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A proposed new frame score system for Nellore cattle

Proposta de novo sistema de escore de estrutura corporal para bovinos Nelore

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Abstract
A new frame score system was developed for Nellore cattle, based upon ideal slaughter weights to achieve desired degrees of carcass fat cover. Data consisting of 688 complete records including sex, age, weight, hip height, and subcutaneous fat on growing Nellore cattle (190 males and 498 females) were obtained from the National Association of Breeders and Researchers (ANCP), Ribeirão Preto – SP, Brazil. Weight data were regressed on sex, age, hip height, and fat cover as covariates. Age was then fixed at 550 days and fat cover was set to 6 mm, and new equations for frame scores (1 to 11) in Nellore cattle were developed: $Frame_{Nellore}$ (males) = -42.43 + 0.04919 × Age + 0.3368 × Height – 0.0003369 × Age × Height and $Frame_{Nellore}$ (females) = -41.76 + 0.04919 × Age + 0.3368 × Height – 0.0003369 × Age × Height (Age and Height in days and cm, respectively). The Nellore equations resulted in average frame of 5.3, ranging from 2.3 to 7.7. Values were similar for males (5.4) and females (5.3). By contrast, previous equations gave higher values, that were very different between males and females. The new Nellore frame scores appear reasonable, particularly regarding body composition.
Key-words: animal breeding; cattle; structure; zebu

Resumo
Um novo sistema de escore para estrutura corporal foi desenvolvido para bovinos Nelore, baseado em pesos de abate ideais para atingir os graus desejados de cobertura de gordura da carcaça. Dados de 688 registros completos incluindo sexo, idade, peso, altura do quadril e gordura subcutânea de bovinos Nelore em crescimento (190 machos e 498 fêmeas) foram obtidos da Associação Nacional de Criadores e Pesquisadores (ANCP), Ribeirão Preto – SP, Brasil. Os dados de peso foram regredidos por sexo, idade, altura do quadril e cobertura de gordura como covariáveis. A idade foi então fixada em 550 dias e a cobertura de gordura foi fixada em 6 mm, e novas equações para escores de estrutura corporal (1 a 11) em bovinos Nelore foram desenvolvidas: $Frame_{Nelore}$ (machos) = -42,43 + 0,04919 × Idade + 0,3368 × Altura – 0,0003369 × Idade × Altura e $Frame_{Nellore}$ (fêmeas) = -41,76 + 0,04919 × Idade + 0,3368 × Altura – 0,0003369 × Idade × Altura (Idade e Altura em dias e cm, respectivamente). As equações de Nelore resultaram em estrutura corporal médio de 5,3, variando de 2,3 a 7,7. Os valores foram semelhantes para machos (5,4) e fêmeas (5,3). Por outro lado, as equações anteriores deram valores mais altos, que eram muito diferentes entre machos e fêmeas. As novas pontuações de estruturacorporal no Nelore parecem razoáveis, principalmente em relação à composição corporal.
Palavras-chave: bovino; estrutura; melhoramento genético; zebu

1. Introduction

The size that an animal will achieve at maturity is determined primarily by genetics, and in turn determines many aspects of growth and reproduction. Genetics includes variation among and within breeds. Animal size is most often expressed in terms of body weight, but also reflects linear skeletal dimensions and changes in body composition. Larger mature size animals grow more rapidly[(1)]. At similar weights, larger mature size animals are leaner than smaller mature size animals, because the allometric curve for fat accretion is displaced to the right[(2,3)]. For meat animals, market demands determine ideal degrees of carcass fatness, so that there are also ideal end weights that vary according to each animal's mature size. Other aspects of animal productivity that vary with mature size include age at puberty, reproductive efficiency, milk production, nutritional requirements, and adaptation to different climatic conditions[(4-8).]

Given the importance of mature size for animal production, a practical system for assessing this trait in individual animals is indispensable. For many years the standard system has been the frame score. Several frame score systems have been developed over the years and in

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different places. All of them assign a numerical score to an animal (1 to 3, 1 to 5, 1 to 9, or 1 to 11) that increases with its expected mature size and ideal slaughter weight. The Beef Improvement Federation (BIF) has published standard equations and tables to estimate frame score based on hip height and age for growing and mature cattle of both sexes[7].

One rule of thumb used in the US beef industry is that: Frame Score = (slaughter wt,lb – 650) / 100. This equation assumes a slaughter weight at the degree of fatness at which steers are most likely to grade Low Choice (28 to 32% carcass fat). Therefore, an average frame score 6 steer should reach market finish around 1250 lb (567 kg); each frame score above or below this value would change the ideal slaughter weight by 100 lb (45.4 kg).

The BIF[7] standards were developed for, and apply to, *Bos taurus* beef cattle breeds. Brazil possesses the world's largest commercial cattle population, currently estimated around 180 to 200 million head[9]. Of those, 80% have predominantly *Bos indicus* breeding, with the Nellore breed being by far the most numerous. Even so, there has been almost no work on a frame scoring system for these types of cattle. In the US, the only (mostly) *Bos indicus* breed with significant numbers is the Brahman. The American Brahman Breeders Association uses the BIF[7] system for its genetic improvement program. This works fairly well, probably because Brahman cattle have been bred (through crossbreeding and selection) to have similar skeletal dimensions as *Bos taurus* breeds. On the other hand, Nellore cattle are typically much taller than *Bos taurus* animals of similar weight or age. One would expect the BIF[7] system to produce erroneous estimates of frame score in Nellore cattle.

Therefore, this study aimed to develop a frame score system for Nellore cattle that is biologically sound, is easy to understand and explain to a layperson, and gives realistic values that are useful for producers.

2. Material and methods

The present study was exempt of the local ethical committee evaluation as phenotypic data was granted from commercial animal breeding program. The approach taken here was to develop a frame score scale of 1 to 11, in which each frame score is equivalent to one *arroba* (@; 1 @ = 15 kg carcass wt), the standard unit used by Brazilian beef packers and producers (Table 1). This makes the system easier to understand and explain, and makes it more useful. Then, the ideal slaughter weights for Nellore cattle, based on measurements of weight, hip height, and subcutaneous fat cover, were estimated. Finally, ideal slaughter weights were converted to the previously established frame scores and equations developed for their calculations.

Table 1. Proposed frame score system and scale for Nellore males.

Frame score	Carcass wt[a], @		Slaughter wt[b], kg	
	Males	Females	Males	Females
1	12	9	333	250
2	13	10	361	278
3	14	11	389	306
4	15	12	417	333
5	16	13	444	361
6	17	14	472	389
7	18	15	500	417
8	19	16	528	444
9	20	17	556	472
10	21	18	583	500
11	22	19	611	528

[a]Carcass weights are expressed as *arrobas* (@) in Brazil, each @ equivalent to 15 kg of carcass weight. [b]Body weight at slaughter estimated assuming a 54% dressing percentage.

Data from the genetic evaluation database of the Genetic Improvement Program of the Nellore Breed (PMGRN) were obtained from the National Association of Breeders and Researchers (ANCP), Ribeirão Preto – SP, Brazil. The data set consisted of 688 complete records including sex, age, weight, hip height and subcutaneous fat on growing Nellore cattle (190 males and 498 females), ranging in age from 407 to 664 days. Data were collected on three farms in central Brazil (Rancho da Matinha, Uberaba-MG; Genética Aditiva, Campo Grande-MS; and Campina Verde, Campo Grande-MS) between January and April of 2009,

Subcutaneous fat was a weighted mean of 12th-13th rib fat (35%) and rump fat at the P8 site (65%), both measured by real time ultrasound using ALOKA 500 V equipment with a 3.5 MHz linear probe. The animals were scanned for rib fat between the 12th and 13th ribs at *the Longisssimus dorsi* muscle and rump fat was measured at the junction of the *Gluteus medius* and *Biceps femoris* muscles, between the ileum and ischium bones (Figure 1).

Image collection was performed by a single technician and interpreted by another specialized technician. Technicians, hardware and software were certified by the Brazilian Association of Ultrasound Technicians (ATUBRA), following the Beef Improvement Federation Guidelines[7].

Data were subjected to an analysis of covariance, with sex as a fixed effect, and age, hip height, and fat cover as covariates. This analysis enabled calculations of body weight. For the present study, age was fixed at 550 days and fat cover was set to 6 mm, which corresponds to the "Uniforme" classification most favored by Brazilian packers. Based on those predicted weights, and those specified in Table 1, new equations for frame

scores in Nellore males and females were developed, based on age and height. The data used in the present analyses are presented in Table 2.

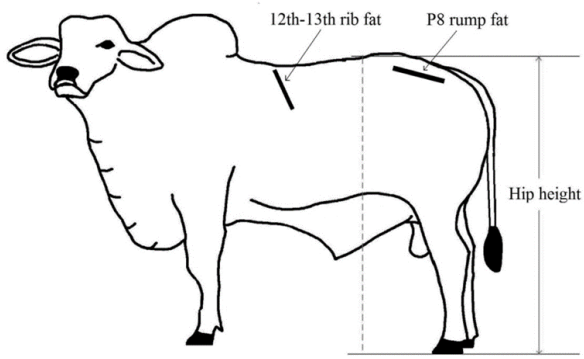

Figure 1. Measurement of hip height and subcutaneous fat in Nellore cattle.

Table 2. Data used to generate frame score equations for Nellore cattle.

Trait	Sex	Mean	Standard deviation	Minimum	Maximum
Age, days	Male	501	45.6	373	664
	Female	513	33.8	396	567
Weight, kg	Male	438	45.4	296	586
	Female	370	38.0	245	493
Hip height, cm	Male	139	4.5	128	153
	Female	134	4.3	117	148
Fat cover, mm	Male	3.2	1.0	2.2	10.6
	Female	3.5	1.9	2.4	17.1

Finally, existing frame score equations[7,10], developed for *Bos taurus* and *Bos indicus* cattle respectively, were compared to the new equations. The BIF[7] equations for young cattle include height (inches) and age (days):

Frame Score (males) = -11.548 + (0.487 x Height) – (0.029 x Age) + (0.0000195 × Age^2) + (0.0000334 × Height × Age)

Frame Score (females) = -11.709 + (0.472 × Height) – (0.024 × Age) + (0.0000146 × Age^2) + (0.0000759 × Height × Age)

The Horimoto *et al.*[9] equations for young cattle include height (cm) and weight (kg), both measured at or standardized to 18 months of age:

Frame GMA (males) = -7.019 + 0.063 × Height - 0.149 × Weight + 0.00119 × Height × Weight

Frame GMA (females) = -93.476 + 0.699 × Height + 0.140 × Weight - 0.000930 × Height × Weight

The BIF[7] equations were used on the raw data; to apply the Horimoto *et al.*[9] equations the height and weight data were standardized to 18 months using the coefficients from the analyses of covariance.

3. Results

Analysis of covariance of weight against sex (as a fixed effect), and age, hip height and fat cover as covariates enabled estimation of weights at different ages, heights and degrees of fat cover (Table 3).

Table 3. Covariance analysis of body weight against sex (fixed effect), age, hip height, and fat cover (as covariates) in Nellore cattle

Term	Coefficient	Standard error	P
Intercept	-961.3	398.6	0.016
Sex (0 = female, 1 = male)	32.366	1.625	< 0.001
Age (days)	1.3665	0.7707	0.077
Hip height (cm)	9.344	2.95	0.002
Fat cover (mm)	9.3232	0.6563	< 0.001
Age x hip height	-0.009359	0.005686	0.10

Based upon the definitions of frame scores set out in Table 1 and the results of the covariance analysis, new equations for frame scores in Nellore males and females were developed. These equations for male and female Nellore cattle are:

Frame Nellore (males) = -42.43 + 0.04919 × Age + 0.3368 × Height – 0.0003369 × Age × Height

Frame Nellore (females) = -41.76 + 0.04919 × Age + 0.3368 × Height – 0.0003369 × Age × Height

Outputs from these equations are presented in tabular form in Tables 4 and 5.

Table 4. Frame scores by age and hip height for Nellore males[a]

Hip height, cm	Age, months						
	16	17	18	19	20	21	22
120	2.2	2.5	2.7	3.0	3.3	3.5	3.8
130	3.9	**4.1**	**4.3**	**4.4**	4.6	4.7	4.9
140	5.7	**5.7**	**5.8**	**5.8**	5.9	6.0	6.0
150	7.4	**7.3**	**7.3**	**7.3**	7.2	7.2	7.1
160	9.1	9.0	8.8	8.7	8.5	8.4	8.2
170	10.8	10.6	10.3	10.1	9.8	9.6	9.4

[a]Numbers in bold type show the most common age and height combinations.

Table 5. Frame scores by age and hip height for Nellore females[a]

Hip height, cm	Age, months						
	16	17	18	19	20	21	22
110	1.1	1.5	1.9	2.3	2.6	3.0	3.4
120	2.9	**3.1**	**3.4**	**3.7**	3.9	4.2	4.5
130	4.6	**4.8**	**4.9**	**5.1**	5.3	5.4	5.6
140	6.3	**6.4**	**6.4**	**6.5**	6.6	6.6	6.7
150	8.0	8.0	8.0	7.9	7.9	7.8	7.8
160	9.8	9.6	9.5	9.3	9.2	9.1	8.9

[a]Numbers in bold type show the most common age and height combinations.

Comparisons between existing frame score equations and the new equations showed marked discrepancies. The Nellore equations resulted in average frame score of 5.3, ranging from 2.3 to 7.7. Mean values for males and females were similar (5.4 and 5.3, respectively). By contrast, the BIF[7] equations gave a mean value of 9.4, ranging from 6.0 to 13.2. Mean values for males and females were very different (7.9 and 9.9, respectively; Figure 2). The Horimoto *et al.*[9] equations also gave a higher mean value of 8.0 and ranged from -1.1 to 19.9. Mean values for males and females were also very different (10.8 and 7.0, respectively; Figure 3).

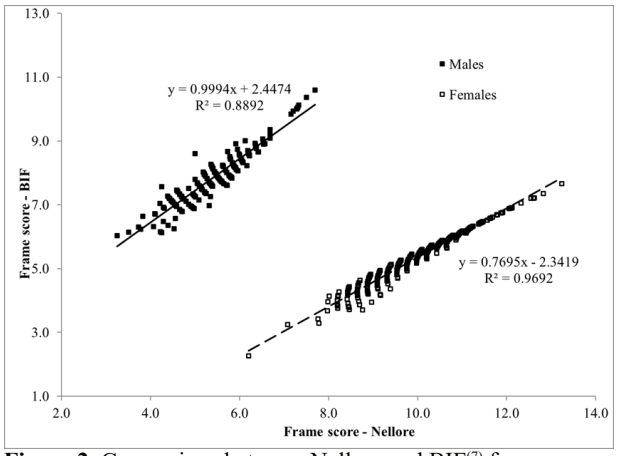

Figure 2. Comparison between Nellore and BIF[7] frame scores.

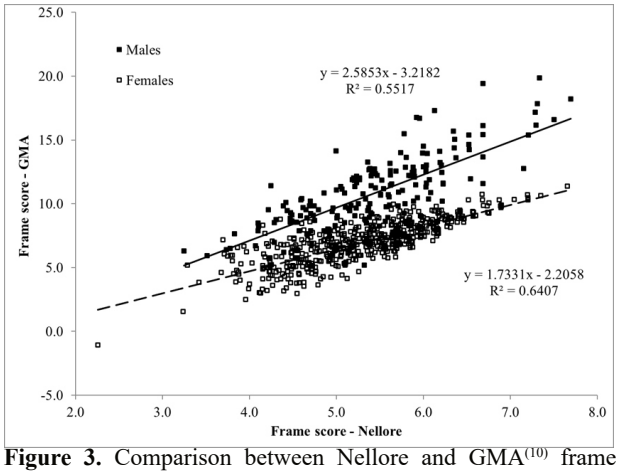

Figure 3. Comparison between Nellore and GMA[10] frame scores.

4. Discussion

The data cover the range required for animals participating in genetic evaluation for carcass traits (Table 2). Most importantly, the age and fat cover values selected as standard (550 days and 6 mm) lie well within the range of the data, lending more confidence to the estimates. Values beyond these ranges must be viewed with caution.

As can be seen in Tables 3 and 4, the Nellore frame score is very sensitive to hip height, but much less sensitive to age. In fact, frame score increases with age at the time of measurement for cattle below 140 cm, but decreases with age for cattle taller than 140 cm. The relative lack of sensitivity to age is an advantage in situations where it is impossible to determine an animal's age accurately and precisely in the field (e.g., in feedlots).

The BIF[7] frame score equations, like those developed here, are based upon age and hip height. Different equations are used for young males and females, because height, weight, and body composition vary between sexes, however frame scores for genetically similar males and females should be the same. Mercadante *et al.* [10] reported that the BIF equations gave very high frame scores (mainly 7, 8 and 9 in yearlings) when applied to Nellore cattle. These would imply ideal slaughter weights of 614, 659 and 704 kg, clearly far beyond the normal range. When compared with the new Nellore frame equations on this data set, the BIF equations produced very high values that were very different between males and females (Figure 2). Considering that frame size is a genetically determined trait, and that the males and females used in this study came from the same herds, one would not expect to find a difference in frame size due to sex. Values obtained using the new Nellore equations give similar values for males and females, as expected.

Horimoto[11] reported equations to estimate frame score in Nellore cattle, based on height and weight at 18 months. In that study, the criteria for defining frame scores were limited to the empirical relationships between height and weight. Horimoto *et al.*[9] evaluated those equations jointly with the BIF equations and confirmed the phenotypic and genetic correlations between weight and height, concluding that genetic selection for increased body weight may indirectly lead to taller animals. Inclusion of frame score in selection decisions would allow producers to select animals with superior weight gains without increasing mature size. That study also reported that neither frame score system had any significant relationship to visual muscle score, scrotal circumference, and an empirical classification index (CEIP). When compared with the new Nellore frame equations on this data set, the Horimoto *et al.*[9] equations produced somewhat higher values that were also different between males and females (Figure 3), in contrast to the results of the present study.

The proposed frame scores were developed in purebred (i.e., seedstock) cattle herds. However, it would be important to validate it in herds with different nutritional managements (pasture x confinement) so that the equations can be widely used by all Nellore breeders.

5. Conclusions

In conclusion, this study used field data obtained by the Genetic Improvement Program of the Nellore breed to develop a new frame score system specific to the breed. The values produced by this system appear reasonable, particularly with regard to differences in body composition. It remains to be seen whether frame scores estimated using the Nellore system will display appropriate behavior when subjected to genetic evaluation. Also, to be determined is how these scores will correlate to other productive and reproductive traits. The proposed Nellore frame score system should be seen as an initial step and may be amended and improved as more data become available.

Declaration of conflict of interest

The authors certify that they have no conflict of interest in the subject matter or materials discussed in this manuscript.

Author contributions

Conceptualization: R. D. Sainz and C. U. Magnabosco; *Data curation:* N. C. Guimarães; *Formal analysis*: N. C. Guimarães; *Methodology*: R. D. Sainz and C. U. Magnabosco; *Supervision*: R. D. Sainz, A. S. do Carmo and C. U. Magnabosco; *Writing (original draft, review & editing):* R. D. Sainz and A. S. do Carmo.

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