SALAMANDRA **51**(2) | 209–211 | 30 June 2015 | ISSN 0036–3375

Correspondence

To have a frog in the throat: micro-CT imaging of anuran prey in *Ceratophrys ornata* (Anura: Ceratophryidae)

Thomas Kleinteich

Christian-Albrechts-Universität zu Kiel, Funktionelle Morphologie und Biomechanik, Am Botanischen Garten 9, 24118 Kiel, Germany

e-mail: tkleinteich@zoologie.uni-kiel.de

Manuscript received: 21 May 2014
Accepted: 11 July 2014 by Alexander Kupfer

Frogs of the genus *Ceratophrys* are sit-and-wait predators that feed on a variety of different prey types, including spiders, insects, crabs, annelids, but also vertebrates like snakes, lizards, rodents, and other frogs (Duellman & Lizana 1994). Among amphibian pet keepers, *Ceratophrys* spp. are often referred to as pac-man frogs on account of their ability to consume vast amounts of prey as well as relatively large prey items. Chávez et al. (2011) reported on an individual of *C. cornuta* preying upon *Leptodactylus dydimus* (Anura: Leptodactylidae) that was approximately two thirds of its own snout–vent length. To overcome large prey, *Ceratophrys* spp. have wide mouths and heavily ossified skulls (Lynch 1971, 1982, Wild 1997). However, besides of them being able to overcome and capture large prey items, it is critical for these frogs to fit large and bulky prey objects into their body cavity. Here I provide a first description on how large anuran prey is placed inside the body of a frog of the genus *Ceratophrys* by using micro-CT imaging.

The specimen described herein is a 70 mm (snout–vent length) female *Ceratophrys ornata* housed in the herpetological collections of the Zoologisches Museum Hamburg, Germany (ZMH A11917). Unfortunately, this specimen lacked locality and collection information. Most likely the specimen was kept in captivity, either by a private person or a zoo, before it was donated to the ZMH. I scanned the entire specimen using a Skyscan 1172 desktop micro-CT scanner (Bruker micro-CT, Kontich, Belgium) at a resolution of 26.6 µm. Due to limitations in the field of view of the micro-CT scanner, a small part of the distal aspect of the pelvic region was excluded from the micro-CT scan (Figs 1A–C). To be able to visualize soft tissues with the micro-CT scanner, I used 1% Lugol's iodine-potassium iodide solution as a contrast agent, following the protocol suggested by Metscher (2009) but with a staining time of three weeks. The specimen was scanned in distilled water.

In the resulting micro-CT dataset, I identified a second frog inside the digestive tract of the *Ceratophrys ornata* specimen (Figs 1A–C). By using the 3D analysis and visualisation software package Amira 5.4.3, I virtually separated the prey frog from the *C. ornata* to visualise the prey specimen separately for estimating volume measurements. The volume of the *C. ornata* was 52.26 cm^3. From this volume, 11.04 cm^3 (21.1%) were occupied by the prey item. However, it should be noted that the volume of the *C. ornata* specimen is slightly underestimated because the caudal tip of the frog was not part of the micro-CT scan (Figs 1A–C). The prey frog had been swallowed head-first and its head was positioned in the caudal region of the *C. ornata*'s abdomen. The prey had a curved body posture; the dorsal face of the prey was bent from the midline of the pelvis along the left body wall of the *C. ornata*. The left hind leg of the prey frog was extending rostrally through the oesophagus to the buccal cavity of the *C. ornata*; the left foot was lying on top of the tongue.

After micro-CT imaging, I dissected the *Ceratophrys ornata* specimen to remove the prey frog from its digestive tract (Figs 1D–F). I identified the prey frog as a juvenile individual of *Lithobates pipiens* (Ranidae). This is vague however, because the natural distributions of *C. ornata* in South America (Kwet et al. 2004) and *Lithobates pipiens* in North America and Panama (Hammerson et al. 2004) do not overlap, but *L. pipiens* is widely available in the international amphibian trade as a laboratory animal (Woodhams et al. 2008). Unfortunately, without any background on where the *C. ornata* specimen originated from, this

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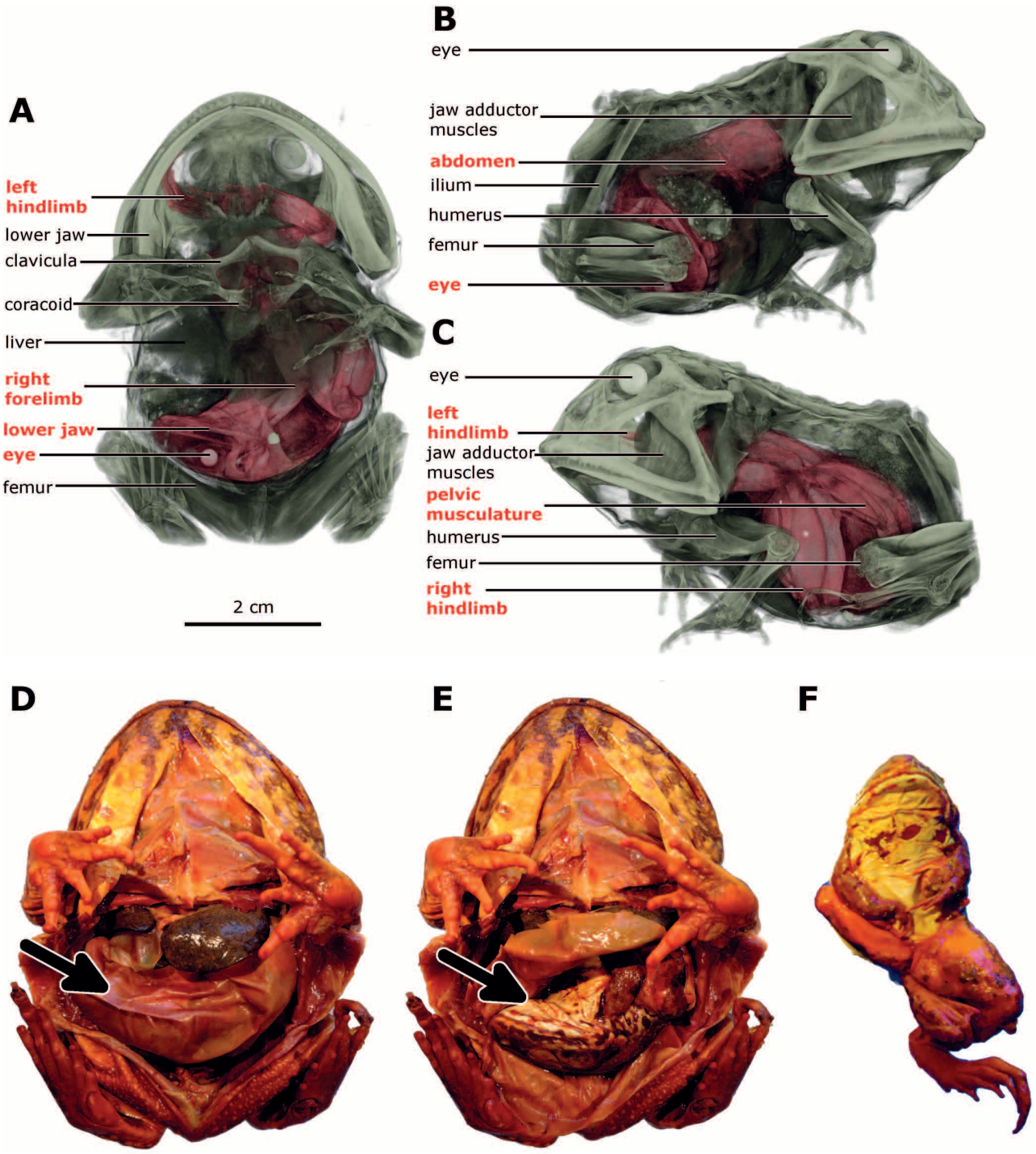


Figure 1. A–C) Micro-CT images of the prey frog inside the *Ceratophrys ornata* specimen. A) ventral view; B) lateral view from the right; C) lateral view from the left. To visualize the prey object, the *C. ornata* specimen is rendered slightly transparent; the prey frog is virtually stained red, structures belonging to the prey are labelled in red and bold face. The prey occupies a large volume of the abdomen. The position of the prey is curved; the dorsal face of the prey pushes against the left body wall of the *C. ornata*. The left hind leg of the prey extends through the oesophagus to the buccal cavity of the *C. ornata* specimen. The caudal tip of the frog is cut-off in the micro-CT scan due to limitations in the field of view of the micro-CT scanner. D–F) Dissection of the *Ceratophrys ornata* specimen in ventral view. The brownish colour of the specimen is caused by the Lugol's solution that was used as a contrast agent for micro-CT imaging. D) The abdomen of the frog is opened. The arrow points to the stomach. E) The stomach is opened. The head of the *Lithobates* sp. is visible (arrow). F) *Lithobates* sp. after it has been removed from the digestive tract of the *C. ornata* specimen. The left hind leg was slightly stretched inside *C. ornata*.

identification is tentative and I prefer to refer to the prey specimen as *Lithobates* sp.

The *Lithobates* sp. had a snout–vent length of 43 mm and a body mass of 8.65 g. The body mass of the *Ceratophrys ornata* specimen after removal of the prey was 33.48 g, which results in a prey/predator weight ratio of 0.26. However, due to the prior fixation and storage of the animals in ethanol, the mass values measured herein may only be used as estimates for the in vivo conditions of the specimens. The prey frog was in excellent condition with only minor ruptures along its ventral side (Fig. 1F). The relative size of the *Lithobates* sp. is roughly similar to the prey size given by Chávez et al. (2011). Furthermore, Chávez et al. (2011) described that the prey was "in a semicircular position inside the frog's stomach". While the same general position of the *Lithobates* sp. was found in the present case, my observations differ in that parts of the prey were still in the buccal cavity. It is well possible that the position of the left hind leg of the *Lithobates* sp. interfered with the breathing in the *C. ornata* specimen. Furthermore, movements of the hyoid, which are important for feeding and breathing (De Jongh & Gans 1969, Emerson 1977), might have been impeded by the position of the prey's leg in the buccal cavity. The condition of the *Lithobates* sp. suggests that the *C. ornata* specimen died shortly after it had consumed the prey frog. Although, the exact cause of death of the predator cannot be reconstructed without any doubt herein, it might be possible that swallowing this relatively large prey specimen proved lethal in the end.

Acknowledgements

I wish to thank Alexander Haas and Jakob Hallermann (both Zoologisches Museum Hamburg) for facilitating access to the *Ceratophrys ornata* specimen described herein. Furthermore, I am grateful for the support received by Stanislav N. Gorb and the Functional Morphology and Biomechanics group at Kiel University. My research on feeding in amphibians is funded by the German Research Foundation (DFG grant KL 2707/2-1).

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