Estimation of Body and Carcass Weights in Saudi Arabian Najdi Male Camels

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ABSTRACT. Data on 227 Najdi male camels *Camelus dromedarius* were used to determine the relative value of body measurements in predicting body and carcass weights. Seven body measurements were obtained for each camel; length of neck. length of arm, length of leg, length of body, chest girth, hump girth and hip girth. The correlations of carcass weight with body measurements were higher than the observed correlations between body weight and body measurements. Correlations of body weight and carcass weight with chest girth. hump girth and hip girth were the highest among all the studied body measurements. Prediction equations were developed by a maximum R^2 procedure. The most efficient equations for estimating body or carcass weights were :

Body weight = 1.02 (length of neck, cm) + 0.72 (chest girth, cm) +

1.59 (hump girth, cm) + 1.95 (hip girth, cm) − 385.5

Carcass Wegith = 0.57 (length of neck, cm) + 0.56 (chest girth, cm)

+ 0.85 (hump girth, cm) + 0.41 (length of body, cm)

+ 1.04 (hip girth, cm) − 274.6

Camels are potentialy important for meat production in desert and semi-desert conditions (Yagil 1982). Few attempts have been made to determine the value of individually recorded body measurements for predicting the weight of camel carcasses. The acquisition of such information might be of considerable practical importance, particularly in a breeding program where improvement of body weight and carcass quality are major objectives. Few workers, therefore, have studied the relationships between body or carcass weight and various body measurements of camels. Field (1979) found a close relationship between body weight and the sum of heart girth, hump girth and shoulder height in male Kenyan camels. Also, Abouheif *et al.* (1985) recorded positive and significant correlations between

carcass weight and hip girth, chest girth and hump girth in male Abhawi camels of Saudi Arabia. Consequently, they also found a number of reliable prediction equations to determine carcass weight using the latter body measurements. On the other hand, Wilson (1978) found that prediction of live weight from the knowledge of chest girth measurements in male Sudanese camels was less reliable than in the case of cattle. The objectives of this study were: (a) to determine carcass weights and dressing percentages in 136 to 535-kg Najdi male camels, (b) to determine relationships among the various body measurements of camels, and (c) to determine the relative value of various body measurements for predicting body or carcass weight of camels.

Material and Methods

Data were obtained from 227 Najdi male camels at Riyadh slaughterhouse, Saudi Arabia, between August 1982 and March 1983. Camels were chosen randomly and divided according to their body weights into eight groups: 32 camels weighed between 136 and 185 kg, 50 camels weighed between 186 and 235 kg, 35 camels weighed between 236 and 285 kg, 33 camels weighed between 286 and 335 kg, 32 camels weighed between 336 and 385 kg, 19 camels weighed between 386 and 435 kg, 12 camels weighed between 436 and 485 kg and 14 camels weighed between 486 and 535 kg. Camels were kept off feed at least 12 to 18 hours previous to slaughter. Fasted body weight was obtained just before slaughter using a heavy duty walk-in balance. Thereafter, the hot carcasses were weight 30-45 min after slaughter using a heavy duty sling balance. Carcass weight included all meat and bones posterior to the atlas joint except below the knee and hock, and included the kidneys, heart, hump fat and kidney fat.

The following body measurements were recorded to the nearest centimeter: length of neck, measured as the distance between the atlas joint and the first thoracic vertebra; length of arm, measured as the length from the tip of the olecranon process of the ulna to the distal edge of the inner side of the radial carpal bone; length of body, measured as the distance between the shoulder point and hip point; length of leg, measured as the length along the femur bone; chest girth, measured as the circumference of the body around the chest with a measuring tape, placed immediately behind the front legs but in front of the sternal pad; hump girth, measured as the circumference of the body along the curve over the mid point of the hump and abdomen; and hip girth, measured as the circumference of the body around the hip at the level of the sixth lumbar vertebra.

Dressing percentages of different weight groups were transformed by arcsin $\sqrt{p}$ transformation before any statistical analysis (Steel and Torrie 1960). Statistical analysis performed on the data included averages, correlations and stepwise multiple regression analysis. The stepwise regression technique included the maximum coefficient of determination (R^2) improvement procedure. The max-

imum R^2 analyses selected the one to seven-variable models that maximized the R^2; the procedures were restricted in that only variables that had an effect with a probability of less than 0.15 were used in the equation, regardless of R^2 improvement. All analysis were accomplished by the use of the statistical analysis system (SAS 1982).

Results and Discussion

The averages and standard errors for body weights, carcass weights, dressing percentages and body measurements of different weight groups of Najdi male camels are presented in Tables 1 and 2. Progressive and significant ($p<0.01$) increase in carcass weight, dressing percentage and body measurements from lower weight groups to higher weight groups were observed. The average carcass weight of the studied sample of Najdi male camels was calculated at 168 kg. For camels of other breeds, average slaughtered carcass weights ranging between 195.3 kg to more than 400 kg were reported (Congiu 1953, Knoess 1977, Wilson 1978, Abouheif et al. 1985). The estimated slaughter age of Najdi male camels ranged from 9-months of age to 5-years of age (unpublished data), which were, in general, younger and lighter in weights than previously reported data about different breeds of camels. This results explained the findings of Abdo et al. (1986) who reported that young camel meat consumption rated second after mutton in respect to red meat consumption among the Saudi citizens of Riyadh city. This is because young camel meat is highly favored among the citizens due to its juiciness and flavor.

Table 1. Average[a] body weights, carcass weights and dressing percentages of Najdi male camels.

| Weight of Camels (kg)	No. of Camels	Body Weight (kg)	Carcass Weight (kg)	Dressing (%)
136 to 185	32	165.1 ± 2.7[b]	88.8 ± 1.4[b]	53.8[b]
186 to 235	50	207.1 ± 2.1[c]	114.1 ± 1.2[c]	55.1[c]
236 to 285	35	261.9 ± 2.5[d]	147.7 ± 1.4[d]	56.4[c]
286 to 335	33	319.2 ± 2.3[e]	188.3 ± 1.3[e]	59.0[d]
336 to 385	32	346.2 ± 2.5[f]	205.6 ± 1.5[f]	59.4[de]
386 to 435	19	401.5 ± 3.9[g]	235.9 ± 2.3[g]	58.8[d]
436 to 485	12	460.3 ± 4.6[h]	281.3 ± 2.7[h]	61.1[ef]
486 to 535	14	494.6 ± 8.1[i]	310.1 ± 6.3[i]	62.7[f]
Average	227	291.3 ± 6.4	168.0 ± 4.2	57.7

[a] Average ± standard error

[b,c,d,e,f,g,h,i] Averages on the same column bearing different superscripts are different ($p<.01$).

Table 2. Averages and standard errors of different body measurements of Najdi male camels.

Weight of Camels (kg)	Length of Neck (cm)	Length of Arm (cm)	Length of Body (cm)	Length of Leg (cm)	Chest Girth (cm)	Hump Girth (cm)	Hip Girth (cm)
136 to 185	72.5 ± 1.3[a]	33.5 ± 0.3[a]	108.8 ± 0.8[a]	39.5 ± 0.6[a]	113.2 ± 1.2[a]	134.9 ± 1.3[a]	91.1 ± 0.9[a]
186 to 235	76.5 ± 0.8[a]	35.8 ± 0.5[b]	116.8 ± 0.8[b]	40.8 ± 0.4[b]	122.3 ± 0.9[b]	153.8 ± 1.1[b]	99.0 ± 0.8[b]
236 to 285	83.3 ± 1.1[b]	38.8 ± 0.4[c]	126.9 ± 1.3[c]	43.1 ± 0.5[c]	134.1 ± 1.0[c]	167.7 ± 1.3[c]	108.0 ± 0.9[c]
286 to 335	94.9 ± 1.1[c]	42.2 ± 0.6[d]	137.4 ± 1.2[d]	43.9 ± 0.6[c]	144.4 ± 0.9[d]	180.9 ± 1.2[d]	116.8 ± 1.0[d]
336 to 385	99.6 ± 1.3[d]	44.1 ± 0.4[e]	144.4 ± 1.4[e]	46.3 ± 0.6[d]	149.5 ± 1.3[e]	188.9 ± 1.1[e]	122.6 ± 0.9[e]
386 to 435	105.6 ± 2.0[e]	46.3 ± 0.5[f]	151.8 ± 1.7[f]	49.4 ± 1.0[e]	158.1 ± 1.8[f]	197.5 ± 2.2[f]	127.9 ± 1.2[f]
436 to 485	113.2 ± 2.2[f]	48.9 ± 0.6[fg]	159.8 ± 3.0[g]	46.3 ± 0.9[d]	165.8 ± 2.6[g]	209.0 ± 3.5[g]	134.9 ± 1.4[g]
486 to 535	116.9 ± 1.2[f]	48.4 ± 0.7[g]	169.5 ± 2.7[h]	50.6 ± 1.0[e]	176.4 ± 2.5[h]	214.9 ± 3.1[h]	138.2 ± 1.2[g]
Overall averages	89.3 ± 1.0	40.1 ± 0.4	132.1 ± 1.3	43.8 ± 0.3	138.3 ± 1.3	169.4 ± 1.6	111.2 ± 1.0

[a,b,c,d,e,f,g,h,i] Averages on the same column bearing different superscripts are different (p<0.01).

The recorded data for body weights, carcass weights and body measurements in the different weight groups of Najdi male camels were expressed as percentages in relation to their data recorded for the 136-185-kg weight group. However, the percentage increases in carcass weights were higher than those calculated for the corresponding percentage increases in body weights (Fig. 1). Possibly, this indicated that the increases in body weight were accompanied by an increasing amount of gain in weight of muscle and fat rather than gain in weight of viscera and non-edible portions as evidenced by significant (p<0.01) increases in the dressing percentages from lower weight groups to those of higher weight groups. These results are in agreement with the conclusions of Abouheif *et al.* (1985) who found that Abhawi male camels up to 5-years old were still undergoing growth of muscles, bones and fat. The percentage increases in carcass weight and body weight in relation to increases of body weight were linear. Except for length of leg, the percentage increase in all other body measurements with the increase in body weights were also determined to be linear. However, the percentage increase in chest girth, hump girth, hip girth, length of arm and length of body were identical and lower than those calculated for percentage increase in neck length.
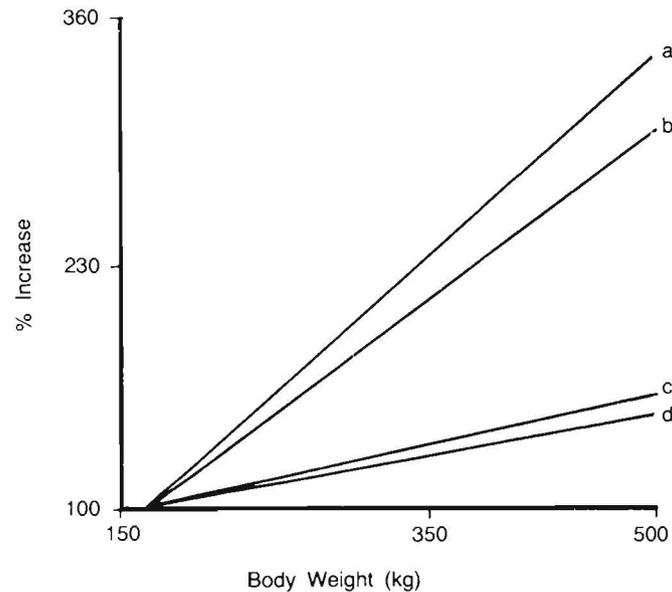
Fig. 1. The increases of different body characters of Najdi male camels in relation to increases in body weight expressed as percentages of the data recorded for the 136-186 kg weight group; a=Carcass Weight, b=Body Weight, c=Length of Neck, d=Length of Arm, Length of Body, Chest Girth, Hump Girth and Hip Girth.

Table 3 shows the correlation coefficients between the various body measurements, with each other and with the body weight and carcass. Significant positive correlation coefficients ($p < 0.01$) between body and carcass weights were observed. Correlations of body and carcass weights with different body measurements were positive and significant ($p < 0.01$). The associations of carcass weight with body measurements were higher, in general, than those observed between body weight and body measurements. Correlations of body weight and carcass weight with chest girth, hump girth and hip girth were the highest among all the body measurements studied, while the corresponding correlations with length of leg were the lowest. Abouheif *et al*. (1985) assumed that the relatively higher associations between Saudi Arabian Abhawi carcass weight and hip girth, chest girth of hump girth were probably due to a greater dependence of carcass weight on the amount of muscle, fat and bone in the carcass trunk rather than in the carcass limbs. Prediction equations for the different variable models derived by maximum R^2 analysis are presented in Table 4. In each case, the R^2 was improved by the addition of more variables to the model. However, the addition of length of leg, length of arm or length of body to the models for predicting body weight were not significant. Also, the addition of length of leg or length of arm in the prediction models for estimating carcass weight was not significant. Therefore, the best equation for predicting body weight, found by maximum R^2, was the four-variable equation:

Body Weight = 1.02 (length of neck, cm) + 0.72 (chest girth, cm)

+ 1.59 (hump girth, cm) + 1.95 (hip girth, cm) − 385.5

Also, the best equation for predicting carcass weight was the five-variable equation:

Carcass Weight = 0.57 (length of neck, cm) + 0.56 (chest girth, cm)

+ 0.85 (hump girth, cm) + 0.41 (length of body, cm)

+ 1.04 (hip girth, cm) − 274.6

These prediction equations offers a practical, and possibly an accurate, method of estimating the carcass weight or the body weight of Najdi male camels weighing between 136 and 535 kg without the need for slaughter or the use of scales. This method, when used in conjunction with camel breeding programs will allow for an easy and trouble-free estimation of camel weights during the growing phase of production.

Table 3. Coefficients of correlations[a][b] between different body characters of Najdi male camels.

Character	BW	CW	LN	LA	LB	LL	CG	HG
Body Weight (BW)								
Carcass Weight (CW)	.91							
Length of Neck (LN)	.82	.89						
Length of Arm (LA)	.81	.86	.86					
Length of Body (LB)	.89	.94	.89	.87				
Length of Leg (LL)	.58	.69	.66	.70	.69			
Chest Girth (CG)	.91	.94	.89	.86	.92	.67		
Hump Girth (HG)	.90	.95	.85	.82	.92	.65	.93	
Hip Girth (PG)	.91	.94	.87	.84	.93	.70	.94	.92

[a] Based on an overall estimation; N = 227.

[b] All values are significantly different (P<0.01).

Table 4. Stepwise multiple regression[a] equations utilizing body measurements to predict body weight or carcass weight of the Najdi male camels.

| Equation | Intercept | b value ± SE[b] | | | | | |
		HG[c]	PG	LN	CG	LB	R^2
				Body Weight			
1	−363.3	3.86 ± .08					.902
2	−398.7	2.09 ± .18	3.01 ± .28				.936
3	−383.6	1.82 ± .17	2.31 ± .28	1.23 ± .20			.945
4	−385.5	1.59 ± .19	1.95 ± .31	1.02 ± .21	.72 ± .26		.947
				Carcass Weight			
1	−258.9	2.52 ± .06					.893
2	−282.6	1.34 ± .12	2.02 ± .19				.929
3	−271.9	1.13 ± .12	1.53 ± .19	0.87 ± .14			.939
4	−273.5	0.95 ± .13	1.23 ± .21	0.70 ± .15	.59 ± .18		.943
5	−274.6	0.85 ± .13	1.04 ± .22	0.57 ± .15	.56 ± .18	.41 ± .17	.944

[a] All independent variables listed are significant (P<0.01).

[b] b=regression coefficient; SE=standard errors.

[c] HG=hump girth; PG=hip girth; LN=length of neck; CG=chest girth; LB=length of body.

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تقـديـر وزن الجسم ووزن الـذبيحة لـذكور الجمال النجدية السعودية

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جمعت بيانات هذه الدراسة من ذكور ٢٢٧ جمل نجدي لتقدير أهمية مقاييس الجسم المختلفة في استنباط وزن الجسم ووزن الذبيحة، وقد سجل لهذا الغرض مقاييس طور الرقبة، طول الـذراع، طول الرجل، طول الجسم، محيط الصـدر، محيط الجسم عند السنام، ثم محيط الخصر لكـل جمل بجانب وزن جسمه ووزن الذبيحة الناتجة منه بعد الذبح. وقد لوحظ أن علاقات الارتباط بين وزن الذبيحة ومقـاييس الجسم المختلفة أقـوى من علاقـات الارتباط بـين وزن الجسم ونفس مقاييس الجسم السابقة. وكـانت علاقـات الارتباط بـين كل من وزن الجسم أو وزن الذبيحة مـع محيط الصدر أو محيط الجسم عنـد السنـام أو محيط الخصر هي أعـلا العـلاقـات من بـين جميـع مقاييس الجسم المدروسة. وكانت أفضـل معادلات استنباط وزن الجسم أو وزن الذبيحة هي :

وزن الجـسـم = ١,٠٢ (طـول الـرقبـة) + ٠,٧٢ (محيط الصـدر) + ١,٥٩ (محيط الجـسم عنـد السنـام) + ١,٩٥ (محـيـط الخصر) - ٣٨٥,٥.

وزن الـذبيحـة = ٠,٥٧ (طـول الرقبـة) + ٠,٥٦ (محيط الصـدر) + ٠,٨٥ (محيط الجـسم عنـد السنـام) + ٠,٤١ (طـول الجـسم) + ١,٠٤ (محيط الجسم) – ٢٧٤,٦ .