

Altitudinal range and reproduction  
of the Hainan endemic treefrog,  
*Rhacophorus yinggelingensis*  
CHOU, LAU & CHAN, 2007

Hainan Island, People's Republic of China, is part of the Indo-Burma biodiversity hotspot with high rates of biodiversity and endemism (MYERS et al. 2000). To date, 12 amphibian species are endemic to Hainan (LAU & CHAN 2012). New amphibian species and new island records continue to be documented (XIAO et al. 2008; LAU & CHAN 2012).

Over 90 % of the island's endemic amphibians are considered threatened and listed as either Endangered or Vulnerable by the IUCN Red List of Threatened Species (IUCN 2013). However, research on the amphibian fauna of Hainan has largely been limited to taxonomy and biogeography (SHI 2002; FEI et al. 2003; FEI et al. 2007), with little quantitative research on their ecology, hampering effective conservation measures.

*Rhacophorus yinggelingensis* CHOU, LAU & CHAN, 2007 is the latest addition to Hainan's amphibian fauna. Since its discovery in 2007, *R. yinggelingensis* has been considered rare, being known only from Yinggeling Nature Reserve, Hainan, and as such is listed as Vulnerable D2 by the IUCN Red List (IUCN 2013). Our understanding of the ecology of this highly restricted species is extremely limited. The objectives of the current study were to investigate the altitudinal range, and the reproductive seasonality of *R. yinggelingensis* so as to provide baseline information for future population monitoring and conservation plans.

The authors conducted this study opportunistically between July 2010 to January 2012 in Yinggeling Nature Reserve (18°49' – 19°06'N; 109°11' – 109°34'E). Surveys were conducted all months except in October and December (Fig. 1). The total area of Yinggeling Nature Reserve is ca. 505 km<sup>2</sup>, and the highest peak, Mt. Yinggeling, is 1,812 m a.s.l., that is the second tallest mountain in Hainan. Over 200 km<sup>2</sup> of continuous primary rainforest remain inside the Reserve.

The altitudinal ranges of *R. yinggelingensis* were investigated with a team of four

to six surveyors, by conducting transect surveys along trails ranging from 900 m to the summit at 1,812 m. The area surveyed was mainly covered by primary and secondary forest, about 20 % were non-forested habitats including grassland and shrubland. A zone, extending 15 m to the left and right of the transects was searched to locate *R. yinggelingensis* and their breeding sites. In addition, searches were conducted in 40 m x 40 m squares, centered at potential microhabitats that *R. yinggelingensis* may use as breeding sites, including all pools and swampy areas encountered. Breeding sites were identified based on the presence of eggs, tadpoles or calling males.

Three transect surveys covered a total of 48.33, 48.66 and 9.61 km at 900-1,199, 1,200-1,499 and 1,500-1,812 m elevation ranges respectively. A total of eight, 14 and 10 quadrat searches were performed at 900-1,199, 1,200-1,499 and 1,500-1,812 m elevation ranges respectively. The number of adult *R. yinggelingensis* detected was 132, of which 79 were found between 1,200-1,499 m elevation and 53 between 1,500-1,812 m elevation. Not one specimen of *R. yinggelingensis* was found at altitudes below 1,200 m during the study. All adults were encountered in breeding sites by quadrat searches. All observations of *R. yinggelingensis* were made between March and June (Fig. 1). The number of individuals detected was highest in March.

From quadrat searches of 32 pools, 18 were identified as breeding pools. None were found below 1,200 m, while ten were located at 1,200 to 1,499 m elevation and eight were at 1,500 to 1,812 m elevation (Fig. 2). All pools were within primary rainforest.

The present research supports that *R. yinggelingensis* is restricted to high-elevation sites, being found only above 1,200 m in mature tropical montane rainforest. This is of particular conservation concern in the face of climatic change, as it indicates that the species may be susceptible to global warming, which has been linked to the decline of other montane amphibian species (POUNDS et al. 1999). Notably, over 40 % of breeding pools identified in this study are above 1,500 m a.s.l.; with the highest peak reaching a mere 1,812 m at the summit, the

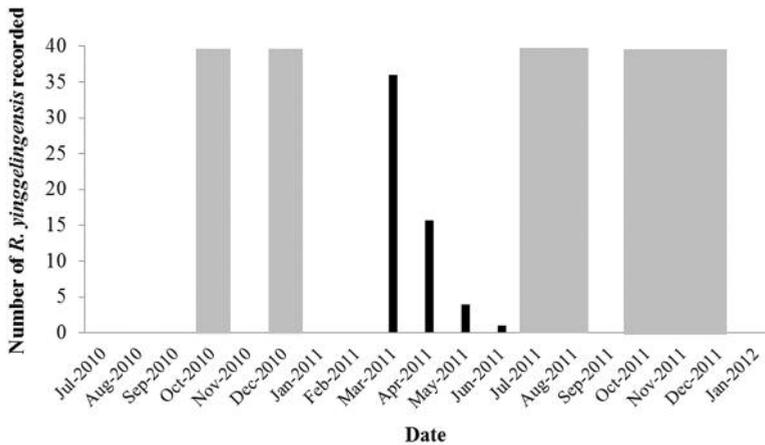


Fig. 1: Number of individuals of *Rhacophorus yinggelingsis* CHOU, LAU & CHAN, 2007, recorded in different months between July 2010 to January 2012 in Yinggeling Nature Reserve, Hainan, People's Republic of China. Grey columns indicate periods in which no survey was conducted.

room for upslope migration in the face of climate change for this species (RAX-WORTHY et al. 2008) is very limited.

The seasonal peak of *R. yinggelingsis* reproduction was found to occur in March, before the onset of the major rainy season, which is from May to October; and breeding activities of the species cease in late May. This short reproductive period is distinctive among anurans on Hainan Island as most other species have prolonged breeding activity throughout the rainy season. More detailed study is needed to examine the variability of and the factors affecting the reproductive seasonality of frog species in Hainan.

There have been extensive studies showing the importance of forests to amphibians (GARDNER et al. 2006; SUNG et al. 2012). All identified breeding pools and sightings of adults were located in mature tropical montane rainforests, suggesting that well-preserved old-growth forest is essential for successful reproduction and survival of *R. yinggelingsis*. In Hainan, there has been extensive forest degradation, with less than 5 % of the original forest cover remaining (YAN 2008). This may be one of the possible reasons for the extremely narrow geographic distribution of *R. yinggelingsis*.

One important observation is that *R. yinggelingsis* appears to only breed in pools that are found in shallow depressions amidst the upland knolls of the complex terrain, and maintained by the wallowing activity of large ungulates, such as sambar deer (*Rusa unicolor*) and wild boar (*Sus scrofa*). It was shown that mammal activities can create breeding microhabitats for amphibians (OHLER & SWAN 2004), and there is a possibility that the availability of breeding pools for *R. yinggelingsis* is limited by mammal activities. This warrants quantitative studies on the relationship between mammal activities and reproduction of *R. yinggelingsis* to understand this potential commensalism between mammals and amphibians.

Due to the remoteness and rugged terrain of the study sites, there were certain limitations in this study; for example, breeding pools were not surveyed regularly throughout the year, more in-depth and systematic investigation should be conducted. Measurement of environmental parameters at breeding and non-breeding pools should be done, to investigate preferences of breeding habitat.

There are at least 12 endemic amphibian species in Hainan (LAU & CHAN 2012). The ecology of most, if not all, endemic

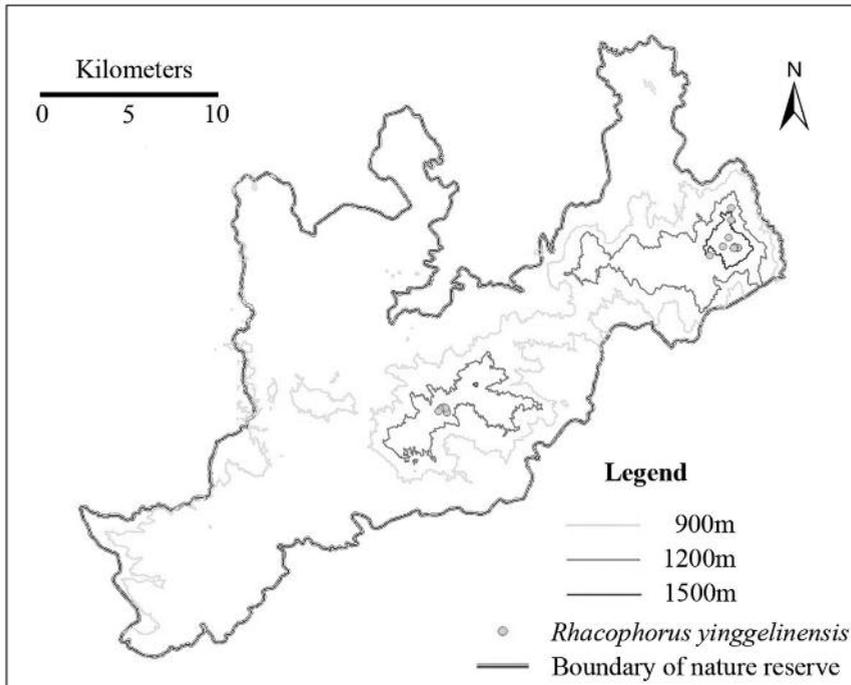


Fig. 2: Distribution of breeding pools of *Rhacophorus yinggelinensis* CHOU, LAU & CHAN, 2007, at three altitudinal zones, 900-1,199 m, 1,200-1,499 m and 1,500-1,812 m a.s.l., in Yinggeling Nature Reserve, Hainan, People's Republic of China.

species remains poorly known. Many of these endemics share the mature high-altitude forest habitat (over 900 m a.s.l.) with *R. yinggelinensis*, and are therefore susceptible to climate change and deforestation (LAU & CHAN 2012). With the combined risk of climate change and limited mature montane forest, the authors strongly encourage more research effort investigating the basic ecology of the little-known Hainan endemic frog species.

**ACKNOWLEDGMENTS:** The authors thank Hainan Wildlife Conservation Bureau of Hainan Provincial Forestry Department for their support of this research, Y. D. ZHOU, L. LIU, F. LI, J. HUANG and H. Y. WANG for their help with surveys and logistic arrangements to make this research possible and express their gratitude to D. B. FEI for his valuable advice.

**REFERENCES:** CHOU, W. H. & LAU, M. W. N. & CHAN, B. P. L. (2007): A new treefrog of the Genus *Rhacophorus* (Anura: Rhacophoridae) from Hainan Island, China.- *The Raffles Bulletin of Zoology*, Singapore; 55 (1): 157-165. FEI, L. & YE, C. Y. &

JIANG, J. P. (2007): A new species of Ranidae, *Hylarana (Nidirana) hainanensis* from China (Amphibia: Anura).- *Herpetologica Sinica*, Beijing; 11: 1-4. FEI, L. & YE, C. Y. & JIANG, J. P. (2003): A new bufonid genus *Parapelophryne* from China (Amphibia, Anura).- *Acta Zootaxonomica Sinica*, Reading; 28 (4): 762-766. GARDNER, T. A. & RIBEIRO-JUNIOR, M. A. & BARLOW, J. & CRISTINA, T. & AVILA-PIRES, S. & HOOGMOED, M. S. & PERES, C. A. (2006): The value of primary, secondary, and plantation forests for a Neotropical herpetofauna.- *Conservation Biology*, Malden; 21 (3): 775-787. IUCN (2013): The IUCN Red List of Threatened Species. Version 2013.2. WWW document available from < [www.iucnredlist.org](http://www.iucnredlist.org) > [last accessed on 02 March 2014]. LAU, M. W. N. & CHAN, B. P. L. (2012): Amphibian fauna of Hainan Yinggeling Nature Reserve, with new genus and species record for Hainan Island.- *Chinese Journal of Zoology*, Beijing; 47 (1): 51-61. MYERS, N. & MITTERMEIER, R. A. & MITTERMEIER, C. G. & DA FONSECA, G. A. B. & KENT, J. (2000): Biodiversity hotspots for conservation priorities.- *Nature*, London; 403 (6772): 853-858. OHLER, A. & SWAN, S. (2004): *Rhacophorus dorsovirens*. In: IUCN (2013): IUCN Red List of Threatened Species. Version 2013.2. WWW document available from < [www.iucnredlist.org](http://www.iucnredlist.org) > [last accessed on 02 March 2014]. POUNDS, J. A. & FOGDEN, M. P. L. & CAMPBELL, J. H.

(1999): Biological response to climate change on a tropical mountain.- *Nature*, London; 398: 611-615. RAXWORTHY, C. J. & PEARSON, R. G. & RABIBISOA, N. & RAKOTONDRAZAFY, A. M. & RAMANAMANJATO, J. B. & RASELIMANANA, A. P. & WU, S. & NUSSBAUM, R. A. & STONE, D. A. (2008): Extinction vulnerability of tropical montane endemism from warming and upslope displacement: a preliminary appraisal for the highest massif in Madagascar.- *Global Change Biology*, Oxford; 14 (8): 1703-1720. SHI, H. (2002): Amphibian fauna and zoogeographic division of Hainan Island.- *Sichuan Journal of Zoology*, Chengdu; 21 (3): 174-176. SUNG, Y. H. & KARRAKER, N. E. & HAU, B. C. H. (2012): Terrestrial herpetofaunal assemblages in secondary forests and exotic *Lophostemon confertus* plantations in South China.- *Forest Ecology and Management*, Amsterdam; 270: 71-77. XIAO, Z. & LI, Z. C. & GAO, L. B. (2008): A new record of *Theloderma kwangsiensis* in Hainan Province, China.- *Chinese Journal of Zoology*, Beijing; 43 (4): 131-132. YAN, J. A. (2008): The study on evolutionary history of Hainan Island's ecological environment; Beijing (Science Press), pp. 381.

KEY WORDS: Amphibia: Rhacophoridae: *Rhacophorus yinggelingensis*, amphibians altitude, reproduction, ecology, habitat, Hainan, China

SUBMITTED: May 28, 2013

AUTHORS: Changle LIAO <sup>1, 2)</sup>; Bosco P. L. CHAN <sup>1, 3)</sup>; Yik-Hei SUNG (Corresponding author < yhsung@kfbg.org > <sup>3)</sup>; Hesheng WANG <sup>4)</sup>

<sup>1)</sup> Yinggeling Nature Reserve, Baisha County, 57800 Hainan, China;

<sup>2)</sup> Current address: Chengmai Forest Farm, Chengmai County, 571900 Hainan, China;

<sup>3)</sup> Kadoorie Conservation China, Kadoorie Farm and Botanic Garden, Tai Po, Hong Kong SAR, China;

<sup>4)</sup> Current address: Mihouling Forest Farm, Dongfang County, 572600 Hainan, China.