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First record of Anderson's Bubble-nest Frog *Raorchestes andersoni* (Ahl, 1927) (Amphibian: Rhacophoridae) from the Himalayan Kingdom of Bhutan.

Jigme Tshelthrim Wangyal[1, 2*], Sherab Jamtsho [3]

[1]University of New England, Armidale NSW 2351, Australia.
2Jigme Khesar Strict Nature Reserve, Department of Forest and Park Services, Royal Government of Bhutan, Haa 15001, Bhutan
[3]Zhemgang Forest Division, Department of Forest and Park Services, Royal Government of Bhutan, Zhemgang 34001, Bhutan
*Corresponding author. Jigme Tshelthrim Wangyal (jigmewangyal@gmail.com)

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ABSTRACT. We report the discovery of the Anderson's Bubble-nest Frog, Raorchestes andersoni, from Central Bhutan's Zhemgang district, in the Himalayan Kingdom of Bhutan. The frog was found in moist dense forests with lots of green bushes. This record will help Bhutan understand its species diversity and help in prioritizing conservation actions for this species and other batrachian fauna.

KEYWORDS. Conservation, distribution, habitat, location, morphometrics, species description

Introduction

Family Rhacophoridae (Hoffman, 1932), the closest relative of the true frogs Ranidae, Rafinesque, 1814, is so far represented by as many as 440 species belonging to 21 genera worldwide (Frost 2020), of which the genus *Raorchestes* has kept changing over the last few years based on proposals by various batrachologists conducting molecular as well as morphometric research (Hou et al. 2017). However, the accepted name *Raorchestes andersoni* (Ahl, 1927) is considered valid for now (Hou et al. 2017; Chen et al. 2020) for Anderson's Bubble-nest Frog, which has several nomenclatures like, *Ixalus tuberculatus* Anderson 1879, *Rhacophorus andersoni* Ahl 1927, *Rhacophorus (Philautus) andersoni*, Ahl 1931, *Philautus tuberculatus*, Bourret 1942, *Philautus andersonii*, Bourret 1942, *Rhacophorus (Philautus) andersoni*, Bourret 1942, *Philautus andersoni*, Bourret 1942, *Philautus (Philautus) tuberculatus* Bossuyt & Dubois 2001, *Aquixalus tuberculatus*, Fei, Hu, Ye & Huang 2009, *Theloderma andersoni*, Li, Che, Murphy, Zhao, Zhao, Rao & Zhang 2009, *Liuixalus tuberculatus*, Fei, Ye & Jiang 2012, *Theloderma (Theloderma) andersoni*, Poyarkov, Orlov, Moiseeva, Pawangkhanant, Ruangsuwan, Vassilieva, Galoyan, Nguyen & Gogoleva 2015, *Theloderma tuberculatus*, Hou, Yu, Chen, Liao, Zhang, Chen, Li & Orlov 2017 and *Raorchestes andersoni* Chen, Prendini, Wu, Zhang, Suwannapoom, Chen, Jin, Lemmon, Lemmon, Stuart, Raxworthy, Murphy, Yuan & Che 2020.

Other than the mention of habitat by Anderson (1878) as "on level marshy flats on the banks of the Nampoung in the centre of the Kakhyen Hills Myanmar", which was later explored by Hou et al. (2017) and confirmed to be in fact in China's Yingjiang County, Yunnan Province, there are no detailed studies on any other aspects of the species. Thus, it is pertinent that we report the presence of the species in Bhutan, towards studying this lesser-known frog.

The anuran fauna of the Kingdom of Bhutan is represented by ca. 79 species (Wangyal & Gurung 2017; Tenzin & Wangyal 2019; Wangyal et al. 2020; Wangyal et al. 2021) and the family Rhacophoridae, which is represented by 21 genera gets another species, *Raorchestes andersoni* from Bhutan in this research. Wangyal & Das (2014) mentioned the presence of Anderson's Bubble-nest Frog from Bhutan based on the information obtained through verbal interviews with local people living in Central Bhutan. Through a crude method of data collection where they showed the photos of the frogs to the interviewees and when they identified the type of frogs they have seen around in the region, they listed the species as present. They used habitat clues to predict the presence of *Theloderma* or *Raorchestes* species, and went on to ask people if they have seen the species at any point in time. Thus, they did not have enough information to verifiably say that the species existed. However, with this report, the occurrence of *Raorchestes andersoni* in Bhutan can be confirmed.

Material and Methods

A visual encounter survey (VES) (Heyer et al. 1994) was conducted in the last week of August 2020 to look at the biodiversity of selected forest types of Shingkhar Gewog (sub-district). The frog was located on a curvilinear trail that led inside the forest vicinity of Zangling village. The second author noted geo-coordinates, elevation, plant species of the forest patch (Figure 1) near Zangling Village, in Shingkhar Gewog (sub-district), Zhemgang District, Central Bhutan (Figure 2).

The specimen was caught, photographed, measured and released back to the same place. Another round of VES did not yield any results till the end of August, as the vicinity is pretty cold. Ohler et al. (2018) was used to identify the species, and the speciment was also verified as *Raorchestes andersoni* by Annemarie Ohler through personal communication.

Habitat data, especially those of plant species surrounding the habitat, were collected, and plant species were identified using the book Flora of Bhutan (Barneby 1988).

Results

Species description. Snout to vent length = 20.5 mm, length of hind limb = 35 mm, length of foot = 12 mm, and width of gape (Opened mouth) / head width = 7.5 mm. Snout — short (rather broad), canthus rostralis (CR) — feeble and rounded. Nostril little below the CR, small but with swollen margin. Eyes — large with finely tubercular eyelids. Tympanum about one-fourth the dimension of eye. Finger disc dilated and larger than those on the toes. Feebly webbed toes, reaching only up to the first phalanx. Small, scattered, isolated tubercles on the dorsum and sides of the body and belly. Inner part of the upper third of the thighs finely granular. General color of the upper parts is uniform dark olive with all white small tubercles (Figure 3a, 3b). The ventral color is brown with white granulated tubercles, but the belly has a white patch with white granulated tubercles too (Figure 3c). The groin has large black irregular spot. Morphological comparisons that distinguish *Raorchestes andersoni* from other species of *Raorchestes* in the region that include southeast Asia, Himalaya and northeastern India are provided in Table 1, which has been adapted from Wu et al. (2021) with minor changes.

Location. Zangling village, Shingkhar Gewog (sub-District), Zhemgang District. Geo-coordinates, 27.159722°N, 90.884748°E, 2006.300 m asl, obtained using a GPS with WGS 84 datum. Observed and caught on 25th August 2020 at 14:34:19 hrs (GMT+06:00). The species was found 730.9 km (to 4 SF*) away from the type Locality (24.445457°N, 97.535572°E, 1408 m asl), on the bank of the Nampoung River, China's Yingjiang County, Yunnan Province. The distance was obtained by using Movable Type Scripts (Veness 2002) found at URL: https://www.movable-type.co.uk/scripts/latlong.html. (Figure 5).

Habitat. There are no specific habitat or reproduction ecology studies on the species. However, it is known to occupy tropical forest edges and marshes (Döring 2020). In our study, the area had thick bushes (see Figure 1) and the species of trees found in the habitat were, *Symplocos sumuntia, S. ramossisima, Quercus ategoriz, Elaeocarpus sikkimensis, Acer campbellii, Eurya acuminata, Viburnum erubescens* and *Measa rugosa*. The shrubs on which the

Figure 1. The second author, while searching for orchids, bumped into a frog (Photo: Sherab Jamtsho).

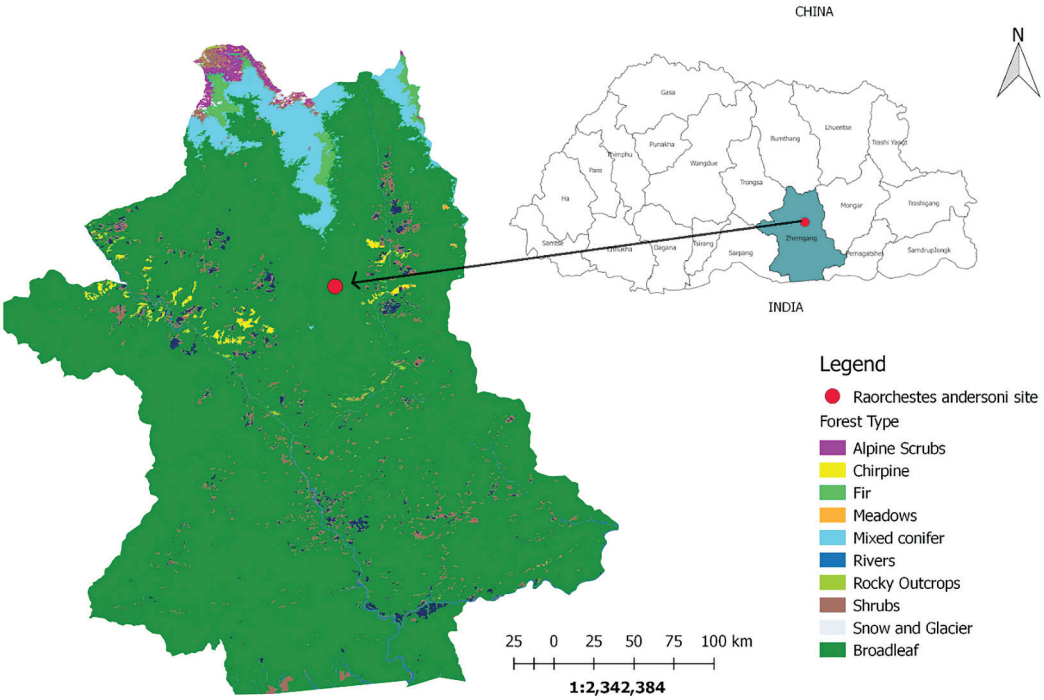

Figure 2. Map showing the exact spot where the *Raorchestes andersoni* specimen was found.

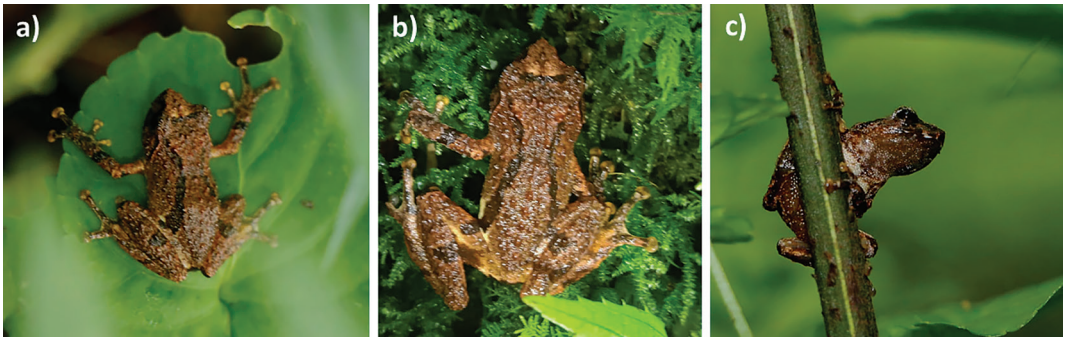

Figure 3. a) Dorsal view of *Raorchestes andersoni* in the field (Photo: Sherab Jamtsho).; b) Close-up view of the dorsum of *Raorchestes andersoni* (Photo: Sherab Jamtsho).; c) Ventral view of *Raorchestes andersoni* from the habitat (Photo: Sherab Jamtsho).

Figure 4. Distant view of the habitat from where *Raorchestes andersoni* was found (Photo: Sherab Jamtsho). In the background is Zhangling village.

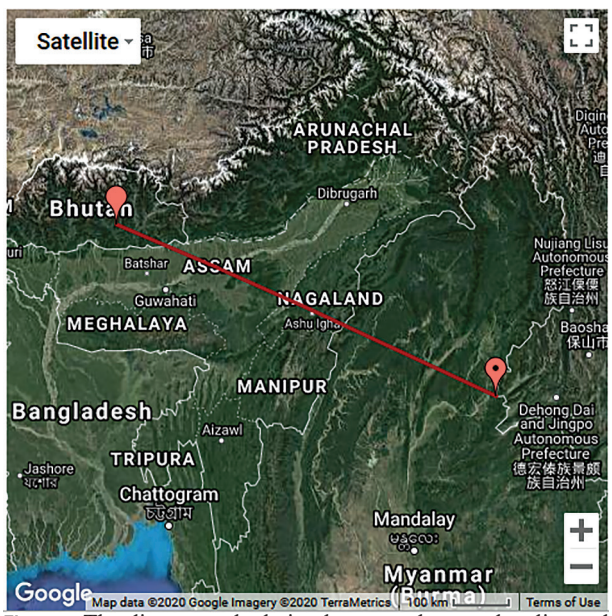

Figure 5. The distance calculation between the type locality and the current location of *Raorchestes andersoni.*

frog hopped before being caught were *Dichora febrifuga*, *Melissa axillaries*, *Impatiens pseudo-lavigata*, *Elatostema sessile*, *E. himalayana, Piper suipigua, Thladianthia cordifolia, Urtica dioca, Viola atego, Rubus calycinus, Sarcopyramis* sp., *Clematis* sp. And plenty of *Diplazium* spp.(ferns). Our preliminary observation shows that the species likes thick forests with abundant bushes that hold a lot of moisture.

Weather and climate. The highest daily maximum temperatures recorded at Zhemgang when the frog was first spotted in May 2020 was 24.5 °C, while the minimum was 9 °C which averages to 17.5 °C. the highest daily rainfall recorded at Zhemgang in May 2020 was 101.6 mm, with the total rainfall for the month being 374.9 mm (https://www.nchm.gov.bt/).

Conservation. In the Red List of the International Union for Conservation of Nature (IUCN), the species is categorised as Least Concern (Van Dijk et al. 2004), while the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) does not list it. Unfortunately, the species does not receive any protection as no amphibians are listed either for protection or use in Bhutan. However, the habitats are well protected because of which animals are deemed safe. The photo at the study site (Figure 4) show that this species was discovered in a moist pristine forest protected by the Kingdom as a

Table 1. Morphological characters that distinguish *R. andersoni* from other *Raorchestes* species in the region (Adopted/adapted from Wu et al. 2021)

Character	*R. dulongensis*	*R. menglaensis*	*R. longchuanesis*	*R. cangyuanensis*	*R. parvulus*	*R. gryllus*
SVL of male (mm)	15.0–19.0	16	17.8–21.2	16.1–20.0		25.0–27.0
HDL/HDW	HDL>HDW	HDL almost equal with HDW	HDL almost equal with HDW	HDW>HDL	HDW>HDL	HDW>HDL
Tympanum	Distinct	Indistinct	Distinct	Distinct	Distinct	Indistinct
Nuptial pad	Absent	Present	Present	Present		
Vocal sac	External single subgular vocal sac	Internal single subgular vocal sac	External single subgular vocal sac	External single subgular vocal sac		A large subgular vocal sac
Finger web	Absent	Absent	Absent	Absent	Absent	A rudiment of a web between the two outers
Toe web	Rudimentary webbing	Rudimentary webbing or 1/4 webbing	1/4 webbing	Rudimentary webbing	Webbing present, medium	A little more than half webbing
Inner metacarpal tubercle	Present	Present	Present	Present	Present	
Outer metacarpal tubercle	Present	Present	Present	Present	Present	
Inner metatarsal tubercle	Present	Present	Present	Present	Present	Present
Outer metatarsal tubercle	Absent	Present	Absent	Absent	Absent	Present
Relative toe lengths	I<II<V<III<IV	The third and fifth toes almost equal in length, or fifth toe slightly longer	The third and fifth toes almost equal in length	I<II<V<III<IV	I<II<III<V<IV	
Range	Gongshan, Yunnan, China	Mengla, Yunnan, China	Gaoligong Shan and Hengduanshan mountains, Yunnan, China; Lai Chau, Vietnam	Cangyuan, Yunnan, China	Indochina Peninsula and peninsular Malaysia	South Annam and Tonkin, Vietnam; Sepian, Boloven Highlands, Champasak Province, Laos

Table 1. (continued)

Character	*R. rezakhani*	*R. andersonii*	*R. annandalii*	*R. manipurensis*	*R. sahai*	*R. shillongensis*
SVL of male (mm)	18.9–20.9	24	16	25	25.0–26.0	10.0-20.0
HDL/HDW	HDW>HDL	HDW>HDL	HDW>HDL	HDW>HDL	HDW>HDL	HDW>HDL
Tympanum	Indistinct	Distinct	Distinct	Distinct	Distinct	Distinct
Nuptial pad	Absent					
Vocal sac	Vocal sac single, subgular, translucent	Internal single subgular vocal sac	A large subgular vocal sac			Males with large vocal sac
Finger web	Absent	Absent	Absent	Rudimentary webbing	Absent	Absent
Toe web	Webbing moderate, formula: I2-2+II1¾- 2+III1½-3IV2¾-2-V	Rudimentary webbing or 1/3 webbing	Webbed at the base	Almost 2/3rd webbed	Nearly half-webbed	A very indistinct rudiment of web present between the fourth and fifth
Inner metacarpal tubercle	Absent	Present	Present			
Outer metacarpal tubercle	Absent	Present	Present			
Inner metatarsal tubercle	Absent	Present	Absent	Present		Indistinct
Outer metatarsal tubercle	Absent	Absent	Absent	Absent		Present
Relative toe lengths	I<II<V<III<IV	I<II<IV	I<II<III<V<IV			I≤II<V≤III<IV
Range	Northeastern Bangladesh	Northeast India, North Myanmar, Southeast Tibet and Yunnan, China	Himalayas and northeastern India	Churachandpur district, Manipur, northeastern India	Eastern Himalayas	Khasi Hills in the region of Shillong, Meghalaya, northeastern India

biological corridor (which has a special conservation status) that connects two protected areas of Bhutan. Also, the country with a majority of Buddhism followers considers the killing of any animals a sin and thus, the animals can be considered to be safe in Bhutan.

Distribution. The species is so far not known from other areas of Bhutan other than the current spot. Outside Bhutan, the species is known to occur in the northeast Indian states of Arunachal Pradesh (Sarkar & Ray 2006), Assam, Meghalaya, Mizoram and Nagaland (Sen & Mathew 2009). The species is also reported from northern Myanmar and south-eastern Tibet (Yingjiang County), Yunnan, China.

Since the species is lacking information on its ecology, nothing much can be discussed until more research is conducted. However, on the list for the country, it is the fifth formal species of *Raorchestes,* the others being *R. annandalii*, *R. longchuanensis, R. menglaensis* and *R. shillongensis* (Wangyal et al. 2020). However, with the ever-changing taxonomy due to the influence of molecular studies, the species gets placed in a new genus and specific epithet from time to time.

Amphibians are not the conservation priority of the Kingdom of Bhutan, but the people do not harm animals of any taxon unless it is a real threat. The majority of Buddhist followers do not think it is correct to kill any animal. Thus, the animals (in any group or taxa) are safer in Bhutan than in other countries. Although protected by the societal concept, the problem is the lack of data to conserve and monitor this species. Thus, research is important for this group of animals.

This is the first record of *Raorchestes andersoni* which adds value to the biodiversity of the country. Studies on this species must be initiated to understand its systematic status and ecology, to conserve it.

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