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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 camelids. 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 then 60 seconds. He wrote (e-mail 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" [*Lemna 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.

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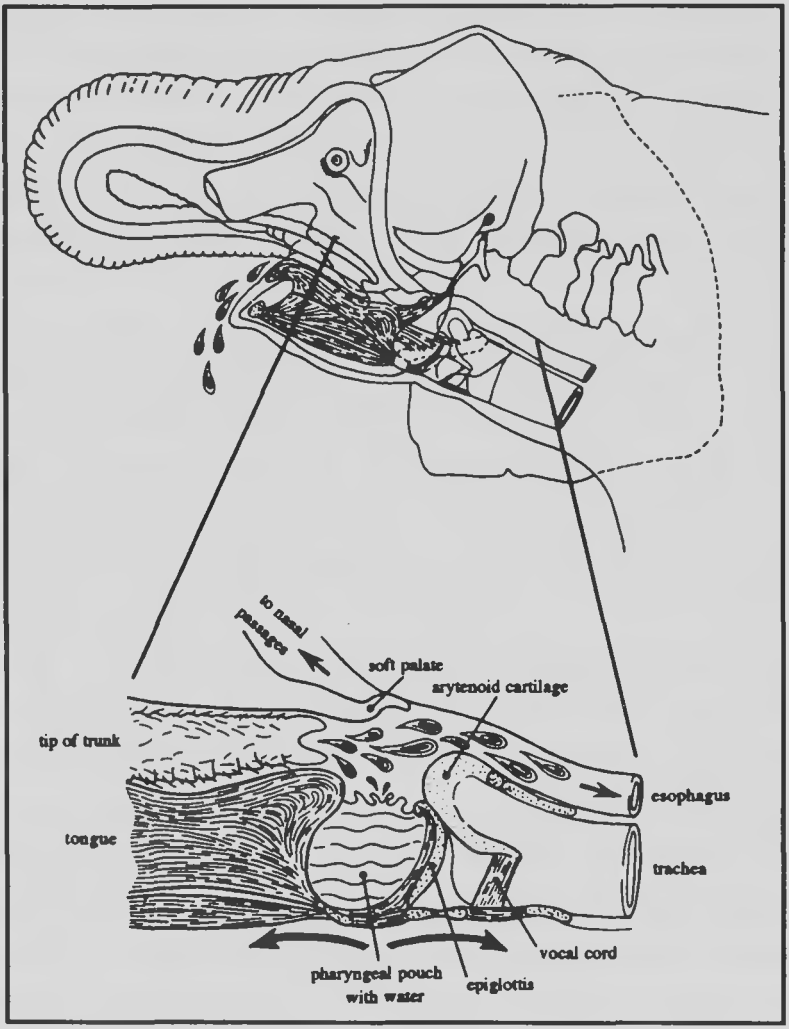

Figure depicting position of the pharyngeal pouch in an elephant with enlargement showing the pouch filled with water [Reprinted from Trends in Ecology & Evolution, Volume 13, Shoshani, J., "Understanding proboscidean evolution: a formidable task", page 485, Copyright (1998), with permission from Elsevier Science].

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