Pyramiding is not caused by excess calcium and/or phosphorus in young Red-eared sliders, *Trachemys scripta elegans*

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Pyramiding, is a condition in which the scutes of the carapace of turtles become deformed and elevated, taking on a pyramid shape. Pyramiding is believed to be a nutritional problem, however its exact cause is unknown. Given that the turtle carapace is composed largely of bone, it was hypothesized that it may be caused by an imbalance in dietary calcium (Ca) and/or phosphorus (P). Therefore, a study was performed to determine if calcium and phosphorus supplementation induced pyramiding in a group of young, rapidly growing turtles.

Red-eared sliders were obtained from a commercial supplier in September at 8-10 weeks of age and given 25 days to adapt to the new environment Turtles were maintained in groups of 4 in 12, 10-gallon aquariums with heat lamps and "full spectrum" bulbs. Water was changed weekly with calcium and phosphorus ion exchange resins added to the filter to maintain water quality. On Day 1 of the experiment, all turtles were weighed and divided into 3 groups of 16 turtles based on body weight Within each group, turtles were randomly assigned to one of the four experimental diets and fed for 150 days (n=3 tanks/diet). The control diet was 67% krill and 33% flour, with 1.38% Ca and 1.03% P. The high Ca (2.24%) and high P (2.56%) diets were created by adding limestone or sodium phosphate, respectively, to the control diet The fourth diet contained 2.95% Ca and 2.48% P, with a Ca:P ratio similar to the control diet Every 50 days, shells were inspected for pyramiding, body weight was measured, and carapace length was determined using a digital caliper.

Dietary intake could not be measured in this study, but all tanks were fed such that a small amount of feed was left uneaten. All diets were consumed by the turtles, with no statistically significant differences in the amount of feed offered among the diets. During the first 50 d, each tank of turtles was offered 0.43 ± 0.06 g/d of diet, increasing to 0.52 ± .05 g/d from Day 51 - 100, and 0.61 ± .05 g/d from Day 101 -150.

Over the course of the l50-day experiment, no visible signs of pyramiding occurred. All turtles had shells that were normal in shape and development, with no differences among dietary treatments.

At the beginning of the study, the turtles weighed 8.37 ± 1.50 g, with a carapace length of 35.08 ± 1.88 mm, but subsequent growth performance was affected by dietary treatment. Absolute body weight was not different at the start of the study, but by Day 100 the turtles receiving the high calcium diet were significantly lighter than the turtles receiving either the control or high calcium/high phosphorus diets. The turtles receiving the high phosphorus diet were not significantly different from any of the other three groups. Body weight gain over the entire 150 days (Table 1) was significantly less for the turtles receiving the high calcium diet as compared to those receiving either the control or high calcium/high phosphorus diets. The turtles receiving the high phosphorus diet were not significantly different from any of the other three groups.

A similar pattern was seen in the growth of the carapace. Absolute carapace length was not different at the start of the study, but by Day 100 the turtles receiving the high calcium diet were significantly smaller than the turtles in all other groups. Carapace length gain over the entire 150 days (Table 1) was also significantly less for the turtles receiving the high calcium diet than for the turtles in all other dietary groups.

Table 1. Body weight and carapace length gain from Day 1 to Day 150 in growing red-eared sliders (*Trachemys scripta elegans*) receiving diets that vary in calcium and/or phosphorus content (mean±SEM).

	Control	High Ca	High P	High Ca +P	P-value
Body weight Gain	10.83 ± 1.49a	5.82 ± .78a	7.77 ± 1.94ab	9.01 ± 1.88a	0.013
Carapace length gain (mm)	9.87 ± 1.10a	5.18 ± .73a	8.22 ± 2.17a	8.20 ± 1.07a	0.010

Pyramiding was not induced, in this study, by dietary supplementation with calcium and/or phosphorus. While it cannot be concluded that excess calcium and/or phosphorus plays no role in pyramiding, attempts were made to maximize the likelihood of an effect. The red-eared slider was chosen for the study because pyramiding has been described in this species, turtles were studied during their most rapid growth phase, and the diet was as close to the natural diet (small aquatic crustaceans and small amounts of plant material) as possible. The experimental diets were formulated so that both supplementation of either calcium or phosphorus was studied, as well as supplementation of both minerals, while keeping the Ca:P ratio similar to the control diet. Therefore, while it is possible that calcium and/or phosphorus may contribute to pyramiding, it does not appear that a dietary excess of one or both of these minerals is a primary cause.

Supplementation of calcium did, however, have a significant negative impact on growth performance. The turtles receiving the high calcium diet were smaller in both body weight and carapace length than all other turtles. The turtles receiving the high

phosphorus diet were also slightly, but not significantly, smaller than the control turtles. The turtles that received supplements of both calcium and phosphorus such that the Ca:P ratio was similar to the controls were not different from the controls in any variable.

Calcium is commonly added to turtle diets using products (i.e. bonemeal, ground cuttlefish bones, calcium pills or powder) that very greatly in composition, and may skew the Ca:P ratio. The data from this study strongly suggest that not only is such supplementation unnecessary if a balanced diet is fed, but may also be detrimental to normal growth and development. Feeding these turtles a diet that is similar to their natural diet allows for rapid rates of growth and normal shell development, even during their period of most rapid growth.

The decreased growth measured in this study in the turtles receiving excess calcium compounded by an elevated calcium to phosphorus ratio suggests that the practice of calcium supplementation may need to be reviewed.