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Abstract

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BRIEF REPORT

Comparative Study on the Growth of Juvenile Galapagos Giant Tortoises (*Geochelone nigra*) at the Charles Darwin Research Station (Galapagos Islands, Ecuador) and Zoo Zurich (Zurich, Switzerland)

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Key words: captive breeding; conservation; diet; Testudinidae

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INTRODUCTION

Galapagos giant tortoises (Geochelone ssp.) are classified as threatened or endangered [Groombridge, 1993]. Consequently, the trade is regulated by Convention on International Trade in Endangered Species (CITES) and the species is classified in Appendix I. Although Galapagos giant tortoises are regularly on display in zoos throughout the world (there are more than 192 animals in 48 institutions; (International Species Information System) ISIS data 2002), their reproduction outside the Galapagos archipelago remains sporadic. Only 10 institutions worldwide have had success in breeding this species.

The breeding and general husbandry of the tortoises, and care of the hatchlings at Zoo Zurich were previously described by Honegger and Rübel [1991] and Casares et al. [1995]. The first two hatchlings of 1989 died at the ages of 13 and 15 months, respectively. The postmortem examination revealed chronic interstitial pneumonia, interstitial nephritis, and thymitis. In addition, both animals revealed signs of metabolic bone disease. In 1992, the zoo altered the diet offered to the hatchling tortoises by reducing the protein and increasing the fiber, which prevented additional mortalities [Casares et al., 1995; Hatt and Honegger, 1997].

Data on the growth rates of free-living Galapagos giant tortoises are lacking. The only available data were obtained from free-living Aldabra tortoises (Geochelone gigantea) [Grubb, 1971]. At the Charles Darwin Research Station (CDRS), eggs of giant tortoises were artificially incubated. For 4 years, the juveniles were reared in large outdoor enclosures. After that time, they were released into their natural habitat [MacFarland et al., 1974; Pritchard, 1996]. Unpublished data on the growth of G. nigra hoodensis were provided by the CDRS (Snell and Cruz, personal communication) for this study. The opportunity to compare the growth rates of the animals from the CDRS and Zurich Zoo is of great importance for evaluating the appropriateness of captive husbandry programs.

MATERIALS AND METHODS

According to their origin on the Galapagos islands, the breeding female at Zoo Zurich is a G. n. porteri and the breeding male is a G. n. becki. Since 1992, 27 Galapagos giant tortoises have hatched at Zoo Zurich. The juveniles were weighed monthly, and the straight length, width, and height of the carapace were measured with callipers to the nearest millimeter. The hatchlings from Zoo Zurich are currently kept by five institutions in Europe. The growth pattern (carapace length and weight) of the captive tortoises in Zoo Zurich was compared with data obtained from six G. n. hoodensis (1981–1985) and 73 G. n. hoodensis (1994–1999) at the CDRS. At the CDRS, the carapace was measured over the curve. To obtain comparable measurements, these data were divided by a factor of 1.17. This figure was generated by comparing the carapace length over the curve with the straight carapace length in four adult and eight juvenile G. nigra.

The Statview SE package was used for statistical analyses. The data were arcsine square root transformed. Repeated-measures analyses of variance (ANOVAs) were conducted for the carapace length and weight data. Each tortoise’s initial body weight was also used as a covariate in the analyses, to ensure that the significant effects were not due to differences in the mean mass of individuals in the
two groups before they entered the experiment. Since this procedure requires a balanced design, the number of animals in the CDRS cell was randomly reduced, using a random table method, to the same number in the Zoo Zurich cell (n = 8). Means were given ±1 standard error, and $P < 0.05$ was accepted as the level of significance.

RESULTS

One week after hatching, the tortoises did not show any significant differences in weight relative to origin ($F_{1,81} = 0.4, P = 0.55$).

During the first 4 years there were significant differences between the two groups concerning weight ($F_{1,15} = 64.0, P < 0.0001$) and size (carapace length) ($F_{1,15} = 110.5, P < 0.0001$) (Figs. 1 and 2).

DISCUSSION AND CONCLUSIONS

The difference in growth patterns between the two groups is obvious when one compares the exponential weight increase observed in the Zurich specimens with the linear weight increase of the tortoises raised at the CDRS. The subspecies *G. n. hoodensis* does not grow at the same rate as *G. n. porteri* [Ernst and Barbour, 1989]. Second, *G.n. hoodensis* passed through a bottleneck of 20–30 individuals and may be inbred, while the Zoo Zurich tortoises are hybrids. Nevertheless, we do not attribute the enormous difference in growth rates that we found in this study to genetics. The difference is probably due primarily to the different diets used by the two groups. An increased growth rate of juvenile chelonians in captivity compared to those in nature was reported in a review by Hailey and Coulson [1999]. Juveniles at the CDRS are fed local plants (including *Sapindus saponaria*, *Sonchus oleraceus*, *Commicarpus tuberosus*, *Ipomoea alba*, and *Erythrina pheogigiana*) three times a week. The nutritional value of these native plants is unknown (Marquez, personal communication). At Zoo Zurich, the juveniles were offered food six times a week. The diet consisted of 70% herbs, vegetables, and fruits; 25% hay; 3% curds; and a mixture of different forms of calcium (Ca), including egg shells, sepiolite, calcium carbonate, and cadiphasphate (Multiforsa Zoo®; Multiforsa AG, Steinhausen, Switzerland) (for details see Liesegang et al., 2001). During the summer season (June–September) in Zurich, the animals are kept in direct sunlight in an outdoor enclosure, up to 90% of which is planted with grass (Poaceae, Cyperaceae). The grass is an important food base that is grazed by the tortoises within the exhibit. Grass from meadows within the zoo grounds is also offered. During their first 4 weeks in the outside enclosure, the tortoises eat only fresh grass (Ca:P = 2:1). Subsequently, they receive the diet described above. One kilogram of freshly cut, Ca-rich *Ficus* sp. leaves is offered weekly. The diet consists of 5.72% Ca on a dry-matter basis (Ca:P ratio = 14:1). The digestibility of Ca is approximately 60% [Liesegang et al., 1999]. Liesegang et al. [2001] reported that higher Ca concentrations in the diet lead to an increased apparent digestibility of Ca, Mg, and P. During the winter season, additional ultraviolet B and infrared lighting is provided on a daily basis [Honegger, 1998].

The carapace osteoderms and scutes of the juvenile tortoises at Zoo Zurich showed a slight pyramiding, but they were hard and firm. In addition, x-ray
Fig. 1. Comparison of the weights of Galapagos giant tortoises from Zoo Zurich and the CDRS. Bars represent ± standard errors.
Fig. 2. Comparison of the carapace lengths of Galapagos giant tortoises from Zoo Zurich and the CDRS. Bars represent ± standard errors.
examinations showed good ossification. In 1999, seven juvenile tortoises at Zoo Zurich were examined by coelioscopy. No pathology or significant fat deposits were reported (Hatt and Schildger, personal communication). The rapid growth observed in the giant tortoises at Zoo Zurich is probably best explained by sufficient sunlight and oversupplementation of Ca and protein [Noegel and Moss, 1989]. Pyramiding has been attributed to different factors, such as excessive protein supply, endoparasitic diseases, and low environmental humidity [Häfeli and Zwart, 2000; Wiesner and Iben, 2003]. Fecal examinations were performed twice a year, and endoparasites did not appear to be a problem. The animals were exposed to an environmental humidity of 70–90% and were provided unlimited access to water for drinking and bathing, so low humidity was not considered an issue. No other land vertebrate increases its weight from birth to adulthood by a factor of 3,000! This phenotypic plasticity enables the tortoises to adapt their growth to their feeding conditions. With the current data, we cannot predict the consequences of such an unnatural growth rate, but we speculate that rapid growth may result in the development of sexual maturity at a young age and a shorter life expectancy, based on previous findings in gopher tortoises [Aresco and Guyer, 1999], crocodiles [Ross et al., 1989], and spiders [Furrer and Ward, 1995].

To ensure that the Zoo Zurich tortoises grow at a more natural rate, we changed the diet by reducing the protein and increasing the fiber (90% hay and 10% herbs, vegetables, fruits, and Ca). Ca supplementation will continue as described previously. To avoid aggression due to food jealousy within the group, the quantity of the diet offered to the tortoises will not be reduced significantly. Further reports on our experience with this new diet at Zoo Zurich are planned.

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REFERENCES


