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The tadpoles of nine Cameroonian *Leptodactylodon* species (Amphibia, Anura, Arthroleptidae)

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Abstract

We describe and compare the tadpoles of nine *Leptodactylodon* species from Cameroon. The tadpoles of *Leptodactylodon bicolor*, *L. mertensi*, *L. ovatus*, *L. perreti* and *L. ventrimarmoratus* are herein reinvestigated, partly based on larger series than previously available. In addition we present first descriptions for the tadpoles of *L. boulengeri, L. erythrogaster, L. ornatus*, and *L.* cf. *polyacanthus*. The morphology of these exotrophic, lotic and neustonic tadpoles is discussed in comparison with other stream-dwelling tadpoles. Based on the assumed biology of these tadpoles, living in interstices of gravel or debris, the functioning of several special morphological features, in particular the funnel-mouth of *Leptodactylodon* tadpoles, are interpreted.

Key words: Barcoding, Cameroon, forest, funnel-mouth tadpoles, lotic waters, *Leptodactylodon*, mountain endemics

Introduction

Western Central Africa is particularly rich in anuran taxa, and Egg Frogs, *Leptodactylodon* Andersson, 1903, are endemic to this region (Amiet 1980). *Leptodactylodon* is distributed from eastern-most Nigeria, through Cameroon, south to Gabon and Equatorial Guinea, reaching the highest diversity in western Cameroon (Schiøtz 1963; Amiet 1971a, c, 1980; Ohler 1999; Amiet & Dowsett-Lemaire 2000; Frétey & Blanc 2000; Rödel & Pauwels 2003; Fig. 1). The genus currently comprises 15 species, three with several subspecies (Frost 2013). Most *Leptodactylodon* species live in forests at specific altitudes, ranging from lowland to more than 2000 m, and only at higher altitudes does the genus partly occur outside forest (see e.g. Cruz *et al.* 2013). Adult *Leptodactylodon* species almost always live well concealed between stones, leaf litter or roots, on the edges of small to medium sized streams (e.g. Amiet & Schiøtz 1973; Amiet 1980, 1989; Amiet & Dowsett-Lemaire 2000; Fig. 2). Descriptions of their larvae are available for six of the 15 species, namely *Leptodactylodon axillaris*, *L. bicolor*, *L. mertensi*, *L. ovatus*, *L. perreti* and *L. ventrimarmoratus* (see Channing *et al.* 2012). However, for only three of these: *L. axillaris* (Cruz *et al.* 2013), *L. perreti* (Cruz *et al.* 2013) and *L. ventrimarmoratus* (Amiet 1970), have detailed descriptions been published. As adults of the genus are usually more difficult to catch than larvae (e.g. Amiet 1972; Cruz *et al*. 2013; personal experience of the authors), surveying or monitoring the presence of the respective species would profit from the knowledge of the tadpoles. Herein we present comparative tadpole descriptions of nine taxa, all collected between 2010 and 2012 in Cameroon.

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body with a long and muscular tail axis, relatively narrow fins, as well as eyes and nostrils positioned laterally, *Leptodactylodon* tadpoles show all typical characters of bottom-dwelling lotic tadpoles (Altig & Johnston 1989). The lateral line system may indicate that *Leptodactylodon* tadpoles, although inhabiting fast flowing water, in fact prefer almost stagnant microhabitats within these streams. So far, all tadpoles of this genus have been collected from minute to mid-sized forest and montane rivers. Here they can usually be captured in-between pebbles, rocks or debris.

One of the most peculiar characteristics of the tadpoles in this genus is their umbelliform mouthparts (Fig. 15; Amiet 1970). Similar arranged lower lip morphology (covered with papillae and reduced or absent labial tooth rows) has been described from various, non-related stream/pond tadpoles, including representatives of the genera *Megophrys, Xenophrys* (Megophryidae; Altig & Johnston 1989; Wang *et al.* 2012), *Phasmahyla* (Hylidae; Altig *et al.* 2007), *Mantidactylus* (subgenus *Chonomantis;* Mantellidae; Grosjean *et al.* 2011) and *Silverstoneia* (Dendrobatidae; Grant & Myers 2013). Umbelliform oral apparatus or funnel-mouths, are generally hypothesized to be used in microphagous filter-feeding from the surface tension (e.g. Smith 1926; Inger *et al.* 1986; Hoff *et al.* 1999; Altig *et al.* 2007; Grosjean *et al.* 2011; Strauß *et al.* 2013). However, there is evidence that this might not hold true, at least in some tadpole species.

For instance, Amiet (1970) never observed *Leptodactylodon* tadpoles feeding, neither during day nor during the night. Our observations that tadpoles live in relatively stagnant parts of the streams under stones, in between sand and gravel or below debris agree with those of Amiet (1970). Neither he nor we ever observed these tadpoles surfacing and "feeding" from the surface *in situ*. Amiet (1970) thus speculated that the pumping movements of the funnel mouth at the water surface might merely be breathing. It seems possible that this "surface-feeding" (tadpole floating vertically with mouthparts in contact with water surface) is simply an artifact of tadpoles breathing in containers with stagnant water. These containers may not contain sufficient oxygen (compare Fig. 15) in contrast to their relatively cool, flowing and oxygenated natural habitats (Amiet 1970). This interpretation is supported by observations on Malagasy *Chonomantis* tadpoles, which morphologically are most similar to *Leptodactylodon*. Grosjean *et al.* (2011) also reported that these tadpoles only rarely leave their hiding places and hypothesize that surfacing is only necessary to acquire gulps of air. We thus believe that *Leptodactylodon* tadpoles, living in interstices of gravel or debris, are ecologically more similar to tadpoles like *Leptobrachella baluensis* and *Leptolalax arayai*, which seem to feed with their cup-like expanded lips (Malkmus 1999), within their substrate. This is in contrast to *Megophrys* tadpoles that appear to feed from the water surface (Malkmus *et al.* 2002). *Leptodactylodon* tadpoles seem well adapted to an interstitial microhabitat, not only by their long and narrow body, but Amiet (1970) reports that these larvae have specialized movement. Amiet (1970) noted *Leptodactylodon* tadpoles can move backwards quickly and thus exhibit a very unique and specialized movement pattern, which is certainly advantageous when traversing narrow and unstable cavities. Future observations are necessary to clarify the biology and ecology of these highly-specialized and increasingly threatened stream-dwelling tadpoles.

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References

Altig, R. (2006) Discussions of the origin and evolution of the oral apparatus of anuran tadpoles. *Acta Herpetologica,* 2, 95–105.

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

Altig, R. & McDiarmid, R.W. (1999a) Diversity – familial and generic characterizations. *In*: McDiarmid, R.W. & Altig, R. (Eds.), *Tadpoles – The biology of anuran larvae*. University of Chicago Press, Chicago and London, pp. 295–337.

Altig, R. & McDiarmid, R.W. (1999b) Descriptions and biological notes on three unusual mantellid tadpoles (Amphibia: Anura: Mantellidae) from southeastern Madagascar. *Proceedings of the Biological Society of Washington*, 119, 418–425. http://dx.doi.org/10.2988/0006-324x(2006)119[418:dabnot]2.0.co;2

Altig, R., Whiles, M.R. & Taylor, C.L. (2007) What do tadpoles really eat? Assessing the trophic status of an understudied and imperiled group of consumers in freshwater habitats. *Freshwater Biology*, 52, 386–395. http://dx.doi.org/10.1111/j.1365-2427.2006.01694.x

Amiet, J.-L. (1970) Morphologie et développement de la larve de *Leptodactylodon ventrimarmoratus* (Boulenger) (Amphibien Anoure). *Annales de la Faculté des Sciences du Cameroun*, 4, 53–71.

Amiet, J.-L. (1971a) Espèces nouvelles ou mal connues de *Leptodactylodon* (Amphibiens Anoures) de la Dorsale camerounaise. *Annales de la Faculté des Sciences du Cameroun*, 5, 57–81.

Amiet, J.-L. (1971b) Le têtard d'*Astylosternus corrugatus* Boulenger (Amphibien Anoure). *Annales de la Faculté des Sciences du Cameroun*, 6, 85–98.

Amiet, J.-L. (1971c) *Leptodactylodon* nouveaux du Cameroun (Amphibiens Anoures). *Annales de la Faculté des Sciences du Cameroun*, 7–8, 141–172.

Amiet, J.-L. (1972) Notes faunistiques, éthologiques et écologiques sur quelques amphibiens anoures du Cameroun. *Annales de la Faculté des Sciences du Cameroun*, 9, 127–153.

Amiet, J.-L. (1980) Révision du genre *Leptodactylodon* Andersson (Amphibia, Anura, Astylosterninae). *Annales de la Faculté des Sciences de Yaoundé*, 27, 69–224.

Amiet, J.-L. (1989) Quelques aspects de la biologie des amphibiens anoures du Cameroun. *Année Biologique*, 28, 73–136.

Amiet, J.-L. & Dowsett-Lemaire, F. (2000) Un nouveau *Leptodactylodon* de la Dorsale camerounaise (Amphibia, Anura). *Alytes*, 18, 1–14.

Amiet, J.-L. & Schiøtz, A. (1973) Voix d'Amphibiens camerounais I. Astylosterninae: genres *Leptodactylodon, Scotobleps* et *Nyctibates*. *Annales de la Faculté des Sciences du Cameroun*, 12, 79–100.

Channing, A., Rödel, M.-O. & Channing, J. (2012) *Tadpoles of Africa – The biology and identification of all known tadpoles in sub-Saharan Africa*. Edition Chimaira, Frankfurt am Main, 404 pp.

Cruz, D., Dawson, A.L. & Blackburn, D.C. (2013) Description of the tadpoles of two Cameroonian frogs, *Leptodactylodon axillaris* and *L. perreti* (Anura: Arthroleptidae). *African Journal of Herpetology*, 62, 28–39. http://dx.doi.org/10.1080/21564574.2013.777370

Frétey, T. & Blanc, C.P. (2000) Liste des Amphibiens d'Afrique centrale. Cameroun, Congo, Gabon, Guinée-Equatoriale, République Centrafricaine, République Démocratique du Congo, São Tomé et Príncipe. *Les dossiers de l'ADIE, Série Biodiversité*, N°2, 1–39.

Frost, D.R. (2013) Amphibian species of the World: an online reference. Version 5.6 (9 January 2013). Available from: http://research.amnh.org/vz/herpetology/amphibia (accessed 30 September 2013)

Frost, D.R., Grant, T., Faivovich, J., Bain, R.H., Haas, A., Haddad, C.F.B., de Sá, R.O., Channing, A., Wilkinson, M., Donnellan, S.C., Raxworthy, C.J., Campbell, J.A., Blotto, B.L., Moler, P., Drewes, R.C., Nussbaum, R.A., Lynch, J.D., Green, D.M. & Wheeler, W.C. (2006) The amphibian tree of life. *Bulletin of the American Museum of Natural History*, 297, 1–370.

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

Grant, T. & Myers, C.W. (2013) Review of the frog genus *Silverstoneia*, with descriptions of five new species from the Colombian Chocó (Dendrobatidae: Colostethinae). *American Museum Novitates*, 3784, 1–58. http://dx.doi.org/10.1206/3784.2

Grosjean, S., Strauß, A., Glos, J., Randrianiaina, R.-D., Ohler, A. & Vences, M. (2011) Morphological and ecological uniformity in the funnel-mouthed tadpoles of Malagasy litter frogs, subgenus *Chonomantis*. *Zoological Journal of the Linnean Society*, 162, 149–183. http://dx.doi.org/10.1111/j.1096-3642.2010.00667.x

Hirschfeld, M., Barej, M.F., Gonwouo, L.N. & Rödel, M.-O. (2012) Tadpole descriptions of three *Cardioglossa* species from southwestern Cameroon (Amphibia: Anura: Arthroleptidae). *Salamandra*, 48, 147–156.

Hoff, K.v.S., Blaustein, A.R., McDiarmid, R.W. & Altig, R. (1999) Behavior – interactions and their consequences. *In*: McDiarmid, R.W. & Altig, R. (Eds.), *Tadpoles – The biology of anuran larvae*. University of Chicago Press, Chicago and London, pp. 215–239.

Inger, R.F., Voris, H.K. & Frogner, K.J. (1986) Organization of a community of tadpoles in rain forest streams in Borneo. *Journal of tropical Ecology*, 2, 193–205. http://dx.doi.org/10.1017/s0266467400000808

Lannoo, M.J. (1987) Neuromast topography in anuran amphibians. *Journal of Morphology*, 191, 115–129. http://dx.doi.org/10.1002/jmor.1051910203

Malkmus, R. (1999) Die Kaulquappengemeinschaft eines Bergbaches in Borneo. *herpetofauna*, 21 (120), 13–19.

Malkmus, R., Manthey, U., Vogel, G., Hoffmann, P. & Kosuch, J. (2002) *Amphibians and reptiles of Mount Kinabalu (North Borneo)*. A.R.C. Gantner Verlag, Ruggell.

Ohler, A. (1999) Une nouvelle espèce du genre *Leptodactylodon* (Arthroleptidae, Astylosterninae) du Gabon. *Alytes*, 17, 73–80.

Randrianiaina, R.-D., Strauß, A., Glos, J., Glaw, F. & Vences, M. (2011) Diversity, external morphology and 'reverse taxonomy' in the specialized tadpoles of Malagasy river bank frogs of the subgenus *Ochthomantis* (genus *Mantidactylus*). *Contributions to Zoology*, 80, 17–65.

Rödel, M.-O., Barej, M.F., Hillers, A., Leaché, A.D., Kouamé, N.G., Ofori-Boateng, C., Assemian, N.E., Tohé, B., Penner, J., Hirschfeld, M., Doumbia, J., Gonwouo, L.N., Nopper, J., Brede, C., Diaz, R., Fujita, M.K., Gil, M., Segniagbeto, G.H., Ernst, R. & Sandberger, L. (2012) The genus *Astylosternus* in the Upper Guinea rainforests, West Africa, with the description of a new species (Amphibia: Anura: Arthroleptidae). *Zootaxa*, 3245, 1–29.

Rödel, M.-O. & Pauwels, O.S.G. (2003) A new *Leptodactylodon* species from Gabon (Amphibia: Anura: Astylosternidae). *Salamandra*, 39, 139–148.

Rowley, J.J.L., Tran, D.T.A., Le, D.T.T., Hoang, H.D. & Ronald, A. (2012) The strangest tadpole: the oophagous, tree-hole dwelling tadpole of *Rhacophorus vampyrus* (Anura: Rhacophoridae) from Vietnam. *Journal of Natural History*, 46, 2969–2978.
http://dx.doi.org/10.1080/00222933.2012.732622

Schiøtz, A. (1963) The amphibians of Nigeria. *Videnskabelige Meddelelser fra Dansk Naturhistorisk Forening*, 125, 1–92 + 4 plates.

Smith, M.A. (1926) The function of the "funnel" mouth of the tadpoles of *Megalophrys*, with a note on *M. aceras* Boulenger. *Proceedings of the Zoological Society of London*, 1926, 983–988.
http://dx.doi.org/10.1111/j.1096-3642.1926.tb02229.x

Strauß, A., Randrianiaina, R.-D., Vences, M. & Glos, J. (2013) Species distribution and assembly patterns of frog larvae in rainforest streams of Madagascar. *Hydrobiologia*, 702, 27–43.
http://dx.doi.org/10.1007/s10750-012-1301-z

Strauß, A., Reeve, E., Randrianiaina, R.-D., Vences, M. & Glos, J. (2010) The world's richest tadpole communities show functional redundancy and low functional diversity: ecological data on Madagascar's stream-dwelling amphibian larvae. *BMC Ecology*, 10, 12.
http://dx.doi.org/10.1186/1472-6785-10-12

Wang, Y.-Y., Zhang, T.-D., Zhao, J., Sung, Y.-H., Yang, J.-H., Pang, H. & Zhang, Z. (2012) Description of a new species of the genus *Xenophrys* Günther, 1864 (Amphibia: Anura: Megophryidae) from Mount Jinggang, China, based on molecular and morphological data. *Zootaxa*, 3546, 53–67.