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The elephant pharyngeal pouch — was the mystery resolved?

by Jeheskel Shoshani with comments by Joseph P. Dudley

In response to the article published in Trends in Ecology and Evolution (1998; reference below), Joseph P. Dudley (e-mail message, March 12, 1999), provided an alternative explanation to the one given in the article. Detailed description and function of the pharyngeal pouch in elephants was first given by Watson (1875). Shoshani et al. (1997) provided additional descriptions, including anatomical specifics and suggested mechanism for the function of this pouch — it serves as a receptacle for water that the elephants spray on themselves in time of stress, e.g., hot weather. Shoshani’s (1998) paper included a summary of Shoshani et al. (1997) article, with a new illustration depicting the pouch filled with water, see figure on page 76.

Joseph P. Dudley’s alternative explanation to Shoshani et al.’s pharyngeal pouch hypothesis. The volumes of water which I have seen elephants extract from their gullets DE NOVO are inconsistent with the SOLE use of water retained within the pharyngeal pouch in such contexts (too much water used, and the process is repetitive). Also, how could the elephant move around feeding and breathing for several hours without emptying this pouch, or contaminating it with foodstuffs? The pouch function seems, to me, more likely that of a “transfer receptacle” for water siphoned from the stomach. What I think happens is that an elephant seals the esophageal orifice with the trunk tip, inhales to create suction, and removes trunk immediately when water begins to enter trunk. The suction is broken when elephant pulls trunk away, but additional water already flowing in the esophagus spills into the pouch. The elephant sprays off the first load (acquired through direct suction) and then refills out of the pouch for the next go. And then repeats the process.

Shoshani’s response: We do not think an elephant retrieves the water directly from the stomach because:

* When an elephant drinks, some of the water (about one gallon, or four liters, in a mature, fully grown elephant) remains in the pharyngeal pouch. The pouch is surrounded by muscles that can squeeze the opening, thus food and water can pass over the pouch. “Old water”, I believe, is being replaced when the elephant drinks afresh. Otherwise, it remains as “water in a canteen”, ready to be used when in need.

* The liquid that elephants spray on themselves in hot weather if there is no water close by is almost clear; there may be a few pieces of grass, not digested food. These pieces of grass could easily get mixed with the water in the pharyngeal pouch, as it is positioned ventral to the opening to the esophagus.

* I cannot agree or disagree with your suggestion/hypothesis that the pharyngeal pouch functions as “transfer receptacle” for water siphoned from the stomach. Note, however, that the anatomical and behavioral observations made thus far appear to support the hypothesis that the pharyngeal pouch acts as the sole water receptacle to be used for spraying. If an elephant can suck water from its stomach, it would have special anatomical adaptation for such purpose (to keep the water separated or partly separated from the food inside the stomach, because the liquid sprayed is almost clear). Such structures are absent in an elephant whose stomach is simple, not compartmentalized as in bovids or camels. As suggested by M. P. Kahl (see notes below), one way to learn of the source of the liquid is to test its pH. If it is a strong acid with a pH of 3.13 at cranial of stomach and 3.36 at caudal stomach, as it has been reported by Clemens and Maloiy (1982; reference provided by Dr. Raman Sukumar) it would be disadvantageous for an elephant to spray itself with acidic solution on its face, especially on its eyes.

* The flushing with water is repeated, yes, but, we believe not sucked from the stomach, as it was observed that elephants repeat the process of spraying themselves with liquid/water during very brief time intervals [footnotes A, B, C].

Footnotes:

[A]. In 1997, Dr. David Western told J. Shoshani of observations he made in Amboseli National Park, Kenya. During one hot day, elephants were running fast and while on the run, they inserted their trunks into their mouths, withdrew liquid/water and sprayed themselves. They repeated the spraying a few times, with what appears to be only a fraction of a minute between each spray. Western believes that it would be close to impossible, for an elephant to suck water from the stomach under such extreme conditions; the pharyngeal pouch would appear to be a more reasonable source of water while on the run. A similar observation is recounted by Katharine Payne (1998, page 107), when she saw two bull elephants in Damaraland, an arid region of Namibia “Drawing water out of their throats, they had splashed it on their bodies, cooling themselves as they fled”.

[B]. Dr. M. Philip Kahl has observed and filmed African elephants several times in the wild in Zimbabwe spray themselves with liquid after inserting the trunk in the mouth, the entire process [from the instant of inserting the trunk until withdrawing it with the liquid] takes less than 60 seconds. He wrote (email message dated April 4, 1999): << I have never seen quantities too large to have come from the pouch alone. I have not seen it done repeatedly — with so much fluid that one must invoke another source — but that does not mean that it does not happen. It is not always “clear water”, however; I have often seen the “green wash” on the sides of the face and ears that appear to be chewed vegetation. It looks like a coating of “duckweed” [Lemma minor]. This could mean “stomach contents” or just “mouth contents” that found their way into the water in the pouch. There is no easy way to test this. Perhaps spending enough time with captive elephants on a hot day, one could see repetitive spraying in quantities too large to have come from the “canteen” alone. One could also test the pH of the spray on a captive elephant when it occurs. One would expect “stomach contents” to have a much lower pH [pH of the stomach in human is close to 4.0]. Water that never made it below the pouch is close to pH 7.0. >>

[C]. Definite distinction between contents of pharyngeal pouch and stomach was made by Tim Frisco (of Carson & Barnes Circus, Hugo, Oklahoma USA; as related to Sandra Shoshani on July 31, 1999) based on observations of circus elephants, including “Bunny” (“Little water-monger”, female Asian, 31 years old) that will over-drink to the point that she vomits, producing greenish stomach content with food pieces, whereas liquid sprayed from what is believed to be the throat region by other elephants has been clear and more “watery” in its consistency.

LITERATURE CITED


Hannibal and the elephants

compiled by Eleanor C. Marsac — Elephant Research Foundation

Recent correspondence with interested people in the Elephant Listserver, particularly Diane Guerrero, has resurrected our interest in the history of Hannibal of Carthage. Below is a summary of Hannibal’s encounters in crossing the Alps and his battles in Italy and northern Africa, with additional references.

According to Cottrell (1961, p. 46), Hannibal, the young commander of the Carthaginian forces began his famous march against Rome from southern Spain, over the Alps into Italy. He left Cartagena, Spain, in 218 BC with 37 elephants (36 African and 1 Asian), each under its own well-trained mahout. The Asian, “Surus” (meaning Syrian), Hannibal’s personal elephant, was the only elephant that survived to reach Italy. According to Lamb (1958, pp. 79-80), the African elephants were no more than 9 feet in height, and more agile than the 11 foot Asian species [appear to be the Forest African elephants, *Loxodonta africana cyclotis*]. In crossing the Rhône River (France), several mahouts were thrown off the frightened elephants and drowned. The loss must have caused some staff problems, since the mahouts were highly trained men, not easily replaceable (Cottrell, 1961, p. 46). It is said (de Beer, 1969, p. 190) that Hannibal left the Po Valley (Italy) in the spring of 217 BC and crossed the Apennines and into the valley of the Arno (vicinity of today’s Florence, northern Italy, ancient Etruria). “That river was so mightily swollen from the melting of the snow on the Apennines and the spring rains, that the low ground was a marshy swamp, in crossing which the troops suffered great hardships. Livy relates that for four days the army marched through water, unable to find any dry places to bivouac other than piles of baggage or heaps of dead pack-animals. Many died from drowning or of disease, and Hannibal himself caught an infection and lost the sight of one eye” (de Beer, 1969, p. 190). Many elephants died from hunger and fatigue in the mountains, and some of their carcasses were eaten by the troops. In Italy, Hannibal’s army inflicted a series of crushing defeats on Roman armies and roved at large for fifteen years up and down the peninsula and into Sicily. In 208-207 BC, Hannibal’s brother, Hadrabal Barca, left Spain with 32 elephants and arrived in Italy with about 12 (Lamb, 1958, p. 203). Six were killed by the Romans and the rest were captured (Lamb, 1958, p. 207). In 202 BC, during the battle of Zama in North Africa (about five days journey west of Carthage), Hannibal used 80 elephants against Scipio Africanus, and lost the battle. Twenty years later while in Bithynia (Asia Minor, today’s Anatolia, within Turkey), he committed suicide with poison to avoid falling into the hands of the Romans.

**Literature Cited**


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**Items passed through elephants’ digestive systems and a warning**

compiled by Jeheskel Shoshani — Elephant Research Foundation

Much of what an elephant eats (66%), goes through its digestive system undigested (Benedict, 1936, p. 291). Benedict fed his elephant, “Jap”, pieces of inner tube inside bread. When examining for pieces of rubber in her feces, he found that only some had teeth marks. The rest passed through her huge molars untouched. Sever (1982) documents whole oranges passing through elephant digestive systems intact. Elephants in the same captive herd would wait for elephants to defecate and would then insert their trunks up the anus of the defecating elephant to retrieve and eat the oranges. The case reported here is not uncommon. “Karaunda”, a female Asian elephant, swallowed the bolt figured on next page and eliminated it about one week later. It measures 9.0 cm (~4 inches) long, 2.0 cm (~1 inch) in diameter, and weighs 160 grams (5.7 ounces). This bolt was given to J. Shoshani by the late Mr. Axel Gauthier (elephant trainer with Ringling Brothers and Barnum & Bailey Circus=RBBBC), October 15, 1982, when RBBBC was performing at the Joe Louis Arena in Detroit, Michigan. Karaunda once swallowed a small transistor radio “like it was an apple.” Other cases of animals swallowing what to us are inedible items were reported by Hanks (1979, figure on p. 35; same picture appears in Spinage, 1994, p.