 \pm 0.83 (2.37–4.04)
Tail Muscle Width	1.13	1.70	1.58 \pm 0.11 (1.23–1.85)	1.46 \pm 0.07 (1.35–1.59)	1.68 \pm 0.13 (1.51–1.93)	2.30	1.85 \pm 0.12 (1.62–2.12)	1.84 \pm 0.19 (1.64–2.03)
Total Length	18.57	16.95	24.81 \pm 1.49 (19.23–27.02)	25.70 \pm 1.26 (23.95–28.15)	26.03 \pm 2.69 (22.27–30.11)	27.00	28.23 \pm 1.84 (23.37–30.65)	30.00 \pm 0.45 (29.54–30.45)

^aNostrils not visible in 4 individuals at Stage 35, 1 at 37, and 1 at 39.

Research carried out thanks to the Program UNAM-DGAPA-PAPIIT number IA209820 granted to VHJA. We thank Rosamond Coates, head of the Estación de Biología Tropical Los Tuxtlas, UNAM, as well as Edgar Quinto and Yovany Cabañas for the logistical support during field work. The field work was carried out under the collection permit granted by the DGVS, Secretaría de Medio Ambiente y Recursos Naturales number 09/K4-1072/11/21. We appreciate comments and corrections of Florencia Vera and Rafael O. de Sá that substantially improved this work. We especially thank Larry D. Wilson for providing us with specific literature. Thanks to Grupo Acuario Lomas SA de CV for their invaluable donations that support the performance of our laboratory.

References

- Altig, R. (1970) A key to the tadpoles of the continental United States and Canada. *Herpetologica*, 26, 180–207.
- Altig, R. & McDiarmid, R.W. (1999) Body plan. Development and morphology. In: McDiarmid, R.W. & Altig, R. (Eds.), *Tadpoles—The Biology of Anuran Larvae*. The University of Chicago Press, Chicago, Illinois, pp. 24–51.
- Altig, R. & McDiarmid, R.W. (2015) *Handbook of larval amphibians of the United States and Canada*. Cornell University Press, Ithaca, New York, 358 pp.
<https://doi.org/10.7591/9780801456084>
- Castillo, A., Velasco-Morón, A., Arroyo-Arroyo, Y. Aranda-Fragoso, A., Aguilar-Román, E., Pérez-Escobedo, M., Tapia-Hernández, K.T., Coates, R. & Vega-Rivera, J.H. (2021) Two tropical research stations in Mexico: 50 years of contributions and challenges. *Environmental Challenges*, 3, 1–11.
<https://doi.org/10.1016/j.envc.2021.100037>
- de Sá, R.O., Streicher, J.W., Sekonyela, R., Forlani, M.C., Loader, S.P., Greenbaum, E., Richards, S. & Haddad, C.F.B. (2012) Molecular phylogeny of microhylid frogs (Anura: Microhylidae) with emphasis on relationships among New World genera. *BMC Evolutionary Biology*, 12, 241.
<https://doi.org/10.1186/1471-2148-12-241>
- Donnelly, M.A., de Sá, R.O. & Guyer, C. (1990) Descriptions of the tadpoles of *Gastrophryne pictiventris* and *Nelsonophryne aterrima* (Anura: Microhylidae), with a review of morphological variation in free-swimming microhylid larvae. *American museum Novitates*, 2976, 1–19.
- Gosner, K.L. (1960) A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica*, 16, 183–190.
- Greenbaum, E., Smith, E.N. & de Sá, R.O. (2011) Molecular systematics of the Middle American genus *Hypopachus* (Anura: Microhylidae). *Molecular Phylogenetics and Evolution*, 61, 265–277.

<https://doi.org/10.1016/j.ympv.2011.07.002>

- López-Luna, M.A. (2017) Estado actual de la diversidad y poblaciones de los anfibios y reptiles de Los Tuxtlas. *In*: Reynoso, V.H., Coates, R.I. & Vázquez-Cruz, M.L. (Eds.), *Avances y Perspectivas en la Investigación de los Bosques Tropicales y sus Alrededores: La Región de Los Tuxtlas*. Instituto de Biología, Universidad Nacional Autónoma de México, México City, pp. 347–369.
- Nelson, C.E. (1966) *The evolution of frogs of the family Microhylidae in North America*. Ph.D. Thesis, University of Texas, Austin, Texas, 293 pp.
- Nelson, C.E. & Altig, R. (1972) Tadpoles of the microhylids *Gastrophryne elegans* and *G. usta*. *Herpetologica*, 28, 381–383.
- Taylor, E.H. (1942) Tadpoles of Mexican Anura. *The University of Kansas Science Bulletin*, 18, 37–56.
- Torres-Orozco, R.E., Jiménez-Sierra, C. & Buen Abad, J.L.E. (1994) Caracterización limnológica de dos cuerpos de agua tropicales de Veracruz, México. *Anales del Instituto de Ciencias del Mar y Limnología*, 21, 11–19.
- Vogt, R.C., Villarreal-Benítez, J.L. & Pérez-Higareda, G. (1997) Lista anotada de anfibios y reptiles. *In*: González-Soriano, E., Dirzo, R. & Vogt, R.C. (Eds.), *Historia Natural de Los Tuxtlas*. Universidad Nacional Autónoma de México-CONABIO, México, D.F. pp. 507–522.