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Determination of Linear Regression Models for Estimation of Body Weights of Eastern Anatolian Red Cattle

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ABSTRACT: The study was conducted to develop linear regression models for prediction of body weights of Eastern Anatolian Red cattle from various body measurements taken at birth, 3, 6, 9, 12, 15, 18, 24 months of ages and at mature cows that were older than 24 months of age. Among the body measurements, hearth girth resulted in highly significant ($P<0.01$) and the highest correlation coefficients with body weights. It was concluded that the models including heart girth alone could be used to predict precisely body weights of Eastern Anatolian Red cattle. Additionally, body weights at different ages were also predicted by using the linear regression models and results were tabulated and presented in the tables for practical purpose.

Key words: Body Measurements, Body weights, Eastern Anatolian Red, Cattle.

Doğu Anadolu Kırmızısı Sığırlarında Vücut Ağırlıklarının Tahmini İçin Doğrusal Regresyon Modellerinin Belirlenmesi

ÖZET: Bu çalışma, Doğu Anadolu Kırmızısı ırkı 3, 6, 9, 12, 15, 18, 24 aylık hayvanlarından ve ergin ineklerden alınan çeşitli vücut ölçülerinden bu hayvanların canlı ağırlıklarını tahminleyen doğrusal regresyon modellerini belirlemek için yürütülmüştür. Vücut ölçüleri arasında, göğüs çevresinin vücut ağırlıkları ile çok önemli ($P<0.01$) ve yüksek düzeyde bir ilişkiye neden olduğu belirlenmiştir. Tek başına göğüs çevresinin dahil edildiği modellerin Doğu Anadolu Kırmızısı sığırlarda vücut ağırlıklarının doğru bir şekilde tahmin edilmesinde kullanılabileceği sonucuna varılmıştır. Ayrıca, değişik yaşlardaki canlı ağırlıklar, belirlenen doğrusal regresyon modelleri kullanılarak tahminlenmiş ve sonuçlar pratikte kullanım amacıyla tablolar halinde sunulmuştur.

Anahtar Kelimeler : Vücut Ölçüleri, Vücut Ağırlıkları, Doğu Anadolu Kırmızısı, Sığır.

INTRODUCTION

Determination of the body weights of cattle at certain ages is important for various management practices for example, selection of culled calves according to their body conformation, calculation of amount of milk to be offered to calves based on birth weight and determination of end of fattening period, etc. (Özhan et al. 2004). Although weights can be precisely determined by using platform scales, unfortunately, these facilities in the many farms are not available in our country (Şekerden et al. 1991; Yanar et al., 1995). Hence, the body weights of cattle at different ages have to be predicted with reasonably accuracy by taking various body measurements (Ensminger, 1991).

The relationships between body measurements and body weights depend on many factors such as, breed, age, and fattening level of the animal. Hence, the regression equations have to be determined separately for all cattle breed reared in different countries and locations (Şekerden and Aydın, 1992).

In a study conducted on Eastern Anatolian Red (EAR) calves, only possibility of prediction of body weights of the calves at birth, weaning and 6 months of age was investigated by Ulutaş et al. (2002). However, there is no study about developing linear regression equations for prediction of the body weights of EAR at 9, 12, 15, 18, 24 months of ages and at mature age. Therefore, the present study was undertaken to investigate relationships between body measurements and weights taken at various ages and to develop linear regression equations for prediction of body weights of Eastern Anatolian Red cattle at different ages.

MATERIALS AND METHODS

The data regarding body weights and measurements were obtained from EAR cattle herds reared in the Region of Eastern Anatolia. Body weights and measurements were taken at birth, 6, 9, 12, 15, 18, 24 months of ages and from mature cows that were older than 24 months. Body measurements such as body length (from point of the shoulder to the point of tuber ischii), height at withers (from base of hoof to the highest point of the wither), and chest depth (from sternum area immediately caudal to the fore limbs to top of thoracic vertebra area) were measured by using a large callipers. Heart girth (circumference of the thoracic cavity immediately behind the fore limbs) was determined by using a tape measure. The distribution of animals to the age groups is presented in Table 1.

Simple correlation coefficients were calculated to ascertain interrelationships among body measurements and weights at various ages. Additionally, the stepwise regression method was used to determine the best fitted regression equation (Neter et al., 1989). Coefficients of determination values (R^2) were used to compare the efficiency of the best-fitted regression equations. Statistical analyses were performed by using SAS statistics program (Cody and Smith, 1987). Predicted body weights were calculated by using the EXCEL computer program.

Table 1. Number of Eastern Anatolian Red Cattle at Different Ages (Months).

Sex	Birth	3	6	9	12	15	18	24	Mature
Male	262	238	235	172	158	60	-	-	-
Female	182	162	159	119	98	39	44	36	45

RESULTS AND DISCUSSION

Interrelationships among body measurements and weights for female and male calves at birth, 3, 6, 9, 12, 15 months of ages are presented by simple correlations in Table 2 and 3. Similar relationship between weights and body measurements of Eastern Anatolian female cattle at 18, 24 months of ages and at mature cows are demonstrated by simple correlation coefficients and the results are presented in Table 4.

The highest relationship was determined between heart girth and weights measured at various age periods for both sex groups (Table 2, 3 and 4). Several researchers worked on different breeds reported similar findings (Dhangar and Patel, 1990; SeokGeun et al., 1998; Tüzemen et al., 1993; Mantysaari, 1996, Varade et al. 2002). Francis et al., (2002), and Soysal and Konak (1992) indicated that body weight was highly correlated with heart girth (r=0.96) and (r=0.97) respectively. Yanar et al., (1995) also calculated high correlation values between heart girth and body weights obtained at birth, 2 months, 6 months, 12 months, 2 and 3 years of ages were 0.844, 0.792, 0.838, 0.769, 0.868, 0.883 for females respectively.

Table 2. The correlation coefficients between body measurements and weights for females and males at birth, 3 and 6 months of ages.

	Birth		3 Month of age		6 Month of age	
Body Measurements	Female n=182	Male n=262	Female n= 162	Male N=238	Female n=159	Male n=35
Height at withers	0.544**	0.596**	0.665**	0.615**	0.759**	0.809**
Body length	0.641**	0.620**	0.311**	0.492**	0.846**	0.854**
Heart girth	0.759**	0.759**	0.634**	0.668**	0.898**	0.916**
Chest depth	0.578**	0.568**	0.367**	0.346**	0.700**	0.777**

** : P< 0.01

Best fitted regression equations for each age and sex groups were determined based on the magnitude of determination coefficients (R^2). According to the results obtained from the stepwise regression analysis, the highest R^2 value was obtained when the heart girth alone included into the regression models. Additional use of other body measurements did not significantly increase R^2 values. Similar results were already reported by SeokGeun, et al., (1998); Francis et al. (2002). The weights might be predicted with precisely by using heart girth alone due to its major contribution for increasing R^2 values. The measurement also can be taken easily and exactly. The result was in agreement with findings of studies conducted on different cattle breeds throughout the world (Akman, 1982; Şekerden et al. 1991; Willeke and Dursch, 2002; Ulutas et al. 2002; Yawongsa et al., 2003).

Table 3. The correlation coefficients between the body measurements and weights measured at 9, 12 and 15 months of ages.

	9 Months of age		12 Months of age		15 Months of age	
Body Measurements	Female n= 119	Male n=172	Female n= 98	Male n=158	Female n= 39	Male n=60
Height at withers	0.630**	0.802**	0.739**	0.865**	0.746**	0.876**
Body length	0.598**	0.867**	0.804**	0.937**	0.869**	0.917**
Heart girth	0.733**	0.893**	0.936**	0.944**	0.960**	0.970**
Chest depth	0.585**	0.844*	0.663**	0.886**	0.722**	0.923**

* : P< 0.05, ** : P< 0.01

Table 4. The correlation coefficients between the body measurements and weights measured at 18, 24 months of age and at mature cows.

	18 Months of age	24 Months of age	Mature
Body Measurements	Female n= 44	Female n= 36	Female n=45
Height at withers	0.861**	0.356*	0.482**
Body length	0.881**	0.788**	0.630**
Heart girth	0.961**	0.961**	0.903**
Chest depth	0.791**	0.752**	0.672**

** : P< 0.01

Table 5. Linear Regression Equations for Body Weights at Various Ages.

	Female				Male			
Weights at	a^{θ}	$b^{\#}$	R^2 (%)	F	a	b	R^2 (%)	F
Birth	-28.7	0.737	57.7	245.3	-35.6	0.851	57.6	352.9
3 Months	-62.4	1.37	40.2	107.4	-61.0	1.38	44.6	190.1
6 Months	-190	2.60	80.7	657.3	-183	2.57	83.8	1207.6
9 Months	-168	2.42	53.8	136.0	-250	3.15	79.7	669.2
12 Months	-372	4.07	87.5	674.4	-393	4.24	89.2	1284.6
15 Months	-424	4.40	92.1	430.8	-512	5.06	94.1	917.2
18 Months	-320	3.66	92.4	511.3	-	-	-	-
24 Months	-465	4.60	92.4	413.9	-	-	-	-
Mature	-391	4.11	81.6	191.0	-	-	-	-

$^{\theta}$: Intercept, $^{\#}$: Regression coefficient of the heart girth

The body weights of male and female Eastern Anatolian Red cattle were predicted by using the regression equations given in Table 5 and the estimates of body weights for different ages are tabulated in Table 6, 7 and 8.

The results of this study revealed that prediction of body weight would be accomplished with relative accuracy by using heart girth, when weighing facilities are not available. Also, tables for the predicted weights developed in this study would be useful to determine body weights rapidly.

Table 6. Predicted Birth, 3 and 6 Months of Age Weights of Eastern Anatolian Red Cattle

Birth Weight			3 Month of age			6 Month of age		
Heart Girth (cm)	Male (kg)	Female (kg)	Heart Girth (cm)	Male (kg)	Female (kg)	Heart Girth (cm)	Male (kg)	Female (kg)
50		8	75	43	40	95	61	57
51		9	76	44	42	96	64	60
52	9	10	77	45	43	97	66	62
53	10	10	78	47	44	98	69	65
54	10	11	79	48	46	99	71	67
55	11	12	80	49	47	100	74	70
56	12	13	81	51	49	101	77	73
57	13	13	82	52	50	102	79	75
58	14	14	83	54	51	103	82	78
59	15	15	84	55	53	104	84	80
60	15	16	85	56	54	105	87	83
61	16	16	86	58	55	106	89	86
62	17	17	87	59	57	107	92	88
63	18	18	88	60	58	108	95	91
64	19	18	89	62	60	109	97	93
65	20	19	90	63	61	110	100	96
66	21	20	91	65	62	111	102	99
67	21	21	92	66	64	112	105	101
68	22	21	93	67	65	113	107	104
69	23	22	94	69	66	114	110	106
70	24	23	95	70	68	115	113	109
71	25	24	96	71	69	116	115	112
72	26	24	97	73	70	117	118	114
73	27	25	98	74	72	118	120	
74	27	26	99	76	73	119	123	
75	28	27	100	77	75	120	125	
76	29	27	101	78	76			
77	30	28	102	80	77			
78	31	29	103	81	79			
79	32	30	104	83	80			
80	32	30	105	84				
81	33		106	85				
82	34		107	87				

Table 7. Predicted 9, 12 and 15 Months of Age Weights of Eastern Anatolian Red Cattle

9 Month of age			12 Month of age			15 Month of age		
Heart Girth (cm)	Male (kg)	Female (kg)	Heart Girth (cm)	Male (kg)	Female (kg)	Heart Girth (cm)	Male (kg)	Female (kg)
110		98	120		116	125		126
111	100	101	121	120	120	126		130
112	103	103	122	124	125	127	131	135
113	106	105	123	129	129	128	136	139
114	109	108	124	133	133	129	141	144
115	112	110	125	137	137	130	146	148
116	115	113	126	141	141	131	151	152
117	119	115	127	145	145	132	156	157
118	122	118	128	150	149	133	161	161
119	125	120	129	154	153	134	166	166
120	128	122	130	158	157	135	171	170
121	131	125	131	162	161	136	176	174
122	134	127	132	167	165	137	181	179
123	137	130	133	171	169	138	186	183
124	141	132	134	175	173	139	191	188
125	144	135	135	179	177	140	196	192
126	147	137	136	184	182	141	201	196
127	150	139	137	188	186	142	207	201
128	153	142	138	192	190	143	212	205
129	156	144	139	196	194	144	217	210
130	160	147	140	201	198	145	222	214
131	163	149	141	205	202	146	227	218
132	166	151	142	209	206	147	232	223
133	169	154	143	213	210	148	237	227
134	172	156	144	218	214	149	242	232
135	175		145	222	218	150	247	236
			146	226	222	151	252	240
			147	230	226	152	257	245
			148	235	230	153	262	249
			149	239	234	154	267	254
			150	243	239	155	272	258
			151	247		156	277	262
			152	251		157	282	267
						158	287	271

Table 8. 18, 24 Months of Age Females and Mature Cows Weights of Eastern Anatolian Red Cattle

18 Month of age		24 Month of age		Mature	
Heart Girth (cm)	Female (kg)	Heart Girth (cm)	Female (kg)	Heart Girth (cm)	Female (kg)
136	178	141	184	146	209
137	181	142	188	147	213
138	185	143	193	148	217
139	189	144	197	149	221
140	192	145	202	150	226
141	196	146	207	151	230
142	200	147	211	152	234
143	203	148	216	153	238
144	207	149	220	154	242
145	211	150	225	155	246
146	214	151	230	156	250
147	218	152	234	157	254
148	222	153	239	158	258
149	225	154	243	159	262
150	229	155	248	160	267
151	233	156	253	161	271
152	236	157	257	162	275
153	240	158	262	163	279
154	244	159	266	164	283
155	247	160	271	165	287
156	251	161	276	166	291
157	255	162	280	167	295
158	258	163	285	168	299
159	262	164	289	169	304
160	266	165	294	170	308
161	269	166	299	171	312
162	273	167	303	172	316
163	277	168	308	173	320
164	280	169	312	174	324
165	284	170	317	175	328
166	288	171	322	176	332
167	291	172	326	177	336
168	295	173	331	178	341
169	299	174	335	179	345
170	302	175	340	180	349
171	306	176	345	181	353
172	310	177	349	182	357
173	313	178	354	183	361
174	317	179	358	184	365
175	321	180	363	185	369

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