

Crocodile Tears: And thei eten hem wepynge

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Whether crocodiles shed tears while eating has been fodder for fable and controversy for hundreds of years. We present the first unequivocal evidence that crocodilians lacrimate during meals and that they do so in a peculiar fashion.

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In mythology, tears of the crocodile are attributed to feigned sorrow. While the exact origins of this fancy are unknown, references date to 340 CE (Seckersen 1979). This crocodilian remorse is considered insincere because the crocodile continues to gobble its prey. *The Voyage and Travel of Sir John Mandeville*, a book distributed widely around 1400, popularized for the general public the picture of the crocodile tearfully consuming humans: “In that contre...ben gret plentee of cokodrilles.... These serpentes slen men, and thei eten hem wepynge” [In that country be a great plenty of crocodiles....These serpents slay men, and they eat them weeping] (<http://etext.library.adelaide.edu.au/h/hakluyt/voyages/mandeville/complete.html>; Seckersen 1979).

That crocodiles shed tears while eating was accepted widely until the early 1700s, when John Scheuchzer, a physician and naturalist in Zurich, wrote: “The foundations and substance of this famous old tale are so feeble that today we would be well advised to do without it” (Guggisberg 1972). George Johnson examined these foundations most recently (Johnson 1927). After applying a mixture of onion and salt directly to the persistently dry eyes of four species, he concluded that “the popular notion of Crocodiles shedding tears is entirely a myth.”

At approximately the time of Johnson’s investigation, F. A. Bogorad, in Russia, named a human neurologic syndrome “the symptom of crocodile tears” (Seckersen 1979). Upon eating, profuse, involuntary tears pour from the affected eye of some individuals afflicted with facial palsy. Bogorad invoked a theory of “parareflexes” to explain the medical phenomenon. He claimed, after André Thomas, that defects in a newer phylogenetic system might lead to the appearance of older phylogenetic reflexes (Seckersen 1979). In other words, the human facial weakness allowed older, possibly crocodilian neurological pathways to emerge. This hypothesis presumes that crocodilians lacrimate while eating. Our investigation of this human ailment prompted us to pursue the biological basis of the crocodilian metaphor and its underlying scientific theory.

On 22 March 2006, we digitally filmed seven crocodilians—two common caimans (*Caiman crocodilus*), two Yacare caimans (*Caiman yacare*), and three American alligators (*Alligator mississippiensis*)—as they were fed. Other species within the order Crocodylia, such as crocodiles and gharials, were not examined. Five of the seven crocodilians developed moisture in their eyes, bubbles, or overflow bubbles within minutes before, during, or after eating (figure 1). One Yacare caiman and one common caiman did not lacrimate.

All animals used in the study had been trained to move to feeding stations, where they were out of the water and relatively dry. We fed them dried foods (chicks, quail, and a pelletized alligator food biscuit made by Mazuri Feeds). We perceived no environmental effects that might account for moisture in the eyes from any source other than ocular secretions. One of the common caimans developed a small patch of foam in the rostral canthus of its left eye 40 seconds after it began to feed; the foam dissipated over the next 20 minutes. A Yacare caiman developed small bubbles in the right eye within 15 seconds of receiving its first dry food. This animal was agitated, hissing, and snapping before it began to feed. With continued feeding, no additional lacrimation or bubbles were seen.

All three American alligators produced tears. A 3.4-meter (m) male developed small bubbles in the left eye 64 seconds after receiving the first quail. The eye was also moist around the lids. The right eye demonstrated bubbling 2 minutes and 18 seconds after the alligator began to feed. A 3.5-m male American alligator witnessed the feeding of the above-

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Figure 1. Bubbles in the eyes of “Bomber,” a 4.1-meter-long male American alligator. Bubbles formed as researchers approached the alligator with food. The photo was taken 2.75 minutes after the first feeding in the trial. Photograph: Kent A. Vliet.

mentioned alligator and may have anticipated being fed. This alligator already had small bubbles in its right eye and obvious glistening in its left eye before it began feeding. It emitted a low growl as we approached with the food. Two minutes and 5 seconds after feeding on five biscuits, fluid appeared in its left eye. Three minutes and 25 seconds after the animal initiated feeding, extensive bubbling began in its right eye. This continued in three or four bouts. The left eye of a 4.1-m male also began bubbling, though to a milder degree, immediately upon our approach, after an aggressive gape but before any audible hiss. This alligator was fed 13 times with biscuits and quail without the bubbles changing in appearance or new bubbles forming. When present in either alligator or caiman, bubbling predominated in one eye, with the jaws closed and without any particular associated jaw movement.

The nasolacrimal duct of crocodylians opens directly into the nasopharynx, near the posterior limit of the preconcha, where it is greatly expanded as a lacrimal sinus (Parsons 1970, Hillenius 2000). The duct is conveyed in a lacrimal bone into the lower eyelid in *Crocodylus porosus*, splitting into two small but distinct ducts in the embryo (Meek 1892, 1911). We speculate that the ebullition of tears results when

air forced from the lungs through the throat and into the nasopharynx drives secretions up the lacrimal duct into the eye. Surfactants or proteins may cause the tears to bubble (Rehorek et al. 2005). One of the authors of this article (K. A. V.) has noted extensive bubbling of tears during aggressive exchanges between adult males and following agonistic social display in the absence of eating. Crocodiles also shed overflow tears unassociated with eating when they have been out of the water for some time (Britton 1995–2003). This latter phenomenon is separate from the behavior and physiology described here.

Whether prandial lacrimal ebullition is a mere epiphenomenon (e.g., a result of anatomic construction) or serves a function in chemoreception or lubrication remains to be determined. The theory of “parareflexes” has not been negated by these findings. Physicians and biologists may continue to refer to the “symptom of crocodile tears,” confident of its biological basis.

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