Different supplementation of minerals in bats and the consequences on bone mineral density

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Abstract

We investigated the consequences of mineral supplementation of mealworms at a facility where mustached bats (Pteronotus parnellii rubiginosus) from Trinidad were kept for experimental purposes. For 11 months after capture from the wild, the animals were constantly housed indoors and fed a diet of mealworms without mineral supplementation. After several animals died with skulls soft at palpation, this diet was suspected to be mineral deficient. From then on, mealworms were placed on a mineral mix one day prior to feeding, thus increasing their calcium content. For an assessment of the efficacy of the mineral supplementation, bone mineral density (BMD) was measured in the left radius with peripheral quantitative computer tomography. The animals were divided into 3 groups: six animals that died on capture were representing the free-ranging controls (Group A), eight animals died on the preliminary feeding regime without supplementation (Group B), and six animals fed the final, mineral-supplemented mealworms (Group C). BMD was highest in group A. Group B had significantly lower bone mineral density than Group A. Interestingly, Group C, receiving supplementation, showed no significant difference compared to Group A. This supports the assumption that it is important to feed a mineral supplementation to captive bats to conserve their normal bone structure.

Key words

insectivore, mineral supplementation, calcium, bone, mealworms

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Introduction

In feeding insectivorous animals with live insects, the mineral supplementation of the insects is an important part of the dietary management. Basically, the body composition of the insects themselves is unlikely to be influenced by different feeding and supplementation regimes (Hatt et al. 2003); however, the gut contents can be manipulated effectively, and thus also the total amount of nutrients and minerals ingested by the predator species (Finke 2003).

Although calcium (Ca) homeostasis has not been extensively studied in bats, it has been shown that extensive bone remodelling occurs in insectivorous bats, presumably to maintain extracelluar Ca concentrations (Whalen et al. 1972, Kwietinski et al. 1987). Recently, questions concerning Ca metabolism in some bats have arisen because of their consumption of Ca-poor diets and because females usually give birth and nurse one large off-spring in a short period of time (Kurta and Kunz 1987, Keeler and Studier 1992, Studier et al. 1994ab, Barclay 1995, Bernard and Davison 1996, Hood 1998, Adams et al. 2003). The intestinal barrier in a megachiropteran bat species was reported by Keegan et al. (1980) to be freely permeable for Ca in both directions, with no demonstrated active transport mechanism. 25-hydroxyvitamin D does not seem to play a major role in bat Ca metabolism (Kwiecinski et al. 2001).

It is still very difficult to fed bats in captivity and many problems arise. We investigated the consequences of mineral supplementation of mealworms at a facility where mustached bats (Pteronotus parnellii rubiginosus) from Trinidad were kept for experimental purposes.

Material and Methods

For 11 months after capture from the wild, the animals were constantly housed indoors under a constant photoperiod of 12h at 75% humidity and fed a diet of mealworms. The mealworms were kept on a substrate of oat flakes (Group B). Death occurred spontaneously in several animals for no obvious reason, but as the cranial skeleton was soft at palpation, a mineral deficiency was suspected. Consequently, the mealworms were placed on a mineral supplement (20 g Ca-carbonate, 40 g Ca-citrate, 7 g sodium chloride, 0.5 mg potassium iodid, 0.5 g of a vitamin mix, filled with soy meal up to 100 g) (group C) one day prior to feeding them to the bats. A one-day period was considered sufficient based on reports in the literature (Anderson 2000, Klasing et al. 2000). After one day on this supplement, the Ca:P ratio of mealworms was 1.7 as compared to 0.1 on the unsupplemented oat flake diet. We investigated bodies from bats that died at different stages of the husbandry process. Six animals were killed at capture from the wild, representing the free-ranging controls (Group A), eight animals died or were killed for experimental purposes while on the preliminary feeding regime (Group B), and six animals died or were
killed for experimental purposes while on the final, supplemented feeding regime (Group C). After measuring the length of the radius with a digital caliper, total bone mineral density (BMD) was measured in the left radius with peripheral quantitative computer tomography (Stratec XCT 2000 bone scanner, Stratec Medizinaltechnik GmbH, Pforzheim, Germany). The measurements were taken in the middle of the diaphyses (at 50% of total length). Cortical BMD (Cortical mode 2; threshold for cortical bone > 640 mg/cm$^3$) was calculated by automated computation. The results were evaluated using non-parametric statistics, by pair-wise U-tests with Bonferroni adjustment.

**Results**

Bone mineral density was highest in group A (wild group). Group B had significantly lower bone mineral density than Group A (p = 0.014). Interestingly, Group C, receiving supplementation, showed no significant difference to Group A (p = 0.522) but also no significant difference to group B (p = 0.245, Figure 1).

![Figure 1: Bone mineral density of three groups of bats: Group A: bats caught from the wild, group B: bats fed with mealworms kept on oak flakes only, group C: bats fed mealworms kept on mineral supplementation for 1 day.](image-url)
Discussion

When compared to free-ranging individuals, it could be shown that bats fed on unsupplemented mealworms had lower bone mineral densities, whereas there was no difference between free-ranging specimens and those receiving the supplemented mealworms. This appears particularly relevant with regard to the fact that the captive animals do not practice flying to an extent anywhere similar to free-ranging specimens; therefore, inactivity osteoporosis could be expected in captive animals.

Peripheral quantitative computed tomography (pQCT) is a non-invasive technique commonly used to measure bone mineral density (BMD) in vivo and is used diagnostically in humans to assess osteoporosis (Formica et al. 1998). It has been adapted to measure bone quality in vivo in poultry, budgerigars (*Melopsittacus undulatus*) and other animal species (Liesegang et al. 2002ab, Korver et al. 2004, Fischer et al. 2005). Even in small animals such as mice the pQCT yielded satisfactory results in precision and accuracy for skeletal characterization in vivo (Schmidt et al. 2003). Cooperation with an institution that has access to pQCT, therefore, offers an interesting opportunity to monitor bone mineral status also in zoo animals – particularly in animals kept in large groups, with a representative number of deaths occurring regularly, so that meaningful results can be obtained.

The results support the assumption that it is important to feed a mineral supplementation to captive bats to conserve their normal bone structure. Bats are adapted to extensive bone remodelling during periods of low calcium intake or during times of peak mineral demand (Kwiecinski et al. 2001), which will lead to loss of bone integrity if such a situation continues for too long.

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References


