

How litter size influences the body composition of *Rattus norvegicus*

Como o tamanho da ninhada influencia a composição corporal de *Rattus norvegicus*

Cómo influye el tamaño de la camada en la composición corporal en *Rattus norvegicus*

Rodney Murillo Peixoto Couto

Master in Animal Science and Technology
Institution: Universidade Estadual Paulista (UNESP)
Address: Ilha Solteira - São Paulo, Brazil
E-mail: couto.murillo@gmail.com

Priscilla Soares dos Santos

PhD in Ecology and Conservation
Institution: Universidade Federal de Mato Grosso do Sul (UFMS)
Address: Campo Grande - Mato Grosso do Sul, Brazil
E-mail: priscillasoares1989@gmail.com

Antônio Elivelton Paiva de Oliveira

Master's degree in Ecology
Institution: Universidade Federal do Pará (UFPA)
Address: Belém - Pará, Brazil
E-mail: elivelton99oliveira@gmail.com

Daniel Montanher Polizel

Doctor in Animal Nutrition and Production
Institution: Universidade Estadual Paulista (UNESP)
Address: Botucatu - São Paulo, Brazil
E-mail: daniel.polizel@unesp.br

Maiara Cabrera Miguel

Master's in Animal Biology
Institution: Universidade Federal de Mato Grosso do Sul (UFMS)
Address: Campo Grande - Mato Grosso do Sul, Brazil
E-mail: maiaramiguel05@gmail.com

Rosemeire da Silva Filardi

PhD in Animal Science
Institution: Universidade Estadual Paulista (UNESP)
Address: Ilha Solteira - São Paulo, Brazil
E-mail: rosemeire.filardi@unesp.br

Antônio Carlos de Laurentiz

Doctor of Animal Science

Institution: Universidade Estadual Paulista (UNESP)

Address: Ilha Solteira - São Paulo, Brazil

E-mail: antonio.laurentiz@unesp.br

ABSTRACT

The management during the lactation period is crucial for the development of animals, positively or negatively impacting their growth depending on the quality of the practices adopted. Studies have shown that animals subjected to proper management tend to present higher weights at weaning compared to those that do not receive such care. The present study randomly selected ten cages containing female Mercois that gave birth on the same day. Among them, five cages (Batch 1) were limited to eight pups per female, while the remaining were discarded. The five remaining cages (Batch 2) retained the total number of born pups, varying between 14 and 21. At weaning, the animals of Batch 2 exhibited sizes and weights consistent with the expected standards, with average sizes of 7.5 cm and average weights of 22 g. In contrast, individuals from Batch 1 presented average sizes of 9.5 cm and average weights of 34 g. Additionally, Batch 1 displayed an average of 204 kcal/g, while Batch 2 recorded 175 kcal/g. Statistical analysis indicated a significant difference in the caloric averages between the two batches, with a p-value of 0.0276 and a 95% confidence interval for the difference between the means. It is concluded that the size of the litter during the lactation period exerts a significant influence on the weight, dimensions, and energetic values of rodent carcasses.

Keywords: Animal nutrition, lactating, management, *Rattus norvegicus*.

RESUMO

O manejo no período de lactação é fundamental para o desenvolvimento dos animais, impactando seu crescimento de forma positiva ou negativa, conforme a qualidade das práticas adotadas. Estudos demonstram que animais submetidos a um manejo adequado tendem a apresentar maiores pesos ao desmame em comparação àqueles que não recebem tais cuidados. O presente estudo selecionou aleatoriamente dez caixas contendo fêmeas de Mercois que pariram no mesmo dia. Entre elas, cinco caixas (Lote 1) foram limitadas a oito filhotes por fêmea, enquanto o restante foi descartado. As cinco caixas restantes (Lote 2) mantiveram a quantidade total de filhotes nascidos, variando entre 14 e 21. Ao desmame, os animais do Lote 2 apresentaram tamanhos e pesos compatíveis com os padrões esperados, com tamanhos médios de 7,5 cm e peso médio de 22 g. Em contraste, os indivíduos do Lote 1 apresentaram tamanhos médios de 9,5 cm e peso médio de 34 g. Adicionalmente, o Lote 1 exibiu uma média de 204 kcal/g, enquanto o Lote 2 registrou 175 kcal/g. A análise estatística apontou uma diferença significativa nas médias calóricas entre os dois lotes, com um valor-p de 0,0276 e um intervalo de confiança de 95% para a diferença entre as médias. Conclui-se que o tamanho da ninhada durante o período de amamentação exerce uma influência significativa sobre o peso, as dimensões e os valores energéticos das carcaças de roedores.

Palavras-chave: lactação, manejo, nutrição animal, *Rattus norvegicus*.

RESUMEN

El manejo durante el período de lactancia es fundamental para el desarrollo de los animales, influyendo positiva o negativamente en su crecimiento según la calidad de las prácticas adoptadas. Estudios demuestran que los animales sometidos a un manejo adecuado tienden a presentar mayores pesos al destete en comparación con aquellos que no reciben dichos cuidados. El presente estudio seleccionó aleatoriamente diez cajas que contenían hembras de Mercois que parieron el mismo día. De estas, cinco cajas (Lote 1) fueron limitadas a ocho crías por hembra, descartándose el excedente. Las cinco cajas restantes (Lote 2) mantuvieron el número total de crías nacidas, el cual varió entre 14 y 21. Al destete, los animales del Lote 2 presentaron tamaños y pesos compatibles con los estándares esperados, con longitudes medias de 7,5 cm y un peso medio de 22 g. En contraste, los individuos del Lote 1 presentaron longitudes medias de 9,5 cm y un peso medio de 34 g. Adicionalmente, el Lote 1 mostró un valor energético promedio de 204 kcal/g, mientras que el Lote 2 registró 175 kcal/g. El análisis estadístico indicó una diferencia significativa en las medias calóricas entre ambos lotes, con un valor de $p = 0,0276$ y un intervalo de confianza del 95 % para la diferencia entre las medias. Se concluye que el tamaño de la camada durante el período de lactancia ejerce una influencia significativa sobre el peso, las dimensiones y los valores energéticos de las carcasas de roedores.

Palabras clave: lactancia, manejo, nutrición animal, *Rattus norvegicus*.

1 INTRODUCTION

Rodents are widely used as a food source for captive carnivorous animals (BIRD & HO, 1976). Due to their use as laboratory animals, a growing number of studies have focused on the reproduction, health, and welfare of these species (NEVES, 2013). These characteristics make rodents easy to handle, requiring little space and exhibiting a high reproduction rate under controlled conditions, in addition to the availability of literature, such as breeding manuals, that facilitate production (NEVES, 2013). However, there are few studies aimed at assessing the development of these animals, as well as management and nutritional and energy information (BIRD & HO, 1976; DOUGLAS *et al.*, 1994; DIERENFELD *et al.*, 2002).

Metabolic energy refers to the organism's ability to convert nutrients into usable energy, which is essential for performing all biological functions. These processes occur in various ways, including cellular respiration, where cells metabolize carbohydrates, lipids, and proteins to produce adenosine triphosphate (ATP). Metabolic energy is vital for all cellular activities, ranging from muscle contractions to the synthesis of complex molecules (FRIEDMAN & HALAAS, 1998; FATIMA *et al.*, 2020).

Management during the lactation period is essential for the development of animals throughout their lives, resulting in either enhanced or restricted development, depending on the quality of management applied during this phase (NERY *et al.*, 2011). Some authors report that animals subjected to proper management during lactation wean at greater weights compared to those that do not receive such management (PLAGEMANN *et al.*, 2009), While others indicate that there are no differences, although these may be observed during the post-weaning growth (NERY *et al.*, 2011).

The objective of this work was to evaluate how litter size influences the body and energy composition of Mercois during the lactation phase.

2 MATERIAL AND METHODS

The study was conducted at the Pantanal Bioterium, which aims to provide whole frozen prey for the feeding of captive carnivorous animals, approved by the CONCEA 01/2024. For this experiment, Mercois were used (*Rattus norvegicus*). Ten random boxes with female Mercois that gave birth on the same day were selected for this experiment. After selection, five of these boxes (Lot 1) were left with only 8 pups per female, and the rest were discarded. The remaining five boxes (Lot 2) each had females with the number of pups born, ranging from 14 to 21 pups per female (TABLE 1). To exclude any interference in sampling, the females were separated from the males, with each female remaining with her pups in each box numbered from 1 to 10. Each female was fed with rodent-specific feed, provided ad libitum, with water supplied through automatic drinking devices. The ambient temperature ranged from 22 to 24°C during the sampling period, and the photoperiod was 12 hours. The pups remained with their mothers for 21 days, and on the 22nd day, they were subjected to stunning by electrocution and then euthanized with CO₂, followed by being placed in an ultra-freezer for rapid freezing.

The animals were grouped by lots, identified by box number and lot. To prepare the material for bromatological analyses, each lot of prey was initially fractionated into smaller pieces for greater effectiveness in drying. The material was weighed and dried in forced-air ovens at temperatures ranging from 65° to 70° C, not exceeding 75° C. The weights of each lot were recorded before and after drying. Drying was carried out for 72 hours, and after weighing, the material was ground in a ball mill in quantities of 30 g at a time. This mill was used because it is

made of stainless steel, thereby preventing sample contamination with metals, especially iron, zinc, and copper. Each sample lot was homogenized and placed in hermetic ziplock bags, labeled with the material information for sending to the bromatology laboratory

In the bromatology laboratory, the samples were subjected to analyses for the quantification of total dry matter, crude protein, ether extract, and minerals, following the procedures of Silva & Queiros (2006). Based on the bromatological composition, the values of gross energy (kcal/kg) were estimated using the following equation: Gross Energy (kcal/g) = Ether Extract (g) x 9 kcal + Protein (g) x 4 kcal + Carbohydrates (g) x 4 kcal.

Table 1. Number of pups per female mercois used for experimentation.

	Boxes	Number of pups per female
BATCH 1	1	8
	2	8
	3	8
	4	8
	5	8
BATCH 2	6	14
	7	17
	8	18
	9	19
	10	21

Source: Prepared by the authors.

3 RESULTS AND DISCUSSION

In the preparation of the animals for analysis, significant visual differences between the two lots were already observed. The animals from lot 2 exhibited size and weight corresponding to the expected standard for their age, with a normal body score and average sizes of 7.5 cm and average weights of 22 g. In contrast, the animals from lot 1 showed average sizes of 9.5 cm and weights of 34 g (Figure 1).

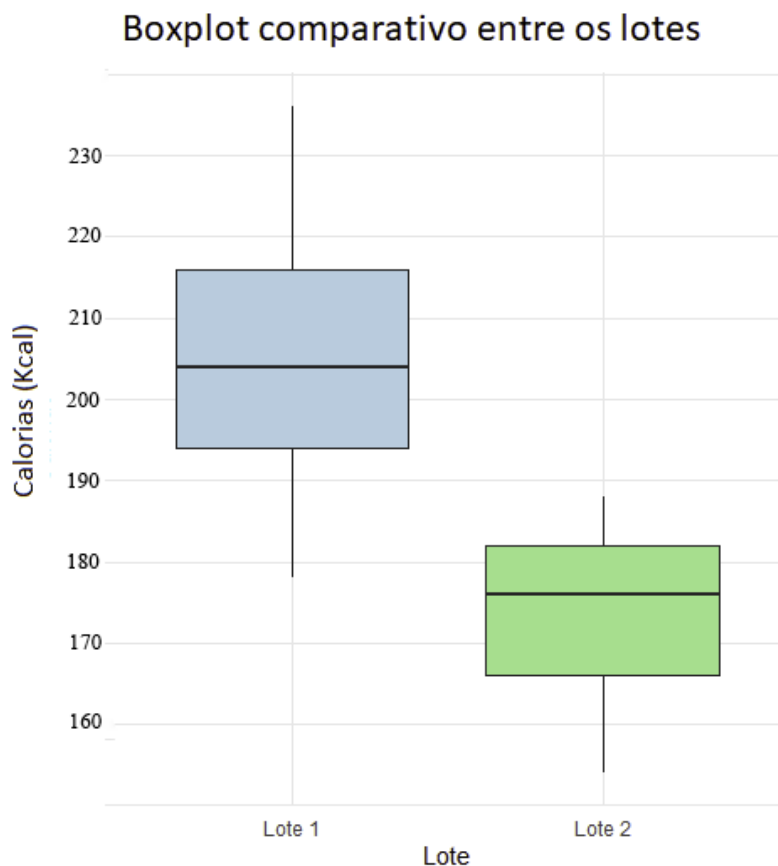
Figure 1. Mercois with average weight and size of lots 1 and 2. A = Mercois from lot 1 with an average weight of 34 g and 9.5 cm; B = Mercois from lot 2 with an average weight of 22 g and 7.5 cm.



Source: Prepared by the authors.

In addition to the visually notable difference influenced by the number of pups in each lot, lot 1 had an average of 204 kcal/g, while lot 2 had an average of 175 kcal/g. The Welch's t-test shows that there is a significant difference between the average calories of the two lots. The average of Lot 1 is higher than that of Lot 2, and the difference between these averages is significant with a p-value of 0.0276 and a 95% confidence interval for the difference between the means (Figure 2).

Figura 2. Difference in energy value between two batches of piglets subjected to different management practices during lactation.



Source: Prepared by the authors.

According to how management during the nursing phase is conducted, it can influence the composition of rodents (WURTMAN & MILLER, 1976; PLAGEMANN *et al.*, 2009) influencing the energy value. The Mercois (*Rattus norvegicus*) has six pairs of mammary glands (NEVES, 2013). The average litter size of Mercois varies between 6 and 12 pups. (GEIGER & HOOPER, 1981) But they can reach up to 27 pups through selection and genetic improvement as implemented at the Pantanal Bioterium LTDA. These litter size numbers are remarkable in terms of intensive large-scale production systems; however, an increase in litter size during the nursing phase can cause damage to the nervous system and malnutrition (ROCHA-DE-MELO *et al.* 2006; ROCHA-DE-MELO & GUEDES, 1997). Lactation is a period of great relevance for the development of the offspring and the determination of future nutritional status (MORGANE *et al.*, 1993; PASSOS *et al.*, 2001).

The size of adult rats is closely related to their nutritional status during the lactation period (**Erro! Fonte de referência não encontrada.**). There is an inverse relationship between litter size and average body weight at weaning. One of the suggested experimental models to induce overeating, resulting in subsequent weight gain and hyperphagia in adulthood, is the reduction of litter size at birth (WURTMAN & MILLER, 1976; PLAGEMANN *et al.*, 2009).

Nery *et al.* (2011) They reported divergent results compared to those presented in this study, concluding that the reduction in the number of pups during lactation did not result in weight gain in the offspring; however, they observed improved performance in the post-weaning phase. These results emphasize the importance of management during the lactation period, as the most pronounced growth of rodents occurs until 60 days of age, with the first 30 days characterized by rapid growth. Proper management during this phase has a significant impact on the animal's lifelong development (ANDREOLLO *et al.*, 2012).

Boxes with smaller numbers of pups have advantages regarding food, space, and maternal attention compared to boxes with larger litters, as pups must compete for food, have reduced space, and have divided maternal attention. Therefore, animals intended for feeding carnivorous animals, when kept with eight individuals per mother, become more energetic compared to larger litters. Thus, we can affirm that management practices after birth influence the energy value, weight, and size of animals intended for animal feed. In this way, we can produce some prey that are more or less energetic, according to the demand being produced. According to Barbosa (2020), Animals produced in university bioteriums exhibit more reliable and appropriate nutritional values compared to commercial bioteriums, due to the applied standardizations. This result corroborates our findings that the way animals are raised means that when taking lots from different locations, produced with different methodologies, the results will differ significantly, showing a large oscillation among them.

Awareness of the importance of applying appropriate methodological approaches will enable the production of nutritionally balanced and tailored prey, accurately meeting the metabolic demands of carnivorous animals. In summary, this study contributes to strengthening knowledge in the field of carnivore nutrition, promoting effective practices.

4 CONCLUSION

Litter size during the nursing period influences the weight, dimensions, and energy values of the carcasses of rodents.

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