

# The relationships between length and weight of the Aldabra giant tortoise, *Dipsochelys dussumieri*, in Mauritius

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**Abstract:** In the Republic of Mauritius Aldabra giant tortoises, *Dipsochelys dussumieri* (also known as *Geochelone gigantea*), are kept in captivity mainly in private parks, public gardens, a few sugar estates and by some people as pets. The study was carried out in two private parks: Casela and La Vanille and two public gardens, SSR Botanical Garden at Pamplemousses and Balfour Garden. The private parks were better managed and maintained by virtue of their commercial purpose. Improvements were needed for Balfour Garden. Regressions were established between straight, curved carapace lengths and weight of juveniles, adults, both males and females. Regressions for adult males and females were compared using two different methods (straight and curved carapace lengths). A strong positive relationship was observed between the weight and straight carapace length of juveniles ( $R^2=0.96$ ) and adult males ( $R^2=0.88$ ), whereas, for adult females there was a weaker relationship ( $R^2=0.69$ ). The same coefficient of regression was observed when the curved carapace length was regressed with weights for juveniles. A strong positive relationship was observed between weight and curved carapace length of adult males ( $R^2=0.94$ ), and for adult females there was a positive relationship ( $R^2=0.74$ ). From the work carried out, it had been found that both methods could be used to estimate weights of the tortoises using their respective equations. The equation for straight carapace length was  $\text{Log } Y = 2.47\text{Log } X + 0.2$  ( $Y$  = weight in grammes;  $X$  = length in cm). The equation for curved carapace length was  $\text{Log } Y = 2.51\text{Log } X - 0.15$ . The curved carapace length gave a better estimation than the straight carapace length method.

**Keywords:** Chelonia, Testudinidae, captive maintenance

## Introduction

Tortoises are terrestrial turtles within one family, the Testudinidae (Ernst & Barbour 1989). Among all reptiles, the turtle is the only one with a shell (Dorit *et al.* 1991). Burton (1975) mentioned that throughout the world, there are only seven main groups of turtles, namely the mud and musk turtles, pond and marsh turtles, sea turtles, side-necked turtles and finally the tortoises.

Tortoises form a family of about 50 species (Anon 2000). Burton (1975) reported that these land turtles live in tropical and subtropical regions of Africa, Asia, Europe, North and South America, and on certain oceanic islands. At present, only two genera of giant tortoise exist: one on the Galapagos Islands in the Pacific Ocean, the Galapagos giant tortoise (Paull, 1996) and the other one on the Seychelles islands (including the Aldabra giant tortoise, *Dipsochelys dussumieri* (Gray, 1834) also known as *Geochelone gigantea*). Captive Aldabra tortoises can also be found in the Mascarene Islands, Madagascar, Tanzania and United States (Anon 1994).

The actual number all around the world is not known as no record or survey has been carried out (Anon, 2001). The wild population on Aldabra is approximately 100,000 (J. Gerlach pers. comm.) while the captive US population is estimated to be around 1000. The populations of many tortoise species are fast declining because of habitat destruction and killing for food and other purposes. In addition, many tortoises die from diseases introduced by humans (Anon 2000). Aldabra tortoises are listed in the International Union

Conservation of Nature (IUCN) red list of threatened animals (Anon 1994) and are protected by the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) (Anon 1996).

In Mauritius, the Aldabra tortoises were imported during the 1880's following the recommendation of Charles Darwin and other scientists, who were concerned that the Aldabra species would become extinct (Arnold 1979). There was a need to have populations on other islands as a security against extinction (Gunther 1877). Aldabra tortoises are kept in captivity mainly in private parks and public gardens. A few sugar estates also hold small collections and some people keep one or two giant tortoises as pets (Owadally 1988). Aldabra giant tortoises are protected in Mauritius by the Wildlife and National Parks Act (Anon 1993). Table 1 shows the different places where Aldabra giant tortoises were recorded .

Aldabra giant tortoises were introduced in the different gardens and parks at different times. According to Rouillard (1983) the earliest introduction dated back as far as 1881 when the tortoises were brought to Pamplemousses garden. No records of the initial stock or any subsequent introductions were found. Tortoises were brought to La Vanille park only 17 years ago. Table 2 indicates the number of giant tortoises at different times.

Little research has been carried out in the country and there are no reliable data on these animals. The objectives of this study were to collect information on the management of tortoises and data on these animals, leading to the establishment of regressions between the length and weights of juveniles, males and females adults.

**Table 1** A list of the places where Aldabra giant tortoises had been recorded in Mauritius (source: Aworer 2003)

Place	Location	Number of Aldabra giant tortoises		
		Adults	Juveniles	Total
Public Garden	SSRBG <sup>a</sup>	19	9	28
	Balfour Garden	6	0	6
	R.E.H Garden <sup>b</sup>	8	0	8
Private Park	Casela bird Park	17	1	18
	La Vanille park	101	340	441
Sugar Estates	Belle Vue Mauricia	6	0	6
	Bel-air S.E	19	0	19
Others	State House	27	3	30
	Ile aux Aigrettes	16	0	16
	Le Coco Beach Hotel	2	0	2
	Chamarel	8	0	8
Total		229	353	582

Key: a: Sir Seewoosagur Ramgoolam Botanical Garden at Pamplemousses, b: Robert Edward Hart garden

**Table 2** Number of tortoises present in the Private parks and public gardens (1979-2002)

Place	Number of tortoises								
	1979	1981	1983	1985	1998	1999	2000	2001	2002
<b>Balfour</b>	N.A	10 <sup>c</sup>	8 <sup>d</sup>	8 <sup>e</sup>	6 <sup>e</sup>	6 <sup>e</sup>	6 <sup>e</sup>	6 <sup>e</sup>	6
<b>SSRBG</b>	22 <sup>a</sup>	28 <sup>a</sup>	29 <sup>d</sup>	28 <sup>a</sup>	19	19	19	28	28
<b>Casela</b>	7 <sup>b</sup>	17 <sup>c</sup>	11 <sup>d</sup>	N.A	17 <sup>a</sup>	20 <sup>a</sup>	17 <sup>a</sup>	15 <sup>a</sup>	18
<b>La Vanille</b>	0	0	0	5 <sup>f</sup>	219 <sup>f</sup>	283 <sup>f</sup>	283 <sup>f</sup>	302 <sup>f</sup>	441

Notes: N.A – Not Available. Source: a: (Aumeer, pers. comm., 2003), b: (De Chazal, pers. comm., 2003), c: (Owadally 1988), d: (Bour 1984), e: (Dinally, pers. comm., 2003), f: (Griffiths, pers. comm., 2003).

## Methods

The investigation was carried out in two private parks and two public gardens where Aldabra giant tortoises were kept in Mauritius. The private parks were the La Vanille Crocodile Park, situated in the south of Mauritius and Casela Bird park, located in the western part of the island while the two public gardens selected were the Botanical Garden at Pamplémousses (SSRBG) in the north and Balfour Garden in the centre of the island.

The weights and measurements of the straight and curved carapace lengths of the tortoises were recorded. These were carried out using simple devices available locally. All adults were measured while for the juveniles present at La Vanille park, a random sampling of 20 tortoises out of each age group were taken (group 1: <5 months, group 2: <1 year old, group 3: 1-3 years old and group 4: 3-5 years old).

Measurements of the straight and curved carapace length: The tortoises were numbered using an oil-based paint. To measure the straight carapace length, a wooden ruler was pressed against the front of the shell and another ruler was pressed against the caudal end. Finally the distance between these two points was measured in centimeters using a measuring tape. The curved carapace length was measured using a string and a measuring tape.

Weighing: Sub-adult tortoises were measured using a tarpaulin and a Roman balance. The numbered animals were made to walk on a tarpaulin (1x1m), which had three holes at each corner. Then the tarpaulin was hooked to the Roman balance (100kg) and this was lifted (Plate 3). This method could only be used for tortoises weighing under 100kg. For bigger tortoises a large scale weighing balance (140kg) was used. The animals were lifted by three labourers and placed on the large scale balance (Plate 4). Weights of animals over 140kg were obtained only at La Vanille park as a load (1000kg) was available at the park. Weights of juveniles were taken using a scale (8kg) and an electronic balance (1.5kg) at Pamplémousses garden and La Vanille park respectively.

Raw data were  $\log_{10}$  transformed to stabilise the extent of variation. All the data were analysed statistically using Microsoft Excel, Office 2000. Weight and straight carapace length and curved carapace length of the animals were regressed. Anova was used to analyse whether there is a difference between the regressions of straight carapace length and weight of the males and females and also whether there is a difference in using straight carapace or curved carapace length.

## Results

Housing structure: Table 3 shows the different ways in which the animals were housed in the different parks and gardens.

From Table 3, it can be seen that adults were kept in open enclosures while juveniles were kept in closed nurseries. Basically, the goal in housing the giant tortoises should be to re-construct their natural habitat (Cohen 1994). The objectives of keeping giant tortoises in the parks can be categorised as: commercial, leisure and recreational and finally conservation. The private parks being commercials had sufficient fund to provide all the important features for the proper welfare of the tortoises as compared to the public gardens which were accessible free of charge to the visitors.

### Regression analyses

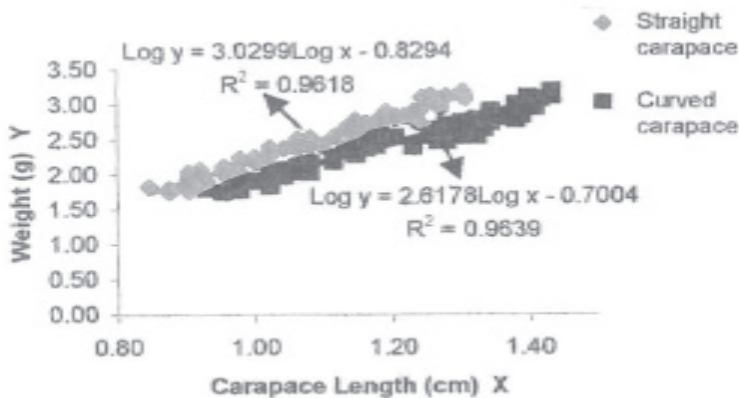
Relationships between weights (g), straight and curved carapace length (cm) were established for the juveniles, adult males and females. Fig. 1 shows the relationship between the straight and curved carapace length and weights of the juveniles.

The coefficients of regression ( $R^2$ ) when using straight and curved carapace methods was highly positive for the juveniles tortoises found at La Vanille. Both methods gave similar correlation coefficients. This implies that 96% of the variation in weight can be explained by the relationship between weight and straight carapace length. However 4% of the variation should be accounted to other factors. These were probably concerned with the feeding practices, health and physiological state of the animal as well as climatic factors. Fig. 2 and Fig. 3 show the regressions of the adult tortoises.

**Table 3:** Structure of pens/buildings, category and number of animals contained (in 2002)

Park	Pens/ buildings	Size (m <sup>2</sup> )	Number of animals	Category	Area/ animal (m <sup>2</sup> )	Features				
						Pond	Nest	Pool	Ground	Shade
<b>Balfour garden</b>	Pen	95	6	Adult	16	A	A	A	concrete	P
<b>SSRBG</b>	Pen	493	15	Adult	33	P	P	A	Grass cover	P
	Building	110	4	Adult	28	P	P	A	concrete	P
	Nursery	0.4	9	> 1 yr	0.04	A	A	A	Wooden box	P
<b>Casela Park</b>	Pen 1	308	10	Adult	31	P	P	P	Soil	P
	Pen 2	767	5	Adult	153	P	A	P	Soil	A
	Pen 3	800	2	Adult	400	P	A	P	Soil	A
	Nursery	0.5	1	>4 yrs	0.5	A	A	A	Grass	P
<b>La Vanille Park</b>	Pen	9334	103	Adult	90	P	P	P	Grass cover	P
	Sub-adult		119	20	8-12 yrs	10	P	A	P	
Grass cover	P									
	Nursery 1115		46	3-5yr	2.5	P	A	A	Grass, concrete	P
	Nursery 233		49	1-3yrs	0.7	P	A	A	Grass, concrete	P
	Nursery 335		54	<1 yr	1.5	P	A	A	Grass, concrete	P
	Nursery 470		47	1-3yrs	0.7	P	A	A	Grass, concrete	P

Key: P: Present, A: Absent



**Fig. 1** Weight against straight carapace length and curved carapace length for juveniles

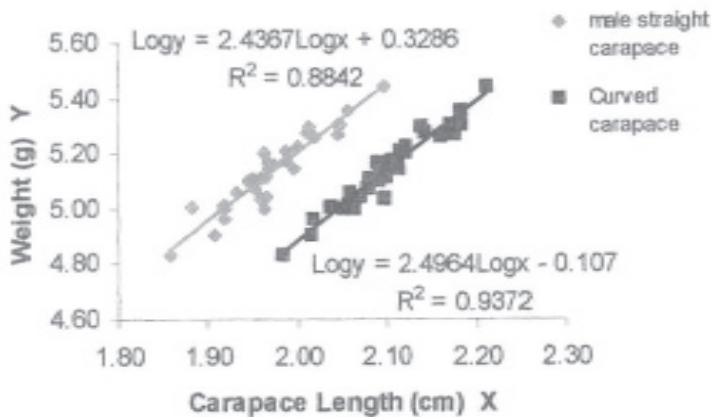


Fig. 2 Weight against straight carapace length for male adult tortoises

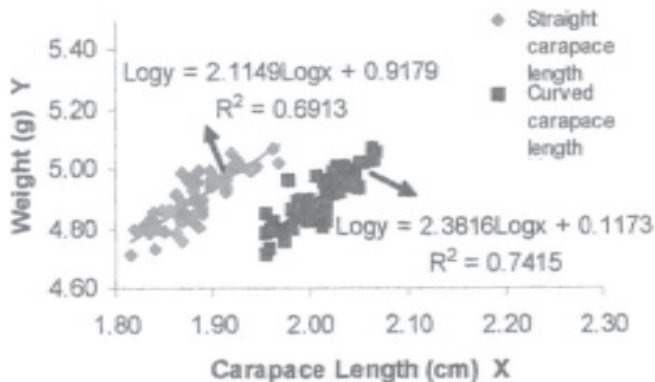


Fig. 3 Weight against straight carapace length and curved carapace length for female tortoises

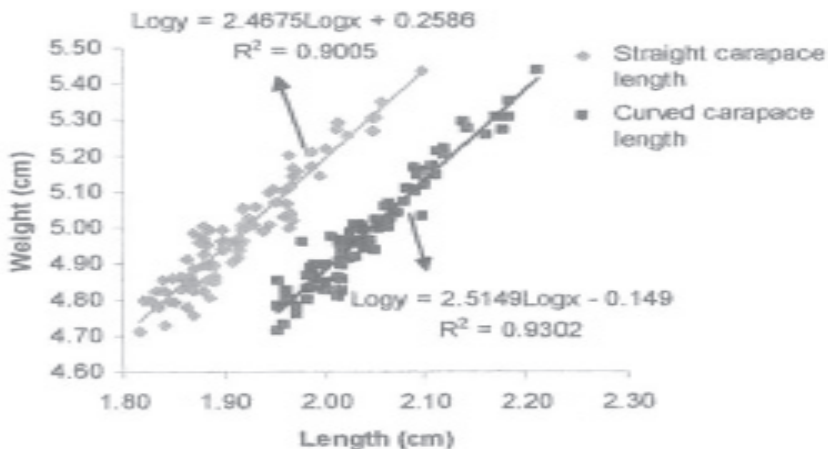


Fig. 4 Regression of adult tortoises using the straight and curved carapace length method.

Again, both  $R^2$  demonstrate a fairly high positive correlation between weight and the straight and curved lengths of male tortoises. It can be seen that the curved carapace length gave a greater  $R^2$  compared to the regression between straight carapace and weight of the animals.

A comparison of the regressions of adult males and females showed that  $F_{cal}(2.59) < F_{table}(3.18)$  (Appendix 1) indicating that there was no significant difference between the regression of straight carapace length and weight of adult males and females at 5% level. This might be because data collected for the males and females were not from the same age groups.

From these values, it may be deduced that at the juvenile stage, the relationship between weight and length is stronger than at adult stage as juveniles grow more rapidly than adults and after sexual maturity (16-30 years) the rate of growth of adults starts to decrease. This is especially significant for females as they invest their resources into egg production instead of growth.

Comparison of the straight carapace and curved carapace lengths as predictors of weight found no significant difference between the two methods as  $F_{cal}(1.23) < F_{table}(1.40)$ , (Appendix 2). This implies that both methods could be used for estimating the weights of the Aldabra giant tortoises. The curved carapace method gave a better estimation, as the use of the wooden rulers in the straight carapace method might not give accurate results.

## Conclusions

The Aldabra giant tortoises were kept in the private parks and public gardens to serve various purposes namely, commercial, leisure and recreational and finally for conservation purpose. The two private parks and SSRBG -Pamplemousses maintained the tortoises at a satisfactory level whereas at Balfour Garden improvements are needed. From the investigation, it can be concluded that the straight and curved carapace lengths can be used to estimate the animals' weights. The curved carapace length method would give a better estimation than the straight carapace length and moreover can be measured more easily. The regression analysis could be performed for other Aldabra tortoises found in zoos all around the world. This would be a good indicator of the assessment of health status of the animals.

## Acknowledgements

The authors are thankful to the following persons, for their help and collaboration during the research work namely: Mr Owen Griffiths (Director of La Vanille Crocodile Park, Rivière des Anguilles), Mr Tatayah Vikash (Mauritian Wildlife Foundation, Madam De Chazal Caroline, Consultant at Casela), Mr Aumeer (Officer in charge - SSR Botanical Garden, Pamplemousses), Mr Dinally Swalay (Welfare Officer, Municipality of Beau Bassin Rose-Hill), Mr Naidoo (Director of Areu) and Dr Justin Gerlach (Nature Protection Trust of Seychelles and University Museum of Zoology, Cambridge).

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#### Appendix 1: Difference in regressions of adult males and adult females

Source	SS	Df	Ms	F	
Residual male	0.07	29	0.00		
Residual female	0.13	54	0.00		
Total Residual	0.20	83	0.00		
Residual (M+F combined)	0.21	85	0.00		
Difference in regression	0.01	2	0.01	2.59	
		From table:		3.18	F calculated < F table (NS)

#### Appendix 2: Difference in regressions of adult tortoises using straight and curved length

Source	SS	Df	Ms	F	
Residual straight length	0.21	85	0.00		
Residual curved length	0.15	85	0.00		
Total Residual	0.35	170	0.00		
Residual (straight + curved combined)	0.13	84	0.00		
Difference in regression	0.22	86	0.00	1.23	
58		From table:		1.40	F calculated < F table (NS)