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BONE CONSUMPTION BY CHEETAHS AT UNDISTURBED KILLS: EVIDENCE FOR A  
LACK OF FOCAL PALATINE EROSION

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The feeding behavior of wild and wild-caught, captive cheetahs (Acinonyx jubatus) was observed to determine time spent at kills, the amount of food consumed, and especially, which, if any, bones were consumed. Wild cheetahs stayed with kills for up to 11 h. Individual cheetahs consumed up to 10 kg of food in < 2 h. Cheetahs consumed all bones, except the skull, of prey weighing < 10 kg, and consumed a substantial proportion of the rib cage and vertebral column of 30 - 50 kg prey. Juvenile cheetahs (aged 6 - 16 mo) had no difficulty crushing and consuming bones.

Key words: Acinonyx jubatus, bone consumption, focal palatine erosion

Running head: BONE CONSUMPTION BY CHEETAHS

Hunting behavior of cheetahs (Acinonyx jubatus) is well known: a short distance high-speed chase, culminating when the cheetah "slaps" the hindleg of the prey, the subsequent overpowering of the victim, and death by strangulation (Bigalke, 1964; Kruuk and Turner, 1967; Mitchell, et al., 1965;

Schaller, 1968). Similarly, the prey of cheetahs has been documented thoroughly (Pettifer, 1981; Pienaar, 1969; Schaller, 1968; Smithers, 1971), and although the prey base varies considerably between locales, preferred prey species generally weigh < 60 kg.

Despite these studies, no definitive information is available about consumption of prey by cheetahs when undisturbed at kills. Limited observations concluded that cheetahs feed rapidly, and often appeared nervous at kills (Schaller, 1968). Most accounts reported cheetahs feeding only once and then abandoning prey 1-2 h after a kill, or earlier if disturbed by other large carnivores, such as lion (*Panthera leo*) or hyena (*Crocuta crocuta*; Skinner and Smithers, 1990; Stander, 1990). When feeding, cheetahs concentrated their initial effort on the ventral surface of prey, first consuming the soft organs, with the exception of the intestines, which were discarded (Skinner and Smithers, 1990). At many kills the appendicular musculature was relatively untouched (Schaller, 1968). Bones were thought only to be consumed when prey are small (Brain, 1981).

The lack of definitive information on consumption of natural food items by cheetahs has management implications -- this species is considered vulnerable, and several captive breeding programs have been established (IUCN, 1990). Many captive-raised cheetahs have developed focal palatine erosion (FPE), a condition characterized by the perforation of the soft palate (and often hard palate) by the lower first molar (Fitch and Fagan, 1982). This condition has never been shown to occur in wild cheetahs (Phillips et al., 1991), and artificial diets lacking sufficiently hard materials have been implicated as a potential causes of this condition (Fitch and Fagan, 1982; Phillips et al., 1991). Accordingly, the present study examined feeding behavior of wild and wild-caught captive cheetahs, with special attention given to the type and amount of bone consumed.

#### METHODS

**Field study.**-- The study was conducted at Etosha National Park, north-central Namibia (17° E, 19° S) during a 21-mo period that began in August 1989. The park covers 2,200,000 ha and is completely fenced, thus home ranges of large terrestrial animals generally do not extend past the park boundaries. Approximately 100 cheetahs reside in the south-central and south-eastern portions of the park. Seventeen kills by cheetah were observed during the study period. Prey species were springbok

(*Antidorcas marsupialis*; n = 15) and steenbok (*Raphicerus campestris*; n = 2). All kills reported here were made by one of three adult females, and then consumed by the female and her respective cubs (either three or four, age 6 to 16 mo).

The approximate home range of cheetahs was known and kills were located opportunistically. The time of the kill was noted and the total time the cheetahs remained at the kill was determined. Most cheetahs at Etosha are relatively calm around vehicles, and feeding behavior could be observed at a distance of from 10 to 30 m. Feeding behavior was videotaped for short periods (1-2 min segments) every 15 - 30 min. The remains of the carcass were examined and photographed once the cheetahs had abandoned the kill. Particular attention was given to the amount of bone consumed. Maximum dimension (width or breadth) of remaining ribs, long bones, and vertebral spines were measured with a digital caliper (to the nearest 0.1 mm). Because the cheetahs consumed nearly everything at the two steenbok kills, skeletons of seven adult steenbok were measured at the South African Museum, Cape Town, to obtain bone measurements.

Experimental study. -- An experiment was conducted at Tsoabis Leopard Park, a private game reserve, located 250 km southwest of Etosha, near Karibib, Namibia. Two wild-caught, captive cheetahs, a large 55 kg male (captive < 1 year) and a 40 kg female (captive > 1 year), were offered a whole, fresh (euthanized) 30 - 42 kg domestic goat or sheep restrained by a ground ring in a 1-ha enclosure. Cheetahs were offered the carcasses at 72-96 h-intervals at between 07:00 - 08:00 (local time). A total of seven carcasses were fed over a 20-day period. The carcasses were weighed just after euthanasia, and the remains were weighed once the cheetahs had abandoned the carcass. The entire feeding sequence was videotaped on three occasions.

## RESULTS

Field study. -- At all kills, the adult female opened the abdomen of the prey. The intestines were discarded, and the soft organs (liver, kidneys, heart, and lungs) were consumed first. In the three instances where a fetus was present, the female extracted the fetus, carried it away, and consumed it while her cubs fed on the adult springbok. Once the soft body parts were eaten, the cheetahs concentrated on the musculature of the back, hind- and forelimbs, and neck. Skin that covered the

trunk and upper limbs was consumed with the underlying musculature. When prey items were small, either adult steenbok or springbok fawns, all of the ribs, long bones, and vertebrae were eaten. At adult steenbok kills only the head, hooves, and digestive tract were abandoned, whereas at kills of newborn springbok only the digestive tract remained. When adult springbok were killed ( $n = 13$ ), the cheetahs consumed up to half of the ribcage when the cubs were ca. 6 mo old ( $n = 3$ ), and  $>75\%$  of the ribcage when  $\geq 9$  mo of age ( $n = 10$ ; Figure 1A). The bones consumed were never greater than 15 mm wide. The mean  $\pm$  SD of femurs from museum specimens of steenbok was  $11.4 \pm 0.3$  mm thick. At all kills of adult springbok, the dorsal spines of the vertebral column, and the scapular spines also were partially consumed. While consuming bone, cheetahs adopted a typical "gnawing position" by rotating the head and crushing the bone with their carnassial teeth. Juveniles, even 6 - 7 mo old, appeared to have no difficulty in crushing the ribs of adult springbok. Little skin remained at any kill.

Cheetahs appeared alert when feeding, and frequently paused to survey the area adjacent to the kill. This behavior was most apparent during the first 15 - 30 min; however, after several hours at the larger kills (adult springbok), cheetahs appeared more calm, and often slept within 10 m of the kill. Although black-backed jackal (*Canis mesomelas*) were present within minutes after a kill, the cheetahs paid them little attention, and only occasionally were interactions observed. The mean  $\pm$  SD length of initial feeding bout of a female and her cubs was  $82 \pm 7$  min at adult springbok kills ( $n = 13$ ). Feeding bouts were punctuated with periods of rest and allogrooming. Cubs returned to feed on adult springbok kills up to six times ( $x = 3.2 \pm 1.1$  SD,  $n = 40$ ). By the end of the initial feeding bout most body musculature had been eaten. Length of time spent feeding at subsequent bouts was generally  $< 15$  min. On the two occasions when the cheetahs remained at a kill for  $> 8$  h, the carcass was stripped of all muscle and skin, and the juvenile cheetahs returned to gnaw on ribs or long bones alone. On only one occasion did an adult female return to feed at a kill more than three times. Total time spent at adult springbok kills was  $4.8 \pm 2.5$  h ( $n = 13$ ), whereas  $< 1$  h was spent at steenbok kills. When undisturbed by either lions or hyenas, time spent at an adult springbok kill appeared to be restricted only by the absence of shade. In the three instances where the cheetahs abandoned their kill after three or fewer hours, the kill had been made after dawn in areas with no available shade. By

midmorning air temperatures were  $> 33^{\circ}\text{C}$  on those days and the cheetahs left the prey before consuming most of the rib cage.

Experimental study.-- The feeding behavior of the wild-caught, captive cheetahs was similar to that seen at natural kills. The male cheetah "killed" the goat or sheep by strangulation in all seven trials, and when "dead," the male opened the abdomen of the carcass, and extracted and discarded the intestines. Both cheetahs fed on the internal organs first and then concentrated on the body musculature. After consuming most of the skin and muscle, the cheetahs cracked and ate the ribs, on two of seven carcasses within 50 mm of the vertebral column (Fig. 1B). On the three occasions when feeding behavior was videotaped, the male broke apart the vertebral column and ate several vertebrae. The female was never observed to eat vertebrae. The two cheetahs abandoned the carcasses after 2 - 3 h, having consumed a mean  $\pm$  SD of  $19.7 \pm 1.1$  kg during that period. At all trials only the intestines, long bones, a portion of the ribs and vertebral column, and the skull remained.

#### DISCUSSION

Cheetahs exhibit health problems in both wild and captive situations (Caro et al., 1987; Evermann et al., 1988). In no instance, however, has a wild cheetah been diagnosed to have focal palatine erosion (FPE), a condition that frequently develops when juvenile cheetahs in captivity are fed a diet deficient in hard materials (Fitch and Fagan, 1982). This condition, characterized by the perforation of the soft palate by the lower first molar (carnassial tooth), apparently develops in captive cheetahs during the period when the permanent teeth are erupting (Phillips et al., 1991). When cheetahs are introduced to captivity (and therefore artificial diets) after complete eruption of their permanent teeth, FPE does not ensue. The resistance forces required to slow eruption of the permanent teeth during this critical developmental period are probably provided by gnawing on bones, cartilage and skin of natural prey.

Results of the feeding experiment and the observations at natural kills suggest that about 3 - 4 kg of food per day are required to maintain cheetahs in excellent health, an amount similar to that reported by Schaller (1968). More importantly, in the feeding experiment and at natural kills, cheetahs can consume large amounts of food ( $>10$  kg) in  $<2$  h. Thus, the report (Schaller, 1968) that cheetahs

abandon carcasses after one to two hours may suggest that the cheetahs had consumed a sufficient amount of food, and further defense of the prey from would-be competitors might be counterproductive.

The sequence of consuming the various body parts of prey is consistent with previous accounts of feeding behavior in cheetahs (Schaller, 1968; Skinner and Smithers, 1990). That cheetahs consumed a substantial portion of the skeleton and skin, remained at a kill for up to 11 h, and returned to feed several times on larger kills, often to gnaw on bone alone, differs considerably from previous studies. A single study by Stander (1990) mentions cheetahs feeding on a giraffe (*Giraffa camelopardalis*) carcass over a 5-h period. That unique observation and the differences presented here possibly result from the relatively low lion and hyena population at Etosha (Gasaway, et al., 1989; Skinner and Smithers, 1990; Stander, 1991).

The cheetah population of the Republic of Namibia is considered to be the most viable of any African nation, but < 10% are thought to occur in protected areas such as Etosha National Park (D. Morsbach, pers. commun.). The remaining 90% reside on farms. Many of these farms raise domestic sheep and goats, and on these farms the cheetah is considered to be a problem animal. Yet, biologically, cheetahs thrive in farm situations. Although springbok are not represented on many of these farms, sheep and goats appear to be a viable substitute. Because the axial skeleton of sheep and goats is approximately the size of springbok (or other 30 - 60 kg natural prey), cheetahs are likely receiving an appropriate dietary minimum in the absence of natural prey. Thus, in juvenile cheetahs, FPE is unlikely to occur in situations where natural prey or proper substitutes are available. Indeed, FPE has not been reported in skulls of cheetah killed on sheep and goat farms in Namibia ( $n > 75$ ; D. Morsbach and J. Phillips, unpublished).

The cheetah is an threatened species, and the captive North American population is currently managed by a consortium of zoological gardens. The feeding regimen of many of these institutions is based on commercially prepared diets and disarticulated limbs of bovids or equids. Although such diets are possibly complete with regard to calorie and protein requirements, they may not satisfy the mineral and nonmetabolic requirements of maturing cheetahs. Supplying cheetahs, especially mothers

with young, with domestic sheep or goats would seem an appropriate solution. In addition to providing a diet known to be sufficient for proper growth in wild cheetahs (as on Namibian farms), domestic prey species could also provide the impetus to maintain proper hunting behavior in cheetahs, as in the experiment with fresh sheep and goat carcasses.

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Fig 1. -- (a) Remains of adult springbok after 2 h feeding by an adult female and her three 9 mo old cubs near Okaukuejo, Etosha National Park. Note that approximately 50% of the rib cage has been consumed. The cheetahs remained at this kill for an additional 2.5 h. (b) Remains of ribcage of an adult domestic goat consumed in 2.5 h by an adult male and female cheetah at Tsoabis Leopard Park, Namibia.

