EFFECTS OF AGE AND SEX ON BODY COMPOSITION OF THAI NATIVE AND CROSS-BRED GOATS

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Summary

This paper presents results from a study of the effects of age and sex on body and carcass composition of different goat genotypes. A completely randomized 3 × 3 × 2 factorial design was used. Factors were genotype (Thai Native; TN, 50% TN × 50% Anglo-Nubian (AN) and 25% TN × 75% AN goats), age (206 ± 8, 349 ± 9 and 428 ± 8 days or 6.9, 11.6 and 14.3 months, respectively) and sex (male and female). It was shown that TN kids had significantly higher ($p < 0.05$) hind percentage (7.9%) compared with 50% TN × 50% AN (7.2%) and 25% TN × 75% AN (7.1%) kids. TN kids had a significantly ($p < 0.05$) higher heart percentage (0.44%) than that of 25% TN × 75% AN kids (0.38%). However, there was no significant difference in heart percentage between TN and 50% TN × 50% AN and between 50% TN × 50% AN and 25% TN × 75% AN kids. TN and 50% TN × 50% AN kids had significantly higher ($p < 0.05$) carcass muscle content (63.1 and 63.7%, respectively) than did 25% TN × 75% AN kids (59.9%). Kids at 6.9 months of age had significantly higher percentages of hide, feet, intestinal tract, liver, heart, kidneys and carcass bone than those of kids at 11.6 and 14.3 months of age. There were no significant differences in these characteristics between kids at 11.6 and 14.3 months of age. However, kids at 11.6 and 14.3 months of age had significantly higher percentages of omental fat, dressing carcass, muscle, total fat (subcutaneous + intermuscular + kidney and pelvic fat), muscle to bone ratios (MBR), and muscle plus fat to bone ratios (MFBR) than those of kids at 6.9 months. Males had significantly higher gut contents, but lower percentages of liver, omental fat and heart. Prediction equations were developed relating empty body weight (EBW) to hot carcass weight and some dissectible carcass fractions.

(**Key Words** : Thai Goats, Cross-bred Goats, Body Composition, Effect of Age, Effect of Sex)

Introduction

There are many major factors affecting carcass composition such as live-weight, genotype, sex and nutrition. There is a close relationship between live-weight and carcass weight. In sheep, the bone develops early and the muscle to bone ratio may be as low as 2.5 : 1 at birth. Thereafter bone continues to grow slower and muscle much faster. At birth, the carcass contains little fat but after live-weight reaches about 30 kg fat accelerates and grows faster than muscle (Edey, 1983).

Research has been done on the effect of age on carcass composition (Wilson, 1958; Kirton, 1970; Louca et al., 1977; Owen et al., 1978; Ash and Norton, 1987). In general, at any particular live-weight, entire male goats are leaner than castrates, which are leaner than females (Wilson, 1958; Louca et al., 1977; Owen et al., 1978).

There are some data on the effect of other aspects (genotype, feed and feeding) on body composition of Thai goats (Pralomkarn, 1990; Pralomkarn et al., 1992; Pralomkarn, et al., 1994a; 1994c). This is the first report of the effects of age and sex on body composition of different goat genotypes. The objective of the present experiment was to study the effects of age and sex on body composition of Thai Native (TN), 50% TN × 50% Anglo-Nubian (AN) and 25% TN × 75% AN goats.

Materials and Methods

Location and climate

This experiment was conducted at Khong Hoi Kong

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(KHK) Research Station, Small Ruminant Research and Development Centre, Faculty of Natural Resources, Prince of Songkla University (PSU). Data on the climate has been reported in Kochapakdee et al. (1994).

Animals and their management

The kids were born in the campus of PSU from March to April 1993. Data on the management (feeding, parasite control and vaccination) for pre-weaning kids has been reported in Pralomkarn et al. (1994b). The kids were taken to KHK Research Station.

Twelve each of TN, 50% TN × 50% AN and 25% TN × 75% AN were used. Males and females were held in separated pens and were drenched to control internal parasites with ivermectin, niclosamide monohydrate and toltrazuril immediately prior to introduction to the experimental treatments (about 4 months of age). Twelve kids (male 6 and female 6) were slaughtered at about 6, 11 and 14 months of age. The kids slaughtered at 11 and 14 months were drenched with the anthelminthics every 6 weeks throughout the experiment.

Experimental design

A completely randomised factorial design was used. There were 3 factors : genotype (TN, 50% TN × 50% AN and 25% TN × 75% AN); age (6, 11 and 14 months of age) and sex (male and female).

Diets and feeding methods

Goats were offered a diet of concentrate (1.5% BW daily) and green grass (para grass, *Brachiaria mutica* and napier grass, *Pennisetum purpureum*). The concentrate was composed of corn, palm kernel cake, soybean meal, rice bran, ground oyster shell, salt and dicalcium phosphate. The chemical composition was 15.2% crude protein (DM basis).

Measurements and sampling procedures

Goats were weighed every 2 weeks throughout the experiment and the concentrate was adjusted fortnightly. Clean water was freely available at all times from water troughs. At 6 and 11 months of age 10 kids of each genotype (male and female) were slaughtered for sampling. The remainder were raised till about 14 months of age and slaughtered to study body and carcass composition.

For slaughtering, goats taken from KHK were transported to Hat Yai campus and held in a pen overnight without feed. On the following morning each goat was weighed (fasted live-weight, FLW). All goats were slaughtered by exsanguination and reweighed after bleeding. All organs were weighed to the nearest gram in the following order: head, fore and hind feet, skin, tail, testicles, penis, uterus and ovaries (female), full intestinal tract (esophagus, reticulo-rumen, omasum, abomasum, pancreas, small intestine, caecum, colon, rectum and urinary bladder), liver, lungs and trachea, heart, kidneys, diaphragm and carcass (hot carcass). The carcass was longitudinally divided in two and stored in polyethylene bags at −20℃ pending dissection. The left carcass was dissected, taking care to minimize weight loss into muscle, fat, bone and fascia (largely connective tissues). Following dissection, the fractions were weighed and discarded.

Statistical analysis

Differential growth of tissue occurs during growth and development in animals. Huxley (1932) proposed the allometric equation $Y = ax^b$ to best represent these changes in relation to body size. This equation may be simplified to $\log Y = a + b \log x$, thus facilitating regression analysis.

Differences between treatments for the weights of the empty body and compartments were calculated by analysis of covariance with final empty body weight as a covariate, using the General Linear Models Procedure of Statistical Analysis System (SAS, 1987). Differences between the relative growth coefficient (b) were tested by Student's t-test (Steel and Torrie, 1960).

Results and Discussion

Growth rate of kids

In first week of the experiment, 6 TN kids died due to weakness. These were replaced by 6 other TN kids. Three, 2 and 1 kids were reallocated for the three age groups (slaughtered at 206 ± 8, 349 ± 9 and 428 ± 8 days or 6.9, 11.6 and 14.3 months of age, respectively). The initial live-weights of the replaced kids were not recorded and so the analysis of variance for growth rate of the kids was not calculated. Growth rate of kids slaughtered at 6.9 months of age (n = 7), at 11.6 (n = 8) and at 14.3 (n = 11) months of age was 11.2, 27.8 and 33.1 g/d, respectively. Growth rate of these kids was low when compared with that of kids reported by Pralomkarn (1992, 1994b). Growth rate of TN kids in the village in southern Thailand was low compared with that of kids raised under farm conditions (Pralomkarn et al., 1990) and so the results of this study may be applied for slow growth-rate goats.

Effects of age, sex and genotype on body composition

Mean squares from analysis of variance for body composition are shown in table 1. Table 2 shows mean with standard error of the main effects of genotype, age and sex on composition of goats. Kids at 6.9 months of age had significantly higher percentages of hide, feet, intestinal tract, liver, heart and kidneys than those of kids at 11.6 and 14.3 months of age. However, there was no significant difference in these charcteristics between kids at 11.6 and 14.3 months of age. Kids at 6.9 months of age had significantly lower dressing percentages (47.4%) than did those at 11.6 and 14.3 months of age (52.0 and 53.7%, respectively). This was due to a higher intestinal tract content (12.5, 10.7 and 10.2%, for kids at 6.9, 11.6 and 14.3 months of age).

There was no significant difference in percentages of head plus horn, tail, blood, lungs plus trachea, spleen and kindeys among the age groups.

TABLE 1. MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR BODY COMPOSITION

Source	Genotype (G)	Age (A)	Sex (S)	G × A	G × S	A × S	G × A × S	Error
Hot carcass weight	2861	38302**	1648	1431	314	453	975	2399
Gut contents	36.470	21.613	94.200**	2.981	22.992	10.291	3.430	9.911
Body component								
Head + horn	1.187	0.690	0.315	0.076	0.003	0.888	0.303	0.624
Hide	2.163*	5.429**	0.634	0.416	0.589	0.050	0.708	0.704
Intestinal tract	1.143	15.298**	5.936*	0.524	3.758	1.519	2.698	1.150
Tail	0.0001	0.001	0.0002	0.0005	0.0001	0.0002	0.0002	0.0007
Blood	0.358	1.692	0.235	1.992	3.464	0.219	2.007	1.784
Feet	0.139	1.937**	0.021	0.006	0.012	0.003	0.038	0.286
Liver	0.005	0.224**	0.154*	0.019	0.009	0.014	0.009	0.150
Lungs + trachea	0.131	0.142	0.005	0.057	0.003	0.073	0.093	0.103
Omental fat	0.019	2.833**	3.237**	0.026	0.358	0.234	0.319	0.265
Spleen	0.0002	0.001	0.001	0.001	0.001	0.003	0.001	0.002
Heart	0.008*	0.033**	0.015*	0.003	0.004	0.011*	0.002	0.002
Diaphragm	0.002	0.034	0.011	0.005	0.031	0.003	0.009	0.009
Kidneys	0.001	0.019**	0.005	0.0004	0.003	0.002	0.002	0.001
Dressing percentage								
1	11.393	94.233**	28.028	3.663	15.905	11.536	8.848	9.758
2	0.824	116.779**	0.092	1.853	5.139	9.538	7.389	5.192

* ($p < 0.05$), ** ($p < 0.01$).
1 (hot carcass weight/fasted live-weight) × 100.
2 (hot carcass weight/empty body weight) × 100.

Effects of age, sex and genotype on carcass composition

Table 2 shows mean squares from analysis of variance for dissectible carcass fractions, muscle to bone ratios and muscle plus fat to bone ratios. Mean with standard error of the main effects of genotype, age and sex on these characteristics is shown in table 4. Kids at 6.9 months of age had significantly higher ($p < 0.01$) bone content (23.6%) than that of kids at 11.6 months of age (18.5%) and at 14.3 months of age (17.9). However, kids at 6.9 months of age had significantly lower muscle contents (59.5, 63.8 and 63.4%, for kids at 6.9, 11.6 and 14.3 months of age, respectively), lower fat contents (6.1, 10.4 and 11.6, respectively), lower MBR (2.6, 3.5 and 3.6%, respectively) and lower MFBR (2.9, 4.0 and 4.2%, respectively) than that of kids at 11.6 and 14.6 months of age. Owen et al. (1987) found in male Botswana castrates that goats appear to be relatively late in maturing, with fat tissue not reaching an appreciable proportion on body weight until a heavy live-weight is achieved. In general, muscle of goat carcasses is approximately 60% (Devendra and Owen, 1983); values as high as 66% in intact Malawi goats (Owen, 1975), 65% in Thai entire male goats (Pralomkarn, 1990), 62% in Thai female goats

TABLE 2. MEAN WITH STANDARD ERROR (± SE) OF THE MAIN EFFECTS OF GENOTYPE, AGE AND SEX ON COMPOSITION OF GOATS

Parameter	Genotype			Age (month)			Sex	
	Thai Native (TN)	50% TN × 50% AN#	25% TN × 75% AN	6.9	11.6	14.3	Male	Female
No. of goats	12	11	10	11	10	12	18	15
Fasted live weight (kg)	12.4±0.8	15.2±0.9	14.4±1.0	9.9±0.9[a]	15.0±1.0[b]	17.1±0.8[b]	14.9±0.7	13.0±0.8
Hot carcass weight (kg)	5.3±0.4	6.3±0.5	5.8±0.5	3.8±0.5[a]	6.1±0.5[b]	7.5±0.4[b]	6.0±0.4	5.6±0.4
Gut contents (%)	17.6±0.9	20.6±1.0	20.8±1.0	19.6±1.0	21.1±1.0	18.2±0.9	21.4±0.7[a]	17.9±0.9[b]
Body component (%)								
Head + horn	9.15±0.18	8.68±0.19	8.50±0.21	9.08±0.19	8.61±0.21	8.64±0.18	8.88±0.15	8.68±0.17
Hide	7.94±0.20[a]	7.22±0.22[b]	7.13±0.23[b]	8.23±0.22[a]	6.75±0.23[b]	7.31±0.20[b]	7.29±0.17	7.57±0.19
Intestinal tract	11.51±0.31	10.90±0.33	11.04±0.36	12.51±0.33[a]	10.71±0.36[b]	10.24±0.31[b]	10.71±0.25	11.59±0.29
Tail	0.15±0.01	0.14±0.01	0.15±0.01	0.14±0.01	0.13±0.01	0.16±0.01	0.15±0.01	0.14±0.01
Blood	2.79±0.39	3.11±0.42	3.09±0.46	3.41±0.42	2.95±0.45	2.62±0.39	2.91±0.32	3.08±0.36
Feet	3.17±0.08	3.10±0.09	3.34±0.09	3.69±0.09[a]	3.01±0.09[b]	2.90±0.08[b]	3.23±0.08	3.18±0.07
Liver	1.57±0.04	1.53±0.05	1.54±0.05	1.71±0.05[a]	1.49±0.05[b]	1.43±0.04[b]	1.47±0.04[a]	1.61±0.04[b]
Omental fat	1.36±0.15	1.30±0.16	1.39±0.17	0.80±0.16[a]	1.45±0.17[b]	1.81±0.15[b]	1.03±0.12[a]	1.68±0.14[b]
Lungs + trachea	1.05±0.09	1.01±0.10	1.23±0.10	1.19±0.10	1.15±0.11	0.97±0.09	1.08±0.08	1.11±0.09
Spleen	0.12±0.01	0.12±0.01	0.12±0.01	0.13±0.01	0.13±0.01	0.11±0.01	0.11±0.01	0.12±0.01
Heart	0.44±0.01[a]	0.42±0.01[ab]	0.38±0.01[b]	0.43±0.01[a]	0.35±0.01[b]	0.46±0.01[a]	0.39±0.01[a]	0.44±0.01[b]
Diaphragm	0.36±0.03	0.38±0.03	0.39±0.03	0.33±0.03	0.44±0.03	0.36±0.03	0.36±0.02	0.40±0.03
Kidneys	0.32±0.01	0.30±0.01	0.31±0.01	0.36±0.01[a]	0.29±0.01[b]	0.28±0.01[b]	0.30±0.01	0.32±0.01
Dressing percentage								
1	42.2±0.9	40.8±1.0	40.2±1.0	38.1±1.0[a]	41.0±1.0[ab]	44.0±0.9[b]	40.1±0.7	42.0±0.8
2	51.1±0.7	51.3±0.7	50.7±0.8	47.4±0.7[a]	52.0±0.8[b]	53.7±0.7[b]	51.0±0.5	51.1±0.6

AN = Anglo-Nubian.

a or b means within main effects within rows with different superscripts differ significantly.

1 (hot carcass weight/fasted live-weight) × 100.

2 (hot carcass weight/empty body weight) × 100.

(Pralomkarn et al., 1994a), 68% in intact Alpine goats (Fehr et al., 1976) and as low as 53.9% in male and female Philippine goats (Arganosa et al., 1977) have been reported. Pralomkarn (1990) found in Thai kids (slaughter weight c. 14.8 kg) that there no significant difference in dissectible carcass fractions, MBR and MFBR among TN, 25% TN × 75% AN and 50% TN × 50% AN kids. However, in bigger goats (slaughter weight c. 21.2 kg), TN and 75% TN × 25% AN kids had significantly higher MBR than that of 25% TN × 75% AN kids, and values for TN kids was higher than that of 50% TN × 50% AN kids. These suggest that weight and age affect MBR of goats.

In this study, there was no significant difference in dissectible carcass fractions (muscle, fat and bone) contents, MBR and MFBR between males and females. However, Owen et al. (1978) found that fat levels are highly variable and depend upon weight, breed, plane of nutrition, and sex. In Australian cashmere goats, males had significantly higher muscle and bone contents, but

lower fat contents and MFBR than those of females (Pralomkarn, 1990). In general, at any particular live-weight, entire male goats are leaner than castrates, which are leaner than females (Wilson 1958; Louca et al., 1977; Owen et al., 1978). However, these relationships may be distorted by variations in management (McGregor, 1984).

In this study, TN and 50% TN × 50% AN kids had significantly higher ($p < 0.05$) muscle contents (63.1 and 63.7%, respectively) than those of 25% TN × 75% AN (59.9%) kids. There was no significant difference in fat and bone contents or MBR among the genotypes.

In this study, genotype and sex of goats had no effect on dissectible carcass fractions (except that genotype affects muscle contents), MBR and MFBR. This may be due to a low average slaughter weight. As mentioned above, the growth rate of these kids was only 25.6 g/d, and so growth rates of muscle, bone and fat were different from those of high growth-rate goats.

TABLE 3. MEAN SQUARES FROM ANALYSIS OF VARIANCE FOR DISSECTING CARCASS FRACTIONS, MEAT TO BONE RATIOS AND MEAT PLUS FAT TO BONE RATIOS

Source	Genotype (G)	Age (A)	Sex (S)	G×A	G×S	A×S	G×A×S	Error
% Muscle	38.571*	56.312*	21.143	14.565	5.849	0.533	3.912	9.381
% Total fat	21.256	87.651**	51.548	10.718	13.398	6.473	5.560	13.143
% Bone	9.152	106.091**	0.446	0.530	18.983	1.751	9.804	12.846
% Connective tissue	3.491	41.204**	3.661	0.230	0.143	0.687	0.690	2.973
Muscle : bone ratio	0.600	2.913**	0.015	0.108	0.236	0.033	0.112	0.216
Muscle plus fat : bone ratio	0.341	5.461**	0.089	0.046	0.416	0.136	0.178	0.408

* ($p < 0.05$), ** ($p < 0.01$).

TABLE 4. MEAN WITH STANDARD ERROR (± SE) OF THE MAIN EFFECTS OF GENOTYPE, AGE AND SEX ON DISSECTIBLE CARCASS FRACTIONS, MUSCLE TO BONE RATIOS AND MUSCLE PLUS FAT TO BONE RATIOS

Parameter	Genotype			Age (month)			Sex	
	Thai Native (TN)	50% TN × 50% AN*	25% TN × 75% AN	6.9	11.6	14.3	Male	Female
% Muscle	61.11±0.88[a]	63.69±0.96[a]	59.95±1.20[b]	59.55±0.96[a]	63.77±1.02[b]	63.42±0.88[b]	63.07±0.72	61.42±0.83
% Total fat	8.41±1.05	8.67±1.13	11.09±1.21	6.15±1.13[a]	10.42±1.21[b]	11.59±1.05[b]	8.10±0.85	10.68±0.99
% Bone	19.54±1.03	19.39±1.12	21.15±1.19	23.67±1.12[a]	18.53±1.19[b]	17.87±1.03[b]	20.15±0.84	19.91±0.98
Muscle : bone ratios	3.35±0.13	3.38±0.15	2.93±0.16	2.62±0.15[a]	3.47±0.16[b]	3.58±0.13[b]	3.24±0.11	3.20±0.13
Muslcle plus fat : bone ratios	3.81±0.18	3.85±0.20	3.51±0.21	2.90±0.20[a]	4.04±0.21[b]	4.23±0.18[b]	3.67±0.15	3.78±0.17

* AN = Anglo-Nubian.
a or b means within main effects within rows with different superscripts differ significantly.

Prediction of carcass composition from the empty body weight

Table 5 shows the allometric growth equations describing the relationship between EBW and hot carcass weight and some dissectible carcass fractions for goats. Analysis of variance indicated that there was no significant effect of genotype or sex on the characteristics, and combined equations for these effects are presented. All relationships were significantly different. However, Pralomkarn (1990) found that Australian cashmere (AC) and Anglo-Nubian x AC goats had 2 equations (for males and females) for dissectible fat and bone weights. This may be due to a different mean slaughter weight and rate of gain. AC goats (slaughter weight c. 21.2 kg), gain

approximately 65 g/d, but the rates for Thai goats used in this study were only 26 g/d and 13.9 kg, respectively.

In this study, the relative growth coefficients (b) indicate that when compared with empty body weight (EBW), fat of all kids increased at a faster ($p < 0.01$) rate than did EBW. However, other tissues (muscle, muscle plus fat or bone) of kids increased at the same rate as EBW. Pralomkarn (1990) found that all tissues of Thai kids slaughtered at the same age (fasted live-weight c. 14.8 kg or c. 21.2 kg) increased at the same rate as EBW.

TABLE 5. ALLOMETRIC GROWTH EQUATIONS OF THE FORM LOG Y = B LOG X + A DESCRIBING THE RELATIONSHIP BETWEEN EMPTY BODY WEIGHT (X), G AND CARCASS WEIGHT OR DISSECTIBLE CARCASS FRACTIONS (Y), G

(Y)	Sex	a	b	SE (b)	R-square	RSD	Significant level
Carcass weight	M&F	−1.054	1.188	0.029	0.982	0.023	**
Dissectible muscle	M&F	−2.197	1.134	0.048	0.961	0.039	**
Dissectible fat	M&F	−11.640	3.449#	0.395	0.711	0.322	**
Dissectible muscle + fat	M&F	−2.702	1.481	0.045	0.972	0.036	**
Dissectible bone	M&F	−0.476	0.791	0.055	0.869	0.014	**

M&F = male and female, RSD = residual standard deviation, # Significantly different from 1.000, ** ($p < 0.01$).

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