Ingestion of Bones, Stones, and Soil by Desert Tortoises

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Abstract. We used field observations and radiographs to document that desert tortoises (*Gopherus agassizii*) ingest soil and stones. The ingestion of soil and stones can be a common albeit rarely observed behavior of desert tortoises. We also describe the ingestion of bones by wild tortoises. Desert tortoises readily eat weathered bones, and some individuals persist in eating bone even when they are disturbed. Eating soil, stones, and bones could be important in supplementing the herbivorous diet of tortoises, and thus the relative use of these behaviors in different localities could serve as indicators of nutritive stress. Other possible benefits from the ingestion of soil, stones, and bones include the maintenance of gut pH, nullification of plant secondary compounds, control of intestinal parasites, or maintenance of beak shape (in a fashion analogous to the behavior of birds). Bones and other mineral resources seem to be important to tortoises. However, the mechanistic explanations for eating soil, stones, and bones are currently unknown. Research into the mineral physiology of tortoises is necessary to determine the causes of the ingestion of soil, bones, and stones and to provide guidance for management.

Key words: Bone eating, *Gopherus agassizii*, nutrition, soil ingestion, stones in diet, Utah.

The ingestion of bone, stones, and soil has been observed in a variety of domestic and wild vertebrates (Robbins 1983). These behaviors may be caused by dietary deficiencies of macronutrients such as calcium, phosphorus, and sodium and of micronutrients such as iron, copper, and selenium (Robbins 1983). Mineral deficiencies in vertebrate diets may be caused by a low mineral content of soils where plants grow, low availability of required minerals in plants, use of specific minerals for the detoxification of secondary compounds, imbalances in dietary ratios of essential nutrients, and physiological demand for minerals during certain life stages.

Vertebrates obtain most essential dietary elements from food. Where sufficient amounts of criti-

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cal nutrients are lacking, however, vertebrates may supplement forage. The intake of supplemental minerals is known in ungulates (Sutcliffe 1973; Brothwell 1976; Langman 1978; Barrette 1985), primates (Hyslop 1977; Davies and Baillie 1988), and rodents (Duthie and Skinner 1986; Hansson 1990). Supplementation of nutrients may be more common in herbivores than in carnivores because wild carnivores probably acquire a more diverse selection of minerals in their normal diet (e.g., through the ingestion of bone in prey).

Although supplementation of nutrients seems to be common, it is infrequently observed. During field studies, osteophagia was noted in only 3 of 1,000 observations of mule deer (*Odocoileus hemionus*; Krausman and Bissonette 1977) and in 7 of 2,500 observations of desert bighorn sheep (*Ovis canadensis*; Warrick and Krausman 1986). When osteophagia and related behaviors are observed, they can be an all-encompassing activity for the animal (Warrick and Krausman 1986) and may result in agonistic behaviors toward conspecifics over these resources (Bowyer 1983; Keating 1990).

Birds are also known to supplement their diet with minerals by ingesting, for example, snail shells (Krapu and Swanson 1975; Beasom and Pattee 1978) and lemming bones (MacLean 1974). Developing young and egg-laying females are most likely to supplement calcium in the diet for bone and eggshell formation (Robbins 1983).

Captive herbivorous reptiles are especially prone to nutritional deficiencies when their food lacks minerals (Jacobson 1989), and captive reptiles consume material with minerals. For example, box turtles (*Terrapene ornata*) in captivity ingest stones and soil (Kramer 1973).

The ingestion of stones by desert tortoises (*Gopherus agassizii*) is known in the Mojave Desert of California (Luckenbach 1982; Marlow and Tollestrup 1982) and Nevada (T. C. Esque, field data), but there are few data. Fecal pellets of *G. polyphemus* from Florida contained stones (MacDonald and Mushinsky 1988). In the wild and in captivity, tortoises may consume calcareous stones to supplement dietary elements and to macerate a herbivorous diet (Sokol 1971).

Desert tortoises may mine minerals by scraping away the top soil to reach calcium-rich deposits in the underlying caliche (calcium carbonate) strata (Marlow and Tollestrup 1982). Moreover, tortoises apparently alter their normal patterns of moves to visit these sites, which may be at some distance from the normal home range (Marlow and Tollestrup 1982).

To our knowledge, osteophagy has been observed in captive tortoises and rarely in wild tortoises. We observed captive desert tortoises consuming small bones, stones, and bone meal. Bally (1946) observed a captive leopard tortoise (*Testudo pardalis*) eating bone. Bones were also found in the fecal pellets of wild leopard tortoises (Milton 1992). In Brazil, Moskovits (1985) observed two species of tortoises (*Geochelone denticulata* and *G. carbonaria*) eating carrion containing bones. Another North American tortoise, the gopher tortoise (*G. polyphemus*), was observed eating animal matter (MacDonald and Mushinsky 1988). The giant tortoise (*G. elephantopus*) eats bones and other animal materials on the Galapagos Islands (Cayot 1987).

Here, we describe the occurrence and frequency of phagous behavior in wild desert tortoises, discuss the possible need for mineral supplementation in tortoises, and offer alternative hypotheses for the ingestion or chewing of soil, stones, and bones in tortoises.

Materials and Methods

We recorded 991 observations of 52 desert tortoises in the northeastern Mojave Desert near St. George, Utah, during April–June 1989, May–June 1990, and June–July 1991; on the Beaver Dam Slope, Utah, in June 1989; and near Littlefield, Arizona, in May 1990. We also followed tortoise tracks near St. George, Utah, where sandy soils often revealed the daily routes of tortoises for long stretches (>100 m).

We conducted field trials to observe eating of bone by wild tortoises. We gently tossed weathered pieces of bones in front of tortoises in the wild. We presented samples of cow bones to 11 tortoises near St. George, Utah, during 7–27 June 1990 (Table). For each trial, a bone was placed <10 cm in front of the tortoise. A different piece of bone was used for each trial to reduce the possible attraction or avoidance of it because of lingering

scent of conspecifics from previous trials. The bone samples were too large (>10 cm long and >3 cm thick) to be grasped and broken by the animals.

Furthermore, we examined 185 radiographs (provided by colleagues) of 31 adult tortoises for stones or other material in the intestines. These radiographs were earlier used to denote the number of eggs in female tortoises and, in a few cases, to examine the digestive tract in male tortoises.

Results

Ingestion of Stones and Soil

During 991 observations of foraging behavior of desert tortoises, we recorded 12 cases of ingestion of soil and stones near St. George and on the Beaver Dam Slope, Utah, and near Littlefield, Arizona. Phagous behavior mostly lasted only a few minutes, but one lasted as long as 20 min. Most ingestion of stones and soil was by adult female tortoises in spring.

Although most stones in the St. George study area were brown, grey, or another dull color, tortoises consumed only white stones. White stones in the Mojave Desert are primarily composed of caliche (calcite), which is mostly calcium carbonate (Marlow and Tollestrup 1982). When encountering such stones, some tortoises nudged them with their snouts, took them into their beaks, and manipulated them with the tongue. Some of these stones were large (>1 cm diameter) in relation to the size of the mouth. The behavior was deliberate. Plant material was not present in the immediate area, and the ingestion of stones was not incidental to foraging.

During a study of growth and reproduction in Nevada tortoises (Turner et al. 1987), radiographs (Figs. 1 and 2) revealed many stones in the alimentary canal (R. B. Bury, National Ecology Research Center, Fort Collins, Colorado, personal observation). Similarly, M. Coffeen (Utah Division of Wildlife Resources, personal communication), who studied reproduction in tortoises in southwestern Utah, collected radiographs from 29 adult female tortoises during April–July 1987–89. Radiographs revealed stones and soil in 122 of 183 tortoises from Utah: 9 tortoises had rocks and soil in >90% of the alimentary canal; 18 had aggregations of 30–160-mm-long stones in their guts; 21 had <20 large stones (i.e., >5-mm diameter); and 74 tortoises had scattered small stones (i.e., <5-mm diameter) in their guts.

We observed fewer than 1% of tortoises eating soil and stones. Furthermore, this consumption was brief during surface activity. We could not observe tortoises while they were in their burrows or dens.

Table. Trials in which weathered cow bones were offered to 11 wild desert tortoises (*G. agassizii*) near St. George, Utah, in 1990–1991.

Maximum carapace length (mm)[a]	Accepted[b] bones	Rejected bones
<100	1	1
100–140	2	0
>140–180	3	1
>180	2	1

[a] Tortoises >180 mm were females.
[b] Defined here as grasping bones with the beak and chewing them.

Ingestion of Bones

At St. George, Utah, our first indications of osteophagia were tortoise tracks around weathered cattle bones and the skeletons of a fox, a rabbit, and a tortoise. Concentrated tracks in small areas around the bones resembled patterns of tracks by tortoises who fed on low-growing desert annuals and not track patterns (generally in one direction) by traveling tortoises.

On the morning of 6 June 1989 on the Beaver Dam Slope, Utah, an adult female took several white stones into her mouth without swallowing them. Then, at 1030 h, this tortoise encountered three weathered limb bones of a black-tailed jackrabbit (*Lepus californicus*). The diameters of two of the bones were smaller than the third. The tortoise nudged the bones with her snout, consumed the two smaller bones, and grasped the third bone without breaking it with her beak. This behavior occurred in 4 minutes, and then the tortoise foraged on vegetation. On 4 June 1991, we observed a wild desert tortoise attempting to eat fox bones (Fig. 3).

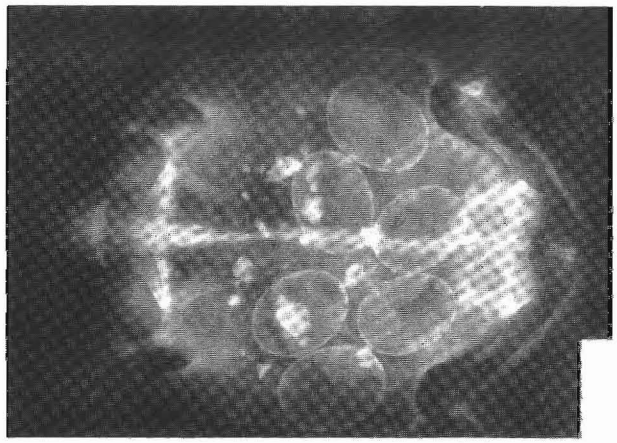

Fig. 1. Radiograph of the intestines of an adult female desert tortoise (*G. agassizii*) from the Nevada test site. Shelled eggs and stones are visible.

On 16 June 1990, we located a female tortoise with a radio transmitter and tossed a weathered cow vertebra (2-cm diameter) about 1 m in front of her. After about 5 minutes, the tortoise nudged the bone with her snout and then began chewing the bone between her mandibles. The bone sample was large and the tortoise could not break it. However, the tortoise scraped off and consumed chips of the bone. As we moved to within about 3 m to photograph the animal, the tortoise became disturbed and turned away from the bone. When we were out of sight at a distance of 15 m, the tortoise quickly resumed chewing the bone.

Tortoises grasped bones in their mandibles and chewed them during 8 of 11 trials (Table). On 1 May 1991, we observed one tortoise remove and eat 28 chips from a large cow bone (about 10-cm diameter). The tortoises usually used their forefeet to hold down the bone, and they were sometimes persistent in these behaviors. If we approached them to within 5 m, the tortoises ceased eating and moved away from the bones, but when the observer retreated, the tortoises sometimes returned to consume the bones (3 of 11 observations).

Osteophagy contrasted with the general feeding behavior. When we inadvertently interrupted tortoises feeding on plants, they abandoned the food and rarely returned to it.

Discussion

Although the ingestion of bones, stones, and soil is known of a wide variety of vertebrate taxa, its importance to the health of herbivores is not well documented. We concur with Sokol (1971), Marlow and Tollestrup (1982), Moskovits (1985), Cayot (1987), and MacDonald and Mushinsky (1988) that eating bones, stones, and soil may be important for mineral supplementation. Calcium can be obtained from the ingestion of all three items and may well be the mineral that tortoises seek. However, we do not know whether the diet of tortoises or the

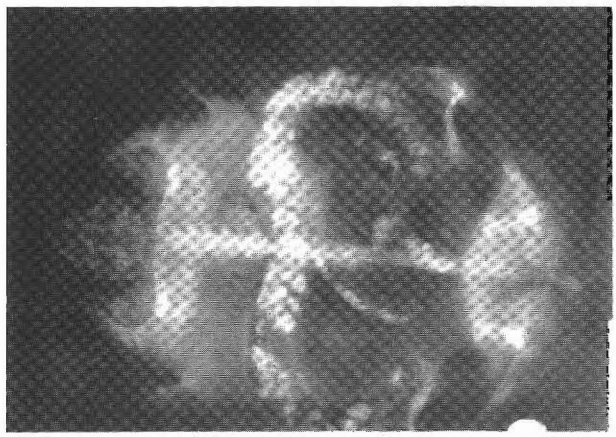

Fig. 2. Radiograph of the intestines of an adult female desert tortoise (*G. agassizzii*) from the Nevada test site. Note the presence of many ingested stones.

Fig. 3. Osteophagy by an adult female desert tortoise (*G. agassizii*) near St. George, Utah, in the spring of 1991. *Photo by T. Schaffer.*

environments are deficient in nutrients and minerals. Tortoises may simply ingest minerals opportunistically or alternatively be able to locate and use mineral-rich deposits (e.g., by mining caliche; Marlow and Tollestrup 1982). However, the deficiency of a mineral other than calcium or a ratio of minerals may be responsible for the ingestion of bones, stones, and soils by tortoises.

Concentrated tracks around plants and bones indicate that tortoises consumed them. In most of these cases, the plants were missing flowers and leaves, and the bones had bite or scrap marks. We found that tortoises who feed on bones usually leave no evidence other than feces or tracks. Furthermore, tortoises may consume bones rapidly (e.g., 2 rabbit leg bones in 4 minutes). Observations of the ingestion of bones are seemingly uncommon but not less frequent than observations of copulation and agonistic behaviors that are also seldom observed in wild tortoises.

The ingestion of stones is seldom noted in the field. However, radiographs of wild tortoises show a high frequency of ingested soil and stones. About 60% of a large sample of tortoises (n = 185) had stones in the intestines; most stones were small (<5-mm diameter), but a few were larger (>5 mm). Thus, the ingestion of stones, soil, and bones seems to be more common in tortoises than was previously known.

The need to supplement the diet of tortoises with minerals may depend on several factors. The regional flora may be diverse or depauperate in mineral-rich plant species, which may affect mineral availability in the forage of tortoises. The physiological condition of tortoises probably affects mineral requirements. For example, juveniles, which grow rapidly, and gravid females are expected to have a large demand for minerals. The availability of different chemical and crystalline forms of mineral species may also affect the assimilation efficiency of the required mineral. Furthermore, tortoises may require additional minerals to nullify the toxic effects of secondary compounds in food plants (Reese 1979).

Alternatively, the ingestion of stones, bones, and soil may be important to the physical well-being of the animals or other functions not directly related to nutrition. Many gallinaceous birds require small stones in their gizzards to grind hard-shelled foods (Welty 1975). Similarly, eating of stones and soil by wild and captive reptiles may be for grinding foods (Cott 1961; Johnson 1966; Sokol 1971).

Furthermore, tortoises may consume quantities of soils or stones as a vermifuge (to expel parasites). Captive and wild tortoises may harbor high densities of parasitic worms in their intestines (personal observation). Stones or soils that are rich in calcium carbonate may rid tortoises of parasites by dislodging parasites or changing the chemical environment of the gut. Herbivorous reptiles may eat soil to acquire cellulytic intestinal flora (Sokol 1971), and tortoises, like birds, may chew hard objects to maintain the quality of their beaks.

Because the ingestion of bones, stones, and soil seems important to the nutrition or other functions in the desert tortoise, management could enhance habitats for tortoises. If tortoises require supplemental minerals, we suggest that weathered bones from carcasses of tortoises and other vertebrate species (i.e., jackrabbits, cattle) are valuable to live tortoises.

Currently, some study protocols (unpublished reports) call for the removal of all tortoise skeletons from study areas during population surveys. As a result, tortoise skeletons may become rare and those that accumulate between surveys may not have become weathered, which is the advanced stage of decomposition necessary for their ingestion by live tortoises. We think that the collection of bones and tortoise shells may deplete supplies of nutrients in the wild and possibly prevent cycling of necessary mineral sources.

There are alternatives to removing all tortoise skeletons from study plots or transect lines. Tortoises and their skeletons (with scutes) can be aged in the field by counting growth rings (Germano 1988). In most cases, only a single skeletal element from each carcass has to be collected or a sample (subset) of the total number of skeletons retained. Thus, we suggest that investigators collect minimal samples or record measurements from tortoise bones and shells in the field.

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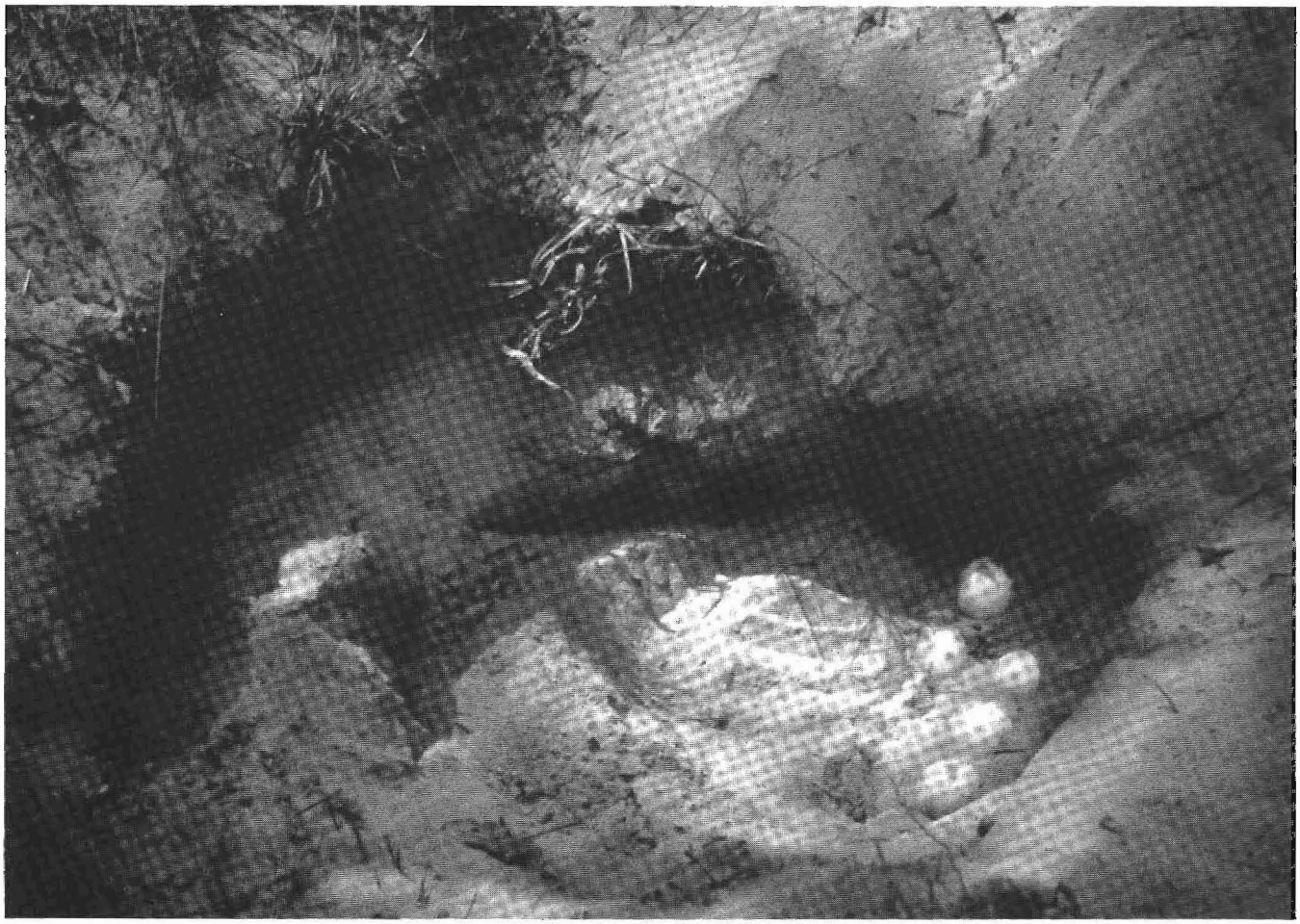

Uncovered nest of a gopher tortoise (*Gopherus polyphemus*), showing position of eggs in front of the burrow mouth. *Photo by J. E. Diemer.*