

COMPARING BODY CONDITION ESTIMATES OF ZOO BROTHER'S ISLAND TUATARA (*SPHENODON GUNTHERI*) TO THAT OF THE WILD, A CLINICAL CASE

Kyle S. Thompson, BS,^{1,2*} Michael L. Schlegel, PhD, PAS²

¹Oklahoma State University, Department of Animal Science, Stillwater, OK 74078 USA

²Nutritional Services Department, The San Diego Zoo, P.O. Box 120551, San Diego CA 92112-0551 USA

Abstract

Brother's Island tuataras (*Sphenodon guntheri*) housed at the San Diego Zoo were measured and weighed routinely as part of the preventative medicine procedure. From June 2000 through April 2009, snout-vent length and mass were used from that data and compared to Brother's Island tuataras that were sampled by Hoare et al.,⁴ in the wild from 1957 to 2001. Along with comparing snout-vent length (SVL) and mass, body condition was estimated using the ratio of the log-transformed mass to the log-transformed snout-vent length. The tuataras that are cared for by the San Diego Zoo (SDZ) are larger and have a greater conditioning score than that of the tuataras sampled in the wild.⁴ Over the 9 year period of sampling the SDZ tuatara had a mean increased in mass of 125.2 %, SVL of 31.7 %, and body condition estimates (BCE) of 7.5%.

Introduction

Tuataras are a rare lizard looking reptile found only on the islands surrounding New Zealand. They represent the only living organism of the Order *Sphenodontida*.³ There are three subspecies of tuatara, Northern (*S. p. punctatus*), Cook Strait (*S. punctatus*) and Brother's Island (*S. guntheri*, Bullar 1877).³

The 4-ha island of Brother's is off the North coast of the Southern Island of New Zealand and is sustaining the population of about 470 adult Brother's Island tuatara.⁴ The population is condensed to approximately 1.7 ha, due to the construction of a light house and supporting buildings in the late 18th century.^{4,6} In January 1998, the U.S. Department of the Interior expanded the endangered status to Brother's Island tuatara due to its separation from the Cook Strait tuatara.²

Tuataras are slow to reproduce and grow, which is possibly one of the many reasons for the declining numbers.² Other reasons include habitat destruction, predation by introduced mammals such as rats, fires, and poaching from illegal visitation to the island.^{2,5} Females reach sexual maturity at approximately 13 years of age.^{3,5} On average, clutches of eggs are laid every 2 - 5 years.^{3,5} It can take approximately 25 - 35 years for a tuatara to reach its potential length and mass.^{5,6} Females can reach a snout-vent length (SVL) of up to 225 mm and a mass of 480 g.^{5,6} While males can reach a SVL around 270 mm and a mass of approximately 790 g, but maximum size is unknown prior to the construction.¹ The objective of this clinical study was to compare the body weight (mass), SVL, and body condition estimates (BCE) of a zoo population of Brother's Island tuataras housed at the San Diego Zoo (SDZ) to that of the wild.

Methods

Eight Brothers Island tuataras (3.5) have been housed at the SDZ since March 1995. All were hatched between March and September of 1992. The group was housed together in a 24.38 m long by 7.62 m wide by 3.05 m tall enclosure. Weekly diet (Table 1) consisted of a rotation of adult crickets, large Phoenix worms (black-solder fly larvae), wax worms (wax moth larvae), giant mealworms and earthworms. The diet was supplemented daily with calcium carbonate and Herptivite (Rep-Cal® Research Labs, P.O. Box 727 Los Gatos, CA). Once a month they received pinkie mice. Periodic weights and measurements were recorded by animal care staff. Morphological measurements, SVL (mm) and mass (g) from June 2000 to April 2009, were used to calculate BCE, the ratio of log-transformed mass to log-transformed SVL.

Data was analyzed using a PROC GLIMMIX, repeated PROC mixed procedure of SAS and Two-tailed Paired T-tests of Microsoft Excel contrasts to separate significant differences. Pearson's correlation coefficients were used to determine the correlation between SVL and mass. Values were considered significant if at $P < 0.05$.

Results and Discussion

The mean increase ($P = 0.0009$) of mass for the SDZ females (Figure 1) from June 2000 to April 2009 was 232.64 g to 567.80 g (rate of gain (RG) = 6.96 g/yr or 144.07 % total increase). The increase ($P = 0.0008$) in SVL (Figure 2) from June 2000 to April 2009 was 173.00 mm to 235.60 mm (growth of length (GL) = 6.9 mm/yr or 36.19 % total increase). Males at SDZ had a mean increase in mass ($P = 0.0009$) and SVL ($P = 0.01$) change over the 9-year period (mass = 297.1 g to 797.8, RG = 55.62 g/yr or 106.29 % total increase, SVL = 187 mm to 260 mm, GL = 8.11 mm/yr or 27.17 % total increase). The SDZ Bother's Island tuataras have larger SVL and mass than that observed in the wild. As of April 2009, the largest male had a mass of 845 g with a SVL of 269 mm and the largest female's mass was 657 g with a SVL of 245 mm (Table 2). Compared with the results from Hoare et al.,⁴ of wild tuataras, the largest male sampled had a mass of 655 g and a SVL of 242 mm. The heaviest female sampled weighed 480 g with a SVL of 225 mm.

A high correlation ($r^2 = 0.95$) was detected between SVL and mass. The animals had a linear increase in body condition over time (Figure 3). A difference ($P = 0.019$) between males and female BCE (Figure 4 and Table 3) was detected after June 2006 to April 2009 with no differences ($P > 0.05$) detected before this time. Males had a greater increase over time in body condition than females [slopes = 3.31×10^{-5} ($P < 0.0001$, SEM = 0.004) for males and 2.65×10^{-5} ($P < 0.0001$, SEM = 0.003) for females] (Figure 4 and Table 3). The absolute mean increase of BCE for SDZ females was 0.106 ($P = 0.002$) and the absolute BCE mean increase of 0.118 ($P = 0.02$) for males. The mean BCE of the SDZ tuataras in June 2000 was 1.06 which is similar to that of the largest tuatara sampled by Hoare et al. (1957, BCE ~1.09).⁴ As of April 2009, the overall mean BCE was 1.14 ± 0.03 for the SDZ tuataras, a 7.5% increase in 9 years. Suggesting that not only are the captive tuatara continuing to gain length, but also gaining mass and conditioning.

By comparing the BCE of the SDZ tuatara to that found in the wild, the SDZ tuatara had more conditioning than that found in the wild. Many factors can contribute to the larger size and conditioning. The zoo tuataras receive a more consistent diet, with no major seasonal variation. According to Hoare, et al.,⁴ the wild Brother's Island tuatara are decreasing in length (SVL), mass, and BCE (slope = $6.5 \times 10^{-5} \pm 2.5 \times 10^{-6}$). The loss in total size and conditioning may be partially explained by the loss of habitat from man-made structures in the late 19th century consisting of a light house and supporting buildings thereby reducing the amount of feed resources available.⁴ Though the SDZ tuatara are larger in size, mass, and BCE than that measured in the wild in 1957, a comparison of pre-construction wild tuatara could not be determined. No data could be found on wild Brother's Island tuatara prior to 1957 and the affects of the loss of habitat may have already taken place, therefore making it difficult to compare BCE of the SDZ tuatara to that of a healthy wild population prior to major human impact.

Acknowledgements

A special thanks to the San Diego Zoo Herpetology Department for their hard work, care, and data collection of the Brother's Island tuatara.

LITERATURE CITED

1. Castanet, J., D.G. Newman and H.S. Girons. 1988. Skeletochronological data on the growth, age, and population structure of the tuatara, *Sphenodon punctatus*, on Stephens and Lady Alice Islands, New Zealand. *Herpetologica*. 44:25-37.
2. Clark, J.R. 1998. Rules and Regulations. *Federal Register*. 63(4):692-694.
3. Cree, A. and D. Butler. 1993. Tuatara recovery plan (*Sphenodon* spp.). Threatened Species Recovery Plan No. 9. Threatened Species Unit Department of Conservation, Wellington, New Zealand.
4. Hoare, J.M., S. Pledger, S.N. Keall, N.J. Nelson, N.J. Mitchell, and C.H. Daugherty. 2006. Conservation implications of a long-term decline in body condition of the Brothers Island tuatara (*Sphenodon guntheri*). *Animal Cons*. 9:456-462.
5. Nelson, N.J., S.N. Keall, S. Pledger and C.H. Daugherty. 2002. Male-based sex ratio in a small tuatara population. *J. Biogeography*. 29:633-640.
6. Thompson, M.B., C.H. Daugherty, A. Cree, D.C. French, J.C. Gillingham, and R.E. Barwick. 1992. Status and longevity of the tuatara, *Sphenodon guntheri*, and Duvaucel's gecko, *Hoplodactylus duvaucelii*, on North Brother Island, New Zealand. *J. Royal Soc. New Zealand*. 22:123-130.

Table 1. Diet rotation fed to tuatara (*Sphenodon guntheri*) at the San Diego Zoo.

Diet Item ¹	Base Diet per Animal		
	Frequency	No.	As-fed, g/d
Crickets, adult	3 d/wk	8	2.200
Phoenix worms, large	1 d/wk	8	0.900
Wax worms	1 d/wk	8	1.900
Mealworms	1 d/wk	8	3.000
Earthworms	1 d/wk	2	8.000
Mouse, pinkie	1 d/mo	2	3.500
Calcium carbonate	Avg. daily	-	0.046
Herptivite (Rep-Cal)	Avg. daily	-	0.046

¹ Nutrient composition of diet as a percent: CP = 57.0, Ca = 1.91, P = 0.91, Ca:P ratio = 2.10.

Table 2. Difference between individual growth in mass, snout-vent length (SVL) and body condition estimate (BCE) of Brother's Island tuatara (*Sphenodon guntheri*) from the beginning of data collection (June, 2000) and the most current (April, 2009).

ID	Sex	----- Mass, g -----			----- SVL, mm -----			----- BCE ¹ -----		
		Jun 00	Apr 09	Diff.	Jun 00	Apr 09	Diff.	Jun 00	Apr 09	Diff.
1	♀	284.8	657.0	372.2	190.0	245.0	55.0	1.08	1.18	0.10
2	♀	188.0	554.0	366.0	160.0	245.0	85.0	1.03	1.15	0.12
3	♀	297.4	591.0	293.6	182.0	233.0	51.0	1.09	1.17	0.08
4	♀	222.2	431.0	208.8	171.0	220.0	49.0	1.05	1.12	0.07
5	♀	170.8	606.0	435.2	162.0	235.0	73.0	1.01	1.17	0.16
6	♂	224.0	689.0	465.0	167.0	246.0	79.0	1.06	1.19	0.13
7	♂	407.7	845.0	437.3	211.0	269.0	58.0	1.12	1.20	0.08
8	♂	259.6	859.0	599.4	183.0	265.0	82.0	1.07	1.21	0.14
\bar{x}^2	♀	232.6 ^a	567.8 ^b	335.2	173.0 ^a	235.6 ^b	62.6	1.05 ^a	1.16 ^b	0.11
\bar{x}^2	♂	297.1 ^a	797.7 ^b	500.6	187.0 ^a	260.0 ^b	73.0	1.08 ^a	1.20 ^b	0.12

¹ Ratio of log-transformed mass to log-transformed SVL.

² Mean of mass, SVL, BCE, and absolute change between June 2000 and April 2009.

^{a,b} Means within category and sex with unlike subscripts differ ($P < 0.05$).

Table 3. A comparison overall mean, standard deviation, slope, r^2 , and intercept of the overall mean body condition estimate (BCE), male and female of Brother’s Island Tuatara (*Sphenodon guntheri*) over a 9-year period (June 2000 to April 2009).

	Mean BCE ¹ Combined	Mean BCE Male	Mean BCE Female	Difference of Males & Females
Mean	1.1317	1.1476	1.1219	0.0256
St. Deviation	0.0307	0.0358	0.0285	0.0074
Slope	2.91 ± 10^{-5}	3.31 ± 10^{-5}	2.65 ± 10^{-5}	6.56 ± 10^{-6}
r^2	0.8828	0.8360	0.8508	-0.0148
Intercept	0.0544	-0.0771	0.1402	-0.2173

¹ Ratio of log-transformed mass to log-transformed SVL.

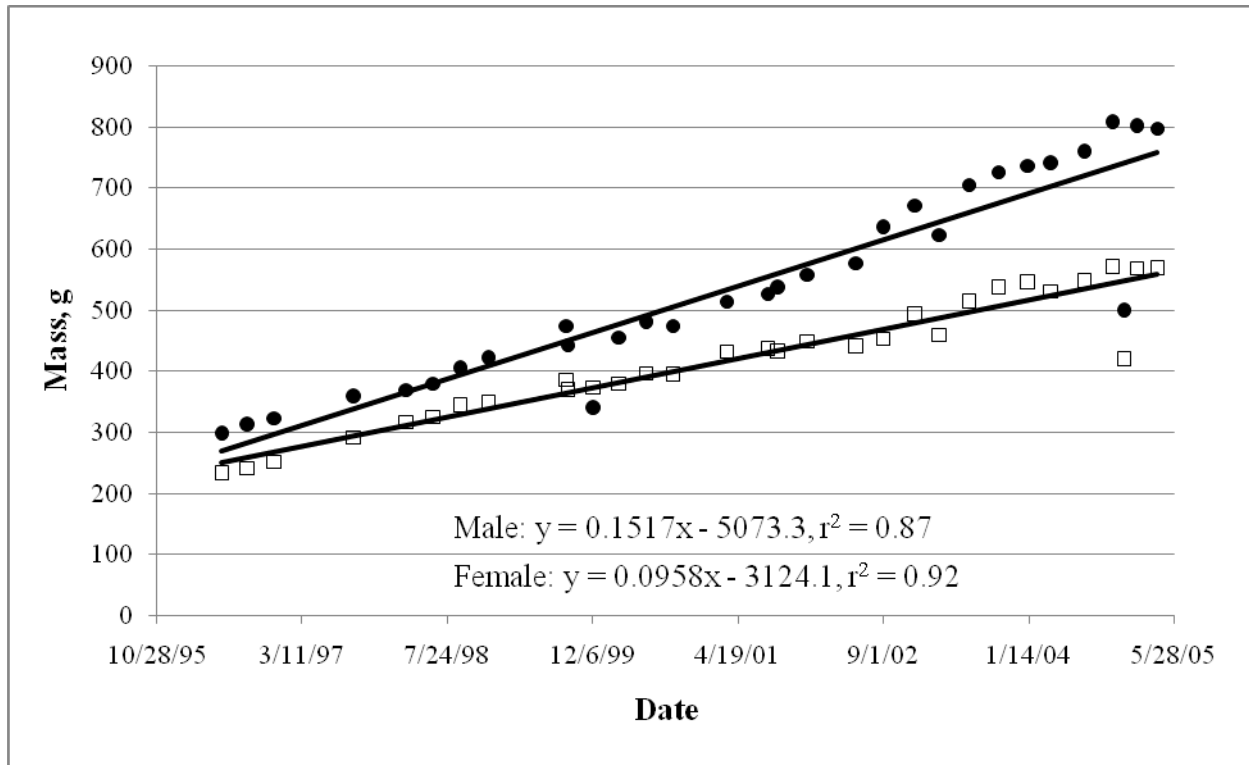


Figure 1. Mean mass, of Brother’s Island tuatara (*Sphenodon guntheri*) from June 2000 to April 2009. Female = □, Male = •.

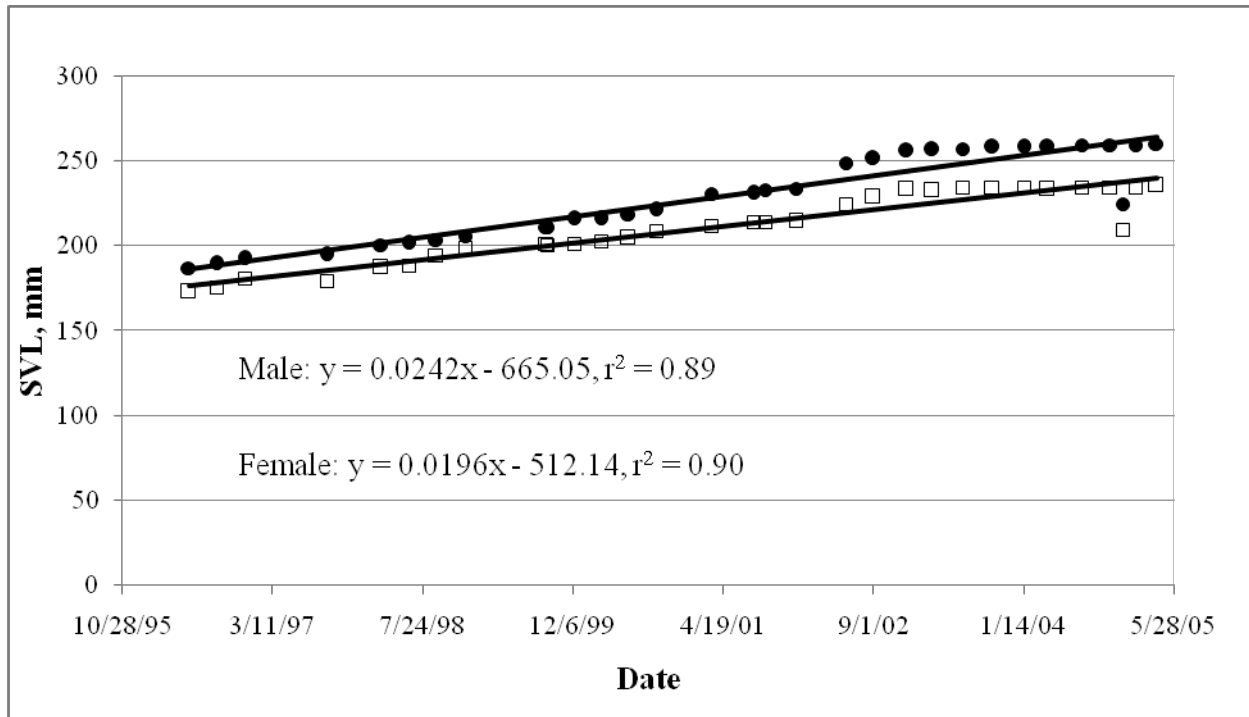


Figure 2. Change in snout-vent length (SVL) of Brother's Island tuatara (*Sphenodon guntheri*) from June 2000 to April 2009. Female = □, Male = •.

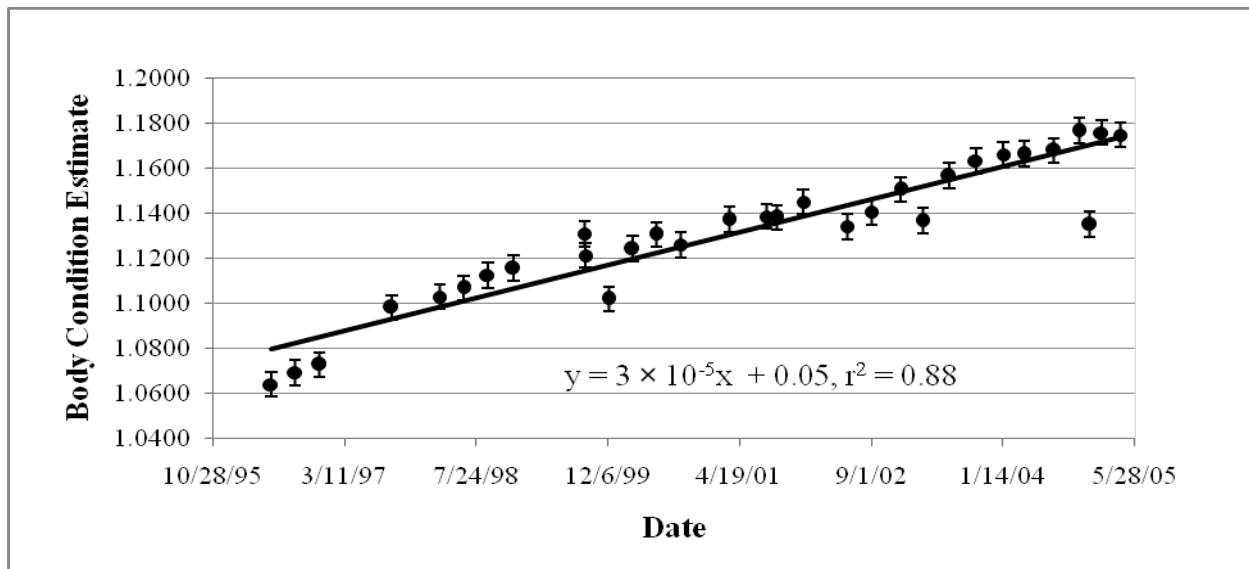


Figure 3. Change in mean body condition estimate (BCE) of the Brother's Island tuataras (*Sphenodon guntheri*) housed at the San Diego Zoo from June 2000 to April 2009. BCE = ratio of log-transformed mass to log-transformed SVL.

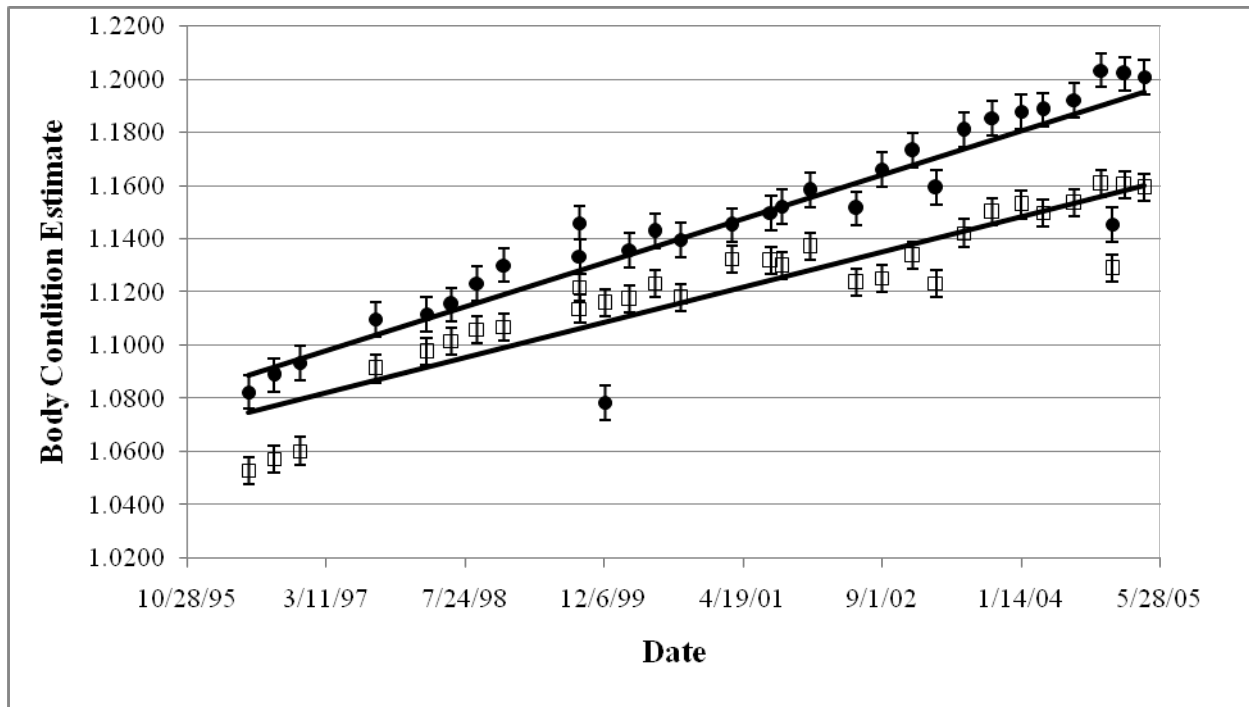


Figure 4. Change in mean body condition estimate (BCE) for males and females Brother's Island tuataras (*Sphenodon guntheri*) at the San Diego Zoo from June 2000 to April 2009. BCE = ratio of log-transformed mass to log-transformed SVL. Female = □, Male = •.