Carcass Traits of the Malagasy Zebu “*Bos taurus indicus*” (Linnaeus, 1758)

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Abstract: Improving Malagasy zebu production in the face of booming Malagasy population and regression of the animal number, this study was initiated to put forth some Malagasy zebu carcass weight performance and dressing percentages following slaughter. Measurements concerned live weight before slaughtering, carcass weights, quarters and carcass halves, left and right and the fifth quarter (blood, leather, intestine, lung, heart, liver, kidneys, spleen and rumen with its content) weights on 544 individuals without distinction (age nor sex). Descriptive statistical analysis was undertaken to qualify and compare the various weights. It results high proportion females (66%), smaller size (live weight less than 250 kg, 60%) and 5 live weight classes. Live weight was different in the 2 sexes starting class 3 (live weight > 250 kg) ($p = 0.0027$). Males fore quarters were heavier than females ($p < 1\%$). Carcass dressing percentage increased according to live weight class, whereas, 5th quarter yield presented a regressive reduction with increasing weight class. Survey shows an average dressing percentage of 46.20% with an average 5th quarter yield of 37.43%. Malagasy zebus are light weighted animals compared to the African zebus. Precocious slaughtering (before 250 kg live weight) doesn't allow a good meat yield.

Key words: Beef cattle, Malagasy zebu, extensive raising system, carcass traits, dressing percentage ratios quarter weight/live weight.

1. Introduction

Madagascar is mostly an agriculture producing country, where the primary sector covers up to 80% of all economic activities. On the matter of animal farming, bovine species play a major role and cover 70% of all animal productions on a grazing area of about 37,158,000 ha (63% of the country total area) [1]. The national livestock is estimated to be 9,647,000 bovine heads (85% Malagasy zebus) versus 1,314,400 swine, 729,000 ovine and 1,279,700 caprine [1]. The west and southwestern parts of Madagascar constitute the bovine main grazing area (supporting more than 60% of the national livestock) where the animal constitutes as much a heritage as a wealth for every farmer family. However, since 2006, a reduction in Malagasy bovine number has been

noted, as opposed to the population whom, in the meantime, didn't stop growing. If a ratio of one zebu per person has been noted at the time of the country independence, around 1960, this ratio fell to only 0.4 zebu per person in 2012 [2-8]. Whatever the applied farming system is (either contemplative, associated with other agricultural production, hoarding or feeder cattle farming), zebu meat is covering up to 75% of local beef consumption quantity. Total Malagasy beef production is estimated to be 1,277,000 tons in 2002 [9]. Madagascar middle west beef producing area covers 2/3 of this production whereas the capital, Antananarivo stays the main site of beef consumption. The latter is the main source of meat for the Malagasy population, the present study aims to show some Malagasy zebu carcass characteristics that may subsequently help to set up a race preservation strategy for a better beef production in Madagascar.

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2. Material and Methods

2.1 Materials

The study has been undertaken in a local slaughtering house situated 20 km west of the capital—Antananarivo (1,300 m of altitude, 18°59' of latitude south and 47°19' longitude west) during 5 months, from March till July 2012. Animals were constituted of Malagasy zebus with no sex or age distinction. They were bought from a local bovine market and placed in confinement within the center during the week of slaughtering. During that week, animals were allowed to graze on natural pasture surrounding the center, from 8:00 am until 4:00 pm and had access to water on an *ad libitum* basis. A total of 544 individuals were studied during the five months period. These measurements were effected with: (1) livestock weighing machine presenting 2,000 kg maximum range and a precision of 500 g; (2) mechanical roman scale having a 100 kg maximum range and a precision of 100 g for the weights of quarters or offals over 3 kg and (3) electronic kitchen scale with a 3 kg maximum range and a precision of 1 g for weights less than 3 kg. SAS JMP 5.0.1 software was used for data analysis.

2.2 Methods

Slaughtering and cutting operations were effected very early in the morning (between 1:00 am and 7:00 am) according to the daily practices of the center. Individual live weights and pieces of meat cutting weights were obtained at every stage of slaughter and cut processes. These measurements concerned: (1) animal live weight before slaughtering (PV); (2) fifth quarter weight: blood, leather, rumen with its content, intestine, lung, heart, liver, kidneys and spleen (PQ5) and (3) the four quarter weights: left forequarter weight (PQAVG); left hind quarter weight (PQARG); right fore quarter weight (PQAVD) and right hind quarter weight (PQARD). A simple descriptive statistical method was used to explore the data, aiming to perform qualitative and comparative analyses for

the different weights: right half carcass weight (PDCD) and left half carcass weight (PDCG) and identify live weight class [10-14].

In additional, a ratio for each quarter weight in relation with live weight class is calculated by Eq. (1):

$$Ratio = \frac{Quarter\ Weight}{Live\ Weight} \times 100 \quad (1)$$

And a ratio for each half carcass weight according to live weight class is calculated by Eq. (2):

$$Ratio = \frac{Half\ Carcass\ Weight}{Live\ Weight} \times 100 \quad (2)$$

Also, carcass dressing percentage (RCT) for each live weight class is given by Eq. (3):

$$Carcass\ dressing\ percentage = \frac{PDCD + PDCG}{Live\ Weight} \times 100 \quad (3)$$

And fifth quarter yield (RCQ) for each live weight class is estimated by Eq. (4):

$$Fifth\ quarter\ yield = \frac{PQ5}{Live\ Weight} \times 100 \quad (4)$$

3. Results and Discussion

3.1 Carcass Weight Characteristics

Weighing results are synthesized in Table 1. Thus, five live weight classes are identified for the studied Malagasy zebu sample, which includes a high proportion of females (66%) (Table 1).

This weight stratification shows that for the majority of slaughtered animals (60% of the total population), live weight is lower than 250 kg. This proportion of small sized animals is very significant and more important among females (90%) than males (only 4%). If, in this study, females tend to be slaughtered at a live weight ranging from 200 kg to 250 kg (59% of females), males, for most (40%), are slaughtered between 300 PV kg and 350 PV kg.

Finally, if, on one hand, males are slaughtered at a live weight of at least 200 kg, females, on the other, never go over 300 kg of live weight, thus, indicating a precocious animal exploitation.

Table 1 Malagasy Zebu carcass characteristics.

Live weight class (kg)	1 (< 200)		2 (200-250)		3 (250-300)		4 (300-350)		5 (> 350)
	Females	Males	Females	Males	Females	Males	Males		
Number	112	7	210	55	37	75	48		
PV (kg)	183.13 ± 12.15	229 ± 11.55	220.24 ± 13.6	277.36 ± 14.17	268.03 ± 14.27	323.85 ± 12.65	386 ± 34.94		
	-	-	-	-	-	-	-		
PQAVG (kg)	19.61 ± 1.73	24.86 ± 3.68	23.52 ± 2.38	33.84 ± 3.72	29.28 ± 3.75	39.99 ± 3.24	49.11 ± 5.28		
	10.71	10.86	10.68	12.2	10.92	12.35	12.72		
PQARG (kg)	21.04 ± 1.99	24.64 ± 1.73	25.34 ± 2.57	32.16 ± 3.06	31.53 ± 4.37	37.97 ± 3.28	46.52 ± 5.28		
	11.49	10.76	11.51	11.6	11.76	11.72	12.05		
PQAVD (kg)	19.65 ± 2.2	24.64 ± 3.72	23.53 ± 2.47	33.75 ± 3.59	29.3 ± 3.99	39.79 ± 3.13	48.77 ± 5.46		
	10.73	10.76	10.68	12.17	10.93	12.29	12.63		
PQARD (kg)	21.4 ± 2.01	24.71 ± 1.52	25.66 ± 2.49	32.05 ± 2.91	31.72 ± 4.2	37.61 ± 3.11	46.27 ± 4.87		
	11.69	10.79	11.65	11.56	11.83	11.61	11.99		
PQ5 (kg)	72.24 ± 7.56	90.47 ± 6.06	84.50 ± 9.35	100.72 ± 10.72	99.09 ± 12.08	117.82 ± 10.02	135.80 ± 18.57		
	39.45	35.51	38.37	36.31	36.97	36.38	35.18		
PDCG (kg)	40.65 ± 3.69	49.50 ± 5.11	48.86 ± 4.71	66.00 ± 6.28	60.81 ± 7.92	77.95 ± 5.58	95.64 ± 10.20		
	22.20	21.62	22.19	23.80	22.69	24.07	24.78		
PDCD (kg)	41.05 ± 3.83	49.36 ± 5.05	49.19 ± 4.69	65.80 ± 6.13	61.01 ± 7.91	77.40 ± 5.40	95.04 ± 9.88		
	22.42	21.55	22.34	23.72	22.76	23.90	24.62		
RCT	44.61	44.48		46.70		47.97	49.40		
RCQ	39.45	38.40		36.57		36.38	35.18		

Within this weight stratification, class 1 (PV < 200 kg) is composed exclusively of females (n = 112). Then, it has been shown that for class 2 (n = 217), the difference in weight between male and female individuals is not significant ($p > 0.05$), implying that live weights as well as the different quarter weights are similar for both sexes. On the other hand, for class 3 (n = 92), this difference in weights has become significant ($p < 0.05$) between male and female individuals, except for the case of the left hind quarter weight ($p = 0.4134$), the right hind quarter weight ($p = 0.6487$) and that of the fifth quarter or offal ($p = 0.4983$). In fact, the difference in weights between male and female individuals becomes significant starting from 250 kg live weight ($p = 0.0027$). From then on, male fore quarters (PQAVG = 33.84 ± 0.50 kg and PQAVD = 33.75 ± 0.50 kg) are heavier than those of the females (PQAVG = 29.28 ± 0.61 kg and PQAVD = 29.30 ± 0.62 kg) ($p < 1\%$).

Among males (n = 185), left (39.95 ± 0.56 kg) and right (39.75 ± 0.56 kg) fore quarter average weight are

similar ($p = 0.7938$). The same observation can be made about left (37.96 ± 0.51 kg) and right (37.72 ± 0.51 kg) hind quarter average weight ($p = 0.7438$). Besides, right fore quarter (39.75 ± 0.56 kg) weighs more than right hind quarter (37.72 ± 0.51 kg) ($p = 0.0071$). And in the same way, left fore quarter (39.95 ± 0.56 kg) is heavier than left hind quarter (37.96 ± 0.51 kg) ($p = 0.0093$). Therefore, fore quarters (79.70 ± 1.07 kg) are significantly more developed than hind quarters (75.68 ± 1.07 kg) ($p = 0.0079$) among males. Whereas, left half carcass average weight (77.91 ± 1.05 kg) is similar to that of right (77.47 ± 1.05 kg) ($p = 0.7651$). Finally, it is noted that half carcasses (left and/or right) weights increase with animal live weights.

Among females, some similar observations are noted. Significant differences ($p < 1\%$) are found between right fore (22.92 ± 0.20 kg) and hind (24.96 ± 0.20 kg) quarter average weight as well as between left hind (24.64 ± 0.20 kg) and fore (22.89 ± 0.20 kg) quarter average weight. Yet, smaller non-significant differences are found ($p = 0.9403$) between left (22.89

± 0.20 kg) and right (22.92 ± 0.20 kg) fore quarter average weight as well as between left (24.64 ± 0.21 kg) and right (24.96 ± 0.21 kg) hind quarter average weight ($p = 0.2869$). On the other hand, it is noted that hind quarter is significantly heavier (49.59 ± 0.40 kg) than fore quarter (45.81 ± 0.40 kg) among females ($p < 1\%$, $n = 359$). Moreover, half carcass average weight tends to increase with the animal live weight, even though this evolution is different among live weight classes ($p < 1\%$) in spite of a similarity between left (47.53 ± 0.40 kg) and right (47.87 ± 0.40 kg) ($p = 0.5491$) half carcass average weight over all classes.

Beef production in Madagascar is essentially the fact of Malagasy zebu. Zebus are deviated from their usual growth cycle at a minimum live weight of 148 kg for meat production while the mature animal average live weight is estimated to be 357.5 kg [15]. So, intensive precocious slaughtering of the animals was observed in relation with (Table 1) results. Malagasy zebu being animals of slow growth rate [16], this precocious exploitation indicates that the slaughtered animals didn't reach yet the term of their normal growth [17-20].

The high proportions of slaughtered females as well as the zebu precocious slaughtering explain among others the Malagasy zebu relentless reduction in number over time. The increased demand in beef on the market due to demographic growth as well as the zebu extensive traditional management type is the main reasons behind the excessive and precocious slaughtering of female zebus [2].

Zebus of Madagascar high lands are lighter (250.65 ± 63.41 kg live weight; $n = 544$) compared to animals from other regions (344.58 ± 65.10 kg average live weight for animals of the northern part of the island; 338.07 ± 69.44 kg average live weight for zebus from the south) [21, 22].

Malagasy zebus are light weighted animals compared to Senegalese Peuhl zebu (350 kg live weight), Nigerien Peuhl zebu (320 kg live weight) or

Sudanese Peuhl zebu (315 kg live weight) [23].

Malagasy female zebus are small sized animals (213.59 ± 28.23 kg average live weight, $n = 359$) compared to Ongole female zebus (312.5 kg average live weight) and the same is also true for males (322.57 ± 49.33 kg average live weight for Malagasy male zebu versus 436.4 kg average live weight for Ongole male zebu) [24].

Malagasy zebus are lighter in average live weight compared to Kouris (550 kg), Afrikanders (301.98 kg), Kapsikis (380 kg) or Gobres (370-407 kg) [24-27].

Besides, they are light compared to Creole bovine of Guadeloupe (590 kg average live weight for males and 366 kg average live weight for females), Criollo of Cuba (900 kg and 600 kg respectively for males and females), Romana Roja (800 kg and 500 kg respectively for males and females), Jamaïca red (855 kg and 455 kg respectively) or Senepol (760 kg and 460 kg respectively for males and females) [28].

Yet, Malagasy zebus present body formats close to those of Ndama of Congo (249.7 ± 26.4 kg average live weight for females; 255.1 ± 19.8 kg average live weight for males), Senegalese Gobra zebus (live weights ranging from 240-250 kg), Arab zebu of Chad (live weight varying between 215 kg and 300 kg), or M' bororo zebu (248.66 kg live weight) as well as Borgou zebu (240 kg live weight) and Haitian Creole (365 kg live weight for males and 300 kg for females) [24, 27-31].

Otherwise, Malagasy zebus present a greater size compared to the Togo and Benin taurine race (172 kg average live weight), the Cameroonian Kapsiki (206 kg average live weight), the Lagunaire race of the gulf of Benin (209 kg live weight) or the Baoulé race of Ivory coast (213 kg live weight) as well as the Namchi of Cameroon (200 kg of live weight) the Toupouri (100-150 kg live weight) or the Somba (172 kg live weight) [26, 27, 32-35].

Besides, the use of cross in breeding can allow Malagasy zebu to get good growth performance. Thus, an average live weight of 429.73 ± 73.15 kg might be

obtained in a crossing with Renitelo, or an average live weight of 413 kg, in a Malagasy zebu and Brahman cross [36, 37].

Therefore, it can be inferred for Malagasy zebu that scapular muscle mass grows faster than buttock muscle for male individuals whereas for females, it is the buttock muscle mass that develops itself more to the detriment of scapular muscle mass.

3.2 Carcass Dressing Percentage and Ratios

Variability among Malagasy zebu carcass quarter

ratios (Eq. 1) is presented in Fig. 1. Beside the type of quarter effect, it is noted that animal sex as well as their weight class significantly affect these ratios. These ratios show a fore quarter greater developments in males (Fig. 1a) whereas, it is the hind quarters that are predominant for females (Fig. 1b).

Among males in this study, the ratio varies from 10.76 to 12.72, and it increases with animal weight class. A ratio of 11.99 to 12.72, observed in class 5 indicates that a live weight at slaughtering of at least 350 kg would be the most favorable to meat

Fig. 1 (a) Malagasy zebu fore quarter over live weight ratio variability according to sex and weight class; (b) Malagasy zebu hind quarter over live weight ratio variability according to sex and weight class.

production since it would yield the heaviest quarters and, therefore, the highest ratios.

Besides, this male class 5 would allow a ratio of half carcass weight over live weight (Eq. 2) of 24.78 for the left side, and 24.62 for the right side, whereas, the ratio of the 5th quarter weight over live weight (Eq. 1) would be 35.18 (Fig. 2).

Among females, the ratio quarter weight over live weight is about 11. It is similar for weight classes 1 and 2, and then it increases for class 3. It should also be noted that the highest ratios are related to the heaviest weight classes (Fig. 1). However, female live weight at slaughtering is limited to a maximum 300 kg. In this case, half carcass weight over live weight ratio would be 22.69 for the left side and 22.76 for the right side, whereas, the 5th quarter weight ratio would be 36.97 (Fig. 2).

Carcass dressing percentages indicate that crossbreeding would yield higher performance (54.40 for Renitelo, 59.20 for 3/4 Brahman and 57.20 for 1/2 Brahman) [16] than the present study Malagasy zebu (dressing percentage: 46.20). Besides, management and feeding practice may present a significant effect on growth performance. Intensive fed zebus are heavier (59.20 carcass dressing percent) [37] than

extensive fed animals (46.20 carcass dressing percent in the present study). Besides, African zebus present higher performance with carcass dressing percent values of 62.00 for Adamaoua zebu of Cameroon; 49.20 for Borgou of Benin [30, 38] compared with this study Malagasy zebu carcass dressing percent of about 46.20. Thus, dressing percent increases with animal live weight. The heavier the animal, the higher the dressing percent would be [19, 20, 39].

In fact, ratios (Eq. 1) would be a muscle mass development indicator, so that of meat production to the level of these quarters.

If half carcasses are considered as a whole, Fig. 3 shows that carcass dressing percentage (Eq. 3) increases according to live weight class, from class 2 up, whereas, fifth quarter yield (Eq. 4) presents a regressive decrease with increasing weight class.

Thus, during this study, an average dressing percentage of 46.20 has been found with an average fifth quarter yield of 37.43. Malagasy zebus are low meat producing animals with live weight at slaughter varying from 148 kg to 511 kg. Moreover, the precocious slaughtering (before 250 kg live weight) of either male or female zebu don't allow a high meat yield for the animal.

Fig. 2 Malagasy zebu half carcass weight ratio variability in relation with sex and live weight class.

Fig. 3 Malagasy zebu carcass dressing percentage and 5th quarter yield.

Zebus usually show a carcass dressing percentage varying from 44% to 56%; this study dressing percentage value (46.20) is coherent with the above-mentioned range [40]. However, low meat yield animal could be deducted according to the fifth quarter ratio (Eq. 1) (37.20%) which is extensively superior to the range, 20% to 25% of live weight [19, 20, 40].

Beside, carcass dressing percentage of this study are close (44.48% to 49.40%, Table 1) to those observed with Malagasy zebus raised on natural grazing (45.90% at the end of the dry season, or 44.80% at the end of the rainy season), as well as those with grass fed zebus (48.30%) [17-20].

Yet, a dressing percentage as high as 54% can be observed among Malagasy zebus raised on an intensive feeding system involving concentrate during three months, or an average dressing percentage value of 59.20% with culled animals fed intensively in confinement [17-20].

On one hand, Malagasy zebu low meat yield is put forth when compared with beef cattle races such as Charolais (60% to 70% carcass dressing percentage), American Brahman (60%) or Afrikander (58%), on

the other hand, it presents a productivity closer to that of Moorish zebu (50% to 52% average carcass dressing percentage), Azawak zebu (48% to 50%) or Boran zebu (54%) [41].

5. Conclusions

The Malagasy zebu is a small sized animal with low meat yield. Male zebus are bigger and heavier than females. At slaughter, carcass fore quarters are more developed compared to hind quarters among males, while carcass hind quarters are more voluminous compared to fore quarters among the females. Carcass weight, generally, is proportionate to animal live weight while the fifth quarter weight decreases progressively with increasing animal live weight. From the present study, it could be deducted that zebu precocious slaughtering is profitable only with live weight of at least 250 kg. Beef cattle productivity is related to management and feeding systems. Malagasy zebu carcass traits might be improved via genetic improvement. Crossbred animals (such as Renitelo) present bigger body formats than Malagasy thorough bred zebu as well as higher meat yield. Thus, a well-thought strategy should be conceived to improve

and preserve the race mainly as a genepool.

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