

## The Tadpole of A Little-known Frog, *Rana tormotus* Wu, 1977

PIPENG LI\*, YUYAN LU, ANG LI AND LINA YU

*Herpetodiversity Research Group, Shenyang Normal University, P. R. China 110034.*

*\*Corresponding author E-mail: lipipeng@yahoo.com*

**Abstract.**— The tadpoles of a Chinese endemic and rare frog, *Rana tormotus* were collected from the type locality and reared with other coexisting tadpoles of *Paa spinosa*, *Rana schmackeri* and *Amolops wuyiensis* in comparison. The tadpole of *Rana tormotus* is small (about 27 mm in total length) and brown to slightly olive in color. Its body is ovoid in dorsal view, widest at about midpoint, depressed and elliptical in lateral view. Body length is nearly one-third of total length. Lateral line pores are visible on the body and tail. No glands (such as ventral and dorsal glands in tadpoles of genus *Amolops*) are visible. The snout is round, slightly flatted in dorsal profile, and rounded in lateral and ventral profiles. Eyes directed dorsolaterally with diameter 31% of body height, closer to tip of snout than eye. Spiracle is short and sinistral posteriorly. Tail approximately 2.1 times body length. Tail fins convex and approximately fusiform. Tail tip is V-shaped or narrowly rounded. Vent tube is dextral and attached to ventral fin.

Oral disc is large and anteroventral in position. Labial tooth row formula 5(2-5)/4(1). Upper jaw sheath is finely serrate and narrow, lower jaw sheath is finely serrate and shallowly V-shaped. No abdominal sucker was observed behind the oral disc. It is similar to those of *Rana andersonii* and *R. schmackeri* in shape and oral disc characters.

From the characters of the tadpole of *Rana tormotus*, it does not belong to the *Amolops* type. It should be placed in the genus *Rana* (*sensu lato*) as *Rana tormotus* firstly or placed in a new genus (as *Wurana* by Li et al. [2006]) by further analysis.

**Keywords.**— *Amolops tormotus*, *Rana tormotus*, *Wurana tormota*, tadpole, sunken ear frog, concave-eared torrent frog.

### Introduction

*Rana tormotus* Wu, 1977 is an arboreal frog in the family Ranidae found in the mountain streams of the Anhui and Zhejiang Provinces of Eastern China (Sichuan Institute of Biology (Wu, G. F.), 1977; Zhao and Adler, 1993). This frog has an interesting characteristic: the males warble melodies like a bird in order to attract females (Feng et al., 2002), calling nightly from the low vegetation along the banks of rivers and streams. Their vocal repertoire is extraordinarily rich; individual calls exhibit multiple upward and downward frequency sweeps, rapid frequency “steps,” and sudden onset and offset of selective harmonic components within a note (Feng et al., 2002; Peter et al., 2004). This is the first species of frog known to use diverse rising and falling modulations – most frog calls only go either up or down. These calls are also the first terrestrial frog noises known to extend into the ultrasonic range (Feng et al., 2002; Peter et al., 2004). Both of these phenomena are related to the frog’s unique ear.

This frog, which is called the “sunken ear frog” or “concave-eared torrent frog” in Chinese, has a conspicuous character that makes it different from most other frogs: the males have visible ear canals leading to eardrums within the skull, similar to *Amolops cavitympanum* Boulenger (Sichuan Institute of Biology [Wu G.

F.], 1977; Feng et al., 2002; Fei et al., 1991, 2005). Fei et al. (1991, 2005) and Dubois (1992) placed this species in *Amolops* because its tadpole might “belong to [the] *Amolops* type” (Fei et al., 1990 (1991); Zhao and Zhao, 1994). Because the tadpoles have never been recorded, however, it has been argued that this species should instead be assigned to “*Rana*” (Zhao and Zhao, 1994; Zhao et al., 2000; Global Amphibian Assessment, 2005).

Here, for the first time, we describe the tadpole of this little-known species of frog and provide information on its natural history. The importance of these findings lies in the necessity for larval characters in anuran classification (Chou and Lin 1997), and may allow for clarification of the uncertain position of *Rana tormotus* in relation to *Rana* and *Amolops*.

### Materials and Methods

Field work was conducted in a small stream of Longjiang Forest, Zhejiang Province (China), and the type locality of Taohuaxi stream in the Huangshan Mts, Anhui province. Field studies were done from June to August 2005.

The tadpoles of *Rana tormotus* Wu, 1977, *Paa spinosa* (David, 1875), *Rana schmackeri* Boettger, 1892 and *A. wuyiensis* (Liu and Hu, 1975) were observed and sampled in Taohuaxi, a permanent stream. Some tad-

poles of *R. tormotus* and *R. schmackeri* were reared until stages 36–38 (Gosner, 1960) for description, or through metamorphosis to confirm their identification and to describe and compare adult coloration. Tadpoles were raised in captivity in a plastic box (260 x 175 x 160 mm) with 1.5 L of water. Egg yolk and vegetable leaves were provided regularly. The tadpoles were preserved in 5% formalin. This material, together with adult voucher specimens, is deposited in the collections of Shenyang Normal University.

Tadpoles were staged according to Gosner (1960). Tadpoles in stage 38, included both reared and freshly captured specimens, were used in the descriptions and measured. No changes were observed in the oral morphology or general shape of reared tadpoles. Measurements, terminology, and labial tooth row formula follow Altig and McDiarmid (1999); labial tooth row formula also follows Dubois (1995).

All measurements were taken with a digital caliper (0.01 mm) and a stereomicroscope, except for total length, which was measured directly with a hand caliper. Drawings were made with the aid of a camera lucida attached to a stereomicroscope. The photographs were taken with a Nikon D100 camera.

Measurements are abbreviated as follows: BL (body length), TL (total length), TaL (tail length), BW (maximum body width), BH (maximum body height), TH (height of tail), DFH (dorsal fin height), VFH (ven-

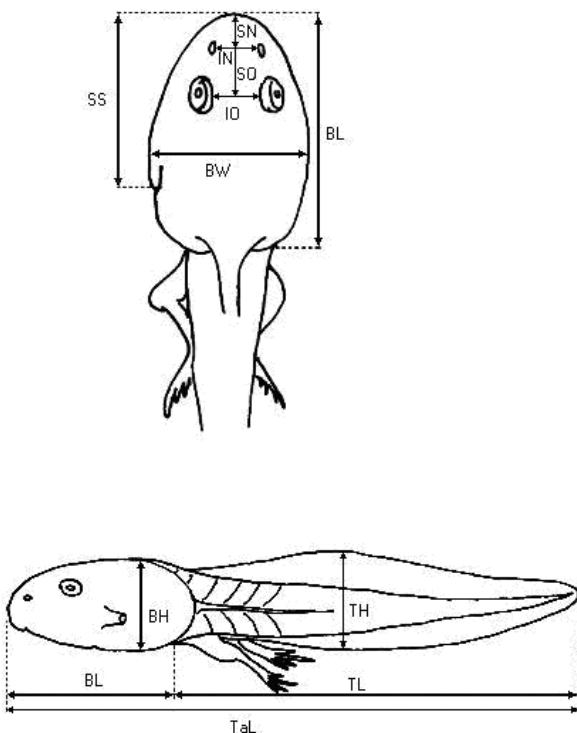


Figure 1. Standard morphometric measurements for tadpoles used in this study.

tral fin height), SO (snout-ocular axis distance), SN (snout-nasal axis distance), E (eye diameter), IN (internarial distance), IO (interorbital distance), SS (snout-spiracle distance), ODW (oral disc width). Standard measurements are shown in Figure 1.

**Description of external morphology at stage 38.**— The mean measurements and standard deviations of eight tadpoles in stage 38 are shown in Table 1. Mean total length at stage 38:  $27 \pm 1.07$  mm ( $n = 8$ ; Table 1). Body ovoid in dorsal view, widest at midpoint, depressed and elliptical in lateral view; lateral part of marginal papillae of oral disc slightly visible; Body length nearly one-third (32%) of total length, body 1.5 times longer than wide, 2.1 times longer than high, 1.4 times wider than high. Lateral line pores (neuromasts of caudal, dorsal, supranaso-orbital, infranaso-orbital, lateral, mental, postgular, postspiracle and pregular lines) visible on body and tail. No glands visible. Snout rounded, slightly flattened in dorsal profile, rounded in lateral and ventral profiles; eyes moderate, not part of dorsal profile, directed dorsolaterally, diameter 31% of body height, separated by distance about 2.8 times eye diameter; interorbital distance 88% of body width; nostrils directed dorsolaterally, closer to tip of snout than eye, internarial distance 60% of interorbital distance.

Spiracle sinistral, short, posterior, opening slightly above midline at about 5/7 of body length, directed posterodorsally at about  $15^\circ$ , lateral wall longer than medial wall, inner wall confluent with body, wall forming around aperture.

Tail approximately 2.1 times body length and 3.0 times body width, maximum height 28% of tail length, maximum tail height at end of first third of tail length. Tail musculature highest at base, slightly higher than dorsal and ventral fins, gradually tapering to pointed tip, weakly developed. Tail fins convex and approximately fusiform. Dorsal fin originates from tail muscle (the posterior edge of the first section) near tail-body junction, tallest just past to midpoint; ventral fin of nearly equal height throughout its length; dorsal fin height 1.3 times ventral fin height at highest point. Tail tip V-shaped or narrowly rounded; vent tube dextral, short, attached to ventral fin.

Oral disc large, anteroventral in position, width about 0.73 times distance between eyes and approximately 45% of body width, emarginate laterally, with single row of truncate marginal papillae in lateral posterior margin of upper lip and wide rostral gap, two rows of completely marginal papillae on lower lip but bases of papillae originate in same line; rostral gap equal in length of A-1. No lateral submarginal papillae. Labial tooth row formula  $5(2-5)/4(1)$  and  $1:4+4/1+1:3$  (following Dubois [1995]); A-1 and A-2 longest, slightly longer

Table 1. Mean measurements and standard deviation (mm) of eight tadpoles in stage 38 of Gosner (1960).

	Mean±SD	Range
TL	27.13±1.07	25.91–27.86
BL	8.69±0.13	8.52–8.92
BW	5.83±0.24	5.47–6.30
BH	4.12±0.20	3.81–4.46
TaL	18.45±1.06	17.10–20.43
TH	5.14±0.36	4.82–5.71
DFH	1.58±0.14	1.40–1.72
VFH	1.21±0.14	1.00–1.41
E	1.28±0.09	2.07–2.20
SO	3.07±0.14	2.68–3.19
SN	1.26±0.13	1.07–1.35
IO	3.62±0.09	3.48–3.75
IN	2.16±0.07	2.07–2.30
SS	6.6±0.23	6.24–6.96
ODW	2.63±0.09	2.51–2.74

than all other rows and similar in length, A-2 gap narrow, length of row becoming progressively shorter from A-3 to A-5 (A-5 22% length of A-2); P-2 and P-3 equal in length and longer than P-1 and P-4 (80% P-2); A-2 gap narrower than P-1. Labial teeth small, blunt and devoid of cusps; longest at middle of row, teeth becoming progressively smaller from P1 to P4, but equal in P2 and P3, teeth of A1 smaller than A2 and those of A2 equal. Jaw weakly developed. Upper jaw sheath finely serrate, narrow, width slightly less than width of lower jaw; lower jaw sheath finely serrate, shallowly V-shaped.

From stage 26 onward, labial tooth row formula stabilizes with very small variation in some specimens. Larval denticles disappear after disappearance of vent tube. Tadpole matching Orton's Type-IV category (Orton, 1953): oral disc elaborate and spiracle sinistral.

In preserved specimens, dorsal surface of body dark brown; gut and heart visible ventrally, not visible laterally; anterior half of ventral part of body pale brown with dark brown spots on sides, and abdominal region whitish without dark brown spots. Coloration of muscular part of tail similar to that of body in reticulated pattern. Tail fins with small brown spots.

In life, tadpole body coloration dark-brown with head pale brown. Pupil of eye round, black, and enclosed by narrow sliver ring.

**Natural history notes.**- Relative to the size of the adult (male 35 mm, female 48 mm), the tadpole is small. If the tadpole had not been reared to adulthood, it would have

been difficult to believe that the tadpole and frog were of the same species.

The tadpoles gathered in groups in the small stream, and were found to swim freely among small stones where there was no swift water current or side pools that were poorly connected with the main permanent stream at night. During the daytime, the tadpoles hid under stones and were rarely seen. The tadpoles were nocturnal and used their sites for grazing, avoiding areas with silty sediment and fast water flow. The large oral disc and numerous blunt rows of teeth suggested a greater capacity for grazing than for suspension feeding.

The color of the tadpoles camouflaged them against the small stones and sand on the bottom of the stream where they spent the day. Although collected from a mountain stream, the tadpoles were able to live in their jars for a long time, sometimes in good condition after three day's travel. After 40 days of captivity, the larvae completed metamorphosis and became froglets similar to the adult in body shape and coloration. The biggest of the tadpoles was less than 30 mm in total length. Froglets were 11.4 mm (10–11.6 mm, n = 5, SD = 0.73) from snout to vent just after metamorphosis.

The frogs and larvae that were found coexisting with *Rana tormotus* in the stream were *Paa spinosa*

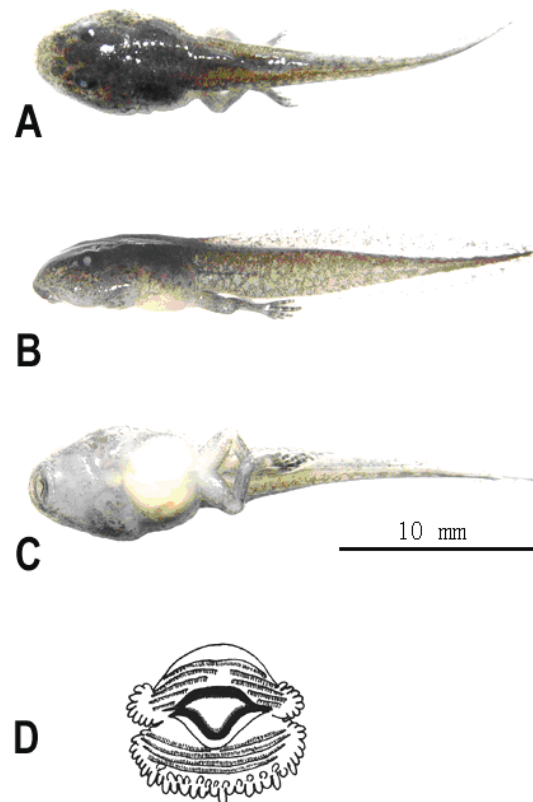


Figure 2. *Rana tormotus* tadpole at stage 38 (Gosner, 1960), (A) Dorsal view, (B) Lateral view, (C) Ventral View, (D) Oral disc.

(Daivid, 1875), *Rana schmackeri* and *A. wuyiensis* (Liu and Hu, 1975). While the tadpole of *R. schmackeri* was similar to *R. tormotus* in shape, coloration and general oral disc characters, the other two appeared conspicuously different.

Although *Rana schmackeri* also had a small tadpole belonging to Orton's Type-IV category (Orton, 1953), it was larger than the tadpole of *Rana tormotus*. The total length of *R. schmackeri* tadpole was more than 30 mm from stage 35, while the maximum total length of the *R. tormotus* tadpole was less than 30 mm at any later stage. At stage 36, the body and tail length was 11.1 mm and 20.25 mm for *R. schmackeri*, and 8.36 mm and 18.83mm for *R. tormotus*. At stage 44, the back of *R. schmackeri* became greenish, and after metamorphosis, yellow patches appeared on the back.

The tadpole of *Amolops wuyiensis* was also of the small type, but the ventral sucker easily identified it. This species was found at the edge of side water-bodies of the stream with little current. The tadpole used the sucker ventral disc to adhere to the rocky substrata to overcome the stream's water current.

The tadpole of *Paa spinosa* is of the big type, and is found alone or in groups of a few individuals at the bottom of pools beside or below cascades and gently flowing parts of the Taohuaxi stream. The oral disc of this species is emarginate, with two rows of marginal papillae, lateral submarginal papillae and a strong beak. The most conspicuous character of the tadpole is a gray or black band at the base of tail. The labial tooth row formula is 5(2-5)/3(1).

**Discussion of taxonomic status.**- Examination of the tadpole of *Rana tormotus* reveals that it is not of the "Amolops type", because there is no abdominal sucker and no ventral or dorsal glands (Yang, 1991). The tadpole of this species is more similar to that of *Rana andersonii* (Liu, 1940) and *O. schmackeri* in shape and oral disc morphology, but the tadpole and froglet just after metamorphosis is smaller, differently shaped, and without green or yellow back patches.

The body and tail length of the *Rana andersonii* tadpole averaged 12.27 mm (12–12.5 mm, n = 3) and 26.27 mm, and the froglet 12.7 mm (Liu, 1940). Four days after metamorphosis, uneven green patches appeared on the back (Liu, 1940).

While the larvae are similar in appearance, the adults of odorous frogs and *Rana tormotus* are remarkably different in morphology, with the sunken ear and absence of odor gland cells in the skin of *R. tormotus* being most the notable characters.

Based on the above evidence, this species should either be left to *Rana* as *Rana tormotus*, or placed in the new genus as *Wurana tormota*, although further study is needed.

## Acknowledgments

We are grateful to Prof. Gu H. Q., Dr. Lu S. Q., Mr. Tang X. S. and Ms. Zhao H. for their field working help. This research was supported by China National Nature Science Foundation and Special Invited Professor Grand of Shenyang Normal University to Dr. Pipeng Li.

## Literature Cited

- Altig, R. and G. F. Johnston. 1989. Guide of anuran larvae: relationships among developmental modes, morphologies and habitats. Herpetological Monographs 3: 81–109.
- Altig, R. and R. W. McDiarmid. 1999. Diversity: familial and generic characterizations. In R. W. McDiarmid and R. Altig (eds). *Tadpoles: The Biology of Anuran Larvae*. Pp 259–337. Univ. of Chicago Press, Chicago.
- Chou, W. H. and J. Y. Lin. 1997. Tadpoles of Taiwan. Special Publication - National Museum of Natural Science 7: 1–98.
- Dubois, A. 1992 Notes Sur la classification des Ranidae (Amphibiens Anoures). Bull. Mens Soc. Linn. Lyon 61(10): 305–352.
- Dubois, A. 1995. Keratodont formula in anuran tadpoles: proposals for a standardization. Journal of Zoological Systematics and Evolutionary Research 33: 1–15.
- Fei, L., C. Y. Ye. and Y. Z. Huang. 1990 (1991). *Key to Chinese Amphibia*. Pp 124–126, Chongqing Branch, Science and Technology Literature Publishing House, Chongqing.
- Fei, L., C. Y. Ye., J. P. Jiang., F. Xie. and Y. Z. Huang. 2005. *An illustrated Key to Chinese amphibians*. Sichuan Publishing Group-Sichuan Publishing House of Science and Technology, Chengdu.
- Feng, A. S., P. M. Narins and C. H. Xu. 2002. Vocal acrobatics in a Chinese frog, *Amolops tormotus*. Naturwissenschaften. 89(8): 352–6. Epub 2002 Jun 22.
- Global Amphibian Assessment. 2005. Global Amphibian Assessment - Detailed Report: *Amolops tormotus*. In: <http://www.globalamphibians.org/ser-vlet/GAA?searchName=Amolops+tormotus>



- Gosner, K. L. 1960. A simplified table for staging anuran embryos and larvae with notes on identification. *Herpetologica* 16:183–190.
- Liu, C. C. 1940. Tadpoles of Western China Salentia. *J. West China Border Res. Soc.*, 12(B): 7–62.
- Narins, P. M., A. S. Feng, W. Y. Lin, et al. 2004. Old World frog and bird vocalizations contain prominent ultrasonic harmonics. *J. Acoust. Soc. Am.* 115(2): 910–913.
- Sichuan Institute of Biology (Wu, G. F.) 1977. A new species of frogs from Huang-Shan, Anhui - *Rana tormutos* Wu. *Acta Zoologica Sinica*, Beijing, 23(1): 113–115.
- Yang, D. T. 1991. Phylogenetic systematics of the *Amolops* group of ranid frogs of Southeastern Asia and the Greater Sunda Islands. *Fieldiana: Zoology*, Chicago (USA), new ser., No.63: 1–42.
- Zhao, E. M., and K. Adler. 1993. *Herpetology of China*. Published by the Society for the Study of Amphibians and Reptiles in cooperation with the Chinese Society for Study of Amphibians and Reptiles. Oxford, Ohio, USA.
- Zhao, E. M., H. W. Chang, and X. L. Zhao. 2000. Taxonomic bibliography of Chinese amphibia and reptilia, including karyological literature. Kaohsiung Fu-Wen Publishing Co. Ltd, Taiwan. *Herpetological Series* 11: 215–238.
- Zhao, E. M. and H. Zhao. 1994. *Chinese Herpetological Literature –Catalogue and Indices*. Chengdu Science and Technology University Press, Chengdu.