Zootaxa 4623 (2): 381–386
https://www.mapress.com/j/zt/

Correspondence

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.4623.2.11
http://zoobank.org/urn:lsid:zoobank.org:pub:CD73EFA4-9B4E-48A3-91CE-F7266F97D2D7

The tadpole of *Phyllodytes praeceptor* (Anura: Hylidae)

LEANDRO OLIVEIRA SANTOS[1,2], RENAN NUNES COSTA[2,3], MIRCO SOLÉ[2,4,5] & VICTOR GOYANNES DILL ORRICO[2,4,6]

[1]*Departamento de Ciências Básicas, Universidade Federal dos Vales do Jequitinhonha e Mucuri, BR-367, 5000, CEP 39100-000, Diamantina, Minas Gerais, Brazil*
[2]*Tropical Herpetology Laboratory, Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, Rodovia Jorge Amado, km 16, CEP 45662-900, Ilhéus, Bahia, Brazil*
[3]*Programa de Pós-Graduação em Sistemas Aquáticos Tropicais, Universidade Estadual de Santa Cruz, Campus Soane Nazaré de Andrade, Rodovia Jorge Amado, km 16, 45662-900, Ilhéus, Bahia, Brasil.*
[4]*Programa de Pós-Graduação em Zoologia, Universidade Estadual de Santa Cruz, Departamento de Ciências Biológicas, Rodovia Ilhéus- Itabuna, Km 16, CEP 45662-900. Ilhéus, BA, Brazil*
[5]*Herpetology Section, Zoologisches Forschungsmuseum Alexander Koenig, Adenauerallee 160, D-53113 Bonn, Germany*
[6]*Corresponding author. E-mail: victordill@gmail.com*

Phyllodytes Wagler 1830 is a genus composed of small species (SVL ranging 2.1–4.2 mm) that present odontoids and dwells in South America (Faivovich *et al.* 2005; Frost 2018). All known species of this genus are bromeligenous using bromeliads as shelter, calling site (males) and as egg deposition site (females). Offspring develops at the water retained in the axils (e.g., Bokermann 1966; Peixoto 1995; Haddad *et al.* 2013).

Tadpole morphology provides information for many aspects of the knowledge of amphibians, including evolution, natural history, and taxonomy (Duellman & Trueb 1994; Altig & McDiarmid 1999, Magalhães *et al.* 2015). To date, of the 14 species assigned to the genus (Frost 2018), only eight have known tadpoles (see Magalhães *et al.* 2015 Table 2). The present contribution describes the external morphology of the recently described species *Phyllodytes praeceptor* Orrico, Dias, and Marciano 2018.

We collected tadpoles at Reserva Particular do Patrimônio Natural (RPPN) Boa União (15º 04' S; 39º 03' W, at 95 m a.s.l.) in October 2016. The RPPN is located at the municipality of Ilhéus, state of Bahia, Brazil. The collection site is characterized by sandy soil with large trees and abundant bromeliads (see Lantyer-Silva *et al*. 2014). We searched these bromeliads for *Phyllodytes* specimens and retrieved 10 tadpoles of Stages ranging 26–38 (*sensu* Gosner 1960). Of those, two were preserved whole as tissue samples and the remaining eight were examined and measured. Specimens are housed at Museu de Zoologia da Universidade Estadual de Santa Cruz (MZUESC), at Ilhéus, Bahia, Brazil under lot numbers MZUESC 17436–40. Terminology and morphometric landmarks follow Altig & Johnston (1989) and McDiarmid & Altig (1999). The following traits were measured under a stereomicroscope: Total length (TL), Body length (BL), Body width (BW), Width of tail musculature (WTL), Body height (BH), Dorsal fin height (DFH), Height of tail musculature (HTL), Ventral fin height (VFH), Interorbital distance (IOD), Internasal distance (IND), Eye-snout distance (ESD), Nare-snout distance (NSD), Eye diameter (ED), and Nare diameter (ND). We compared our results with relevant literature that describes tadpoles of other *Phyllodytes* species.

External morphology (based on MZUESC 17439; Stage 38). Body oval in dorsal view with a slight constriction at midbody and depressed (shallow ellipse) in lateral view (Fig. 1). Snout rounded in dorsal and lateral views. BL corresponds to 33.5% of TL. Nares circular and positioned in the middle third between the eyes and the snout, with anterolateral openings. IND corresponds to 21.3% of BW. Eyes dorsally positioned and oriented dorsolaterally. ED corresponds to 11.8% of BW while IOD corresponds to 30.8% of BW. Spiracle is sinistral and located at the middle third of the body, below the midline of the body, and directed parallel to it. Spiracle cylindrical and with centripetal wall adhered to the body, with opening directed laterally. Caudal musculature tapering to the posterior end. Both dorsal and ventral fins shallow, dorsal fin origin at body-tail junction. Vent tube dextral, median, connected to ventral fin with opening parallel to caudal musculature. Oral disc anteroventral, not emarginated. The oral disc is surrounded by a double row of marginal papillae alternately arranged, with a large anterior gap (Fig. 2). Submarginal papillae are distributed as a single row laterally to the jaw sheaths. Marginal and submarginal papillae varying from conical to rounded with similar sizes. Labial tooth row formula (LTRF) is 1/2 being P1 = P2 in length. Jaw sheaths serrated and pigmented; upper jaw sheath arc-shaped and lower jaw sheath U-shaped. Lateral line system not evident. For measurements see Table 1.

Accepted by F. Candioti: 17 Apr. 2019; published: 25 Jun. 2019

TABLE 1. Measurements (in mm) of 14 morphometrical traits of eight tadpoles of *Phyllodytes praeceptor* at different developmental stages (Lots MZUESC 17436–40). See text for acronyms and abbreviations.

Caracteres	26 (n=2)	27 (n=1)	33 (n=2)	37 (n=1)	38 (n=2)
TL	13.8±0.7	15.2	21.7±1.2	23.7	25.1±0.6
BL	4.3±0.3	5.2	7.7±0	9	8.7±0.6
BW	2.9±0.5	4	5.3±0.5	5	6.2±0.3
WTL	0.8±0.2	1	1.6±0.1	2.2	2.2±0.1
BH	1.9±0.5	2.5	3.2±0.3	3.4	3.4±0.3
DFH	0.5±0	0.5	1.0±0.1	1.1	1.2±0
HTL	1.3±0.1	1.5	1.9±0.2	2.2	2.7±0.4
VFH	0.5±0	0.5	1.0±0.1	1.1	1.2±0
IOD	1.2±0.1	1.2	1.7±0.1	1.8	1.8±0
IND	0.9±0.1	1.1	1.2±0	1.4	1.3±0
ESD	1.0±0.1	1.1	1.3±0.1	1.5	1.4±0.1
SND	0.3±0	0.3	0.3±0	0.2	0.4±0
ED	0.3±0.1	0.4	0.6±0.1	0.7	0.7±0
ND	0.1±0	0.1	0.1±0	0.1	0.1±0

Coloration. In life, tadpoles are yellow to olive-green with small clear brown spots on the dorsum. In preservative, skin fades and becomes transparent gray allowing the visualization of inner organs. Fins transparent with minute brown spots as the remainder of the body.

Variation. Body shape is oval in dorsal view but the exact relationship between the major and minor axes varies individually and is sometimes associated with digestive tract content—especially when non-fertilized eggs are present. Spiracle opening direction varied from lateral to posterolateral. Some individuals present few scattered labial teeth anteriorly, but always at the level of the row A1. Younger individuals (Stages 25–27) may present a single posterolateral papillae row instead of the alternate papillae of older tadpoles. For measurements see Table 1.

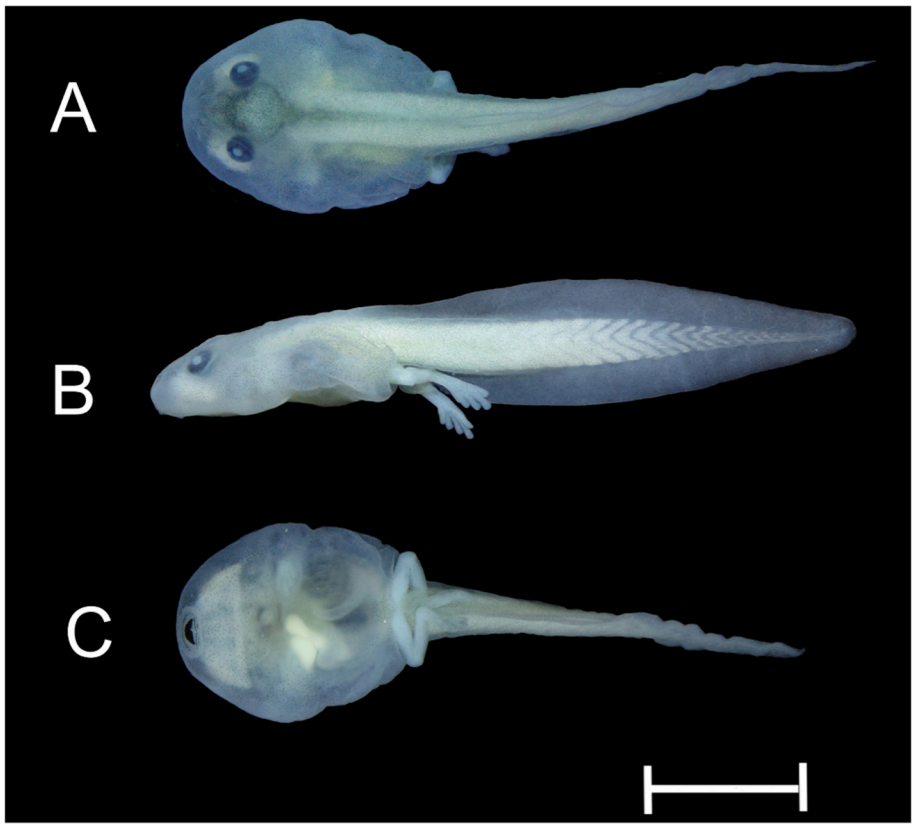

FIGURE 1. *Phyllodytes praeceptor* tadpole (MZUESC 17437; stage 41) in A) dorsal, B) lateral and C) ventral views. Scale = 5 mm. Blue shades are from methylen blue.

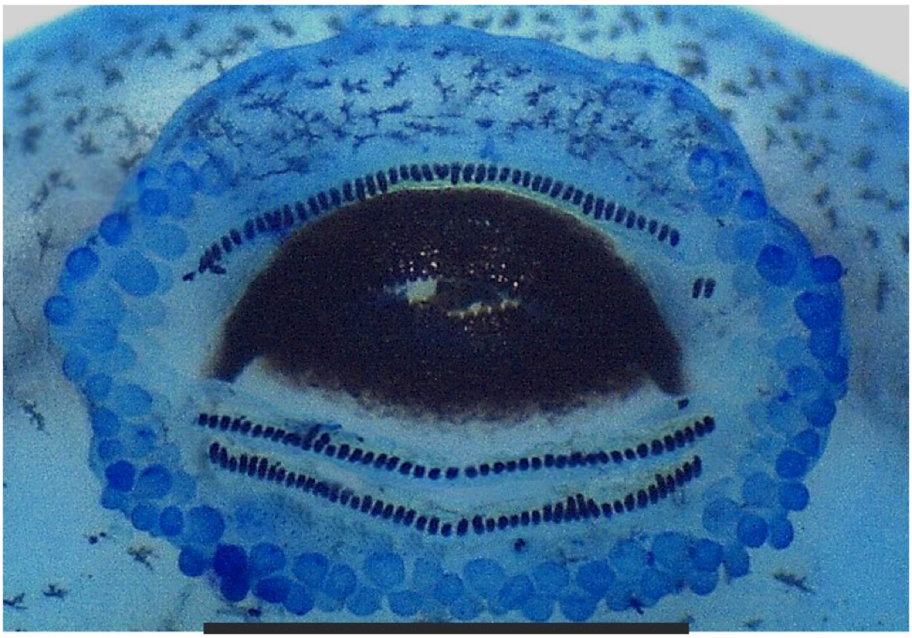

FIGURE 2. *Phyllodytes praeceptor* tadpole (MZUESC 17440; stage 28) oral disc. Scale = 1 mm. Blue shades are from methylen blue.

Natural History Notes. We found tadpoles inside the tanks of bromeliads of two genera (*Vriesea* and *Araeococcus*), with heights of 1 m and a maximum of two eggs or one to three tadpoles of different developmental stages per axilla. Tadpoles were usually at the tank mid-level, reaching for the bottom only after disturbance. Five of ten collected tadpoles (all younger than Stage 34) had eggs in their digestive tracts (X = 4.8 eggs, 2–12). We were able to presence one event where a female laid eggs to feed a tadpole. The tadpole swam to the surface of the water where the female was breaking it and then swam around the female, gently touching her cloaca (Fig. 4).

Comparison with tadpoles of other species of the genus. Tadpoles of *Phyllodytes praeceptor* have a LTRF of 1/2 that is a unique for the genus. Although *P. gyrinaethes* tadpoles present the same number of anterior rows, the number of posterior rows is much larger and the anterior row is interrupted—1(1)/5 (see Peixoto *et al.* 2003). The LTRF of other species are: 2(2)/3 for *P. melanomystax* (Caramaschi *et al.* 1992), 2(2)/5-6 for *P. edelmoi* (Peixoto *et al.* 2003); 2(2)/5 for *P. brevirostris* (Vieira *et al.* 2009), and 2(2)/4 for *P. luteolus*, *P. tuberculosus* (Bokermann 1966), *P. acuminatus* (Campos *et al.* 2014) and *P. wuchereri* (Magalhães *et al.* 2015). Body shape in dorsal view (oval) differentiates *P. praeceptor* from *P. gyrinaethes* (dump bell—Peixoto *et al.* 2003) and *P. brevirostris* (rounded—Vieira *et al.* 2009). The presence of a medial body constriction differentiates *P. praeceptor* tadpoles from those of *P. acuminatus*, *P. brevirostris*, *P. edelmoi*, and *P. wuchereri* (Peixoto *et al.* 2003; Vieira *et al.* 2009; Campos *et al.* 2014; Magalhães *et al.* 2015). The tadpole of *P. praeceptor* has the spiracle positioned at midbody, in lower half while *P. luteolus*, *P. melanomystax* and *P. tuberculosus* tadpoles the spiracle is positioned at the body medial midline (Bokermann 1966; Caramaschi *et al.* 1992). Dorsal fin is originated at body-tail junction and differentiates *P. praeceptor* tadpoles from those of *P. brevirostris* and *P. edelmoi* whose dorsal fins have origins on the body (Peixoto *et al.* 2003; Vieira *et al.* 2009) and from those of *P. luteolus*, *P. melanomystax* and *P. tuberculosus* whose dorsal fins originate above the tail musculature (Bokermann 1966; Caramaschi *et al.* 1992).

So far, internal relationships of *Phyllodytes* are suggested only in the grounds of advertisement calls (Roberto & Ávila 2013; Cruz *et al.* 2014; Orrico *et al.* 2018). However, larval information can suggest groupings as good as those and the need for a strict phylogenetic approach on the internal relationships of the genus is paramount.

Phyllodytes praeceptor tadpoles are oophagous, and eggs are reported within the digestive tract of *P. gyrinaethes* (Peixoto *et al.* 2003). Larvae of *P. luteolus* are reported to feed on different items: whereas Weygoldt (1981) highlights that tadpoles of this species feed on "...frog eggs even of their own species..." among other items, Salinas *et al.* (2018) demonstrated ex-situ that tadpoles are more efficient as predators of culicid mosquito larvae as they become larger. Overall, information on diet of *Phyllodytes* tadpoles is still too scarce to allow generalizations and only future approaches focusing on the diet of tadpoles of far more species may allow a more accurate description of their feeding habits.

Oophagy, as a mechanism of parental care is widespread among Neobatrachia, both in Hyloidea (e.g., *Phyllodytes*, *Leptodactylus, Oophaga*) and Ranoidea (e.g., *Microhyla, Rhacophorus*) and often associated with phytotelm breeding.

Despite *Phyllodytes*, among Hylidae (= Arboranae *sensu* Duellman *et al*. 2016) most of the species known to provide unfertilized eggs to their tadpoles belong to the tribe Lophiohylini. This behavior has also been reported for *Triprion spinosus* (Jungfer 1996), and records of eggs in the digestive tract have also been reported for *Ecnomiohyla* (Wilson *et al*. 1985), and the *Isthmohyla zeteki* group (Faivovich *et al*. 2018).

FIGURE 3. *Phyllodytes praeceptor* tadpole (MZUESC 17436; stage 32) in ventral view. Notice the eggs in the abdomen through transparency. Scale = 5 mm. Blue shades are from methylen blue.

FIGURE 4. *Phyllodytes praeceptor* female attending a tadpole (neither collected).

Lophiohylini phylogeny is still controversial. Every new published study recovers results that are always poorly supported and conflicting with the previous ones regarding the phylogenetic relationships of *Phyllodytes, Phytotriades* and *Itapotihyla*. However, the provision of unfertilized eggs does not seem to be homologous in all the species where it occurs and may have arisen at least four times; one in the ancestor of *Phyllodytes*, another for *Aparasphenodon arapapa* (see Lourenço-de-Moraes *et al.* 2013 and Lantyer-Silva *et al.* 2014), and two more times independently within *Osteocephalus* (see Jungfer *et al.* 2013).

Acknowledgements

This manuscript is a partial result of the Master Thesis "Descrição morfológica externa do girino da espécie *Phyllodytes praeceptor* (Anura: Hylidae), do sul da Bahia, Brasil*"*. We thank CNPq-PROTAX project 440615/2015-1 2 for partially funding this work. We also thank Arthur Bauer and Ramon Dominato for help during field work and Iuri R. Dias and Hélio Ricardo da Silva for comments on previous versions of the manuscript. VGDO and MS acknowledge funding by CNPq (research fellow grants 310467/2017-9 and 304999/2015-6). MS also acknowledges funding by Alexander von Humboldt Foundation/ Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (BEX 0585/16-5).

References

Altig, R. & Johnston, G. (1989) Guilds of anuran larvae: relationships among developmental modes, morphologies, and habitats. *Herpetological Monographs*, 3, 81–109.
https://doi.org/10.2307/1466987

Altig, R. & McDiarmid, R.W. (1999) Body plan: development and morphology. *In:* McDiarmid, R.W. & Altig, R. (Eds.), *Tadpoles. The biology of anuran larvae,* University of Chicago Press, Chicago and London, pp. 24–51.

Bokermann, W.C.A. (1966) O gênero *Phyllodytes* Wagler 1830 (Anura, Hylidae). *Anais da Academia Brasileira de Ciências*, 38, 335–344.

Campos, F.S., Brito, D.S. & Solé, M. (2014) Diversity patterns, research trends and mismatches of the investigative efforts to amphibian conservation in Brazil. *Anais da Academia Brasileira de Ciências*, 86, 1873–1886.
https://doi.org/10.1590/0001-3765201420140170

Caramaschi, U., da Silva, H.R. & Britto-Pereira, M.C. (1992) A new species of *Phyllodytes* (Anura, Hylidae) from Southern Bahia, Brazil. *Copeia*, 1992, 187–191.
https://doi.org/10.2307/1446550

Cruz, D., Euvaldo, M.J. & Napoli, M.F. (2014) Advertisement and courtship calls of *Phyllodytes wuchereri* (Peters, 1873) (Anura: Hylidae). *Zootaxa*, 3774 (1), 97–100.
https://doi.org/10.11646/zootaxa.3774.1.8

Duellman, W.E. & Trueb, L. (1994) *Biology of Amphibians*. McGraw-Hill, New York.

Duellman, W.E., Marion, A.B. & Hedges, S.B. (2016) Phylogenetics, classification, and biogeography of the treefrogs (Amphibia: Anura: Arboranae). *Zootaxa*, 4104 (1), 1–109.
https://doi.org/10.11646/zootaxa.4104.1.1

Faivovich, J., Haddad, C.F.B., Garcia, P.C.A., Frost, D.R., Campbell, J.A. & Wheeler, W.C. (2005) Systematic review of the frog family Hylidae, with special reference to Hylinae: phylogenetic analysis and taxonomic revision. *Bulletin of the American Museum of Natural History*, 294, 1–240.
https://doi.org/10.1206/0003-0090(2005)294[0001:SROTFF]2.0.CO;2

Faivovich, J., Pereyra, M.O., Luna, M.C., Hertz, A., Blotto, B.L., Vásquez-Almazán, C.R., McCranie, J.R., Sánchez, D.A., Baêta, D., Araujo-Vieira, K., Köhler, G., Kubicki, B., Campbell, J.A., Frost, D.R., Wheeler, W.C. & Haddad, C.F.B. (2018) On the monophyly and relationships of several genera of Hylini (Anura: Hylidae: Hylinae), with comments on recent taxonomic changes in hylids. *South American Journal of Herpetology*, 13, 1–33.
https://doi.org/10.2994/SAJH-D-17-00115.1

Frost, D.R. (2018) *Amphibian Species of the World: an online reference. Version 6.0. Electronic Database*. American Museum of Natural History, New York. Available from: http://research.amnh.org/herpetology/amphibia/index.ph (accessed 5 June 2018)

Gosner K.L. (1960) A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica*, 16, 183–190.

Haddad, C.F.B., Toledo, L.F., Prado, C.P.A., Loebmann, D., Gasparini, J.L. & Sazima, I. (2013) *Guia dos Anfíbios da Mata Atlântica—Diversidade e Biologia*. Anolis Books Editora, Curitiba, 544 pp.

Jungfer, K.-H. (1996) Reproduction and parental care of the coronated treefrog, *Anotheca spinosa* (Steindachner, 1864) (Anura: Hylidae). *Herpetologica*, 52, 25–32.

Jungfer, K.-H., Faivovich, J., Padial, J.M., Castroviejo-Fisher, S., Lyra, M.L., Berneck, V.M.B., Iglesias, P.P., Kok, P.J.R., MacCulloch, R.D., Rodrigues, M.T., Verdade, V.K., Torres Gastello, C.P., Chaparro, J.C., Valdujo, P.H., Reichle, S., Moravec, J., Gvoždík, V., Gagliardi-Urrutia, G., Ernst, R., De la Riva, I., Means, D.B., Lima, A.P., Señaris, J.C., Wheeler, W.C. & Haddad, C.F.B. (2013) Systematics of spiny-backed treefrogs (Hylidae: *Osteocephalus*): an Amazonian puzzle. *Zoologica*

Scripta, 42, 351–380.
https://doi.org/10.1111/zsc.12015

Lantyer-Silva, A.S.F., Solé, M. & Zina, J. (2014) Reproductive biology of a bromeligenous frog endemic to the Atlantic Forest: *Aparasphenodon arapapa* Pimenta, Napoli and Haddad, 2009 (Anura: Hylidae). *Anais da Academia Brasileira de Ciências*, 86, 867–880.
https://doi.org/10.1590/0001-3765201420130521

Lourenço-de-Moraes, R., Lantyer-Silva, A.S.F., Toledo, L.F. & Solé, M. (2013) Tadpole, oophagy, advertisement call, and geographic distribution of *Aparasphenodon arapapa* Pimenta, Napoli and Haddad 2009 (Anura, Hylidae). *Journal of Herpetology*, 47, 575–579.
https://doi.org/10.1670/11-326

Magalhães, F.D.M., Juncá, F.A. & Garda, A.A. (2015) Tadpole and vocalisations of *Phyllodytes wuchereri* (Anura: Hylidae) from Bahia, Brazil. *Salamandra*, 51, 83–90.

McDiarmid, R.W. & Altig, R. (1999) *Tadpoles: The biology of anuran larvae*. University of Chicago Press, xvi + 444 pp.

Orrico, V.G.D., Dias, I.R. & Marciano, Jr. E. (2018) Another new species of *Phyllodytes* (Anura: Hylidae) from the Atlantic Forest of northeastern Brazil. *Zootaxa*, 4407 (1), 101–110.
https://doi.org/10.11646/zootaxa.4407.1.6

Peixoto, O.L. (1995) Associação de anuros à bromeliaceas na Mata Atlântica. *Revista da Universidade Rural, Série Ciências da Vida*, 17, 75–83.

Peixoto, O.L., Caramaschi, U. & Freire, E.M.X. (2003) Two new species of *Phyllodytes* (Anura: Hylidae) from the State of Alagoas, Northeastern Brazil. *Herpetologica*, 59, 235–246.
https://doi.org/10.1655/0018-0831(2003)059[0235:TNSOPA]2.0.CO;2

Roberto, I.J. & Ávila, R.W. (2013) The advertisement call of *Phyllodytes gyrinaethes* Peixoto, Caramaschi & Freire, 2003 (Anura, Hylidae). *Zootaxa*, 3669 (2), 193–196.
https://doi.org/10.11646/Zootaxa.3669.2.13

Salinas, A.S., Costa, R.N., Orrico, V.G.D. & Solé, M. (2018) Tadpoles of the bromeliad-dwelling frog *Phyllodytes luteolus* are able to prey on mosquito larvae. *Ethology Ecology & Evolution*, 30, 485–496
https://doi.org/10.1080/03949370.2018.1438518

Vieira, W.L.S., Santana, G.G., Dos Santos, S.C.D.N.C., Alves, R.R.N. & Pereira-Filho, G.A. (2009) Description of the tadpoles of *Phyllodytes brevirostris* (Anura: Hylidae). *Zootaxa*, 2119, 66–68.

Wagler, J. (1830) *Natürliches System der Amphibien : mit vorangehender Classification der Säugethiere und Vögel: ein Beitrag zur vergleichenden Zoologie.* Cotta'schen, München, vi + 352 pp.
https://doi.org/10.5962/bhl.title.58730

Weygoldt, P. (1981) Beobachtungen zur Fortpflanzungsbiologie von *Phyllodytes luteolus* (Wied, 1824) im Terrarium. *Salamandra*, 17, 1–11.

Wilson, L.D., McCranie, J.R. & Williams, K.L. (1985) Two new species of fringe-limbed hylid frogs from nuclear Middle America. *Herpetologica*, 41, 141–150.