A retrospective study on the relationships between age, sex, and weight in captive capybaras (*Hydrochoerus hydrochaeris*)

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Abstract

Weight is an important indicator of health across all vertebrate taxa. Capybaras are held in captivity in 49 AZA-accredited institutions and as pets in the United States. Knowledge about capybaras is limited, including what constitutes normal weight ranges for males and females. The aims of this study were to 1) provide reference information for caretakers about normal growth and body weights and 2) compare growth parameters between capybaras held in AZA facilities and those held as pets. Weights from individuals in captivity were collected from the ROUS Foundation (n=39 individuals) and ten AZA-accredited institutions (n=70 individuals) and growth parameters calculated using Gompertz curves. The results showed that females had faster maximum growth rates (0.62% body mass per day) and had a higher asymptotic weight (51.4 kg) than males (0.50% body mass per day, 50.5 kg, respectively). We hypothesized that individuals from AZA institutions would have superior diets and care and that this would be reflected in their growth parameters. There was no statistically significant difference in maximum growth rates or asymptotic weights for either sex. However, males, and to a lesser extent females, held at AZA institutions both achieved maximum growth rates significantly sooner than pets. This suggest that care and nutrition may be better at AZA institutions but the care given to pets appears to have been sufficient to allow for full compensation in growth rate and asymptotic weight. The growth rate curves and estimated weight by sex and age tables provide information that can be used by veterinarians, owners, breeders, and zookeepers to monitor individuals' weight gain and identify signs of improper growth that may be caused by underlying medical conditions.

Keywords: growth rate, growth, pets, nutrition, compensatory growth, capybara

Introduction

The capybara (*Hydrochoerus hydrochaeris*) is the largest extant rodent in the world. They are native to most of South America, including Colombia, Peru, Brazil, and Venezuela, and live in semiaquatic areas (Monsalve 2019). They are currently found in captivity in 49 AZA-accredited institutions in the United States and Canada (Association of Zoos and Aquariums 2017). They are also kept as pets, in small non-AZA-accredited institutions, and by breeders in the United States.

Care may differ between AZA- and non-AZA-accredited institutions as AZA facilities must adhere to strict requirements in order to maintain accreditation. The AZA evaluations are conducted every five years and areas evaluated include animal care, welfare and well-being, veterinary care, and conservation and scientific advancement, among others (Association of Zoos and Aquariums 2020). AZA institutions must ensure that animals receive nutritionally complete diets that encourage natural feeding responses and behavior. They must allow animals to make choices and have control over their environment to promote natural behaviors. They must ensure their animals are in good physical health and are provided with adequate living space to promote the development of normal behavior and coping skills to avoid chronic stress (Association of Zoos and Aquariums 2020).

By comparison, non-AZA-accredited facilities are not required to meet any of these needs and may have less access to state of the art care techniques. As a result, animals in non-AZA-accredited facilities may not receive appropriate nutrition, veterinary care, enrichment, or adequate housing which may affect their growth and ability to survive, however there are few if any studies explicitly testing this hypothesis.

Knowledge about capybaras is limited, but studies report that the average weight of an adult capybara is about 50 kg, ranging from 35 kg to 66 kg, with the highest recorded weight as 91 kg for a female, and 74 kg for a male (Mones et al. 1986, Moreira and Macdonald 1996, Emmons 1997). Female capybaras have been reported to reach sexual maturity at 26 months of age (Chapman 1990) while males are reported to reach sexual maturity at 1.5 to 2 years (Moreira et al. 2013). Information on growth rates is limited, with the only study to date reporting that wild males and females of mixed ages grew at similar rates nearly tripling in weight and adding about 28 kg over a 10-month period (Herrera 1992).

As capybaras become more popular pets, it is important that their caretakers have an understanding of what their average growth rate should be in order to identify early signs of improper growth and weight loss that may be due to an underlying medical condition. Some of the most common diseases in capybaras that can lead to significant weight loss include dental disease, metabolic bone disease, and vitamin C deficiency (Moreira, et al. 2013, Shim 2017). Ectoparasites, such as scabies, and some endoparasites have also been reported to affect captive populations causing severe anorexia and death (Moreira, et al 2013). Many diseases can be prevented by providing capybara populations with adequate nutrition and husbandry. One study revealed that vegetables high in vitamin C, vitamin B6, and other nutrients improved the quality of hair coat and weight gain (Shim 2017). However, there seems to be no information on age-specific normal weight ranges that can be utilized as an early warning of nutritional or medical problems in capybaras.

The aim of this study is to provide practical information to help define normal, age-specific body weights for male and female capybaras in captivity. We also test the hypothesis that individuals from non-AZA-accredited facilities would grow slower, take longer to reach their maximum growth rate, and have a lower total weight than individuals from AZA-accredited facilities.

Materials and Methods

Selection of Animals

In order to determine average weight parameters for captive capybaras, two groups of capybaras were compared. The ROUS Foundation collected weights from animals kept as pets, by breeders, or at non-AZA accredited facilities over the course of 8 years (n=40 individuals, 592 data points). AZA-accredited zoos in the United States and in Canada were contacted to provide weights for capybaras kept in their collections (N=49 zoos contacted). Of these, 10 institutions in the United States and Canada responded and provided weights (981 data points) for capybaras in their collections (n=80 individuals). Animals in the two categories were further divided by sex, resulting in four groups: female AZA (n=42), male AZA (n=38), female non-AZA (n=21), and male non-AZA (n=19). Any individual whose data did not come from an AZA-accredited facility was categorized as "non-AZA." Animals with unknown sex were excluded from analysis.

In order to ensure that only weights from apparently healthy and normal animals were included in our analysis, individuals that were sick, castrated, dead, or pregnant at the time the weights were recorded were excluded. This included any weights recorded within 1 month of an individual being sick. One additional individual was excluded from the analysis, as this individual appeared to be extremely underweight, grew poorly, and was a clear outlier compared to the remaining animals in the data set.

Statistical Analysis

In order to compare capybara growth parameters between the genders and institution types we fitted Gompertz curves using JMP Pro v 14 and calculated the following parameters: asymptotic weight (an estimate of maximum weight), maximum growth rate (maximum slope of the curve), age at maximum growth rate (the inflection point of the curve) and the 95% confidence intervals for each parameter. The number of weight measurements per individual varied widely (range 1 to 138 weights per individual) and over 50% of the individuals had 6 weights or less (far too few to calculate a meaningful growth curve for separate individuals). As a result, all data points were combined for each study group under analysis (male, female, AZA, non-AZA) and a single curve was fitted for each group. We compared the growth parameters between males and females: when the parameter estimate from the males fell outside the 95% confidence interval for the females we considered the difference to be significant. Similar analyses were conducted for all study groups (AZA male, AZA female, non-AZA male, and non-AZA female). We created a table of capybara ages and expected weights for each gender using both the fitted Gompertz growth curves and the means, standard deviations, and ranges calculated from the original data (data used were from both AZA and non-AZA individuals combined).

Results

The Gompertz growth curves calculated from the combined 1573 data points from 120 individuals had a very good fit ($R^2 = 0.89$), indicating that about 89% of the variation in the data is explained by the curves. The data suggests that combined, the 63 female capybaras had a significantly greater combined asymptotic weight (51.4 kg) and significantly greater maximum growth rate (0.62% of body weight per day), than the 57 males (50.5 kg, and 0.50% of weight per day). Figs. 1, 2, 3, See Tables S1 and S2 for 95% confidence intervals. However, both genders reached maximum growth rates at a similar age (206 days females, 205 days males) (Figure 4, Table S3).

The predicted body weight by age calculated using the Gompertz equation and the mean body weight from the data are quite similar for female capybaras across all ages (Table 1). However, for males, the values from the Gompertz equation calculations are higher compared to the means from the data, until about 90 days, after which, the Gompertz equation calculations are lower compared to the means from the data (Table 2). Using a combination of the Gompertz equation calculations and means from the data, practitioners should be able to identify individuals which have bodyweights that differ widely from the expected values and may be suffering from underlying health issues.

There was no significant difference between the asymptotic weight for non-AZA (50.4 kg) and AZA males (50.3 kg, Table S1) and no significant difference between the maximum growth rates for non-AZA (0.51%) and AZA males (0.53%, Table S2). However, the age at maximum growth rate for AZA males was significantly younger (176 days) than for non-AZA males (231 days, Table S3).

There was no significant difference between the asymptotic weight for AZA (51.4 kg) and non-AZA females (51.2 kg, Table S1) and no significant difference between the growth rate for AZA (0.63%) and non-AZA females (0.61%, Table S2). However, the age at maximum growth rate for AZA females (199 days) was significantly younger than for non-AZA females (211 days, Table S3).

Discussion

We hypothesized that capybaras living in AZA-accredited facilities would grow faster, have a greater asymptotic weight, and reach their maximum growth rate at a younger age than individuals living in non-AZA-accredited facilities. However, this hypothesis was only partially supported by the data: the main difference between the groups was that the individuals in the AZA facilities achieved maximum growth rate earlier (12 days earlier for females and 56 days earlier for males overall). By contrast, there was no statistically significant difference between the maximum growth rate and asymptotic weights between AZA and non-AZA animals for either sex. This finding surprised us as AZA-accredited institutions follow nutritional guidelines and regulate all aspects of care including types and quantities of food (Association of Zoos and Aquariums 2020). We also suspected that owners, breeders, and smaller non-AZA-accredited facilities might not have access to information regarding ideal nutrition and diets for capybaras, and thus may not have been feeding them adequately and this would result in inferior growth.

While this finding was not expected, it appears to be an example of compensatory growth. Across a wide range of mammals and birds, periods of slow growth due to suboptimal nutrition are followed by periods of more rapid growth with the result that individuals with inappropriate nutrition become indistinguishable from individuals that received appropriate nutrition (Wilson and Osbourn 1960). In our study, the average diets and care of the AZA facilities may have been superior, allowing the capybaras to achieve maximum growth rates at a younger age. However, on average, the nutrition and care for the pets and individuals from non-AZA facilities in our study appears to have been sufficient to allow for the full compensation in growth rate and asymptotic weight.

Overall, the estimated asymptotic weight for females at 51.4 kg was significantly greater than that of males at 50.5 kg. However, the finding that the two sexes differed by <3% suggests that size dimorphism is not strongly pronounced. In our study the highest recorded weights for capybaras were 68 kg for a juvenile male at Sedgwick County Zoo, and 66 kg in an adult female at the Alexandria Zoo. The weight estimates from our study match well with the literature that commonly states that adult capybaras weigh about 50 kg (Moreira and Macdonald 1996, Herrera et al 2011) and range from 35 kg to 65.5 kg

(Mones et al., 1986, Emmons 1997). In the wild, Herrera and Macdonald (1993) found dominant male capybaras often weighed over 60 kg while subordinate adult males usually ranged between 55 and 57 kg. From the literature, the highest recorded weight as 91 kg for a female and 73.5 kg for a male (Mones and Ojasti 1986).

In our study, females had maximum growth rates approximately 25% greater than males and capybara growth rates reached their maximum at about 6 months of age followed by a slower progression of weight gain to their asymptotic weight. However, growth measured as weight always needs to be interpreted cautiously, as nutritional considerations can clearly impact body weight: wild capybaras have been documented losing up to 8 kg in body weight during dry seasons with scarce resources (Herrera 1992).

A variety of parasites, diseases and nutritional issues in captivity can cause reduced growth in young capybaras and weight loss in adults (Moreira, et al 2013). The growth curves and tables we present are a resource for veterinarians, owners, zookeepers, and breeders to use to monitor the growth of individual capybaras and identify signs of nutritional problems or underlying disease. The tables (1 and 2) include predicted weights from the Gompertz equation, and average weights from the data for a variety of age ranges. For females, either the predicted weight or the actual weight for each age range can be used for comparison, as there is little difference between the two.. However, for males, it is best to use the average weight calculated from the data until about 90 days of age, as the Gompertz equation seems to provide an overestimate of the expected weight for younger individuals. It is our hope that stakeholders will use these resources to determine when individual capybaras are not meeting their expected growth rates or age specific target weights and use this knowledge to facilitate early intervention and provide the necessary changes in husbandry or veterinary care.

Acknowledgements

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Figure 1a. Growth curves for female capybaras living in captivity calculated with data from 63 individuals from AZA and non-AZA accredited institutions combined. The solid red line represents the Gompertz fitted curve for the data (R^2= 0.89). Each data point represents a female capybara's weight at a given age in days (N = 835 points).

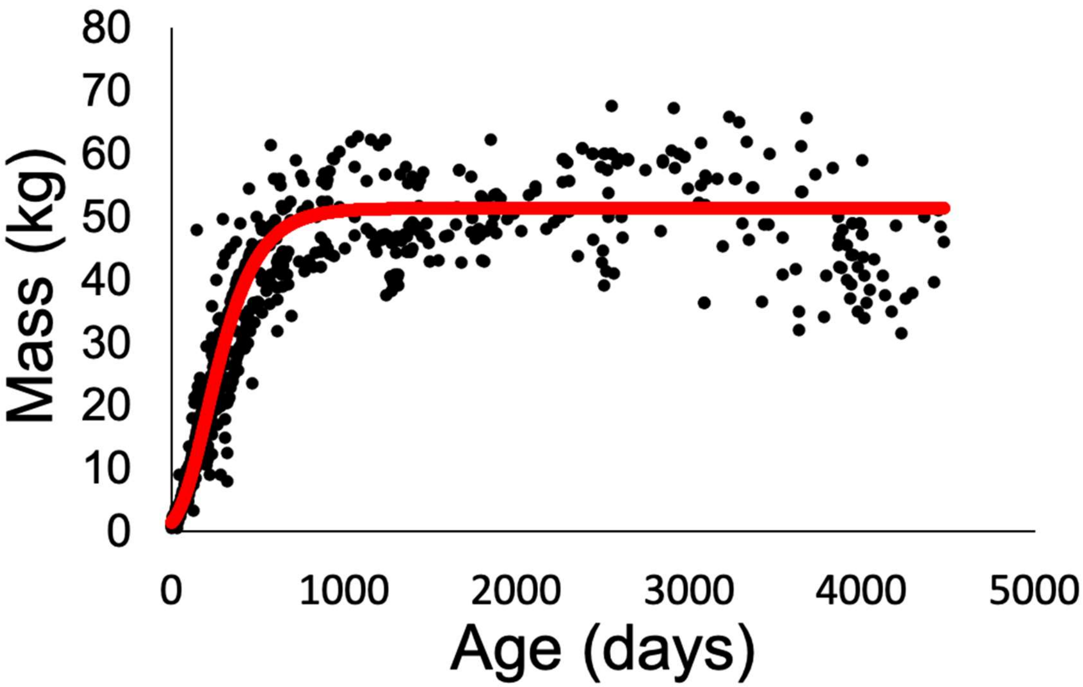

Figure 1b. Growth curves for male capybaras living in captivity calculated with data from 57 individuals from AZA and non-AZA accredited institutions combined. The solid blue line represents the Gompertz fitted curve for the data (R^2= 0.89). Each data point represents a male capybara's weight at a given age in days (N = 738 points).

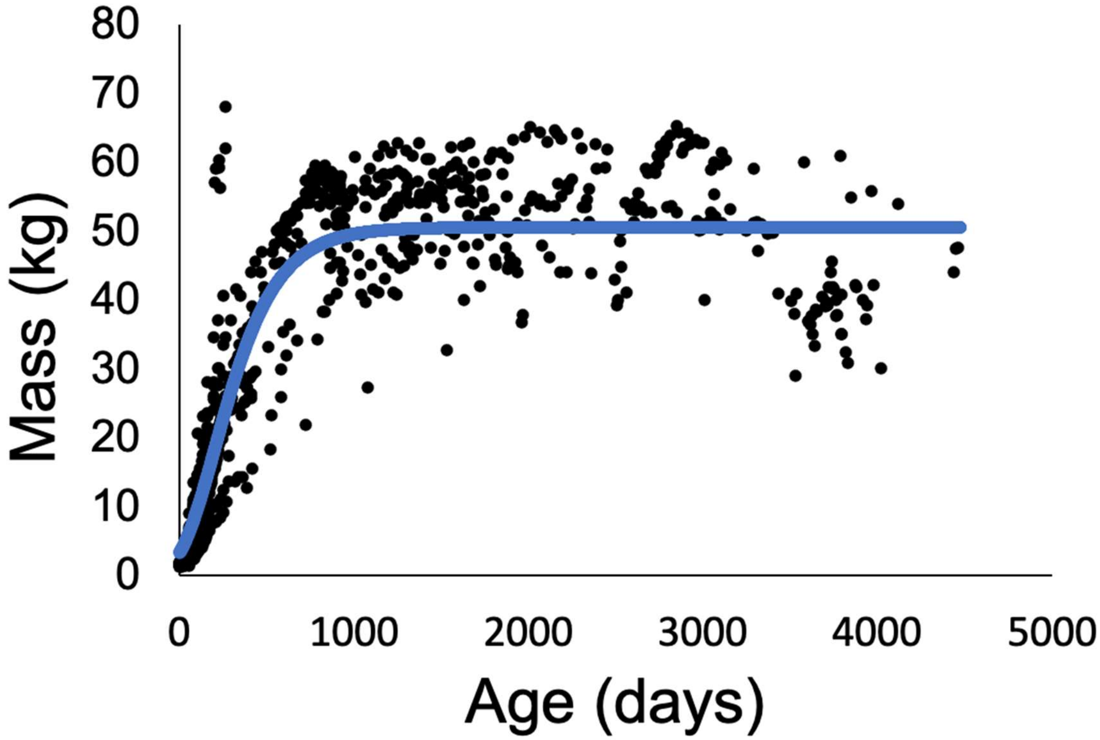

Figure 2. Asymptotic weights (kg) for each of the sex-by-institution type groups: female (F), male (M), animals held by AZA accredited institutions (AZA) and those held as pets and non-AZA institutions (Non-AZA). The estimated asymptotic weight for each group is represented by the diamond-shaped dots. The bars represent the 95% confidence intervals around the parameter estimates. Pairs of parameters differ significantly if the parameter estimate does not fall within the 95% confidence interval of the other parameter (see text for additional information). Sample sizes for each group are given in Table S1.

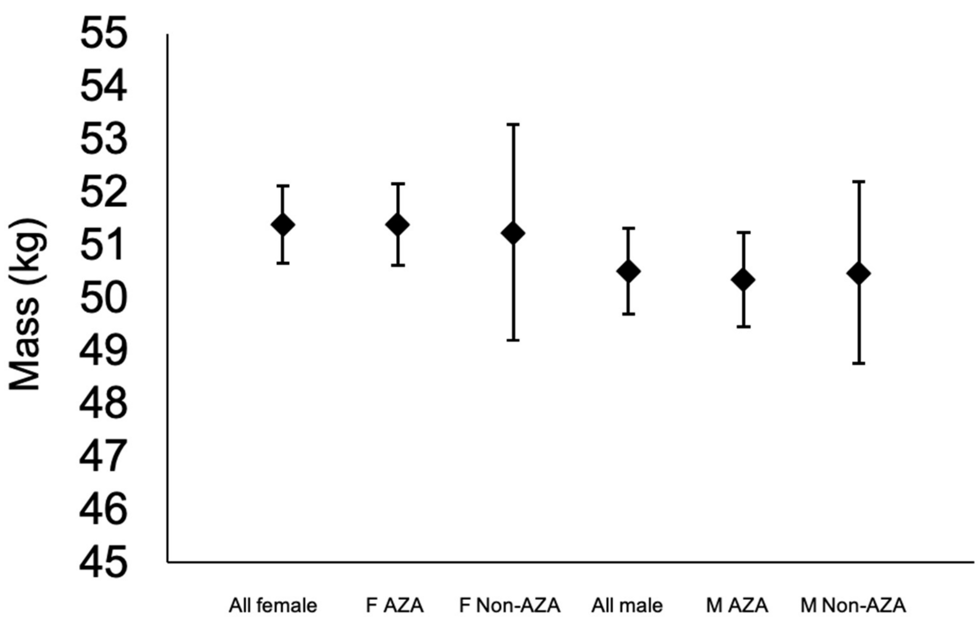

Figure 3. Maximum growth rate (% body mass per day) for each of the sex-by-institution type groups: female (F), male (M), animals held by AZA accredited institutions (AZA) and those held as pets and non-AZA institutions (Non-AZA). The estimated maximum growth rate for each group is represented by the diamond-shaped dots. The bars represent the 95% confidence intervals around the parameter estimates. Pairs of parameters differ significantly if the parameter estimate does not fall within the 95% confidence interval of the other parameter (see text for additional information). Sample sizes for each group are given in Table S2.

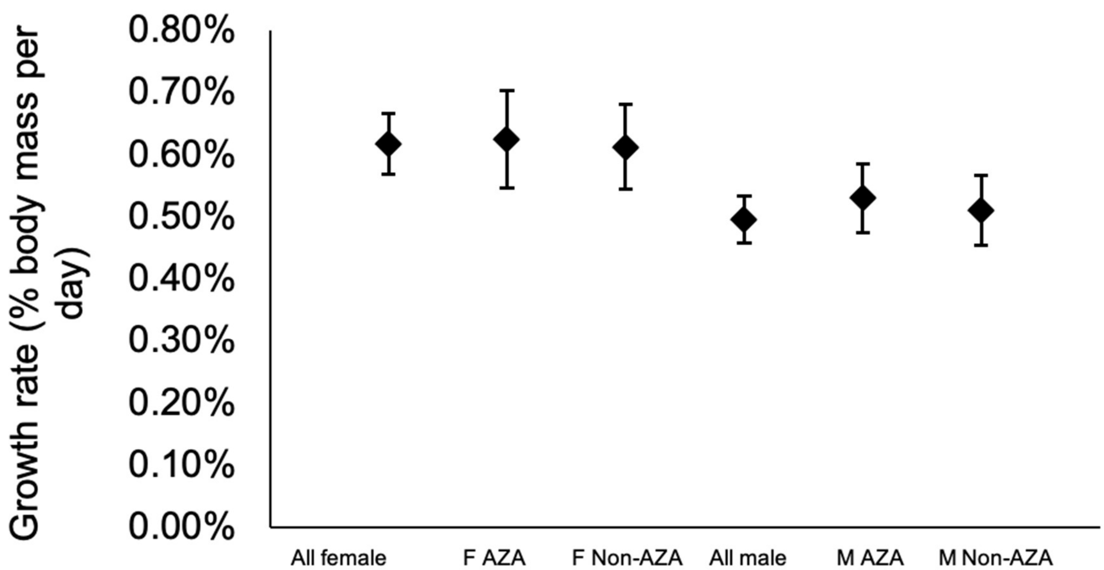

Figure 4. Age in days to reach maximum growth rate for each of the sex-by-institution type groups: female (F), male (M), animals held by AZA accredited institutions (AZA) and those held as pets and non-AZA institutions (Non-AZA). The estimated age for each group is represented by the diamond-shaped dots. The bars represent the 95% confidence intervals around the parameter estimates. Pairs of parameters differ significantly if the parameter estimate does not fall within the 95% confidence interval of the other parameter (see text for additional information). Sample sizes for each group are given in Table S3.

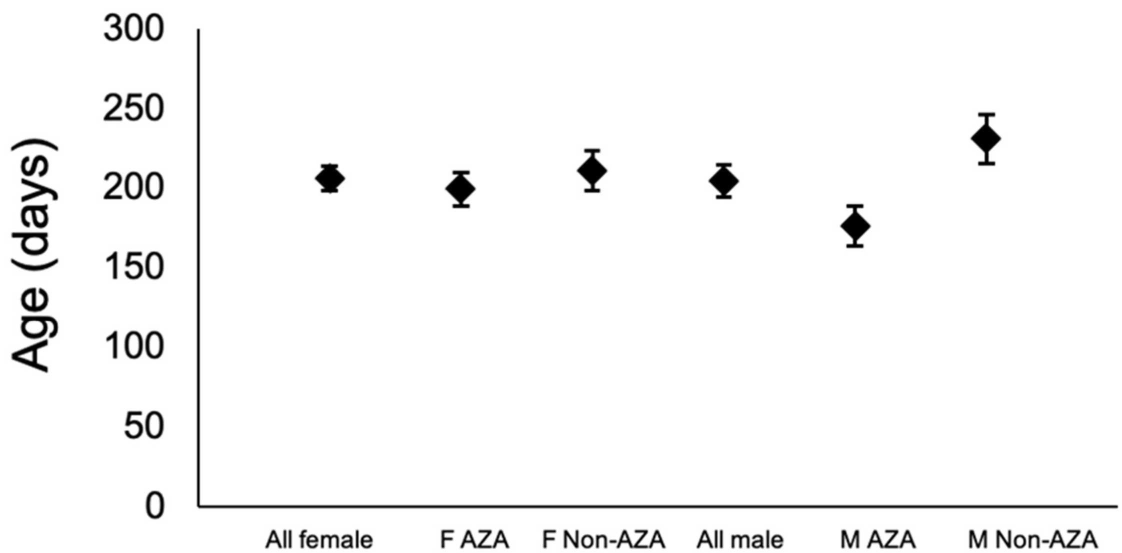

Table 1. Predicted and actual weights by age for female capybaras including combined data from animals held at AZA accredited institutions, pets and other non-AZA facilities (N = 63 individuals). Predicted weights (kg) for each age were calculated using the Gompertz equations calculated in this paper (Figure 1a). The mean and standard deviations were calculated using the raw data within each age range from all individuals combined. The number of points used in the calculation of each mean and standard deviation is given under “N (data).”

Females	**From equation**		**From data**		
Age	**Predicted weight (kg)**	**Age range**	**Mean (kg)**	**Stdev**	**N (data)**
Birth	1.45	0 to 1 days	1.34	0.17	4
7 days	1.68	6 to 8 days	1.45	0.39	7
14 days	1.95	13 to 15 days	1.60	0.45	7
21 days	2.24	19 to 23 days	1.93	0.57	5
28 days	2.56	25 to 31 days	2.54	0.72	9
60 days	4.38	54 to 66 days	4.74	1.54	20
90 days	6.63	81 to 99 days	6.97	2.59	24
120 days	9.37	108 to 132 days	9.79	3.49	25
150 days	12.49	135 to 165 days	13.13	4.33	53
180 days	15.86	162 to 198 days	15.79	3.66	63
210 days	19.35	189 to 231 days	18.39	5.55	51
240 days	22.82	216 to 264 days	22.48	7.41	39
270 days	26.17	243 to 297 days	27.39	7.75	38
300 days	29.33	270 to 330 days	28.89	7.63	37
330 days	32.24	297 to 363 days	30.95	8.57	26
1 year	35.30	328 to 402 days	35.56	6.16	24
18 months	45.57	495 to 605 days	44.94	7.84	20
2 years	49.39	657 to 803 days	51.69	6.28	29
3 years	51.17	985 to 1205 days	53.26	6.65	28
4 years +	51.36	1314 to 1606 days	53.31	5.90	41

Table 2. Predicted and actual weights by age for male capybaras including combined data from animals held at AZA accredited institutions, pets and other non-AZA facilities (N = 57 individuals). Predicted weights (kg) for each age were calculated using the Gompertz equations calculated in this paper (Figure 1b). The mean and standard deviations were calculated using the raw data within each age range from all individuals combined. The number of points used in the calculation of each mean and standard deviation is given under "N (data)."

Males	**From equation**		**From data**		
Age	**Predicted weight (kg)**	**Age range**	**Mean (kg)**	**Stdev**	**N (data)**
Birth	3.20	0 to 1 days	1.02	0.48	2
7 days	3.52	6 to 8 days	1.82	NA	1
14 days	3.85	13 to 15 days	1.73	0.18	4
21 days	4.21	19 to 23 days	2.41	0.45	10
28 days	4.58	25 to 31 days	2.94	0.43	19
60 days	6.51	54 to 66 days	4.99	1.16	30
90 days	8.64	81 to 99 days	7.82	1.96	26
120 days	11.03	108 to 132 days	9.54	3.08	27
150 days	13.61	135 to 165 days	15.83	6.53	41
180 days	16.32	162 to 198 days	17.02	5.28	29
210 days	19.08	189 to 231 days	24.96	14.05	32
240 days	21.82	216 to 264 days	27.22	12.69	28
270 days	24.51	243 to 297 days	27.41	12.29	29
300 days	27.08	270 to 330 days	24.62	8.31	25
330 days	29.52	297 to 363 days	26.56	8.57	23
1 year	32.15	328 to 402 days	29.55	7.98	35
18 months	42.16	495 to 605 days	40.81	8.93	21
2 years	46.90	657 to 803 days	45.18	10.24	14
3 years	49.89	985 to 1205 days	47.87	8.79	16
4 years +	50.40	1314 to 1606 days	49.98	5.33	29

Supplemental Tables

Table S1: Capybara asymptotic weight and associated 95% confidence intervals calculated using a Gompertz curve fitted to the combined data from all individuals in each group. Estimates for females that fall outside the 95% confidence intervals for males indicate a statistically significant difference between the sexes. Individuals were from AZA accredited institutions and from pets and individuals held at non-AZA institutions. “N” shows the number of points used for fitting the curve and “individuals” the number of distinct individuals from which those points were drawn.

Group	Estimate		Lower 95% CI	Upper 95% CI	N (points)	Individuals
Females Combined	51.4	*	50.7	52.1	835	63
Females AZA	51.4		50.6	52.2	524	42
Females Non-AZA	51.2		49.2	53.3	311	21
Males Combined	50.5	*	49.7	51.3	738	57
Males AZA	50.3		49.5	51.2	457	38
Males Non-AZA	50.5		48.7	52.2	281	19

*There was a statistically significant difference between females combined and males combined.

Table S2: Capybara maximum growth rates and associated 95% confidence intervals calculated using a Gompertz curve fitted to the combined data from all individuals in each group. Estimates for females that fall outside the 95% confidence intervals for males indicate a statistically significant difference between the sexes. Individuals were from AZA accredited institutions and from pets and individuals held at non-AZA institutions. “N” shows the number of points used for fitting the curve and “individuals” the number of distinct individuals from which those points were drawn.

Group	Estimate		Lower 95% CI	Upper 95% CI	N (points)	Individuals
Females Combined	0.62%	*	0.57%	0.67%	835	63
Females AZA	0.62%		0.55%	0.70%	524	42
Females Non-AZA	0.61%		0.54%	0.68%	311	21
Males Combined	0.50%	*	0.46%	0.53%	738	57
Males AZA	0.53%		0.47%	0.59%	457	38
Males Non-AZA	0.51%		0.45%	0.57%	281	19

*There was a statistically significant difference between females combined and males combined.

Table S3: Capybara age at maximum growth rate and associated 95% confidence intervals calculated using a Gompertz curve fitted to the combined data from all individuals in each group. Individuals were from AZA accredited institutions and from pets and individuals held at non-AZA institutions. Where estimates for non-AZA animals fall outside the 95% confidence intervals for AZA animals it indicates a statistically significant difference between the two institutions types. "N" shows the number of points used for fitting the curve and "individuals" the number of distinct individuals from which those points were drawn.

Group	Estimate		Lower 95% CI	Upper 95% CI	N (points)	Individuals
Females Combined	206		199	214	835	63
Females AZA	199	*	189	210	524	42
Females Non-AZA	211	*	199	224	311	21
Males Combined	205		195	214	738	57
Males AZA	176	*	164	189	457	38
Males Non-AZA	231	*	216	246	281	19

*There was a statistically significant difference between individuals of both sexes between AZA and non-AZA individuals.