

# Unique breeding biology of the recently described Beytell's bullfrog *Pyxicephalus beytelli*

Louis H. Du Preez<sup>1,2</sup>  | Steven K. Lumpkin<sup>3</sup> | Edward Netherlands<sup>4</sup> | Alan Channing<sup>1</sup>

<sup>1</sup>Unit for Environmental Sciences and Management, North-West University, Potchefstroom, South Africa

<sup>2</sup>South African Institute for Aquatic Biodiversity, Makhanda, South Africa

<sup>3</sup>Rolling Hills Capital, Overland Park, Kansas, USA

<sup>4</sup>Department of Zoology and Entomology, University of the Free State, Bloemfontein, South Africa

## Correspondence

Louis H. Du Preez, Unit for Environmental Sciences and Management, North-West University, Potchefstroom 2520, South Africa.

Email: [louis.dupreez@nwu.ac.za](mailto:louis.dupreez@nwu.ac.za)

## Abstract

At the time of the recent description of Beytell's bullfrog (*Pyxicephalus beytelli*), no information about the breeding biology of this frog was known to science. The intensive publicity in the social media that followed this description caught the eye of a USA-based film maker who incidentally recently filmed the breeding biology of this frog in the Okavango Delta in northern Botswana. This paper is based on these observations.

## Résumé

Au moment de la description récente de la grenouille-taureau de Beytell (*Pyxicephalus beytelli*), aucune information sur la biologie de la reproduction de cette grenouille n'était connue de la science. La publicité intensive sur les réseaux sociaux qui a suivi cette description a attiré l'attention d'un réalisateur américain qui par hasard a récemment filmé la biologie de la reproduction de cette grenouille dans le delta de l'Okavango, dans le nord du Botswana. Le présent document est basé sur ces observations.

## 1 | INTRODUCTION

The recently described Beytell's bullfrog (*Pyxicephalus beytelli* Du Preez, Netherlands, Rödel & Channing, 2024) is the largest frog described in more than a century. It remains a mystery that this striking frog with blueish blotches on a yellow-olive background remained undetected for so long.

Our current understanding of the breeding biology of bullfrogs is largely based on observations of the giant bullfrog (*Pyxicephalus adspersus*) (see Balinsky & Balinsky, 1954; Cook, 1996; Du Preez & Cook, 2004; Haas, 1999; Kok et al., 1989) and to a lesser extent the African bullfrog (*Pyxicephalus edulis*) (see Braack & Maquire, 2005; Engelbrecht et al., 2015). Bullfrogs are extremely explosive breeders that breed for 1 or 2 days following a big rainstorm. Bullfrogs will only breed in temporary waterbodies and successful breeding requires a pool to retain water for 30 days to allow for metamorphosis to be completed (Du Preez & Cook, 2004).

The breeding biology of Beytell's bullfrog has not yet been documented. The species description as well as the social and printed media coverage, that followed the formal description, sparked interest from the public. One such reaction was from co-author SKL who reported filming Beytell's bullfrog in the Okavango Delta in northern Botswana during February 2024 (Filming Permit ENT 8/36/2 XVII 55, issued by the Republic of Botswana Department of Wildlife and National Parks). What we report on in this paper is based on the film material captured by SKL. As the observations were made within a national park, SKL was not allowed exit of his vehicle and thus all observations were thus made from within a vehicle.

## 2 | OBSERVATIONS

Observations were made periodically over a period of 21 days.

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](https://creativecommons.org/licenses/by-nc-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2024 The Author(s). *African Journal of Ecology* published by John Wiley & Sons Ltd.

## 2.1 | Acoustics

On 13 January 2024, at least 100 mm of rain fell before midnight in the Moremi Game Reserve in northern Botswana. The following morning at 7:30 a.m. at a roadside pool near First Bridge (19.285833°S, 23.381111°E) a number of Beytelli's bullfrogs were observed. Over an extensive area of at least 5000 m<sup>2</sup>, it was estimated that more than a hundred male bullfrogs were calling. Although an individual's call is not loud, with a mean dominant frequency of 198.8 Hz (Du Preez et al., 2024) (Figure 1), the noise produced by the entire chorus could be heard over a distance of several hundred meters.

## 2.2 | Male–male aggression

Dominant brightly coloured males (Figure 2a) were observed to chase off any intruding males. Whenever a dominant male observed other males approaching, he would launch himself at the intruder. Subordinate males would immediately flee and often moved away without instigation by the dominant male. No instances where dominant males would bite or grab intruders were observed. As observations were made from within a car, we do not know whether other dominant males were present and if present, what the distance between dominant males was.

## 2.3 | Amplexus and spawning

Females were much smaller than males, lacking the bright yellow colouration of the males and were olive-brown in colour with protruding narrow-set eyes (Figure 2b). They would approach the male from the front. In some instances, the female would pause briefly right in front of the male, sometimes touching the male face-to-face (Figure 2c), before moving head first in under the male while in other instances the female would simply swim or walk directly under the male. The male would instantly position himself over the female and

grab her in an axillary amplexus (Figure 2a). The female would extend her hind legs to raise her cloaca above the water (Figure 2d). Every few seconds she would move her cloaca from side to side followed by releasing a batch of eggs. Eggs are probably fertilised by the male even before they enter the water. The eggs do not sink but float to form a carpet of eggs at the surface (Figure 2d). Breeding activity of a dominant male lasted for over an hour during which the dominant male amplexed with numerous females. Following the spawning event large carpets, of eggs were observed in the area.

## 2.4 | Tadpoles and metamorphs

The section of the pool where the spawning event was documented dried up within a week and no tadpoles survived. At another pool, nearby, that retained water for a longer period, 6 days later on 19 January 2024, several dense schools of tadpoles were observed schooling at the periphery in very shallow water (Figure 3a). Tadpoles developed rapidly (Figure 3b) and were observed to feed on debris and to return to the surface to gulp air. Twenty-one days after the spawning event on 2 February 2024 large numbers of metamorphs were observed at the water's edge, many of them still with remnants of their tails (Figure 3c). Cannibalism by the metamorphs was not observed.

## 2.5 | Predation

Several herons (*Ardea* spp.), marabou storks (*Leptoptilos crumenifer*) and rock monitors (*Varanus albigularis*) were observed to prey on the adult bullfrogs. No predation of metamorphs was observed.

## 3 | DISCUSSION

Bullfrogs typically have a fairly soft call (Du Preez et al., 2024). Bullfrogs calling and breeding in the daytime following a big rain

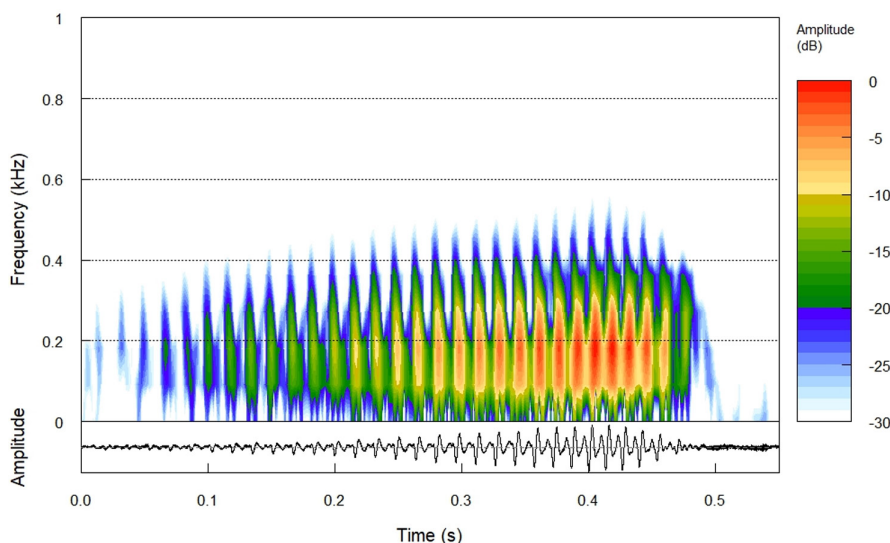


FIGURE 1 Spectrogram of a call of *Pyxicephalus beytelli*.

**FIGURE 2** *Pyxicephalus beytelli* breeding. (a, b) Amplecting pairs; (c) Female approaching a male; (d) spawning, eggs floating on surface.



downpour has been documented for *P. adspersus* (see Balinsky & Balinsky, 1954; Cook, 1996; Haas, 1999; Kok et al., 1989; Yetman & Ferguson, 2011a) and *P. edulis* (see Braack & Maquire, 2005; Du Preez & Carruthers, 2009, 2015; Engelbrecht et al., 2015).

The time of the breeding event as observed for *P. beytelli* is in line with other bullfrogs. Channing (2001) stated for *P. adspersus* that breeding takes place in the daytime with spawning between 0700 and 1600h. Diurnal breeding has also been documented for *P. edulis* (see Braack & Maquire, 2005; Engelbrecht et al., 2015).

Male aggression, where a dominant male chases off subordinate males with severe fighting and biting has been well documented for *P. adspersus* (see Balinsky & Balinsky, 1954, Cook, 1996, Haas, 1999, Kok et al., 1989, Yetman & Ferguson, 2011a) and for *P. edulis* (see Braack & Maquire, 2005; Cook & Minter, 2004; Engelbrecht et al., 2015). Yetman & Ferguson (2011a, 2011b) reported up to 500 *P. adspersus* males at a breeding event and stated that the number of males participating in the breeding event directly correlates with the amount of rain preceding the event. This is in line with what was observed for *P. beytelli*. Although it was not possible to count the number of frogs as the observations were made within a national park and SKL was thus not allowed to get out of his vehicle, based on the density of calling males and the area over which the frogs called there probably were several hundred males present.

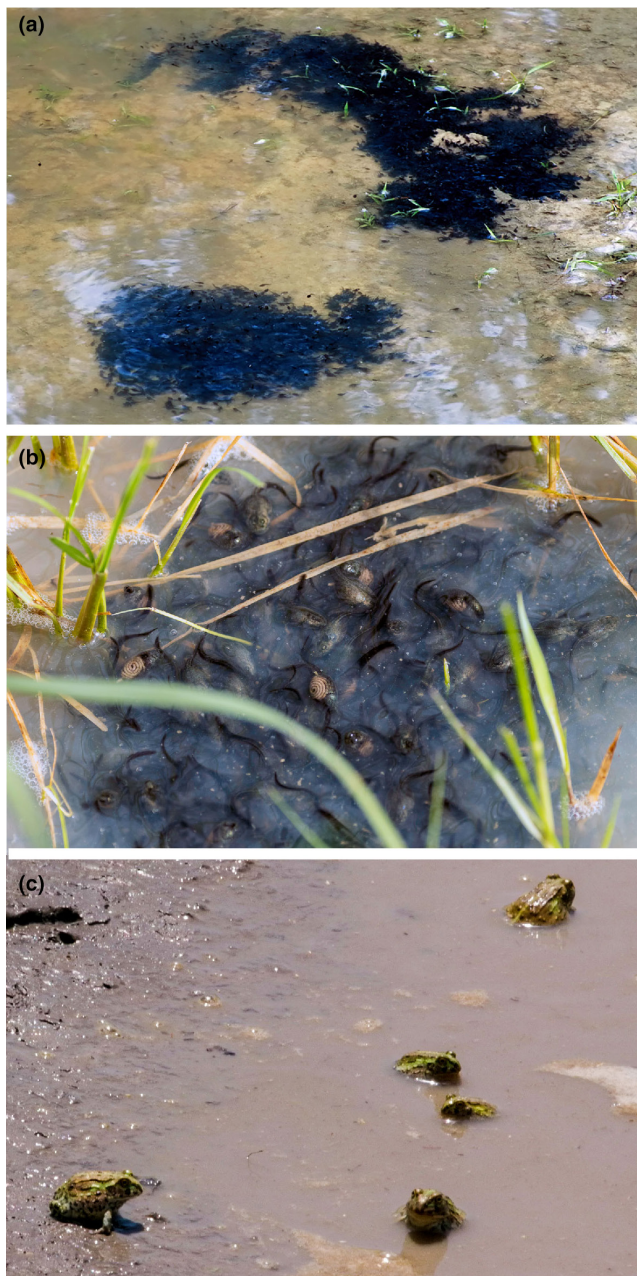
Cook (1996) reported three size-related breeding strategies for *P. adspersus*, namely that of territorial, non-territorial and satellite males. The evidence provided here confirms territorial behaviour for *P. beytelli* with subordinate males being chased off, however severe fighting including biting and flipping the opponent in the air has not been observed for *P. beytelli*. Satellite males intercepting females and leks of fighting non-territorial males as reported for *P. adspersus* (see Cook, 1996; Du Preez et al., 2024) was not observed in the available film footage by SKL. The presence of these different modes of breeding behaviour cannot be ruled out for *P. beytelli* but remains

to be investigated. As with *P. adspersus* and *P. edulis*, the dominant males of *P. beytelli* would raise themselves high on their front legs to display the vibrant yellow colour of the chest and front legs. This physical display is often enough to scare off subordinate males.

The mode of egg deposition, where the female extends the hind legs to raise the cloaca above the water level, has been documented for *P. adspersus* (see Balinsky & Balinsky, 1954; Channing et al., 1994; Cook, 1996; Grobler, 1972; Haas, 1999; Kok et al., 1989) and *P. edulis* (see Channing et al., 1994; Engelbrecht et al., 2015). Eggs are fertilised even before entering the water, a process ensured by the female rubbing her cloaca against the belly and inner thighs of the male.

Floating of eggs on the surface has never before been reported for bullfrogs. The authors have observed many breeding events of *P. adspersus* and *P. edulis*, where the eggs immediately sink to the bottom and soon become covered in dirt. In southern Africa, floating eggs have been reported for species of puddle frogs (*Phrynobatrachus*) and grass frogs (*Ptychadena*). Oxygenation of eggs is important and as eggs develop the demand for oxygen increases (Salthe & Mecham, 1974). Laying eggs as a film on the surface is an adaptation to meet specific oxygen needs (Moore, 1940). While cool water contains higher concentrations of oxygen, hotter water has a lower oxygen tension. Laying eggs as a film on the surface, as observed for *P. beytelli*, may thus be an adaptation to the extremely hot conditions where this species occurs.

Predation on bullfrogs has been reported before and includes yellow-billed kite (*Milvus aegyptius*), marabou stork, saddle-billed stork (*Ephippiorhynchus senegalensis*), yellow-billed egret (*Ardea brachyrhyncha*), grey heron (*Ardea cinerea*), black-headed heron (*Ardea melanocephala*), water monitor (*Varanus niloticus*) and rock monitor (*Varanus albicularis*) (see Branch et al., 2015; Engelbrecht et al., 2015). In the Kruger National Park in South Africa, during a breeding event of *P. edulis* Madeleen van Schalkwyk observed an African civet (*Civettictis civetta*) feasting on adult bullfrogs (Du Preez



**FIGURE 3** (a) Dense aggregations of *Pyxicephalus beytelli* tadpoles; (b) tadpoles stay in the very shallow periphery of the waterbody; (c) metamorphs at the water's edge.

& Carruthers, 2015). The African civet located the bullfrogs underwater by positioning its nose underwater and moving its head from side to side. Predation on *P. beytelli* reported here is thus in line with what we know of the genus.

Harvesting of bullfrogs for human consumption has been reported for Mozambique (Channing et al., 1994), Botswana (Turner, 1987), northern Namibia (Hatutale, 2022; Okeyo et al., 2015), Angola (Du Preez et al., 2024) and South Africa (Badenhorst et al., 2002; Lord & Baines, 1876; Nelson, 2009). Local trade in bullfrogs where people collect and sell bullfrogs has not been well documented. Du Preez et al. (2024) reported that *P. beytelli* are collected during breeding

events and being sold along the side of the road. It is currently unknown how common this practice is, what numbers of *P. beytelli* are being harvested, and whether this harvesting can be regarded as sustainable.

This observation of a breeding event of *P. beytelli* demonstrates the value of incidental observations by non-scientists, especially in the case of explosive breeders like bullfrogs, which are large and breed during the daytime. The chance for members of the public to record observations is high and has proved to be extremely valuable.

#### ACKNOWLEDGEMENTS

We thank Tiaan Botha for assistance in producing the spectrogram.

#### DATA AVAILABILITY STATEMENT

All data used in this paper were captured in the form of a high-definition film by author S.K. Lumpkin.

#### ORCID

Louis H. Du Preez  <https://orcid.org/0000-0002-3332-6053>

#### REFERENCES

- Badenhorst, S., Plug, I., Pelsler, A. J., & Van Vollenhoven, A. (2002). Faunal analysis from Steinaecker's Horse, the northernmost British military outpost in the Kruger National Park during the South African War. *Annals of the Transvaal Museum*, 39, 57–63.
- Balinsky, B. I., & Balinsky, J. B. (1954). On the breeding habits of the south African bullfrog, *Pyxicephalus adspersus*. *South African Journal of Science*, 51, 55–58.
- Braack, H. H., & Maquire, R. L. (2005). Breeding behaviour in the African bullfrog *Pyxicephalus edulis* Peters, 1854. *African Herp News*, 38, 10–11.
- Branch, W. R., Rödel, M.-O., Marias, J., & Coetzee, J. (2015). Varanidae *Varanus albigularis* Rock monitor, diet. *African Herp News*, 62, 26–27.
- Channing, A. (2001). *Amphibians of central and southern Africa*. Protea Bookhouse.
- Channing, A., Du Preez, L., & Passmore, N. (1994). Status, vocalization and breeding biology of two species of African bullfrogs (Ranidae: *Pyxicephalus*). *Journal of Zoology (London)*, 234, 141–148. <https://doi.org/10.1111/j.1469-7998.1994.tb06061.x>
- Cook, C. L. (1996). *Aspects of the ecology and breeding biology of the African bullfrog, Pyxicephalus adspersus*. Unpubl. MSc dissertation, University of Pretoria.
- Cook, C. L., & Minter, L. R. (2004). *Pyxicephalus edulis* Peters, 1854. In L. R. Minter, M. Burger, J. A. Harrison, H. H. Braack, P. J. Bishop, & D. Kloepfer (Eds.), *Atlas and red data book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB series #9* (pp. 303–305). Smithsonian Institution.
- Du Preez, L. H., & Carruthers, V. C. (2009). *A complete guide to the frogs of southern Africa*. Struik Nature.
- Du Preez, L. H., & Carruthers, V. C. (2015). *A complete guide to the frogs of southern Africa. Digital application*. Struik Nature.
- Du Preez, L. H., & Cook, C. L. (2004). *Pyxicephalus adspersus* Tschudi, 1838. In L. R. Minter, M. Burger, J. A. Harrison, H. H. Braack, P. J. Bishop, & D. Kloepfer (Eds.), *Atlas and red data. Book of the frogs of South Africa, Lesotho and Swaziland. SI/MAB series #9* (pp. 300–303). Smithsonian Institution.
- Du Preez, L. H., Netherlands, E. C., Rödel, M.-O., & Channing, A. (2024). A new bullfrog from southern Africa (*Pyxicephalidae*, *Pyxicephalus*

- Tschudi, 1838). *African Journal of Herpetology*, 73, 61–89. <https://doi.org/10.1080/21564574.2023.2296654>
- Engelbrecht, D., Mashao, M., & Halajian, A. (2015). Notes on the breeding behaviour and ecology of edible bullfrogs *Pyxicephalus edulis* Peters, 1854 in the Limpopo Province, South Africa. *Herpetological Notes*, 8, 365–369.
- Grobler, J. H. (1972). Observations on the amphibian *Pyxicephalus adspersus* Tschudi in Rhodesia. *Arnoldia*, 6, 14.
- Haas, A. (1999). Larval and metamorphic skeletal development in the fast-developing frog *Pyxicephalus adspersus* (Anura, Ranidae). *Zoomorphology*, 119, 2335. <https://doi.org/10.1007/s004350050078>
- Hatutale, M. N. (2022). *Microbial diversity, nutritional value and antioxidant activity of the edible giant African bullfrog (Pyxicephalus adspersus Tschudi, 1838) meat from Oshana region of Namibia*. MSc dissertation, University of Namibia, Windhoek.
- Kok, D., Du Preez, L. H., & Channing, A. (1989). Channel construction by the African bullfrog: Another anuran parental care strategy. *Journal of Herpetology*, 23, 435–437. <https://doi.org/10.2307/1564060>
- Lord, W. B., & Baines, T. (1876). *Shifts and expedients of camp life, travel and exploration*. Horace Cox.
- Moore, J. A. (1940). Adaptive differences in the egg membranes of frogs. *American Naturalist*, 74, 89–93. <https://doi.org/10.1086/280874>
- Nelson, C. (2009). An archaeozoology of the Ndzundza Ndebele in the Steelpoort river valley, Mpumalanga, South Africa, c. 1700 AD–1883 AD. *South African Archaeological Bulletin*, 64, 184–192.
- Okeyo, D. O., Kandjengo, L., & Kashea, M. M. (2015). Harvesting and consumption of the giant African bullfrog, a delicacy in northern Namibia. In K. C. Chinsembu, A. Cheikhoussef, & D. Mumbengegwi (Eds.), *Indigenous knowledge of Namibia* (pp. 205–218). University of Namibia Press.
- Salthe, S. N., & Mecham, J. S. (1974). Reproductive and courtship patterns. In B. Lots (Ed.), *Physiology of the amphibians Vol. II* (pp. 309–521). New York Academic Press.
- Turner, G. (1987). Hunters and herders of the Okavango Delta, northern Botswana. *Botswana Notes Research*, 19, 25–40.
- Yetman, C. A., & Ferguson, J. W. H. (2011a). Spawning and non-breeding activity of adult giant bullfrogs (*Pyxicephalus adspersus*). *African Journal of Herpetology*, 60, 13–29. <https://doi.org/10.1080/21564574.2010.550324>
- Yetman, C. A., & Ferguson, J. W. H. (2011b). Conservation implications of spatial habitat use by adult giant bullfrogs (*Pyxicephalus adspersus*). *Journal of Herpetology*, 45, 56–62. <https://doi.org/10.1670/09-186.1>

**How to cite this article:** Du Preez, L. H., Lumpkin, S. K., Netherlands, E., & Channing, A. (2024). Unique breeding biology of the recently described Beytell's bullfrog *Pyxicephalus beytelli*. *African Journal of Ecology*, 62, e13311. <https://doi.org/10.1111/aje.13311>