GROWTH AND COMPOSITION OF THE OMANI DHOFARI CATTLE 2. DISTRIBUTION OF CARCASS TISSUES

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Summary

Distribution of wholesale carcass cuts and tissues was studied in Omani Dhofari bulls and steers raised under intensive management and slaughtered over a range of 110 to 210 kg body weight. The fore quarter of Dhofari cattle carcasses was heavier than the hind quarter with the chuck being the heaviest cut in the half carcass followed by the round whereas the flank was the lightest cut. Proportions of the fore quarter and its cuts increased whereas that of the hind quarter and its cuts decreased with increasing carcass weight. The fore quarter contained higher proportions of carcass tissues especially intermuscular fat than the hind quarter. The chuck and round contained the highest proportions of lean and bone and the flank the least. There was a general trend of increasing proportions of fat and decreasing proportions of lean and bone in carcass cuts and fore and hind quarters with increasing slaughter weight and age. As % total body fat (TBF), total carcass fat (TCF) increased whereas total non-carcass fat (TNCF) decreased. The largest proportion of TBF was deposited in the intermuscular site. Among the TNCF depots, the kidney and omental contributed the highest proportions whereas the pelvic and channel were the lowest. Proportions of *M. rhomboideus* and *M. splenius* increased in the half carcass whereas that of *M. semitendinosus* decreased as the cattle increased in size. The axial skeleton contributed 47.4-51.1, the fore limb 21.6-22.6 and the hind limb 23.9-26.2% of the total carcass bone. Proportions of axial skeleton increased whereas that of fore and hind limbs decreased with increasing slaughter weight and age. There were no major effects of castration on the distribution of weight of carcass cuts or carcass tissues. Steers had higher total body fat at 160 kg body weight and higher proportions of mesenteric, scrotal, pelvic, kidney and total non-carcass fat at 210 kg weight than bulls. As % of total body fat, steers had significantly higher kidney and total non-carcass fat. There was little effects of castration on proportions or dimensions of individual muscles or bones.

(**Key Words** :Omani Dhofari Cattle, Carcass Tissues, Carcass Cuts, Castration)

Introduction

Dhofari cattle respond well to improved management by way of higher growth rates (Mahgoub, Olvey and Jeffrey; 1995). Growth and distribution of carcass tissues under intensive management need to be investigated to evaluate their potential as meat producing animals and for future work to improve their conformation and meat qualities through breeding. Dhofari cattle are small in size and appear to be early maturing. Studies of the pattern of fat deposition in their carcasses are important in assessing their value for production of meat under intensive systems. Unlike temperate beef cattle breeds, information on growth and body composition of tropical unimproved breeds is limited. This study adds to the understanding of performance of tropical beef cattle and their potential as meat producing animals. Bone is not an edible tissue yet its growth is essential in meat animals because of its role in support, protection and movement of the animal body as well as its role as a reservoir of minerals, fat and protein. Linear growth of long bones in sheep stimulates growth in length and consequently growth in weight of muscles related to these bones (Mahgoub, 1988), thus affecting growth of total muscle in the carcass. Length of

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carcass bones determines carcass conformation, i.e., the same amount of muscle attached to longer bone suggests poor conformation. However, it is bone weight that is more important because it affects the proportion of edible tissues in the carcass. If differences in bone content in the body are inherited, genetic gains in meat animals can be achieved by selecting for lighter bones relative to muscles. Castration has been identified as a factor which affects growth in general and skeletal growth in particular (Brännäng, 1971) and therefore its implications for Dhofari cattle raised under intensive conditions for meat production need to be investigated.

The objective of this experiment was to study the distribution of weight in the carcass, individual fat depots, some muscles and bones in Dhofari cattle raised under intensive management when fed *ad libitum* to allow maximum body weight growth.

Materials and Methods

General materials and methods have been described (Mahgoub et al., 1995). Briefly, 24 bull and steer Dhofari cattle (12 of each sex) were slaughtered at 110, 160 and 210 kg body weights (4 of each sex at each slaughter weight). Omental, mesenteric, scrotal, pelvic and kidney fat were separated and weighed. Fat inside the carcass other than the above fat depots was separated and weighed as channel fat. Weights of omental, mesenteric, scrotal, kidney, pelvic and channel fats were added as total non-carcass fat (TNCF). The carcass was split along the vertebral column into left and right halves using a band saw. The left side of the carcass was split into fore and hind quarters between the 12th and 13th ribs. Each quarter was further broken into four wholesale cuts following the procedures of Swatland (1984). The cuts of the fore quarter were the chuck, brisket and foreshank, rack (rib) and plate and those of the hind quarter were the round (leg), sirloin, short loin and flank. Each carcass cut was dissected using scalpels into muscle, bone, subcutaneous and intermuscular fat (TCF) and connective tissue. Total body fat (TBF) was calculated at TCF plus TNCF.

Seven individual muscles from different regions of the carcass were dissected out and weighed. Individual bones of the left side of the carcass were dissected out, cleaned from adhering tissue, weighed immediately after dissection and grouped as: the axial skeleton, fore limb and hind limb. The axial skeletion included cervical, thoracic, lumbar and sacral vertebrae, ribs, pelivs and sternum. The fore limb included: scapula, humerus, radius and ulna, and carpus whereas the hind limb included: femur, tibia, patella and tarsus + tuber calcis. The first, sixth and 12th ribs were identified separately. The vertebral column length was measured using a string whereas the length of long bones was determined using callipers with a measuring rule. Width and circumference of long bones was measured at the mid-length point using a vernier calliper and a string, respectively.

Experimental data were analysed utilising Statistical Analysis Systems (SAS, 1985) General Linear Models procedures. Data pooled from bulls and steers were tested for significant effects of castration and slaughter weight.

TABLE 1. WEIGHT OF CARCASS CUTS AS PERCENTAGE OF LEFT HALF CARCASS AND EFFECTS OF CASTRATION (CAST) AND SLAUGHTER WEIGHT (SLWT) IN DHOFARI BULLS AND STEERS SLAUGHTERED AT 110, 160 AND 210 KG BODY WEIGHT

Cut as % of half carcass	Bulls			Steers			SE	Effects of	
	110 kg	160 kg	210 kg	110 kg	160 kg	210 kg		CAST	SLWT
Chuck	28.68	28.74	29.08	28.85	28.39	27.50	0.68		
Brisket & shank	11.80	11.42	11.39	10.72	11.30	12.04	0.41		
Rack	7.28^{b}	7.70^{b}	8.65^{a}	7.88^{b}	7.81^{b}	8.55^{a}	0.27		**
Plate	5.92^{bc}	6.06^{bc}	7.17^{a}	5.73^{c}	6.57^{ab}	6.71^{ab}	0.30		**
Total fore quarter	53.68^{bc}	53.92^{bc}	56.28^{a}	53.18^{c}	53.87^{bc}	54.81^{b}	0.62		**
Short loin	7.29	8.23	7.28	7.42	7.43	7.38	0.60		
Flank	5.46^{b}	5.14^{b}	6.74^{a}	5.21^{b}	6.47^{a}	6.64^{a}	0.38		**
Sirloin	6.89^{b}	7.43^{ab}	6.77^{b}	7.69^{a}	7.35^{ab}	7.32^{ab}	0.28		
Round	26.68^{a}	25.27^{bc}	22.93^{d}	26.50^{ab}	24.88^{c}	23.86^{cd}	0.60		***
Total hind quarter	46.32^{ab}	46.08^{ab}	43.72^{c}	46.82^{a}	46.13^{ab}	45.19^{b}	0.62		**

^{a,b,c} Means on the same lines without or denoted with the same superscripts do not differ ($p > 0.05$).

*, **, *** Effects of slaughter weight (SLWT) and castration (CAST) are ($p < 0.05, 0.01, 0.001$) significant.

TABLE 2. COMPOSITION OF CARCASS CUTS (% HALF CARCASS) AND EFFECTS OF CASTRATION (CAST) AND SLAUGHTER WEIGHT (SLWT) IN DHOFARI BULLS AND STEERS SLAUGHTERED AT 110, 160 AND 210 KG BODY WEIGHT

Component as % of half carcass	Bulls			Steers			SE	Effects of	
	110 kg	160 kg	210 kg	110 kg	160 kg	210 kg		CAST	SLWT
Chuck									
fat	4.01	4.41	7.15	4.41	5.58	6.13	0.41		***
lean	19.45	19.66	17.97	19.23	18.19	16.96	0.65		*
bone	4.00	3.46	3.13	3.88	3.28	3.05	0.14		***
Brisket & shank									
fat	2.01	2.36	3.16	1.93	2.17	3.41	0.19		***
lean	3.73	6.97	3.49	3.64	3.59	3.67	0.19		
bone	2.71	2.41	2.08	2.53	2.29	1.98	0.09		***
Rack									
fat	1.21	1.41	2.91	1.51	1.83	2.70	0.18		***
lean	4.69	4.95	4.43	4.85	4.62	4.49	0.17		
bone	1.09	1.09	1.07	1.24	1.14	1.03	0.08		
Plate									
fat	1.30	1.32	2.93	1.20	2.03	2.32	0.27		***
lean	3.73	3.97	3.49	3.64	3.59	3.67	0.19		
bone	0.70	0.61	0.52	0.67	0.61	0.47	0.03		***
Fore quarter									
fat	8.52	9.49	16.15	9.04	11.62	14.56	0.84		***
lean	34.48	34.72	31.63	33.47	32.77	31.41	0.76		**
bone	8.50	7.57	6.77	8.32	7.32	6.52	0.24		***
Short loin									
fat	0.90	0.82	1.66	0.94	1.33	1.56	0.13		***
lean	5.09	6.19	4.55	4.95	4.90	4.68	0.60		
bone	1.09	1.02	0.98	1.23	1.07	0.97	0.07		
Flank									
fat	1.68	1.34	2.98	1.39	2.22	2.70	0.30		***
lean	3.17	3.27	3.26	3.24	3.45	3.39	0.19		
bone	0.44	0.53	0.53	0.65	0.58	0.57	0.01		
Sirloin									
fat	0.86	0.90	1.46	0.85	1.21	1.40	0.10		***
lean	4.66	5.10	4.26	5.27	4.85	4.73	0.21		
bone	1.08	1.13	0.88	1.24	1.02	1.01	0.07		*
Round									
fat	1.92	1.57	2.34	1.95	2.12	2.64	0.19		***
lean	19.40	18.78	16.69	19.17	18.08	17.24	0.57		**
bone	4.16	3.71	2.92	4.12	3.41	2.87	0.16		***
Hind quarter									
fat	5.36	4.63	8.44	5.13	6.88	8.31	0.62		***
lean	32.32	3.34	28.76	32.63	31.28	30.04	0.80		**
bone	6.37	5.92	4.84	6.65	5.56	4.91	0.22		***

Footnotes as for table 1.

Least square means were computed and tested for significance using Duncan's Multiple Range Test.

Results

Distribution of weight in the carcass:

More than half (53.2-56.3%) of the weight of the carcass was in the fore quarter (table 1). This means that the hind quarter weighed 78-88% of the fore quarter (table 3). The heaviest cut in the half carcass was the chuck (27.5-29.1%) followed by the round (22.9-26.7%) and the lightest cut was the flank (5.1-6.6%) (table 1). Proportions of the rack, plate, flank and fore quarter as % of carcass weight increased whereas that of the round and hind quarters decreased with increasing carcass weight (table 1).

Distribution of tissues in the carcass:

Table 2 shows the distribution of major tissues in the carcasses with the weight of individual tissues expressed as % of carcass side weight. Proportions of carcass fat increased whereas that of lean and bone decreased in all carcass cuts as well as in the fore and hind quarters with increasing slaughter weight and age. The maximum fat contents in the fore quarter were recorded in bull carcasses at 210 kg. The fore quarter contained more fat, lean and bone than hind quarter (tables 2 and 3). This was more pronounced for the intermuscular fat depot where the hind quarter contained only 37-47% of that of the hind quarter (table 3). There were no large differences between the fore and hind quarter contents of lean tissue (table 3). Proportions of lean in chuck, fore quarter, round and hind quarters decreased with increasing slaughter weight and age (table 2). The highest proportions of lean in the carcass were found in the chuck and round (16.7-19.7%) whereas the lowest proportions were found in the flank (about 3.2%).

Generally bone content in carcass cuts and fore and hind quarters decreased with increasing carcass weight (table 2). The fore quarter contained higher bone content (6.5-8.5%) than the hind quarter (4.8-6.7%), a proportion of 71-80% of fore in hind quarter (tables 2 and 3). The chuck and round contained the highest proportions of bone in the carcass (2.9-4.1%).

TABLE 3. CARCASS TISSUES OF HIND QUARTER AS PERCENTAGE OF FORE QUARTER AND EFFECTS OF CASTRATION (CAST) AND SLAUGHTER WEIGHT (SLWT) IN DHOFARI BULLS AND STEERS SLAUGHTERED AT 110, 160 AND 210 KG BODY WEIGHTS

Item	Bulls			Steers			SE	Effects of	
	110 kg	160 kg	210 kg	110 kg	160 kg	210 kg		CAST	SLWT
Weight	86.3^{b}	85.6^{b}	77.7^{a}	88.1^{b}	85.7^{b}	82.6^{b}	2.1		**
Subcutaneous fat	101.4	80.9	94.8	90.0	88.4	95.0	8.2		
Intermuscular fat	47.3	37.3	37.7	43.7	47.2	42.9	4.6		
Total carcass fat	63.8^{c}	48.9^{a}	52.0^{ab}	56.7^{bc}	58.5^{bc}	57.1^{bc}	3.3		
Carcass lean	93.8	96.3	90.9	97.5	95.5	95.9	3.0		
Carcass bone	75.2^{ab}	78.3^{b}	71.3^{a}	80.0^{b}	76.0^{b}	75.3^{b}	2.2		

Footnotes as for table 1.

Distribution of fat in the body:

The total body fat in Dhofari cattle ranged between 12.9-14.5% at the 110 kg body weight and 22.9-23.6% at 210 kg body weight in bulls and steers, respectively (table 4). Between 110 and 210 kg body weight, and as proportions of slaughter weight, both carcass and non-carcass fat increased from 6.8-7.3 to 12.6-13.1% and 6.1-7.1 to 9.8-11.0%, respectively. As % TBF, the carcass fat increased whereas non-carcass fat decreased (table 4). Proportions of carcass fat were higher (49.1-56.9) than non-carcass fat (43.1-50.9% of TBF) averaging up to a ratio of 1:1.15 in steers and 1:1.32 in bulls at 210 kg. the largest proportion of the total fat was deposited in the intermuscular site which contained almost double that deposited in the subcutaneous site. Among the non-carcass fat depots, the kidney and omental were the highest proportions whereas the pelvic and channel were the lowest (table 4).

Individual muscles and bones:

Seven muscles were weighed and expressed as % half carcasses (table 5). *M. longissimus thoracis et lumborum* (LD) contributed the highest proportions (4.8-7.3%). Proportions of *M. rhomboideus* and *M. splenius* increased

TABLE 4. WEIGHT OF CARCASS AND NON-CARCASS FAT DEPOTS AND EFFECTS OF CASTRATION (CAST) AND SLAUGHTER WEIGHT (SLWT) IN DHOFARI BULLS AND STEERS SLAUGHTERED AT 110, 160 AND 210 KG BODY WEIGHTS

Item	% Slaughter weight								
	Bulls			Steers			SE	Effects of	
	110 kg	160 kg	210 kg	110 kg	160 kg	210 kg		CAST	SLWT
CARCASS FATS :									
Subcutaneous	2.44^{d}	2.30^{d}	4.18^{a}	2.60^{cd}	3.22^{bc}	4.37^{a}	0.33		***
Intermuscular	4.31^{c}	4.87^{c}	8.90^{a}	4.74^{c}	6.48^{b}	8.21^{a}	0.51		***
Total carcass	6.75^{c}	7.17^{c}	13.09^{a}	7.34^{c}	9.70^{b}	12.58^{a}	0.76		***
NON-CARCASS FATS :									
Omental	1.77^{c}	1.99^{c}	3.15^{a}	1.80^{c}	2.52^{b}	2.98^{ab}	0.19		***
Mesenteric	0.93^{d}	1.31^{c}	1.87^{b}	0.93^{d}	1.67^{bc}	2.52^{a}	0.15	*	***
Scrotal	0.97^{d}	1.15^{c}	1.58^{a}	1.00^{cd}	1.41^{b}	1.61^{a}	0.05	*	***
Pelvic	0.38	0.55	0.47	0.51	0.56	0.63	0.05	*	
Kidney	1.78^{c}	2.08^{bc}	2.48^{ab}	2.58^{ab}	2.65^{a}	2.92^{a}	0.23	**	
Channel	0.28	0.33	0.29	0.31	0.34	0.31	0.02		
Total non-carcass	6.11^{c}	7.41^{c}	9.84^{ab}	7.13^{c}	9.15^{b}	10.98^{a}	0.46	**	***
TCF : TNCF	1.10^{b}	0.97^{c}	1.32^{a}	1.03^{bc}	1.06^{bc}	1.15^{b}	0.06		**
TOTAL BODY FAT	12.86^{c}	14.58^{c}	22.93^{a}	14.46^{c}	18.85^{b}	23.56^{a}	1.14	*	***

Item	% Total Body Fat								
	Bulls			Steers			SE	Effects of	
	110 kg	160 kg	210 kg	110 kg	160 kg	210 kg		CAST	SLWT
CARCASS FATS :									
Subcutaneous	18.92^{a}	15.86^{b}	18.08^{a}	18.00^{a}	17.03^{ab}	18.48^{a}	1.07		
Intermuscular	33.49^{b}	33.24^{b}	38.79^{a}	32.69^{b}	34.21^{b}	34.87^{b}	1.06		**
Total carcass	52.40^{bc}	49.10^{d}	56.87^{a}	50.69^{cd}	51.24^{bcd}	53.36^{b}	1.25		**
NON-CARCASS FATS :									
Omental	13.78	13.67	13.72	12.35	13.44	12.70	0.74		
Mesenteric	7.24^{cd}	8.98^{b}	8.15^{bc}	6.43^{d}	8.83^{b}	10.71^{a}	0.60		***
Scrotal	7.54^{ab}	7.93^{a}	7.00^{b}	7.10^{ab}	7.50^{ab}	6.85^{b}	0.38		
Pelvic	3.00^{bc}	3.81^{a}	2.10^{d}	3.55^{ab}	3.00^{bc}	2.67^{cd}	0.28		**
Kidney	13.91^{b}	14.26^{b}	10.87^{c}	17.71^{a}	14.15^{b}	12.40^{b}	0.88	*	***
Channel	2.13^{a}	2.26^{a}	1.28^{b}	2.17^{a}	1.84^{a}	1.31^{b}	0.16		***
Total non-carcass	47.60^{b}	50.90^{a}	43.13^{c}	49.31^{ab}	48.76^{ab}	46.64^{bc}	1.25	**	***

Footnotes as for table 1.

whereas that of *M. semitendinosus* decreased with increasing body weight.

The axial skeleton contributed 47.4-51.1, the fore limb 21.6-22.6 and the hind limb 23.9-26.2% of total carcass bone (table 6). Proportions of axial skeleton increased whereas that of fore and hind limbs decreased with increasing body weight. The 12th rib, total ribs and pelvis increased whereas the limb bones (except for the scapula) decreased with increasing slaughter weight. The femur was the heaviest among the long limb bones. Individual bones of the carcass increased in length, width and circumference with increased slaughter weight (table 7).

Effects of castration:

There was no effect of castration on the distribution of weight in the Dhofari cattle carcass either in proportions of fore and hind quarters or weight of carcass cuts. there was also no effect of castration on distribution of carcass

tissue. Steers had higher TBF (% of slaughter weight) than bulls at 160 kg body weight (table 4). The effects of castration were significant on the non-carcass fat depots. The steers had higher proportions of mesenteric, scrotal, pelvic, kidney and TNCF than bulls. As % TBF, steers had significantly higher kidney and TNCF (table 4).

There was little effect of castration on proportions of individual muscles or bones. Only the proportions of the 1st and 6th rib were higher in the bulls than in the steers (table 6). The single effect of castration on bone dimensions was a longer 1st rib in bulls than steers (table 6).

TABLE 5. WEIGHT OF SOME INDIVIDUAL MUSCLES AS PERCENTAGE OF LEFT HALF CARCASS AND EFFECTS OF CASTRATION (CAST) AND SLAUGHTER WEIGHT (SLWT) IN DHOFARI BULLS AND STEERS SLAUGHTERED AT 110, 160 AND 210 KG BODY WEIGHT

Muscle as % of the left carcass weight	Bulls			Steers			SE	Effects of	
	110 kg	160 kg	210 kg	110 kg	160 kg	210 kg		CAST	SLWT
M. Supraspinatus	1.54	1.50	1.42	1.50	1.14	1.52	0.17		
M. Rhomboideus	1.56^{b}	1.93^{ab}	2.25^{a}	1.58^{b}	1.77^{ab}	2.09^{a}	0.18		*
M. Splenius	0.98^{ab}	0.95^{b}	1.11^{a}	0.94^{b}	0.95^{b}	1.11^{a}	0.07		*
M. Extensor carpi radialis	0.72^{a}	0.74^{a}	0.67^{b}	0.72^{a}	0.66^{b}	0.72^{a}	0.02		
M. Semitendinosus	2.93^{a}	2.47^{b}	2.28^{c}	2.47^{b}	2.42^{bc}	2.45^{bc}	0.08		**
M. Gastrocnemius	2.56^{ab}	2.48^{ab}	2.37^{ab}	2.61^{a}	2.31^{b}	2.33^{b}	0.12		
M. Longissimus thoracis et Lumborum	5.09^{b}	4.75^{b}	7.33^{a}	6.28^{ab}	5.91^{ab}	6.90^{ab}	1.08		

Footnotes as for table 1.

TABLE 6. WEIGHT OF INDIVIDUAL BONES AS PERCENTAGE OF THE LEFT CARCASS HALF AND EFFECTS OF CASTRATION (CAST) AND SLAUGHTER WEIGHT (SLWT) IN DHOFARI BULLS AND STEERS SLAUGHTERED AT 110, 160 AND 210 KG BODY WEIGHT

Weight as % of the left half carcass	Bulls			Steers			SE	Effects of	
	110 kg	160 kg	210 kg	110 kg	160 kg	210 kg		CAST	SLWT
Vertebral column	25.17^{c}	24.39^{d}	26.78^{b}	26.49^{b}	25.45^{c}	27.04^{a}	0.08		
1st rib	0.69^{a}	0.61^{bc}	0.64^{ab}	0.56^{c}	0.56^{c}	0.63^{ab}	0.03	*	
6th rib	1.45^{ab}	1.44^{ab}	1.55^{a}	1.22^{c}	1.34^{b}	1.38^{b}	0.05	**	
12th rib	6.5^{c}	7.1^{bc}	8.4^{a}	6.7^{c}	7.2^{bc}	8.1^{ab}	0.04		**
Total ribs	12.89^{c}	13.04^{c}	14.11^{a}	12.05^{d}	12.90^{c}	13.39^{b}	0.04		*
Sternum	7.63^{b}	8.15^{a}	7.85^{ab}	7.58^{b}	8.08^{a}	8.14^{a}	0.18		
Pelvis	1.74^{ab}	1.85^{ab}	2.38^{a}	1.58^{b}	1.91^{ab}	2.11^{ab}	0.30		*
Total axial skeleton	47.43^{b}	47.43^{b}	51.11^{a}	47.69^{b}	48.34^{b}	50.67^{a}	0.61		***
Scapula	4.36^{b}	4.63^{b}	4.88^{ab}	4.39^{b}	4.65^{ab}	5.00^{a}	0.14		**
Humerus	9.42^{a}	9.41^{a}	8.81^{b}	9.23^{ab}	9.09^{ab}	8.83^{b}	0.19		*
Radio-ulna	7.08^{ab}	7.12^{a}	6.67^{b}	7.11^{ab}	7.07^{ab}	6.75^{ab}	0.16		*
Carpus	1.46^{a}	^{a}	1.20^{b}	1.38^{ab}	1.39^{ab}	1.30^{ab}	0.09		
Total Fore limb	22.33	22.58	21.56	22.12	22.20	21.88	0.40		
Femur	12.96^{a}	12.71^{a}	11.53^{b}	12.44^{a}	12.45^{a}	11.68^{b}	0.20		***
Tibia	8.73^{a}	8.54^{ab}	7.66^{c}	8.71^{a}	8.24^{bc}	7.91^{c}	0.15		***
Tarsus	3.79^{bc}	4.07^{ab}	3.51^{c}	4.25^{a}	4.10^{ab}	3.58^{c}	0.16		**
Patella	0.72	0.77	0.76	0.69	0.73	0.73	0.04		
Total Hind limb	26.21^{a}	26.09^{a}	23.46^{b}	26.08^{a}	25.52^{a}	23.90^{b}	0.36		***

Footnotes as for table 1.

TABLE 7. MEASUREMENTS OF INDIVIDUAL BONES OF THE LEFT HALF CARCASS AND EFFECTS OF CASTRATION (CAST) AND SLAUGHTER WEIGHT (SLWT) IN DHOFARI BULLS AND STEERS SLAUGHTERED AT 110, 160 AND 210 KG BODY WEIGHT

Measurement (mm)	Bulls			Steers			SE	Effects of	
	110 kg	160 kg	210 kg	110 kg	160 kg	210 kg		CAST	SLWT
Length									
Vertebral column	1,136.8^{d}	1,230.5^{c}	1,307.8^{a}	1,099.5^{e}	1,210.8^{c}	1,284.5^{b}	21.7		***
1st rib	143.3	158.0^{b}	169.8^{a}	138.0^{d}	150.0^{c}	163.5^{ab}	3.2	*	***
6th rib	272.5^{c}	296.3^{b}	313.3^{a}	262.0^{d}	287.8^{b}	311.8^{a}	4.4	*	***
12th rib	251.8^{c}	284.8^{b}	306.8^{a}	251.3^{c}	282.3^{b}	313.3^{a}	4.8		***
Scapula	213.3^{e}	238.0^{c}	246.0^{b}	206.8^{f}	229.0^{d}	254.3^{a}	2.9		***
Radio-ulna	270.3^{c}	294.0^{ab}	299.3^{a}	267.3^{c}	285.8^{b}	301.8^{a}	3.7		***
Humerus	209.7^{c}	229.8^{b}	241.5^{a}	201.5^{d}	222.5^{b}	242.3^{a}	3.4		***
Femur	257.5^{c}	285.0^{b}	290.3^{b}	256.0^{c}	246.8^{d}	298.8^{a}	3.3		***
Tibia	257.3^{c}	278.8^{b}	284.3^{ab}	256.0^{c}	279.5^{b}	290.5^{a}	3.5		***
Width:									
Humerus	27.3^{c}	32.0^{b}	35.8^{a}	28.0^{c}	32.5^{b}	35.5^{a}	1.2		***
Radio-ulna	33.5^{c}	37.3^{b}	40.5^{a}	34.0^{c}	37.5^{b}	39.8^{a}	0.6		***
Femur	29.3^{c}	31.5^{b}	33.0^{ab}	28.0^{c}	32.0^{b}	34.0^{a}	0.6		***
Tibia	28.3^{c}	31.8^{b}	33.5^{ab}	28.5^{c}	31.8^{b}	33.8^{a}	0.8		***
Circumference:									
Humerus	80.7^{c}	90.0^{b}	98.5^{a}	80.3	91.0^{b}	95.5^{ab}	2.4		***
Radio-ulna	89.8^{c}	96.3^{b}	103.3^{a}	88.0^{c}	98.8^{b}	103.3^{a}	1.6		***
Femur	83.3^{c}	89.0^{b}	95.3^{a}	82.3^{c}	94.0^{a}	95.8^{a}	2.0		***
Tibia	79.8^{c}	89.3^{b}	95.3^{a}	84.0^{c}	89.0^{b}	92.8^{ab}	1.9		***

Footnotes as for table 1.

Discussion

Distribution of weight:

The study of the distribution of weight of carcass tissues in Dhofari cattle is essential to determine their potential for beef production. The most significant tissue in the carcass is the lean but other carcass tissues are important. Fat in the carcass is partitioned into two depots, intermuscular and subcutaneous and both are essential for the finish of beef carcasses. Bone content affects proportions of other edible tissues in the carcass. Dhofari cattle like many tropical breeds do not have the shape of the typical beef animals. The latter breeds produce high quality carcasses with good yields of high-priced cuts. Effects of conformation on the distribution of carcass tissues particularly the lean have been disputed by Berg and Butterfield (1978). Animals of different conformation compared at the same level of fatness showed little differences in muscle distribution. In fact, subjective assessment of muscling in beef animals may be of little importance and the difference between animals in conformation may be caused more by the total amount of muscle rather than its distribution (Berg and Butterfield, 1978). This applies for Dhofari cattle, although there might be some difficulty in comparing their yields in terms of weight of carcass cuts with those of other beef breeds because of differences in cutting. The fore quarters of Dhofari cattle carcasses weighed more than the hind quarters. In the beef industry higher proportions of the hind quarters in carcasses is a favourable characteristic. Proportions of the fore and hind quarters (53-56% and 44-47% respectively) in Dhofari cattle carcasses were comparable to those reported for improved beef breeds. In USA beef carcasses are split between the 12th and 13th ribs and at least 48% of the weight is found in the hind quarters. About 54% of the carcass weight of British beef is found in the hind quarters (carcasses are cut between the 10th and 11th ribs). Proportions of the carcass in Dhofari cattle appears to be better than those of unimproved zebu cattle in the tropics which have much higher proportions of carcass weight in the fore quarters (Hill, 1988). However, they are not quite similar to those of improved zebu cattle such as the Brahman and Indu-Brazil breeds and the humpless N'dama which contained

about 52% of weight in the hind quarters (Hill, 1988). Findings of the present study confirm the above-mentioned views of Berg and Butterfield (1978) on the reduced importance of conformation on carcass characteristics and indicate the potential of local animals to produce beef.

Proportions of tissues in the fore and hind quarters in Dhofari cattle were also comparable to those reported for improved beef breeds. Dhofari bulls and steers contained 31.6-34.7 and 31.4-33.5 lean in the fore quarter; 28.8-33.3 and 30.0-32.6% of carcass weight in the hind quarter compared to 36.0 and 30.8 in the fore quarter and 33.3 and 33.2% in the hind quarter of bulls and steers of improved beef breeds, respectively (Berg and Butterfield, 1978). They also contained 6.8-8.5 and 6.5-8.3 bone in the fore quarter and 4.8-6.4 and 4.9-6.6% of carcass weight in the hind quarter compared to 9.8 and 7.9% bone for improved beef breeds (Berg and Butterfield, 1978). Proportions of fat are slightly higher for Dhofari cattle (8.5-16.2, 9.0-14.6; 4.6-8.4, 5.1-8.3% carcass weight) than improved beef breeds (5.8, 8.9; 4.8, 7.5% in fore and hind quarters, respectively). This is probably because the Dhofari cattle are small sized and early maturing thus entering the fattening stage earlier.

In terms of weight of carcass cuts Dhofari cattle appear to have slightly different weight distribution in some parts of the carcass. Local steers had higher proportion of the chuck and brisket plus shank cuts (27.5-28.8 and 10.7-12.0% carcass weight) than U.S.A (Barrick and Harmon, 1988) steers (26.8 and 7.0% carcass weight). This may be explained by the fact that Dhofari cattle with its zebu influence have more developed humps. Higher proportions of these cuts in the carcass lowers its value because they yield less tender meat due to the higher connective tissue content. Improvement of local animals by breeding should take into consideration reducing the proportion of these cuts and increasing that of the loin and hind limb by selection.

Fat distribution:

Fat is the most variable tissue in the carcass and its pattern of growth and distribution is extremely important in beef cattle. Fat differs in value according to its location in the carcass. For example, non-carcass fat thrown away at slaughter or sale is of little value compared to intermuscular fat (marbling) or subcutaneous fat that is sold with prime carcass cuts. Improvement of beef breeds over the past years was achieved mainly by increasing levels of subcutaneous fat thus heavier breeds had a higher subcutaneous : intermuscular fat ratio (Berg and Butterfield, 1978).

Both carcass and non-carcass fat in Dhofari cattle increased as proportions of slaughter weight with increasing age and body weight. As proportions of total body fat, carcass fat increased whereas that of NCF decreased. This is in line with reports on other beef breeds (Hill, 1988) where fat is deposited in early life in the non-carcass fat depots such as kidney and mesentery and later in life in the carcass itself with the intermuscular fat the last to deposit. It is believed that marbling is a characteristic of temperate beef breeds and generally lacking in tropical beef breeds because of the latter's closely adhering meat fibres (Hill, 1988). In the present study there were high levels of intermuscular fat contents in Dhofari cattle carcasses which indicate that they produce carcasses of good finish if raised under intensive management. High intermuscular : subcutaneous ratios (as indicated in the present study) means that cattle reach a desired intramuscular fat levels while still low in subcutaneous fat which minimizes losses by trimming at sale. It is a desirable trait in beef producing animals and is generally a characteristic of dairy more than beef cattle (Berg and Butterfield, 1978). Dhofari cattle had similar proportions of non-carcass but higher carcass fats compared to improved beef cattle. The values for omental, mesenteric, kidney and TNCF for local breeds were 1.8-3.2, 0.9-2.5, 1.8-2.9, 6.1-11.0% slaughter weight compared to 2.1, 0.8, 1.8 and 7.5% of slaughter weight of European breeds, respectively. Subcutaneous, intermuscular and TCF proportions were 2.4-4.4, 4.3-8.9 and 6.8-13.1% slaughter weight in Dhofari cattle compared to 1.5, 2.4 and 4.3 in European breeds (Berg and Butterfield, 1978). This may be attributed to the fact that Dhofari cattle are early maturing and therefore, they contained higher proportions of carcass fat (late maturing) at lower weights and ages compared to relatively late maturing European breeds.

Individual muscles and bones:

Proportions of individual muscles in the carcasses of Dhofari cattle as measured in the present study were almost identical to those reported for improved beef breeds. This emphasizes the small effects of shape on carcass yield. The only exception was the *M. rhomboideus* where it weighted 1.7-2.3% carcass in Dhofari cattle compared to 1.5% in improved breeds (Berg and Butterfield, 1978). This is obvious because of the better developed humps in local animals, which are made up mainly of this muscle. The apparent effects of this were the higher proportions of the chuck cut and fore quarter in the carcass. Proportions of *M. rhomboideus* and *M. splenius* increased whereas that of *M. semitendinosus* decreased with increasing body weight or age. This is in line with

the general trend in the present study of the increasing proportions of the fore quarter and the decreasing proportions of the hind quarters.

The axial skeleton contributed about 50% of the total bone weight. The Hind limb bones contributed a higher proportion of the skeleton than those of the fore limb. Proportions of the axial skeleton in the carcass increased, that of hind limb decreased whereas there was no clear effect on the fore limb with increasing body weight and age. Changes in proportions of bone in the carcass with the progress of carcass weight may affect carcass yield and quality.

Effects of Castration:

There were little effects of castration in the present study on distribution of weight or proportions of carcass tissues possibly because the animals were slaughtered at a relatively young age. The major effects of castration were noted on distribution of individual fat depots. Steers had higher proportions of mesenteric, scrotal, pelvic, kindey, TNCF and TBF as % slaughter weight. These differences were significant at the 160 kg body weight. They almost disappeared by the 210 kg body weight indicating that bulls started to lay down fat with age. This is in line with the established fact that steers enter the fattening stage earlier than bulls. Different rates of fattening of bulls and steers in improved beef breeds determine the range of carcass weights over which they should be marketed with optimum or near optimum fat cover (Berg and Butterfield, 1978). In the case of Dhofari cattle differences in rates of fattening between bulls and steers have different implications. In the current study effects of castration were manifested mostly on the non-carcass fats which have little value because they are trimmed at slaughter or sale and therefore, their proportions cause little differences between steer and bull carcasses.

The present study showed that Dhofari cattle, although lacking the traditional beef conformation of improved breeds produced good carcass yields as reflected in the distribution of weight of tissues in the carcass. They indicate a good potential for beef production if the animals are raised under intensive management.

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