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External morphology and biometry of newborn agouti (*Dasyprocta prymnolopha,* Wagler 1831)*

Morfologia externa e biometria de neonates de cutias (*Dasyprocta prymnolopha*, Wagler 1831)

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Abstract

Morphological features are essential to assess neonates' viability. In order to characterize the morphology and biometry of newborn agouti, 36 animals born at 103 days of gestation under human care in Teresina-PI, Brazil were evaluated. After birth, the newborns were weighed on digital precision scales, measured with a flexible tape measure and their external morphology was assessed. The animals observed had coat color trait of adults, open eyes, hairs in the nasal region and four incisor teeth. The forelimbs had developed four digits and the hind limbs three digits, with white edged claws and a short hairless tail. The following were observed: weight of 144.58 ± 33.39g and lengths: crown-rump 14.73 ± 1.82cm, total 19.88 ± 1.52cm, head to tail 16.95 ± 1.55cm, head 7.33 ± 0.59cm, thoracic girth 11.78 ± 1.36cm, abdominal girth 10.73 ± 1.21cm, tail length 1.18 ± 0.25cm, eye diameter 1.27 ± 0.27cm and ear length 0.21 ± 0.35cm. The agoutis presented morphological maturity at birth with external morphology very similar to that of the adult animals. Most of the births in this species are the double type and newborns that weigh more than 90g have better chances of survival in captivity.

Keywords: gross anatomy, offspring, precocious animals, wild rodent.

Resumo

As características morfológicas são essenciais para avaliar a viabilidade dos neonatos. Para caracterizar a morfologia e biometria de cutias recém-nascidas, foram avaliados 36 animais nascidos aos 103 dias de gestação sob cuidados em Teresina-PI, Brasil. Após o nascimento, os recém-nascidos foram pesados em balança digital de precisão, medidos com fita métrica flexível e avaliada sua morfologia externa. Os animais observados apresentavam traço de pelagem de adultos, olhos abertos, pelos na região nasal e quatro dentes incisivos. Os membros anteriores desenvolveram quatro dedos e os membros posteriores três, com garras brancas afiadas e uma cauda curta e sem pêlos. Foram observados: peso de 144,58 ± 33,39g e comprimentos: garupa 14,73 ± 1,82cm, total 19,88 ± 1,52cm, cabeça a cauda 16,95 ± 1,55cm, cabeça 7,33 ± 0,59cm, perímetro torácico 11,78 ± 1,36cm, abdominal perímetro 10,73 ± 1,21 cm, comprimento da cauda 1,18 ± 0,25 cm, diâmetro do olho 1,27 ± 0,27 cm e comprimento da orelha 0,21 ± 0,35 cm. As cutias apresentaram maturidade morfológica ao nascimento com morfologia externa muito semelhante à dos animais adultos. A maioria dos nascimentos nesta espécie são do tipo duplo e recém-nascidos que pesam mais de 90g têm melhores chances de sobrevivência sob cuidados humanos.

Palavras-chave: anatomia macroscópica, prole, animais precoces, roedor silvestre.

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Introduction

The agoutis are wild rodents found throughout the area of Neotropical America and is distributed into 13 different species that constitute the genus *Dasyprocta* (IUCN, 2022). These species are highlighted as ecological and economic importance, and are considered experimental models for endangered hystricognath rodents (Costa and Martins, 2008; Silva et al., 2014; Oliveira et al., 2017). The interest in the use of wild rodents as a model of postnatal development has grown in the last mpor (Ladd et al., 2012; Cavalcanti et al., 2014; Mohammad et al., 2019) because they can easily adapt to *ex situ* conditions and they exhibit prolificity, precocity, and relatively short gestation period (Hosken and Silveira, 2001). These characteristics facilitate studying their physiology and exploring their zootechnical potential (Pachaly et al., 1999; Ribeiro et al., 2008).

In agoutis, studies on the female reproductive biology reported that they are non-seasonal breeder (Campos et al., 2015; Singh et al., 2014), reaching puberty at nine months (Guimarães et al., 2009). The estrous cycle varies among the species, 29.94 ± 6.77 days in *D. prymnolopha* (Carreiro et al., 2018), and 28.2 ± 0.7 days in *D. mportan* (Campos et al., 2015). The gestation period ranges from 103-104 days (Sousa et al., 2012) but there are reports varying 104 to 120 days (Deutsch and Puglia, 1988), 101 and 106 days (Guimarães, 2000), 116 to 135 days (Hosken and Silveira, 2001).

In *ex situ* conditions, when receiving an abundance of food with a high plane of nutrition may produce larger litters, between one and six young (Singh and Garcia, 2015). But the most studies report average litter size of 1.7–2 precocial young (Mayor et al., 2011; Jones and Garcia, 2021). The newborns have teeth, open eyes, a fur-covered body. They are active at birth (Lange and Schmidt, 2007), walk and eat solid foodstuffs within a few hours (Hosken and Silveira, 2001).

Considering the ecological importance and the zootechnical potential of agouti and to support more advanced research, improving productivity in these animals, studies on developmental biology are mportante to determine the viability of animals, in the gestational and neonatal period. Newborn characterization and establishing standard measurements are essential to identify premature births and to assess the viability of the newborn, thus the objective of this study was to morphologically characterize newborn agouti (*Dasyprocta prymnolopha*) at birth.

Material and methods

the protocols used in the present study were authorized by the Chico Mendes Institute for Biodiversity Conservation (Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio) (SISBIO N° 20169-1) and approved by the Ethics Committee for Animal Experimentation at the Federal University of Piauí (N° 001/09).

Thirty-six newborn agoutis were used: born from natural births from 20 female agouti that lived in 2x2m stalls in groups with one male for five females, at the Nucleus for Wild Animal Study and Preservation (Núcleo de Estudos e Preservação de Animais Silvestres) (Registro IBAMA 02/08-618), at the Federal University of Piauí. The females were submitted to daily colpocytology to confirm mating by the presence of sperm on the vaginal smear thus identifying gestation day zero. They were followed by trans-abdominal ultrasound, using a 100LC Pie Medical Scanner, frequency 5.0 and 7.5 MHz, to confirm the gestation at day 25, when the embryo heart was identified and placenta could be observed (SOUZA et al., 2012). At birth, before completing 24 hours of life, the offspring were sexed, the type of birth and gestation period in days were recorded and the animals were weighed on digital scales (Figure 1A) and measured with a flexible tape measure, 0.1 cm accuracy (Figure 1B and 1C). The following lengths were measured: crown rump (CR), corresponding to the distance from the cranium to the base of the tail in a straight line, head to tail (CC), from the cranium to the tail base, following the dorsal curve, and the head (CEF) from the front edge of the nostrils to the articulation with the occipital. The total length (TL) from the front edge of the nostrils to the end of the tail, the thoracic (TG) and abdominal girths (AG), tail length (TaL), eye diameter (ED) and ear length (EL) (Figure 1C) were also measured.

The means and standard deviations were calculated, and the graphs constructed using the Microsoft Excel program from the Office 2003 package. The weight and length values were expressed in grams and centimeters, respectively. Analysis of variance was carried out to compare the means by the SNK test (SAS, 1986).

Results and discussion

All the agouti gestations observed during this study resulted in normal deliveries at 103 days as reported by Lange and Schmidt (2007), Souza et al. (2012), de Oliviera et al., (2019), Jones et al. (2020) and Jones and Garcia (2022), while Guimarães (2000) gave a gestational period ranging from 101 and 106 days and Deutsch and Puglia (1988) 104–120 days.

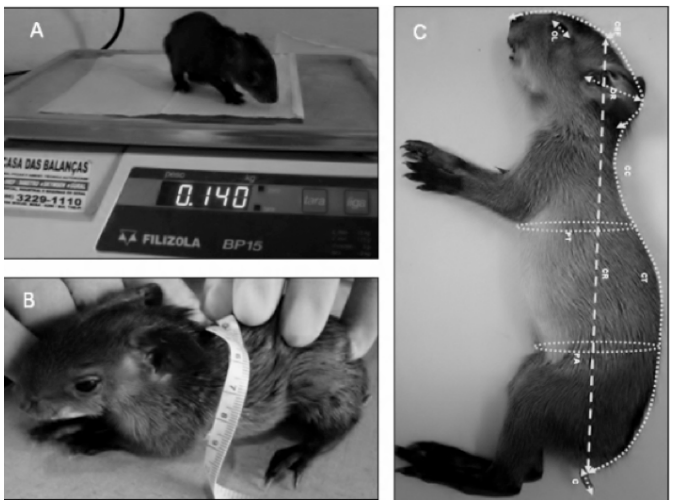
Regarding the type of birth, there were single (20%), double (75%) and triple (5%) gestations coinciding with the results obtained in other studies, 70.59% (Lopes et al., 2004) and 61.7% (Oliveira et al., 2007) double births in agouti. Mohammed et al. (2018) also reported that twin births are predominant (57.7%), while single births represents 34.6%, triplet births 6.4% and quadruplet birth 1.3%. The mean of animals born was 1.8±0.40 offspring per birth, as reported by other authors (Guimarães, Matos and Vale, 1994; Lange and Schmidt, 2007), while Mayor et al., (2011); Jones et al. (2020), Jones and Garcia (2021) reported that average litter size is 1.25–2 precocial young, varying among 1-4 (1.7±0.4).

At birth the agouti presented external morphological characteristics such as open eyes and ears and developed coat, like the adult, and with two upper and lower incisors showing that they could defend themselves shortly after birth and can be considered precocious (Dyce et al., 2010). Besides, the newborn agouti showed morphological maturity that allowed them to walk shortly after birth. These findings corroborated previous studies (Lange and Schmidt, 2007) and differed from the rat that, although belonging to the Rodentia order, has offspring that are born morphologically immature, with closed eyes and ears and no fur, and they only open their eyes 12 or 14 days after birth (Theiler, 1989).

The coat presented coloring characteristic of adult animals and they had open eyes and developed ears (Figure 1). Large black

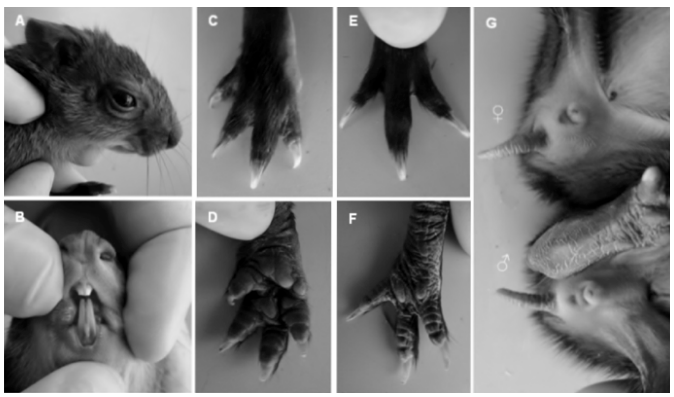
tactile hairs were observed in the nasal region (Figure 2A). Four erupted incisor teeth were identified, the upper were shorter and the lower teeth longer (Figure 2B).

Figure 1: Side view of newborn agouti, showing the procedures performed: A weighing and in B and C means of the lengths crown-rump (CR), total (TL), head to tail (CC) and head (CEF). Thoracic girth (TG) and abdominal girth (AG) and tail (TaL), eye diameter (ED), ear length (EL).



Regarding the limbs of the agouti newborn, four developed digits were found on the forelimbs while on the hind limbs there were only three digits. On both the limbs the digits were covered with hairs on the back and the forelimb palm and the soles of the hind limbs were covered with thick hairless skin that on the hind limbs extended along the metatarsus. Fore and hind footpads were observed and white-tipped claws (Figure 2/C, D, E and F). The genitals were differentiated and the tail was short and hairless (Figure 2G).

Figure 2: Agouti newborn. A – side view of the head showing the ear, open eye, nostril and tactile hairs; B – in detail observe the erupted incisors, upper (shorter) and lower (longer); C – forelimbs with four digits, in dorsal view and D – palm view, E – hind limbs with three digits in dorsal view and in F – sole view, both limbs had white-edged claws; G – ventral view of the inguinal region, showing the different genitals and short hairless tail.



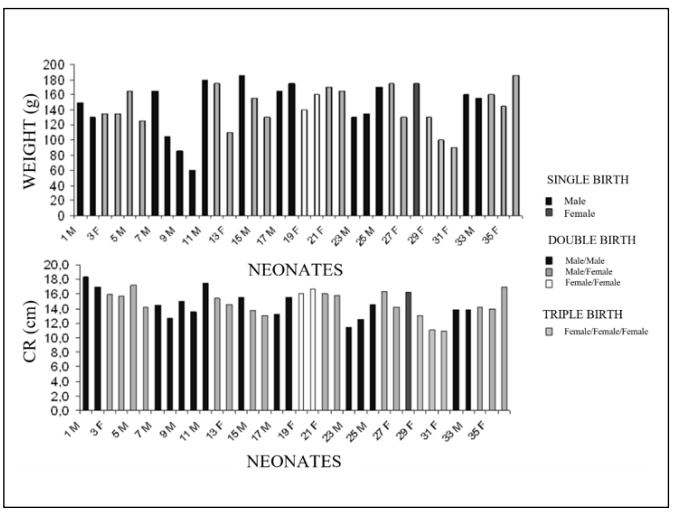
The data for weight (g) and biometric data of the agouti newborn are shown in Table 1.

Among the agouti newborn studied, the average weight was 144.58±30.39g, and the greatest weight recorded was 185 g in a female born in a double birth and a male born in a single birth (5.6%). The lowest weight registered of full term newborns that remained alive after birth was 90 g, a female born in a triple birth.

Two male brothers born in a double birth had the lowest weights (85 and 60g) and died shortly after birth, representing 5.6% of the animals. The mean weight reported in the present study (144.58±30.39g) was similar to that reported by Lopes et al. (2004) (145g) and lower than the 188.92g found by Guimarães, Matos and Vale (1994) also in *D. prymnolopha* and lower than those found by Mohammed et al. (2018) and Mohammad et al. (2019) for *D. leporina* (174-210g) and by Singh et al. (2017) that reported 251g for females and 310g for males. Single birth weights were higher than multiple ones with offspring weighing 209–310 g (Jones and Garcia, 2021; Singh et al., 2017).

The coefficient of variation (CV) for weight was 21%. The data for weight (g) of the agouti newborn were represented individually (Figure 3) and on average by type of birth (Figure 4).

Figure 3: Weight expressed in grams and crown-rump length in centimeters of newborn agouti, male and female, reared in captivity from single, double and triple births from females with 103 day gestation age.



The mean crown-rump (CR) length of the newborns was 14.73±1.82 cm, the total length (TL) 19.88±1.52 cm and the head to tail length (CC) 16.95±1.55 cm. Comparison of the data regarding the lengths crown-rump, total and head to tail showed TL>CC>CR (Figure 5). The data for crown-rump (cm) of the agouti newborn were represented individually (Figure 3) and on average together with the data for total, head to tail and head lengths, thoracic and abdominal girths, tail length, eye diameter and ear length (Fig. 5).

Data on the thoracic girth (TG) and abdominal girth (AG) showed that TG was greater than AG in 91.66% of the cases, with means of TG=11.78±1,36 cm and AG=10.73±1,21 cm (Figure 2D). The mean head length (CEF) was 7.33±0.59cm, representing 36.9% of the total length of the animal, while the tail (TaL) represented 5.9% of the total length, with a mean of 1.18±0.25 cm. Other parameters measured were the eye (ED), or eye socket, with a mean of 1.27±0.27 cm, and ear (EL) with 2.21±0.35 cm (Figure 5).

Table 1: Individual measurements and means ± standard deviation of the weight (g) and the body measurements (cm) of newborn agouti, born in single, double and triple births. Teresina, Piauí, Brazil.

NEWBORN	WEIGHT (g)	CR (cm)	TL (cm)	CC (cm)	CEF (cm)	TG (cm)	AG (cm)	TaL (cm)	ED (cm)	EL (cm)
1 M	150	18.3	20.4	18.9	8.8	11.9	11.3	1.0	1.2	2.1
2 M	130	17.0	19.3	17.4	8.1	12.1	10.7	1.0	1.1	2.2
3 F	135	15.9	19.3	17.8	7.5	11.5	9.5	1.5	1.3	2.0
4 M	135	15.7	20.4	18.2	7.8	10.7	10.1	1.2	1.2	1.8
5 M	165	17.2	21.0	18.6	7.5	13.1	12.4	1.4	1.1	1.6
6 F	125	14.2	19.4	17.3	7.3	11.5	9.8	1.1	1.2	1.9
7 M	165	14.5	19.1	17.1	7.6	12.8	12.5	1.0	1.0	2.2
8 M	105	12.7	16.5	14.6	7.1	10.3	12.1	0.9	1.1	2.1
9 M	85	15.0	17.0	15.5	7.0	8.8	8.6	0.8	1.1	1.7
10 M	60	13.5	16.3	14.4	6.7	7.0	7.6	0.9	0.6	1.5
11 M	180	17.5	20.4	18.5	7.6	13.1	12.2	0.9	1.0	2.1
12 M	175	15.4	20.5	18.4	7.4	13.1	12.0	0.9	1.0	2.1
13 F	110	14.6	17.8	15.8	7.5	10.4	9.2	1.0	0.9	1.7
14 M	185	15.5	21.6	19.7	7.3	12.3	12.0	0.9	1.0	2.3
15 M	155	13.8	19.9	18.0	7.6	12.6	13.2	0.9	1.2	2.3
16 F	130	13.0	19.5	17.6	7.5	12.4	11.9	0.9	1.1	2.2
17 M	165	13.2	20.2	18.2	8.1	13.5	11.0	1.0	1.0	1.9
18 M	175	15.5	20.6	18.4	7.9	13.7	11.0	1.2	1.0	2.1
19 F	140	16.0	20.9	18.8	8.2	10.7	9.8	1.1	1.0	1.9
20 F	160	16.7	21.6	19.4	7.4	10.8	9.8	1.2	1.2	2.2
21 F	170	16.0	21.5	17.2	7.3	12.5	11.4	1.6	1.4	2.4
22 M	165	15.8	21.2	16.2	7.3	11.9	9.9	1.5	1.6	2.5
23 M	130	11.5	19.5	14.5	6.8	11.0	10.5	1.2	1.4	2.4
24 M	135	12.5	20.0	16.8	6.5	11.0	10.5	1.3	1.2	2.4
25 M	170	14.6	20.5	17.5	7.5	12.5	10.5	1.3	1.5	2.0
26 M	175	16.4	22.0	17.5	7.3	12.6	11.6	1.5	1.7	2.8
27 F	130	14.2	20.5	15.4	6.9	11.8	10.5	1.3	1.6	2.7
28 F	175	16.2	21.6	17.5	7.3	13.2	11.4	1.6	1.5	2.6
29 F	130	13.0	19.5	15.8	7.4	11.4	10.0	1.1	1.6	2.5
30 F	100	11.0	18.0	15.0	6.8	11.0	9.6	1.0	1.6	2.1
31 F	90	10.9	18.1	14.7	5.9	10.5	8.9	0.9	1.7	2.4
32 M	160	13.9	20.8	14.7	8.1	12.1	11.5	1.6	1.4	3.0
33 M	155	13.9	18.7	16.0	7.6	12.5	10.4	1.7	1.7	2.4
34 M	160	14.2	19.6	15.4	6.5	12.0	11.5	1.2	1.5	2.3
35 F	145	14.0	19.5	15.3	6.4	12.2	10.8	1.4	1.5	2.4
36 F	185	17.0	23.0	18.2	6.5	13.4	10.7	1.3	1.5	2.9
Mean	144.58	14.73	19.88	16.95	7.33	11.78	10.73	1.18	1.27	2.21
SD	30.39	1.82	1.52	1.55	0.59	1.36	1.21	0.25	0.27	0.35
CV	0.21	0.12	0.08	0.09	0.08	0.12	0.11	0.21	0.21	0.16

CR: crown-rump length; TL: total length; CC: head to tail length; CEF: head; TG: thoracic girth; AG: abdominal girth; TaL: tail length; ED: eye diameter; EL: ear length. F: female newborn; M: male newborn.

Figure 4: Mean weights in grams of newborn agouti born in captivity from females with 103 day gestation age, according to the type of birth. Teresina, Piauí, Brazil.

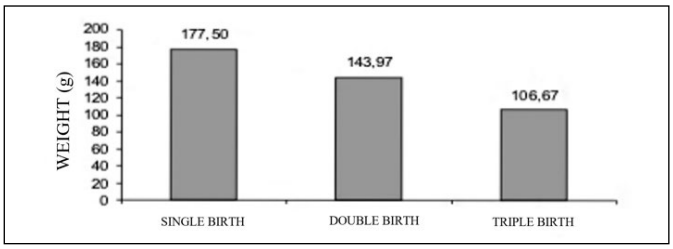
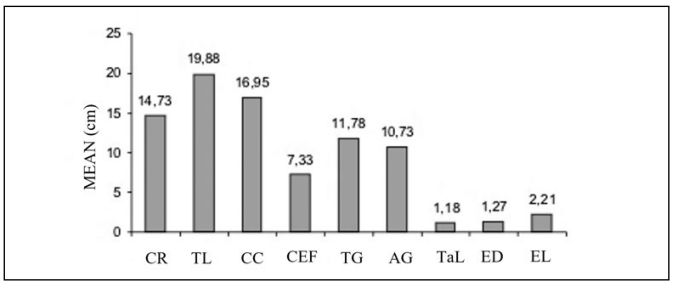


Figure 5: Means of the lengths crown-rump, total, head to tail, head, tail, eye and ear of newborn agouti, male and female, born in captivity from single, double and triple births from females with 103 day gestation age, according to the type of birth.



The body length measured in the present study referred to the crown-rump (14.73±1.82 cm), total length (19.88±1.52 cm) and the head to tail length (16.95±1.55 cm) that were measured differently in previous studies (Lopes et al., 2004) in agouti, with measurements of body length (20 cm), because this measurement was taken considering the body length, taken from the snout to the tail base, accompanying the dorsal curve of the animal. The thoracic girth used in the present study was similar to that reported and observed by Lopes et al. (2004).

Our results corroborated findings by Lopes et al. (2004) when they stated that the agouti thoracic weight and girth, at birth, were not related to gender and the single or double birth types, agreeing further with Lange et al. (2003) for *D. azarae*, when they stated that the weight of the newborn presented high values for the single offspring litters, and decreased gradually for litters of two and three offspring. Because there are no data available in the literature, the other parameters analyzed in the present study could not be discussed, such as measurements for the tail (TaL), eye (ED) and ear (EL), that demonstrated the lack of data and the need for studies on the reproductive biology and development of these animals.

Analysis of the variables of the newborns for weight, CR, CC and ED showed that there was significant statistical difference ($P<0.05$) for the females born in double births (female/female) and triple births (female/female/female) (Table 2), and also for HT ($P<0.05$) compared to the double births (female/female) and (male/female) (Table 3).

Table 2: Difference in the mean ± standard deviation of the weight, CR, TL, CC, CEF, TG, AG, TaL, ED and EL among females born in triple and double births. Teresina, Piauí, Brazil.

Birth	Weight	CR	TL	CC	CEF	TG	AG	TaL	ED	EL
Double (FF)	143 ± 22.63[a]	15.16 ± 1.32[a]	20.30 ± 1.49	17.28 ± 1.4[a]	7.25 ± 0.52	11.72 ± 0.93	10.34 ± 0.86	1.24 ± 0.22	1.27 ± 0.23[b]	2.23 ± 0.37
Triple (FFF)	106.67 ± 20.81[b]	11.63 ± 1.18[b]	18.53 ± 0.83	15.16 ± 0.56[b]	6.7 ± 0.75	10.96 ± 0.45	9.5 ± 0.55	1 ± 0.1	1.63 ± 0.05[a]	2.33 ± 0.2

Means followed by different letters in columns are different by SNK test ($p<0.05$)

Table 3: Difference in the mean ± standard deviation of weight, CR, TL, CC, CEF, TG, AG, TaL, ED and EL among females born in double births (F+F) and females born in double births (M+F) at 103 days gestation. Teresina, Piauí, Brazil.

Birth	Weight	CR	CT	CC	CEF	TG	AG	TaL	ED	EL
Double (FF)	150 ± 14.14	16.35 ± 0.49	21.25 ± 0.49	19.1 ± 0.42[a]	7.8 ± 0.56	10.75 ± 0.07	9.8 ± 0.00	1.15 ± 0.07	1.1 ± 0.14	2.05 ± 0.21
Double (MF)	141.25 ± 24.78	14.86 ± 1.31	20.06 ± 1.58	16.82 ± 1.14[b]	7.11 ± 0.45	11.96 ± 0.88	10.47 ± 0.93	1.26 ± 0.24	1.31 ± 0.23	2.27 ± 0.4

Means followed by different letters in columns are different by SNK test ($p<0.05$)

None of the variables studied differed statistically among the males born in single and double births (male/male) while the TL ($P<0.05$) was statistically different for the double births (male/male) and (male/female) (Table 4).

Table 4: Difference in the mean ± standard deviation of weight, TL, CC, CEF, TG, AG, TaL, ED and EL among males born in double births (M+M) and males born in double births (M+F) Teresina, Piauí, Brazil.

Birth	Weight	CR	CT	CC	CEF	TG	AG	TaL	ED	EL
Double (MM)	134.58 ± 35.32	14.29 ± 1.93	19.03 ± 1.6[b]	16.37 ± 1.64	7.52 ± 0.7	11.39 ± 1.94	10.64 ± 1.36	1.13 ± 0.28	1.15 ± 0.27	2.16 ± 0.38
Double (MF)	161.43 ± 13.75	15.5 ± 1.18	20.65 ± 0.81[a]	17.47 ± 1.21	7.34 ± 0.41	12.28 ± 0.84	11.52 ± 1.18	1.22 ± 0.25	1.32 ± 0.26	2.2 ± 0.4

Means followed by different letters in columns are different by SNK test ($p<0.05$)

Without considering gender, there was no statistical difference for the variables weight and crown-rump among single and double births, but these variables were statistically different (P<0.05) when single and double births were compared to triple births. The TL and CC variables were only different statistically (P<0.05) for the single and triple births (Table 5).

There was no difference among the single and double birth types for all the variables studied without considering gender. However, the variables weight, CR, TL and CC differed among the single and triple births, and also between the double and triple births.

Table 5: Mean ± standard deviation of weight, CR, TL, CC, CEF, TG, AG, TaL, ED and EL among animals born in single, double and triple births, regardless of gender. Teresina, Piauí, Brazil.

Birth	Weight	CR	CT	CC	CEF	TG	AG	TaL	ED	EL
Single	177.5 ± 6.45[a]	15.95 ± 1.22[a]	21.02 ± 0.66[a]	18.3 ± 1.04[a]	7.42 ± 0.15	12.77± 0.44	11.52 ± 0.76	1.17 ± 0.34	1.25 ± 0.28	2.25 ± 0.26
Double	143.97 ± 28.45[a]	14.88 ± 1.61[a]	19.86 ± 1.54[ab]	16.95 ± 1.5[ab]	7.38 ± 0.58	11.72 ± 1.43	10.75 ± 1.22	1.19 ± 0.25	1.23 ± 0.25	2.19 ± 0.37
Triple	106.67 ± 20.81[b]	11.63 ± 1.18[b]	18.53 ± 0.83[b]	15.16 ± 0.56[b]	6.7 ± 0.75	10.96 ± 0.45	9.5 ± 0.55	1.0 ± 0.1	1.63 ± 0.05	2.33 ± 0.2

Means followed by different letters in columns are different by SNK test (p <0.05)

Conclusion

It was concluded that agouti presented morphological maturity at birth, a characteristic of precocious animals, with external morphology similar to that of the adult animals. Most of the births in this species are the double type and newborns that weigh more than 90g have better chances of survival in *ex situ* conditions.

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