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Different corporal structures determining the effective production of Red Angus primiparous cows at 24 months of age

Diferentes estruturas corporais na produtividade efetiva de vacas primíparas aos 24 meses de idade

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Abstract

The objective was to evaluate the production and efficiency of 24-month-old Red Angus primiparous cows of different weights at weaning and repetition of pregnancy. Before calving, the females were managed in natural prairies and fed sweet clover (*Lotus corniculatus*) and ryegrass (*Lolium multiflorum* Lam.), with loads of 315 and 501 kg ha^{-1}, respectively. Females were divided into groups according to the average birth weight into light 346.15 ± 3.39 kg; moderate 381.95 ± 2.99 kg; and heavy 412.63 ± 3.33 kg weights. The indicators evaluated were: primiparous weights and body conditions at calving and weaning, daily average and total gains, fixed-time artificial insemination (FTAI), and accumulation. Calves at birth and weaning had their daily average and total weights evaluated. In terms of production, the daily average and total gains per pair and effective herd production (EHP) of the weight groups were measured. At weaning, morphometric measures, viz. croup height and thoracic perimeter had a linear relationship increasing with the weight at calving. In FTAI and cumulative pregnancy, the groups of light and moderate cows were more efficient than the heavy group cows, with values of 81.25%, 75.00%, and 55.56%, respectively. The EHP differed between the groups with values of 37.07 ± 1.71, 28.13 ± 1.50, and 19.99 ± 1.68 kg, for light, moderate, and heavy, respectively. Light cows were 31.8% and 85.4% higher in effective production than moderate and heavy cows, respectively. Knowledge of the production system is important for enhancing breeding efficiency. The improvement in productive performance is related to the adequacy of metrices used in the production system.
Key words: Croup height. Body condition. Reproductive performance. Frame. Thoracic perimeter.

Resumo

Objetivou-se avaliar a produção e eficiência de vacas Red Angus primíparas aos 24 meses de diferentes pesos do parto a desmama e a repetição de cria. Antes do parto as fêmeas foram manejadas em pastagens naturais e após em pastagens de cornichão (*Lotus corniculatus*) e azevém (*Lolium multiflorum* Lam.) com cargas de 315 e 501 kg ha^{-1}, respectivamente. As fêmeas foram divididas em grupos de acordo com o peso médio ao parto em leves 346,15±3,39 kg; moderadas 381,95±2,99 kg e pesadas 412,63±3,33 kg. Os indicadores avaliados foram: nas primíparas pesos e condições corporais ao parto e ao desmame, ganhos médios diários e totais, prenhez da inseminação artificial em tempo fixo (IATF) e acumulada. Nos bezerros foram avaliados pesos ao nascimento e a desmama, ganhos médios diários e totais. Da

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produção mediram-se os ganhos médios diários e totais do par e a produtividade efetiva de rebanho (PER) dos grupos de pesod. Ao desmame as medidas morfométricas de altura de garupa e perímetro torácico tiveram comportamento linear aumentando com os pesos ao parto das vacas. Na prenhez da IATF e acumulada, os grupos das vacas leves e moderadas se mostraram mais eficientes do que as Pesadas com valores de 81,25, 75,00 e 55,56%, respectivamente. A PER diferiu entre os grupos com valores de 37,07±1,71, 28,13±1,50 e 19,99±1,68 kg, para leves, moderadas e pesadas, respectivamente. As vacas leves foram 31,8 e 85,4% superiores na produtividade efetivado que as moderadas e pesadas, respectivamente. O conhecimento do sistema de produção é importante para elevar a eficiência da cria. A melhora no desempenho produtivo está ligada a adequação do tamanho das matrizes para o sistema produtivo.
Palavras-chave: Altura de garupa. Condição corporal. Desempenho reprodutivo. *Frame*. Perímetro torácico.

Introduction

In the few last decades, the beef cattle industry in the state of Rio Grande do Sul (RS) has undergone several transformations, which made the adoption of managerial practices focused on the constant search for efficiency and control of the production processes necessary under penalty of unfeasibility or even extinction of the activity. The area occupied by soybean plantations in RS, showed an increase of 31.2% in the last five years. This expansion occurred largely on areas formerly intended for livestock. Thus, with the greater demand for agricultural areas, less profitable activities started to give way to cultivation of crops with higher production speed and added value (CONAB, 2018). Several factors culminated in the de-structuring of native pastures for the cultivation of annual crops, including those that result in low productive indexes of the herds and low profitability of livestock when used as fodder (BARCELLOS et al., 2008). Baruselli et al. (2002) reported that the productivity of the herd per unit area is low, being less profitable than rearing and fattening activities. This is owing to factors such as long periods for product (calves) and immobilized capital when considering land values and livestock (MARQUES, 2013).

Limited planning in the use of forage resources without taking into account the different seasons of the year and different requirements of the reared animals contributes to low rearing rates (ROCHA et al., 2007), and directly impacts the economic return of livestock breeding (BERETTA et al., 2002).

A younger age at first mating improves the reproductive efficiency of the herd (FONTOURA JÚNIOR et al., 2009). In addition, it allows for greater selection pressure, greater precocity in choosing the best matrices, and a reduction in the interval between generations, with a faster return on investment (VAZ et al., 2012). These females have the potential to produce larger numbers of offspring and wean more kilograms of calves in their productive lives (JAUME et al., 2000). However, investment in mating age reduction should be accompanied by good conception rates in the subsequent reproductive period. As the system intensifies by reducing the age at first mating, obtaining desirable responses in animal performance becomes essential to achieve the objectives proposed by the production system (VAZ et al., 2012).

In addition to these factors, production efficiency in livestock breeding is directly related to the body size of the cows in the herd, which has biological, productive, and economic impacts (SILVA et al., 2015). The objective of the present study, performed in southern Brazil, was to evaluate the production efficiency of 24-month-old Red Angus primiparous cows with different body sizes (weights), in terms of the efficiency of kilogram stock at calving, which is related to production during lactation and repetition of pregnancy in the subsequent mating season.

Material and Methods

The present study was carried out based on the technical principles of biosafety and ethics in the use of animals in research, under the approval of the Ethics Committee on Animal Experimentation (ECAE) of the Federal University of Pelotas, for the process nº 23110.008250/2015-31, registered by the Department of Research and Scientific Initiation of the University under the code nº ECAE 8250-2015.

The experiment was performed in a private property located in the municipality of Arroio Grande, RS. The region has an average annual precipitation of 1,300 mm, and sandy-loam soil containing 10% to 15% clay, with low levels of phosphorus and potassium, and pH between 5.3 and 5.7.

The study consisted of analysis and monitoring of performance data of 54 Red Angus primiparous females, at 24 months of age, during their first lactation. At calving, these cows were classified according to their body weight. In relation to the average flock weight (381.15 kg) and standard deviation (30.07 kg), the cows were classified into three groups: light cows - weighing less than or equal to half the average standard deviation (average weight of 346.15 ± 3.39 kg); moderate - cows weighing more than half the standard deviation below the general average of the flock and less than half the standard deviation above the general average of the flock (average weight of 381.95 ± 2.29 kg); and heavy - cows weighing at or above the standard deviation of the total average of the flock (average weight 412.63 ± 3.33 kg).

During the pre-partum period, the females were kept in a natural pasture with stocking rate of 315 kg ha^{-1}, and in the postpartum period in a cultivated pasture composed of sweet clover (*Lotus corniculatus*) and ryegrass (*Lolium multiflorum* Lam.), with animal load of 501 kg ha^{-1}. The natural pasture predominantly comprised *Axonopus affinis* (carpetgrass), *Paspalum notatum* (bahiagrass), *Paspalum dilatatum* (dallisgrass), *Piptochaetium stipoides* (purple speargrass), and *Luziola leiocarpa* (Peruvian watergrass).

Births occurred between September 05 and November 09 of 2016, with the cows and their calves being identified and weighed within the first 24 h postpartum and at weaning, with intermediate weighing to monitor and maintain animal loads. The daily average weight variations were determined by the differences between the weighings (kg) divided by the period between them (days).

Weaning was performed when the calves reached an average of 211 days of age (ranging from 184 to 249 days). At this stage, the body measurements of the cows at the croup height (distance from the sacrum to the surface of the ground) and thoracic perimeter were performed, and these measurements were taken with the aid of a square and a measuring tape, respectively. During weighing, the body condition scores of the cows were estimated visually and subjectively, assigning values on a scale of 1-5 (MARQUES, 2013).

The mating method used in the postpartum reproductive season was fixed-time artificial insemination (FTAI), preceded by gynecological evaluation by ultrasonography 30 days before the beginning of the mating season. Subsequently, the cows were mated in a natural mating regime for 60 days, with 4% of bulls, previously tested for their libido and sperm quality. The gestation diagnosis was performed 30 days after the FTAI and 30 days after the bulls were removed, obtaining pregnancy rates by FTAI and accumulation of FTAI and bulls.

The estimates of productive efficiency were obtained from quantified characteristics. The total weight gains of cows and calves (kg) from calving to weaning were used to estimate production. The production efficiencies at calving and weaning were evaluated, by obtaining the ratio of the weight (in kg) of the calves at weaning per 100 kg of cows at calving and 211 days, respectively (RIBEIRO et al., 2001).

The rate of calf production was calculated by the association between calf weight at weaning and cow pregnancy rate, with the result in kg of calves produced by the mated cows (VAZ; LOBATO, 2010).

To calculate the effective herd production (EHP), the total weight (kg) produced by the cow-calf pair were divided by the average weight of the mated cows; then this value was multiplied by the pregnancy rate recorded in the subsequent mating season.

The efficiency of the stock of kilograms of cows (%) determined the effective production between herds by dividing the percentage of the most efficient herd compared with that in the others, decreasing from 1 and multiplying by 100.

The experimental design was completely randomized. The data collected were submitted to an analysis of variance, where the size of the cows was a fixed effect and age and sex of the calves were co-variables. The analyses were performed using the GLM procedure. The data were analyzed by the statistical software SAS, version 9.2 (SAS, 2008), adopting 5% as the level of maximum significance by the *t*-test. The pregnancy rate was analyzed by the chi-square method (GOMEZ; GOMEZ, 1984).

Results

The body weight of the primiparous cows at birth differed significantly, determining the distribution of cows to the respective groups. The "heavy" group continued to weigh more heavily than the other groups at weaning; however, the difference between "light" and "moderate" was no longer present (Table 1). At weaning the cows weighed 373.03 ± 8.23, 391.81 ± 7.24, and 422.29 ± 8.08 kg for light, moderate, and heavy, respectively.

The evaluation of the body condition score at birth showed a similarity between the groups, where the light, moderate, and heavy groups obtained 3.15 ± 0.07, 3.16 ± 0.06 and 3.18 ± 0.06 points, respectively. This is important because it shows that the groups are different according to the size of the cows, with no effect from muscular deposition and body fat.

During lactation a reduction in body score occurred in the three groups with values of -0.055 ± 0.067, -0.043 ± 0.059, and -0.023 ± 0.023 kg, for mild, moderate and heavy, respectively.

Daily average variation in cow weight during lactation did not differ between groups, with values of 0.134 ± 0.038, 0.047 ± 0.033, and 0.043 ± 0.037 kg, for light, moderate and heavy cows, respectively. The accumulated cow weight gains during the lactation period were 26.8 ± 7.6, 9.8 ± 6.7, and 9.6 ± 7.5 kg, for light, moderate, and heavy, respectively.

Weaning measures revealed the superiority of the heavy primers over the lightweight groups in terms of both thoracic perimeter and croup height, showing differences in body structure between the groups under study.

The performance of the calves was not influenced by the size of the mother, presenting similar values for weights at birth and weaning, as well as for daily average variations and total weight gain during the lactation period. The body weight gains of the cow-calf pair were similar between the groups with values of 156.73 ± 8.63, 142.96 ± 7.60, and 149.92 ± 8.48 kg, for light, moderate cows and heavy, respectively.

The rate of repetition of pregnancy of primiparous cows was influenced by cow size, with cows in the light (81.25%) and moderate (75.00%) groups being more superior than those in the heavy group (55.56%).

Table 1. Averages and standard errors for development, reproduction, and efficiency characteristics of Red Angus primiparous cow herds of different body sizes.

Characteristics	Light	Moderate	Heavy
		Cows	
Number of animals per group	16	20	18
Average birth weight, kg	346.2 ± 3.39^{c}	381.9 ± 2.99^{b}	412.6 ± 3.33^{a}
Average weight at weaning (211 days), kg	373.0 ± 8.23^{bc}	391.8 ± 7.24^{b}	422.3 ± 8.08^{a}
Body condition at birth, points	3.15 ± 0.07	3.16 ± 0.06	3.18 ± 0.06
Body condition at weaning, points	3.10 ± 0.06	3.12 ± 0.05	3.15 ± 0.04
Daily average weight gain in lactation, kg	0.134 ± 0.04	0.047 ± 0.03	0.043 ± 0.04
Total weight gain in lactation, kg	26.88 ± 7.68	9.86 ± 6.76	9.65 ± 7.55
Thoracic circumference at weaning, meters	1.73 ± 0.01^{b}	1.75 ± 0.01^{ab}	1.78 ± 0.01^{a}
Height of croup at weaning, meters	1.30 ± 0.01^{c}	1.33 ± 0.01^{b}	1.36 ± 0.01^{a}
		Calves	
Weight at birth, kg	46.65 ± 1.92	48.30 ± 1.69	50.06 ±1.88
Weaning weight (211 days), kg	176.49 ± 5.85	181.40±5.15	189.33 ± 5.75
Daily average weight gain in lactation, kg	0.63 ± 0.03	0.64±0.02	0.65 ± 0.03
Total weight gain in lactation, kg	129.84 ± 5.90	133.10 ± 5.19	139.26 ± 5.79
		Production Efficiency	
FTAI pregnancy,%	43.75^{B}	65.0^{A}	30.00^{B}
Cumulated pregnancy (FTAI + Bulls),%	81.25^{A}	75.00^{A}	55.56^{B}
Total cow/calf weight gain, kg	156.73 ± 8.6	142.96 ± 7.6	149.92 ± 8.5
Average daily gain of cow/calf pair, kg	0.76 ± 0.04	0.69 ± 0.04	0.69 ± 0.04
Productive efficiency at calving, kg[1]	12.6 ± 0.6	12.4 ± 0.5	12.0 ± 0.6
Productive efficiency at weaning, kg[2]	47.6 ± 1.8	46.7 ± 1.6	45.1 ± 1.8
Index of production of calves, kg[3]	144.0 ± 4.1^{a}	136.2 ± 3.6^{a}	104.9 ± 4.0^{b}
Effective herd productivity,%	37.07 ± 1.71^{a}	28.13 ± 1.50^{b}	19.99 ± 1.68^{c}
Relation between effective yields of herds (Light as reference), %		31.80	85.40

$^{a, b, c}$ Averages followed by different lowercase letters in rows differ ($P < 0.05$) for the t-test. $^{A, B}$ Averages followed by different capital letters in rows differ ($P < 0.05$) by the chi-square test. [1] Calf weight at 210 days × pregnancy rate / 100 = kg of calf per cow kept in the herd; [2] Weight of calves at 210 days / Weight of cow at calving × 100 = calf kg / 100 kg cow; [3] Weight of calves at 210 days / Weight of cow at 210 days × 100 = kg of calf / 100 kg of cow.

The productive efficiencies at calving and weaning did not differ among cow body size groups. When analyzing the calf production index (VAZ; LOBATO, 2010) that associates calf weaning weight with the cow's pregnancy rate, the light and moderate cows had a better index than the heavy cows, with values of 144.0 ± 4.1, 136.2 ± 3.6, and 104.9 ± 4.0 kg, in the three groups, respectively. The effective production of the herds was 37.07 ± 1.71%, 28.13 ± 1.50%, and 19.99 ± 1.68%, for light, moderate, and heavy cows, respectively.

Regarding production, light cows were more efficient (37.07%), followed by moderate cows (28.13%), and heavy cows were the least efficient (19.99%). Relatively, the efficiency values demonstrated a superiority of the light cows by 31.8% and 85.4% over that of the moderate and heavy cows, respectively.

Discussion

Cow weight at calving and weaning is an important factor in the productive and reproductive performance of the herds. Higher cow weights at calving and weaning, within the same frame, are correlated with higher calf weights at weaning (VAZ et al., 2014) and better reproductive performance of beef cows (SANTOS et al., 2009). However, in the present study, the largest body size of the cows was related to the weight of the herd. This could be detrimental, especially when environmental conditions are not ideal, and may influence the reproductive performance of cows (SILVA et al., 2015). This could be aggravated when the cows are primiparous, and may result in impaired reproductive performance or future development (CERDÓTES et al., 2004). However, the effects under favorable environmental and nutritional conditions have not been verified (PILAU; LOBATO, 2009).

Studying the nutritional requirements of the different categories is fundamental for the appropriate animal response. Primiparous cows have a higher postpartum metabolic demand than multiparous cows owing to lactation and calving stress, which is also potentiated since the cow is still in the growth phase (WILTBANK et al., 1985). Therefore, these can have greater effects, owing to the animal size, and increase of nutritional requirements of the different animal types. The nutritional requirements of the groups of weights under study are variable, where light-weight cows require 639.73 g day^{-1} of raw protein and 11.17 Mcal day^{-1} of raw energy for their maintenance, growth and lactation, whereas moderate-weight cows need 671.45 g day^{-1} and 11.81 Mcal day^{-1} gross energy, and heavy-weight cows require 707.39 g day^{-1} and 12.46 Mcal day^{-}1 gross energy (NRC, 2000). These values demonstrate that light-weight cows need approximately 4.72% and 9.56% raw less protein than, moderate- and heavy-weight cows, as well as about 5.42% and 10.35% less gross energy, respectively.

During lactation, the primiparous cows experienced a loss of condition and small gains in body weight. Subsequent reproduction of primiparous cows is positively correlated with positive body weight variations, that is, the higher the daily weight gain, the greater the subsequent reproductive success (PILAU; LOBATO, 2009). The chances of conception in beef cows increased from the time when the cows did not lose weight. For each 0.1 kg day^{-1} of positive body variation during the mating period, the rate of conception increased by 17.9%, in Nelore × Hereford cows in subtropical environments (GRECELLÉ et al., 2006), and 7.47% in Nelore cows in the Pantanal, Mato Grosso do Sul State (BATISTA et al., 2012).

In addition, first-calf cows with good body condition postpartum have reduced postpartum anestrus, thus raising conception rates (WILTBANK et al., 1985). The average pregnancy rate of the primiparous cows in the present study (70.0%) may be considered high for the Rio Grande do Sul levels, which presents a pregnancy repetition rate of 56% (SILVA et al., 2015). Vaz and Lobato (2010) verified repetition of pregnancy rates similar to those of the present study, but in primiparous cows at 36 months of age; when calves were weaned early at 67 days of age, the percentage of rearing increased from 40.0% to 91.4%.

In the present study, postpartum cows were maintained on sweet clover and ryegrass pastures, which, if well managed, provide a nutritional level close to the ideal, for the category under study. This fact is strengthened by the fact that the animals are smaller and, consequently, less demanding, resulting in greater weight gains and better body conditions (NRC, 2000). No differences in weight gain during lactation and calf weight at weaning demonstrated that there were three potential body sizes for calf growth in this productive system. However, the equal performance of the calves may be owing to greater stress of the cow, which tries to produce more milk for the calf based on its

requirements (VIEIRA et al., 2005), and undergoing greater stress in adverse environmental conditions (PILAU; LOBATO, 2009). The performance of the calf from birth to weaning is directly related to a combination of factors, such as calf genotype, breeding environment, and maternal ability (VIU et al., 2006).

The height of heifers is an important source of variation of the animals, and is less susceptible to environmental factors than body weight (VARGAS et al., 1999). Higher croup height, in addition to genetics, may be positively correlated with the energy intake of the animals' diet (REZENDE et al., 2011), in addition to increased stature correlated with increased body size of cattle (VAZ et al., 2016a). Metabolic body size is associated with nutritional requirements (BIF, 2014). For Pereira et al. (2000), when animal selection is based on body weight, larger animals are produced, which may be later and/or less efficient.

The thoracic perimeter is the body measurement with the lowest variation and most accurate for determining muscle growth (PACHECO et al., 2008). Body size may be related to the weight of the animals, where taller animals are the later ones, considering the morphometric characteristics, avoiding the use of extreme types, which would have negative correlations with the animal production (SOUZA et al., 2002). Larger developments in thoracic perimeter measurements are usually expressed, owing to greater depositions of muscle and adipose tissue, which have growth curves different from those of the skeleton, which ceases to grow when maturity is reached (ROCHA et al., 2003).

Although without significant differences, the lower values of daily weight variations, loss of body condition during lactation, and maintenance of calf growth, subsequent reproductive outcomes are potentiated. Increases in body size decreased the repetition of pregnancy rates in primiparous cows, with values of 81.00%, 75.00% and 55.56% for light, moderate, and heavy cows, respectively. The nutritional requirements of cows primarily affect their maintenance, growth, gestation, and lactation, and not reproduction (DUARTE JÚNIOR et al., 2013).

The pregnancy rates of the groups reflect the productive system with cows, where lower demand results in greater reproductive successes. The selection of animals should seek a genotype adapted to the environment, such as the production capacity in short cycle systems, maintaining or reducing adult size, maintenance needs, and age at puberty and slaughter without increasing nutritional requirements (McMANUS et al., 2002). According to Magnabosco et al. (2009), higher weight at cow maturity, in extensive breeding systems, is associated with performance losses. Higher weight in non-ideal conditions increased the calving interval, reducing reproductive efficiency, leading to higher maintenance costs, and reducing the production of kilograms of calves per cow during its lifetime. The same author concluded that the productive and economic efficiency of a herd depends on the size of its matrices, since extensive systems usually pass through supply seasonality and quality of food during the year.

Evaluating only the conception of the cows by FTAI, it is verified that cows of moderate size were more efficient when than light and heavy cows. Although not significantly different ($P > 0.05$), body condition in primiparous cows was fundamental to the success of FTAI. Primiparous cows with higher body condition scores at the beginning of the synchronization protocol obtained a higher conception rate with FTAI (MENEGHETTI; VASCONCELOS, 2008). In addition, uterine involution and return of ovarian activity in females are also related to good body condition at birth.

The productive efficiency at weaning is an indicator measuring the ratio of kilograms of calves weaned for each 100 kg of cow kept in the herd. Although not significantly different, light,

moderate, and heavy cows show similar abilities as progenitors, and could be considered good since they wean calves weighing around 50% of their weight (MAGNABOSCO et al., 2009). Vaz et al. (2016b), when working with only two animal sizes in an Abeerden Angus herd, verified greater efficiencies at weaning from light cows than those from heavy cows, with values higher than 50% for the former. In addition to the size of the cow, the productive efficiency at weaning could be influenced by the age of weaning (VAZ; LOBATO, 2010), breed (RIBEIRO et al., 2001), mating system, level of food avaiable to the herd (VAZ et al., 2014), and cow milk production (VAZ et al., 2016a).

The rate of calf production is an important indicator of the association of calf production and subsequent rate of reproduction. There is no point in producing a heavy calf if the cow is not pregnant again and is therefore not considered productive. The probable kilograms of calves produced in the herds for the subsequent mating season could be increased through the age of weaning (VAZ; LOBATO, 2010), use of cultivated pastures and mating systems (VAZ et al., 2014), and size of cows (VAZ et al., 2016a).

Effective herd production is an indicator developed to assess whether the one-year production of a herd interferes with subsequent crop production, as it correlates the productivity of kilograms of the pair (cow-calf) with the repetition rate of pregnancy the following year. Therefore, it can evaluate the production efficiency of kilogram stock at birth for the next calving season.

When comparing the effective productivity between the groups alone, based on the light-weight cows, it was verified that this group has a higher efficiency of 31.8% than moderate-weight cows, and 85.4% than heavy-weight cows. Considering the effective productivity values of the respective groups, as well as their energy and protein demand, according to the NRC (2000), the light-weight group was 25% more efficient than the moderate-weight group, and 67% more efficient than the heavy-weight cows.

Conclusions

Red Angus primiparous cows of different sizes had the same production efficiency at calving and weaning.

Light- and moderate-weight cows had better reproductive performance and, when associated with calf development, were more productive than heavy-weight cows.

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