An Introduction to the Ingestion of Stones, Bones, Fossils and Soil by Turtles by M. A. Cohen

While firsthand observations of this phenomenon are rare, the ingestion of external mineral sources such as stones, bones, fossils, and soil by various turtle species has been documented through field research, scat analysis, and radiography.

Some turtle keepers may be unfamiliar with the behavior described in this article, and some may think this article refers to bladder stones, with which many tortoise keepers are familiar. To avoid ambiguity, it is necessary to clarify the concepts.

Bladder stones, known to science as uroliths, are formed internally and are composed of urates, i.e., uric acid waste products. While the exact cause of bladder stones is unknown, two factors—dehydration and too much protein in the diet—are suspected as contributing to the formation of the uroliths.

The focus of this article is external mineral sources found in the environment and ingested by the animals. In a subsequent section of this article, instances of this behavior from the research of the scientific community will be briefly described.

Terminology

geophagia (also known as geophagy): ingestion of soil substrates, often those rich in clay or limestone. Geophagy occurs in humans and other animals, and reasons for this practice vary by species.

lithophagia (a.k.a. lithophagy): ingestion of small stones to aid digestion, among other probable reasons.

osteophagia (a.k.a. osteophagy): ingestion of bones and bone fragments for purposes of mineral supplementation. Osteophagy provides additional calcium, phosphorus, and other minerals to an herbivore whose diet is typically low in these essential minerals.

Ingestion of soil (geophagy)

Geophagy is a behavior known in humans and other animals. As a traditional cultural practice, humans consume soils for various reasons. Pregnant women in some developing countries believe nutrient-rich soils are beneficial to their pregnancies, some religious observances include the ingestion of soils, and, in areas of extreme poverty, residents may consume soils to supplement a meager diet.

Researchers documenting the ingestion of soils in turtle species surmise that this behavior is primarily for mineral supplementation. Analysis of clay soils consumed by pregnant women in Africa reveals that these soils contain nutrients critical to bone formation (Rosenberg, 2018). Turtles may swallow coarse soils such as sand for the same reasons they ingest small stones, i.e., for grinding tough foods, for controlling internal parasites, and as a source of minerals.

Ingestion of stones (lithophagy)

Generally accepted is the fact that the herbivore diet comprises vegetation and seeds that are difficult to digest because herbivores typically lack grinding teeth. The ingestion of small stones that are retained within the digestive tract assists in the breakdown of the tough cell walls of certain foods, rendering the nutrients within the foods available to the animal.

According to Esque and Peters (1994), other theories of stone ingestion include the following: the presence of stones helps to control intestinal parasites, to neutralize toxic properties of plants, and to maintain of a healthy intestinal pH (acidity/alkalinity balance). Turtles possibly absorb essential minerals such as calcium and phosphorus from the swallowed stones.

Gastroliths

Composed of the Greek root words *gastro-* , meaning stomach, and *-lith*, meaning stone, the term "gastrolith" is generally defined as a stone retained within the gastrointestinal tract to aid in the digestion of tough foods.

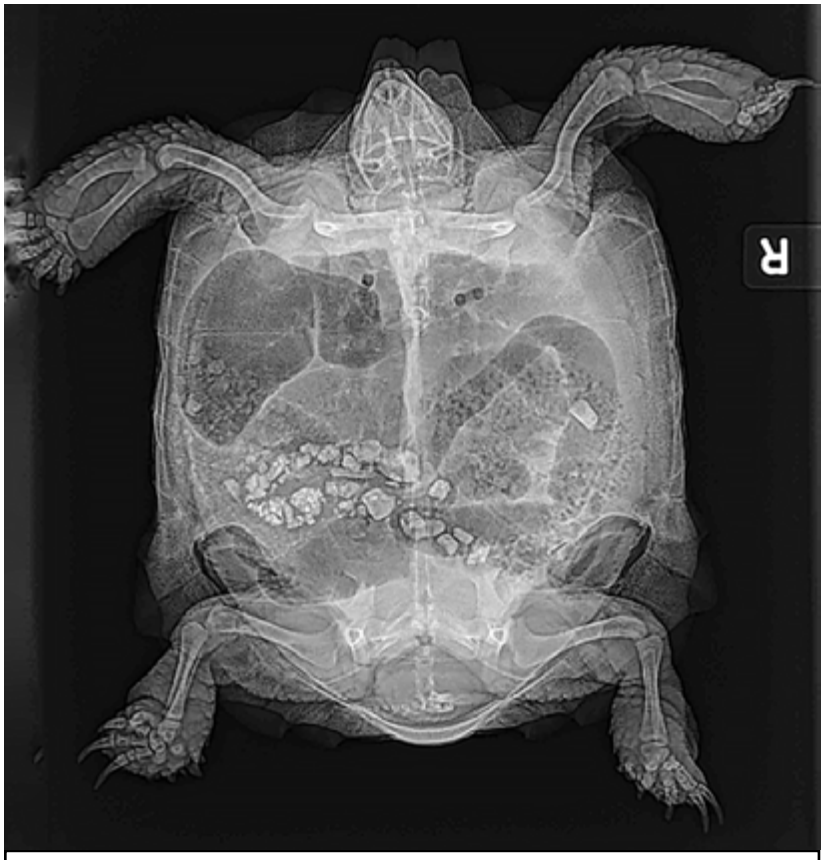
Researchers document that some birds, fish, and reptiles swallow small stones to aid digestion. Researchers also document the ingestion of gastroliths by amphibians and crocodilians, theorizing that, in these cases, the practice serves to control the animals' buoyancy.

Gastroliths, also known as stomach stones or gizzard stones, help to grind tough food items like fibrous vegetation and the hard shells of seeds for herbivores that lack grinding teeth. Scientists have recorded the sizes of gastroliths ranging from sand particles to cobblestones depending on the size of the animal ingesting the gastrolith.

Ingestion of bones and fossils (osteophagy)

Calcium, a vitally important mineral to turtle species, is essential for normal skeletal and shell development. Turtles have exceptionally high calcium requirements because of the amount of bone tissue in their bodies. Female turtles of reproductive age require additional calcium during egg development because both the egg yolk and the egg shell are calcium-rich materials (Yost et al., n.d.).

Osteophagy is the most frequently observed of the three ingestion



X-ray of a large, juvenile male desert tortoise, *Gopherus agassizii*, that swallowed numerous small rocks. The tortoise was turned in to the CTTC Valley chapter by a private party, who had fed the tortoise a diet of kale, radicchio, and Mazuri pellets. The private party kept the tortoise in an enclosure on a substrate of coconut fiber, which the tortoise had apparently been eating.

When the tortoise presented to the veterinarian, it was neither eating nor passing feces. Dr. Kenneth Coscarelli of the **Newbury Park Veterinary Clinic** ordered a diagnostic x-ray, and, following evaluation, recommended a treatment regimen. The treatment included the prescribed medications cisipride and metaclopramide, both of which are used to assist in emptying the stomach and assisting in intestinal motility, plus soaks in warm water.

The diet of the tortoise was also modified to include a chopped salad of organic dandelion greens, a very small amount of organic kale, with some organic iceberg for extra water. To increase the fiber, a small amount of soaked Mazuri pellets made into mush or soaked Bermuda grass hay pellet mush was mixed in with the greens.

By the end of the first week of treatment, four small rocks were passed. It took about two months total to get the rocks completely out.

As of mid-February 2019, this tortoise is in foster care awaiting adoption

behaviors in turtles, and is observed in both wild and captive individuals. Turtles ingest small bones, bone fragments and fossilized bone to supplement their mineral needs. Bones and fossils are rich sources of minerals, not only calcium and phosphorus, but also trace minerals including magnesium, manganese, potassium, selenium, boron, copper, zinc, and many others.

Instances of geophagy, lithophagy, and osteophagy in turtles

Box turtle

Keepers of North American box turtles, *Terrapene* species, have observed osteophagy in their pets (Naish, 2014). Consuming bone fragments and gnawing on larger bones supplement the omnivorous diet of the box turtle with added calcium, phosphorus, and other minerals.

Desert tortoise

Mineral ingestion behavior by the desert tortoise (*Gopherus agassizii*) is well-documented. Esque and Peters (1994) cite instances of mineral ingestion in wild desert tortoises, surmising that this behavior compensates for mineral deficiencies in desert soils and desert plants.

While all desert tortoises require mineral macronutrients and micronutrients for optimal health, it is the young tortoises and the gravid females that have the greatest need for supplemental minerals. Young tortoises need these nutrients for skeletal and shell development, and gravid females require added nutrients for egg development.

Through their field studies in the Mojave Desert, Esque and Peters (1994) found that desert tortoises ingested only *white* stones, not gray, tan, or other colors. In the Mojave, white stones are largely formed of caliche, also known as calcite, which is primarily composed of calcium carbonate.

Desert tortoises have been known to mine caliche soils for ingestion purposes. Researchers R. W. Marlow and K. Tollestrup observed female tortoises scraping away the topsoil to reach the caliche subsoil, as documented in a paper published in 1982. Subsequent research revealed that local desert tortoises routinely visit caliche mines for purposes of mineral supplementation.

Osteophagy in desert tortoises has been observed in both wild animals and captives. Tortoises ingest small whole bones from carrion and gnaw on weathered bones and even on the shells and bones of dead tortoises found in the wild (Esque and Peters, 1994).

Galápagos tortoise

In her Ph.D. thesis, Dr. Linda Cayot (1987) refers to the scat analysis of

Galápagos tortoise fecal material and the finding that those analyses reveal the presence of soil particles and gravel in the scat of tortoises in an earlier study.

Studies by Yost et al. (n.d.) indicate that the tortoises inhabiting the oldest, lowest-elevation Galápagos islands are generally the saddle-backed varieties that are usually smaller in overall size and have thinner shells than their larger, higher-domed counterparts from islands with more humid highland habitats.

Depletion of calcium and other vital nutrients in the soils on the older Galápagos Islands account for the fact that the saddle-backed tortoises are smaller overall. Soils in the humid highlands are more nutritionally complete, therefore, the tortoises in the humid highlands grow larger because of their nutritionally superior foods (Yost et al., n.d.).

Gopher tortoise

Native to the southeastern United States, gopher tortoises, *Gopherus polyphemus,* are herbivores. Moore and Dornberg (2014) conducted studies of the species, concentrating on female gopher tortoises. The scientists used field observation, scat photography, analysis of scat samples, and radiography in their research.

Analysis of the gopher tortoise x-rays revealed that 85% of gravid females had stones, bones, bone fragments, or seashells in their digestive tracts, while only 5% of non-gravid females contained such items.

These findings led Moore and Dornberg to conclude that the gravid females engaged in lithophagy and osteophagy to overcome mineral deficiencies in their diet during the formation of their eggs. As mentioned, egg yolks and egg shells are largely composed of calcium, phosphorus, and other minerals.

Close-up of the stones that passed through the digestive tract of the desert tortoise in the x-ray image on page 9. Photo by Karen Berry.

Hermann's tortoise

Documenting scavenging behavior by Hermann's Tortoise (*Testudo hermanni*) in Serbia, Nikolić et al. (2016) note that, while the species is widely regarded as primarily herbivorous, its diet also includes "mushrooms, soil, sand, pebbles, and animal matter," a fact confirmed by several researchers. Scientists confirm that Hermann's tortoise also periodically ingests soil—geophagy—for mineral supplementation.

T. hermanni also feeds on mammal feces, apparently for the bone fragments and hair it contains, as well as on carrion. Such "sporadical carnivorous behavior" is considered to be relic, and it requires additional investigation to better understand the ecological requirements of the species (Nikolić et al. 2016).

Radiated tortoise

While the radiated tortoise (*Geochelone* [= *Astrochelys*] *radiata*) is primarily herbivorous in its dietary choices, the species is an "opportunistic" omnivore, ingesting various types of animal matter for mineral supplementation (Leuteritz 2003).

During his studies of the feeding behavior of the radiated tortoise in southwestern Madagascar, Thomas Leuteritz (2003) recorded the ingestion of fish and mammal bones and bone fragments, snail shells, mammal hair, dried mammal and reptile carcasses, as well as mammal, reptile, and bird feces. His study also documented the ingestion of charcoal and sand by the species.

Mentioned in this study of radiated tortoise behavior is the fact that the leopard tortoise (*Geochelone* [=*Stigmochelys*] *pardalis*) also engages in osteophagy, according to a 1992 paper by S. J. Milton published in the *South African Journal of Zoology*.

Red-footed tortoise

An omnivorous forest tortoise endemic to northern South America, the red-footed tortoise (*Chelonoidis carbonaria*) consumes more fruit than any other single food item. Like many other tortoise species, however, the red-footed tortoise is an opportunistic feeder.

Wang et al. (2011) conducted studies of the species in the Pantanal, an enormous wetland region in Brazil. Their research confirms that, in addition to fruit, flowers, and leaves, the species also ingests a variety of other items, including invertebrates such as ants, snails, and termites, vertebrate carrion such as bones, egg shells, feathers, scales, and skin, fungi such as mushrooms and toadstools, and soils.

Following scat analysis of samples from both male and female red-footed tortoises, Wang et.al. (2011) identified vertebrate carrion in 25% of the females' scat though it was only 12.5% of their total intake. One might conclude that females ingesting such mineral-rich items as bones and egg shells could be related to reproduction, specifically to the development of egg yolks and egg shells.

Researchers also observed red-footed tortoises ingesting sand during their foraging activities and identified sand in scat analyses. Sand could aid in the digestion of tough foods, and might be a source of minerals for the tortoises. ☯

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