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The Biology and Taxonomic Status of the Sunken Ear Frog (*Rana tormotus* Wu, 1977)

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Abstract.- The biology and taxonomic status of the sunken ear frog, *Rana tormotus* Wu, 1977, are reviewed and briefly discussed. This is a rare species restricted the mountain streams and rivers of Anhui and Zhejiang provinces in East China, and is characterized by a sunken tympanic membrane that forms an external ear canal, similar to that seen in birds. The male, which is known to produce ultrasonic sounds when calling, has a more deeply sunken membrane. The karyotype of this frog is 2n = 26, having five pairs of large, eight pairs of small and seven pairs of submetacentric chromosomes. The frog is active during the night and females are uncommonly encountered. Specimens are often found in the same habitat as *Megophrys boettgeri, Bufo gargarizans, Rana limnocharis, R. schmackeri, Paa spinosa, Amolops wuyiensis* and *A. ricketti*. This frog was first described within *Rana*, but it was recombined in *Amolops* because its tadpole was of the "*Amolops* type", even though the tadpole was unknown at the time. The recently-discovered tadpole has no abdominal sucker and the poison glands, smaller than and similar to those of *R. schmackeri* with LTRF (I:4-4/III:1-1), making it distinct from the "*Amolops*-type" tadpole. Adult and larval morphology, as well as developmental characters, support the placement of this species in *Wurana*, a new genus setup recently.

Keywords.- Amphibia, Ranidae, *Rana*, *tormotus*, *Wurana, Amolops*.

Introduction

Rana tormotus Wu, 1977 is a characteristic frog with a sunken ear membrane that is particularly distinct in the male, giving this species the common name of "sunken eared frog" or "concave-eared torrent Frog," the former of which translates to "Ao Er Wa" or "Wa Er Wa " in Chinese. In 1972 and 1974, Ermi Zhao, Guanfu Wu and two assistants collected one female and 18 male frogs with sunken tympana at Taohua Creek on Mt. Huanshan. These frogs were subsequently described as members of the new species *Rana tormotus* (Sichuan Institute of Biology [Wu, G. F.]). During the next 23 years, only a few reports on this frog's taxonomy and karyotype were published (Chen, 1991; Fei et al., 1991; Guo and Dong, 1986; Huang et al., 1990). The species was subsequently moved to *Amolops* by Fei et al. (1991), because its tadpole might be of the "*Amolops* type", even though the tadpole was unknown at the time. The correct taxonomic placement of this species is currently ambiguous (Global Amphibian Assessment, 2005; Zhao and Adler, 1993; Zhao and Zhao, 1994; Zhao et al., 2000;).

Recently, the ecology, bioacoustics and evolutionary history of this species have been explored by Liu and Hua (2001), Wu and Wu (2002) and Feng et al. (2002, 2006). We have also completed surveys on its distribution and habitat (at Jiande, Zhejiang and its type locality at Huanshan, Anhui), which are presented below. We further placed this species in the new genus *Wurana* on the basis of developmental characters and adult and larval morphology (Li et al., 2006).

Distribution and habitat.- This sunken ear frog is a rare endemic species restricted to the mountain streams and rivers of East China at elevations between 150 and 750 m. It is currently known only from the type locality (Taohua Creek, Hotspring Creek, Fu Creek and Xiang Creek of Huanshan, Anhui Province) and two locations in Zhejiang province (Huang, et al, 1990, personal communication with Prof. Qinghui Gu): two small creeks in the Jiangde Forestry Centre and the creeks of Anji County. The latter creeks are filled with large rocks and are surrounded by trees, brushes and grass (Figs. 1–3).

All frogs were collected at night since they could not be found during the day. Adult males were found on rocks in the river and in the surrounding trees and shrubs, and were located by their calls. No females were observed; in Liu and Hua (2001), it was reported that females were collected only after midnight following the appearance of males. It was suggested that the females were not commonly found because they occupied higher tree branches (Wu and Wu, 2002). Neither sex was observed following the breeding season.

Wu and Wu (2002) reported that the frogs were only found in shrubs along the flat parts of the river. In comparison, at the bases of mountains we found that trees

Figure 1. Distribution of *Rana tormotus* (red square) in Anhui and Zhejiang province.

were preferentially chosen (57.32% at Taohua Creek and 51.9% at Fu Creek), followed by shrubs (31.71% and 40.51%) and then rocks in the water (10.98% and 7.95%). Liu and Hua (2001) observed 11 of 53 frogs on branches, four on sand near vegetation along the river bank and the remainder on exposed sand and rock in the river far from any vegetation. In the present study at Taohua Creek, 20% of frogs were found on tree branches, 40% on shrubs, 20% on grass leaves and 20% on rocks; specimens were never found along sandy river banks, where they may have been excluded by *Rana* species. The differences in observations between surveys may be due to climatic variation.

Males were kept in an aquatic box simulating the natural environment. During the day, the frogs hid in gaps between stones and vegetation, but at night they emerged on the surrounding leaves and rocks despite variation in weather (including rain).

The other frogs found in the same habitat as *Rana tormotus* at the type locality were *Megophrys boettgeri*, *Bufo gargarizans*, *Rana limnocharis*, *Rana schmackeri* (Boettger, 1892), *Paa spinosa* (David, 1875) and *Amolops wuyiensis* (Liu and Hu, 1975) (Liu and Hua, 2001; Li, Lu and Lü, 2006). *Amolops ricketti* was found instead of *A. wuyiensis* at Jiande. Frogs observed in the

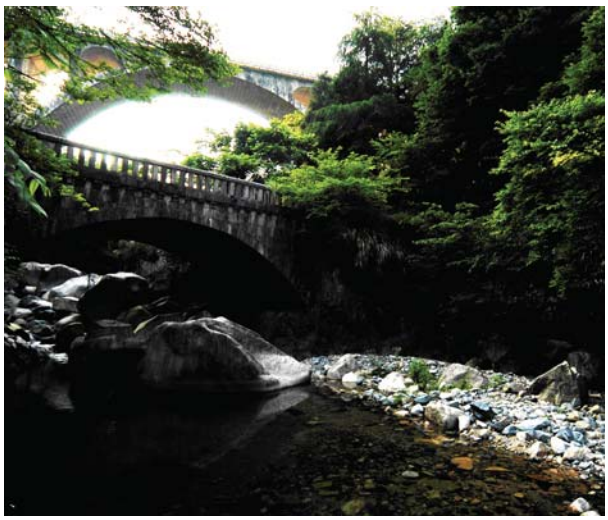

Figure 2. Type locality of *Rana tormotus*, Taohua Creek of Mt. Huanshan in Anhui province, China.

surrounding areas included *Rana nigromaculata*, *Microhyla heymonsi, R. livida* and *R. japonica* (Wu and Wu, 2002). Tadpoles of *Rana schmackeri, Paa spinosa* and *Amolops wuyiensi* were also collected from Taohua Creek.

Karyotype and Ag-banding pattern.- Guo and Dong (1986) reported the karyotype and Ag-banding pattern of *Rana tormotus*. The karyotype is 2n = 26, consisting of five pairs of large and eight pairs of small chromosomes. A secondary constriction is present near the centromere on the long arms of chromosome 6 and 10. No heteromorphic chromosomes were present. One homologous pair of NORs were found in the secondary constriction of chromosome 10 using Ag-AS staining techniques. There were also seven pairs of submetacentric chromosomes, the largest among frogs with a 2n = 26 karyotype in the Raninae (Guo and Dong, 1986; Pan et al., 2002).

Calling and related morphological characters.- Recently, Feng et al. (2002, 2006) detailed the extraordinarily rich vocal repertoire of the sunken ear frog. These frogs produce countless vocalizations, some of which share features of bird songs or primate calls – e.g., ultrasonic frequency, multiple upward and downward FM sweeps and sudden the onset and offset of selective harmonic components within a call note. Most frog calls go either up or down, and no others are known to extend into the ultrasonic range. Frame-by-frame video analysis of the frog's calling behavior suggests the presence of two pairs of vocal sacs that may contribute to its remarkable call-note complexity. Electrophysiological studies of the frog's auditory midbrain confirmed that its audible range extends into the ultrasonic (Xu et al., 2005). This characteristic can likely be explained by the fact

Figure 3. Another locality of *Rana tormotus* at Jiande county of Zhejiang province, China.

that the frog lives by noisy streams that produce acoustic signals with significant ultrasonic harmonics that would mask normal calls; selective pressure on this species could eventually produce a call that would not be masked by the wideband noise produced by the river (Peter et al., 2003).

With regard to sound reception, the sunken ear frog has a unique structural autapomorphy not seen in other Anura – a sunken tympanic membrane that forms an external ear canal like that seen in birds. The tympanic membrane is more deeply sunken in the male, suggesting that it receives the airborne sound in a manner somewhat different from that in the female (Feng et al., 2006; Xu et al., 2005).

Tadpoles and taxonomic status.- Several different species of tadpoles from the frog's type locality were reared to metamorphosis in the lab. The first morphotype was identified as *Amolops wuyiensis*, which had an abdominal sucker and poison glands; the second to fourth morphotypes were without either of these structures. Among latter, one identified as *Paa spinosa* had a relatively larger body and body-tail length, and froglets that very closely resembled the adult in general morphology. The remaining two morphotypes were significantly smaller and had the same LTRF (I:4-4/III:1-1); of these, one was externally similar to the adult of *Rana schmackeri* and one was similar to the adult of *R. tormotus* (Fig. 4); the characters used to aid in the separation of these two species were those listed in Li et al. (2006) and another paper discussing this species in the present journal issue (Li et al., 2007).

These characters are enough to verify that *Rana tormotus* does not have an *Amolops*-type larva, and

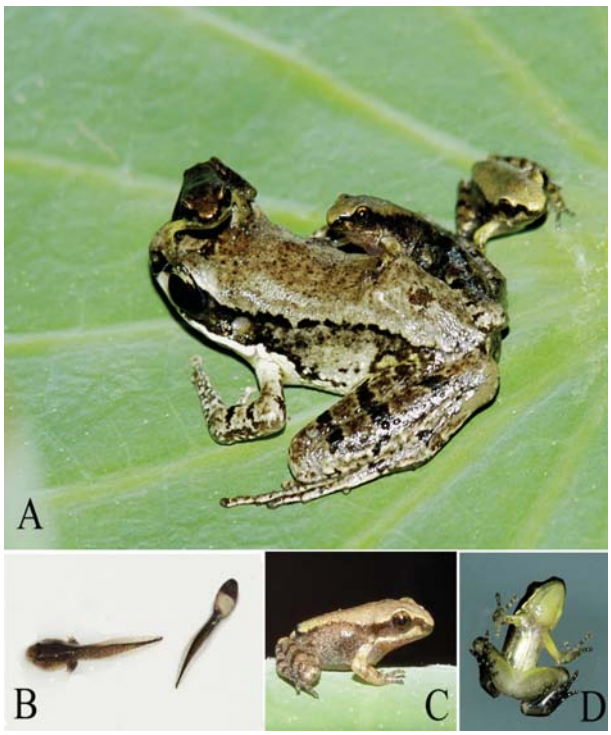

Figure 4. Tadpole, froglets and adult male of *Rana tormotus* (Wu, 1977). (A) Adult male and froglets, (B) tadpoles, (C) froglet just after metamorphosis, (D) froglet in ventral view.

should be placed elsewhere. This conclusion was verified by examining and comparing the skeletons of *Rana tormotus* to the ranine genera *Amolops*, *Pseudoamolops*, *Rana* and *Staurior* (Li et al., 2006).

Li et al. (2006) designated *Rana tormotus* as the type species of the new monotypic genus *Wurana* (etymologically, the specific epithet honors Wu Guanfu for the research on this and other frogs), which is known from Anhui and Zhejiang Provinces, China. *Wurana* is diagnosed as follows:

> ADULT.- Dorsolateral folds relatively thick and wide; tympanum deep, forming an external auditory canal that is pronounced in the male; no temporal folds; male without humeral glands; tarsal folds absent; tips of fingers and toes expanded into small disks with circummarginal grooves on outer three digits; width of crossbar on terminal phalanx much less than 0.3 times phalanx length.
>
> LARVA.- Small type tadpole with weak horny beak; two rows of lower labial papillae with bases originating in same line; oral disc emarginate laterally, with single row of truncate marginal papillae in posterolateral margin of upper lip and with wide rostral gap; labial tooth row formula (LTRF) usual-

ly I:4-4/III:1-1 (sometimes I:3-3/III:1-1); without external gland groups; spiraculum on the left with free tube.

From the general external morphological and skeletal characters, *Wurana* is closer to *Rana*, especially to some of the odorous frogs, than *Amolops*.

The surveys done by Qinghui Gu, Pipeng Li and others have shown that *Wurana tormota* is likely either a threatened or "rapidly declining" species (Global Amphibian Assessment, 2005; Liu and Hua, 2001). It has a restricted distribution in a region that is heavily-impacted by human activities such as sight-seeing, therefore continued biological research and regional conservation are strongly recommended.

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Literature Cited

Chen, B. H. 1992. The Amphibian and Reptilian Fauna of Anhui. Anhui Publishing House of Science and Technology, Heifei, China.

Dubois, A. 2005. Amphibia Mundi 1. Alytes 23(1–2): 1–24.

Feng, A. S, P. M. Narins and C.H. Xu. 2002. Vocal acrobatics in a Chinese frog, *Amolops tormotus*. Naturwissenschaften 89: 352–356.

Feng, A. S, P. N. Narins, C. H. Xu, W. Y. Lin, Z. L. Yu, Q. Qiu, Z. M. Xu and J. X. Shen. 2006. Ultrasonic communication in frog. Nature 440: 333–336.

Fei L, C. Y. Ye and Y. Z. Huang. 1991. Key to Chinese Amphibia. Chongqing Branch, Science and Technology Literature Publishing House, Chongqing, China. Pp 124–126.

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, China. Pp 150–158.

Frost, D. 2006. Amphibian Species of the World 3.0, an online reference. http://research.amnh.org/herpetology/amphibia/index.php.

Global Amphibian Assessment. 2005. Global Amphibian Assessment - *Amolops tormotus.* an online reference. http://www.globalamphibians.org/servlet/GAA?searchName=Amolops+tormotus.

Guo, C. W. and Y. W. Dong. 1986. Studies on the karyotype and Ag-banding pattern of *Rana tormotus* Wu. Acta Herpetologica Sinica 5: 181–184.

Huang, M. H, Y. L. Jin and C. M. Cai. 1990. Fauna Zhejiang: Amphibia/Reptilia. Zhejiang Science and Technology Publishing House, Hangzhou, China. Pp. 77–78.

Li, P. P., Y. Y. Lu, A. Li and F. L. Yu. 2008. Tadpole of a little-known frog, *Wurana tormotus*. Asiatic Herpetological Research, 11:71–75.

Li, P. P, Y. Y. Lu and S. Q. Lö. 2006. Taxonomic status of *Rana tormotus* Wu, 1977 with description of a new genus of subfamily Raninae. Sichuan Journal of Zoology, 25(2): 206–209.

Liu, B. R. and T. M. Hua. 2001. Ecological research of *Rana tormotus*. Journal of Biology 18(3): 27–28.

Pang, Q. P., Y. Ye. and Y. T. Wen. 2003. Chromosome data of Chinese amphibians. Chinese Journal of Zoology 37(4): 49–62.

Peter, M. N, A. S. Feng and W. Y. Lin. 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 tormotus* Wu. Acta Zoologica Sinica 23(1): 113–115.

Wu, H. L. and X. B. Wu. 2002. Habitat selection and food habit of *Rana tormotus*. Herpetologica Sinica 9: 123-126.

Yu, Z. L, Q. Qiu, Z. M. Xu, J. X. Shen, A. Feng, P. Narins and W. Y. Lin. 2005. A study of sound communication and hearing in the concave-eared torrent frog (*Amolops tormotus*). Herpetologica Sinica 10:266–268.

Zhao, E. M. and K. Adler. 1993. Herpetology of China. Published by Society for the Study of Amphibians and Reptiles in cooperated with Chinese Society for Study of Amphibians and Reptiles. Oxford, Ohio, USA.

Zhao, E. M, H. W. Chang and X. L. Zhao. 2000. Taxonimic bibliography of Chinese amphibia and reptilian, including karyological literature. Herpetological Series 11: 215–238. Kaohsiung Fu-Wen Publishing Co. Ltd, Taiwan, China.

Zhao, E. M. and H. Zhao. 1994. Chinese Herpetological Literature - Catalogue and Indices. Chengdu Science and Technology University Press, Chengdu, China.

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