PN ABS-565
90210

# Small Ruminant - CRSP

SUB-BALAI PENELITIAN TERNAK, SUNGAI PUTIH

BALAI PENELITIAN TERNAK

PUSAT PENELITIAN DAN PENGEMBANGAN PETERNAKAN

PN-AB[illegible]

# GROWTH, MORTALITY AND WOOL COVER OF SUMATRA SHEEP AND CROSSES WITH VIRGIN ISLAND, BARBADOS BLACKBELLY AND JAVA FAT-TAIL BREEDS

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Working paper 153, January 1994

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# GROWTH, MORTALITY AND WOOL COVER OF SUMATRA SHEEP AND CROSSES WITH VIRGIN ISLAND, BARBADOS BLACKBELLY AND JAVA FAT-TAIL BREEDS

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## ABSTRACT

Sumatra ewes were mated to give Java Fat-tail crossbred (E1), Virgin Island crossbred (H1) and purebred Sumatra (S) lambs, or were inseminated to give Barbados Blackbelly crossbred (B1) lambs. A total of 882 lambs were born to 407 ewes in 568 lambings between March and October 1992. Average litter size was 1.55 and lamb mortality to weaning at 3 months was 22.5%. Weights of lambs averaged 1.83 kg at birth and 8.7 kg at weaning. For female lambs only, weights averaged 14.4 kg at 6 months and 17.9 kg at 9 months of age. The average increase in weight of the crossbreds above S was E1 7%, H1 15% and B1 20%. At 3 months of age all breed groups had similar wool scores, but in older animals the ranking was B1 (least wool) < H1 < E1 < S (most wool).

## ABSTRAK

Telah dilakukan pengamatan terhadap empat bangsa domba yaitu lokal Sumatera (S) dan hasil persilangannya dengan pejantan ekor gemuk (E1) dan Virgin Island (H1), dan dengan inseminasi buatan semen beku Barbados Blackbelly (B1). Sebanyak 882 anak domba yang dilahirkan dari 467 ekor induk dengan 568 kelahiran, mulai Maret sampai dengan Oktober 1992. Rataan litter size 1,55 dan mortalitas anak sampai sapih (3 bulan) adalah 22,5 %. Rataan bobot lahir 1,83 kg dan rataan bobot sapih 8,7 kg. Rataan bobot badan domba betina umur 6 dan 9 bulan adalah berturut-turut 14,4 dan 17,9 kg. Rataan bobot badan domba hasil persilangan adalah lebih tinggi dibandingkan dengan S; yaitu untuk E1 7%, H1 15%, dan B1 20%. Pada umur 3 bulan skor kondisi bulu pada setiap bangsa domba tersebut hampir sama, tetapi untuk ternak yang lebih tua (umur ≥ 6 bulan) memiliki skor bulu dengan urutan B1 < H1 < E1 < S.

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This paper was presented at the SR-CRSP workshop in San Juan, Puerto Rico, September 1993.

## INTRODUCTION

The local breed of sheep in North Sumatra has a high reproductive potential, but is small and growth rates are usually low. Most Sumatra sheep have some coarse wool which is not used. In some other parts of the humid tropics, sheep are larger and have no wool. The performance of different breeds of hair sheep is not well documented. It has been postulated that sheep without wool are better adapted to a hot humid climate.

The objective of the crossbreeding trial in Sei Putih is to evaluate various genetic stocks of hair sheep and their suitability in the humid tropics. The results presented in this paper are those of the first phase, namely lamb growth, mortality and wool cover.

## BREEDS

In this trial, **Sumatra**, the local breed in North Sumatra, is crossed with

1. **Barbados Blackbelly**, from the Caribbean, which was introduced using frozen semen rather than live animals.

2. **Java Fat-tail**, known in Indonesia as Ekor Gemuk. Thirty-five ewes and 15 rams were introduced from East Java to Sei Putih in 1991.

3. **Virgin Island White**, also known as St Croix, originally from the Caribbean. Seven ewes and seven rams were introduced to Sei Putih in 1986 from the USA via Java.

In addition, **Garut crossbred** ewes (Garut x Sumatra) were used as dams to avoid purchasing more Sumatra ewes. The Garut is a strain of Java Thin-tail, similar to the Sumatra, and is also known as the Priangan. The Garut crossbred ewes in Sei Putih had been produced during a previous experiment.

The symbols used to denote genotypes in this paper are summarised in Table 1.

Table 1. Symbols of genotypes.

| Symbol | Genotype |
|---|---|
| S | Sumatra. |
| B | Barbados Blackbelly. |
| B1 | B x S, first generation. |
| BC | B x S, second and subsequent generations, 50% B + 50% S. |
| E | Java Fat-tail. |
| E1 | E x S, first generation. |
| EC | E x S, second and subsequent generations, 50% E + 50% S. |
| G | Garut, a strain of Java Thin-tail. |
| G1 | G x S, first generation. |
| H | Virgin Island White or St Croix. |
| H1 | H x S, first generation. |
| HC | H x S, second and subsequent generations, 50% H + 50% S. |

## METHOD

### Location

This comparison is carried out at the Suka Damai unit of the Research Institute for Animal Production, Sei Putih in North Sumatra (3°N, 99°E). Altitude is about 50 m above sea level. Annual rainfall totals about 1800 mm, with rain in every month. Mean minimum temperature is 23°C and mean maximum temperature is 32°C, with little seasonal variation.

### Animals and management

The sheep are housed in group pens in four large sheep houses with raised slatted floors. Ewes and suckling lambs are grazed from 0800 h to 1600 h daily in rubber plantations.

Ewes with single lambs are given concentrate for only two weeks after lambing, and those with two or more lambs receive concentrate (300 g/d per head) for 6 weeks. The concentrate comprises rice bran, cassava meal, palm kernel cake, molasses, fish meal, lime and minerals. All ewes are fed 50-100 g/d per head of molasses mixed with urea.

Ewes are exposed to rams for 34-day periods four times a year. Lambs are weaned at exactly 3 months of age. Weaned lambs are grouped according to sex and size, but with a mixture of

genotypes in each pen to prevent bias towards any genotype. From the age of 3 to 6 months lambs are not grazed but are stall-fed with grass and ad libitum concentrate. At 6 months of age females join the ewe flock; they continue to receive a small amount of concentrate (200 g/d per head) until 15 months of age.

All animals are individually identified with a neck tag and a tattoo. Lambs are also given an ear tag. Records are kept of ewe weights at mating and lambing, and of lamb weights at birth, every two weeks until weaning at 3 months, at approximately 6 months and at approximately 9 months. Birthcoats are assessed, and the wool coats of older animals are scored at 3, 6 and 9 months of age.

Mating programme

In October 1991 a mating programme was started with S and G1 ewes aged from 7 months to 7 years, and weighing 12.5 to 37.4 kg. More than 400 ewes were either inseminated with frozen semen from Barbados Blackbelly rams or were mated by East Java Fat-tail, Virgin Island or Sumatra rams.

Ewes were randomly allocated to sire breeds, within S and G1 groups. Ewes allocated to AI with the Barbados Blackbelly semen were also allocated to another breed for subsequent natural mating in case they did not conceive to the AI.

Laparoscopic insemination of Sumatra ewes using Barbados Blackbelly semen was conducted at the beginning of October 1991, following synchronisation of oestrus. We had intended to inseminate 160 ewes, but because of poor semen quality only ninety-five were inseminated.

Natural matings were undertaken during a 34-day period starting 15 October 1991. Natural services were individually supervised following twice-daily detection of oestrus by vasectomised rams. All ewes were given the chance to mate again in January-February and April-May 1992.

A total of 407 ewes (312 S and 95 G1) ewes in this trial lambed in three seasons, starting early March, mid-June and mid-September 1992. The numbers of ewes lambing in these three seasons were 314, 70 and 184, respectively (Table 2). The majority (161) of the 184 ewes which lambed in September had previously lambed in March. A total of 882 lambs were born.

Table 2. Numbers of ewes lambing and lambs born in crossbreeding experiment, 1992.

| Breed group | March | | June | | September | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Ewes | Lambs | Ewes | Lambs | Ewes | Lambs | Ewes | Lambs |
| B1 | 49 | 83 | 0 | 0 | 0 | 0 | 49 | 83 |
| E1 | 93 | 148 | 27 | 41 | 66 | 100 | 186 | 289 |
| H1 | 90 | 135 | 22 | 29 | 59 | 91 | 171 | 255 |
| S | 82 | 123 | 21 | 33 | 59 | 99 | 162 | 255 |
| Total | 314 | 489 | 70 | 103 | 184 | 290 | 568 | 882 |

Lambs were also born to East Java Fat-tail, Virgin Island and Sumatra x Virgin Island ewes, which allow us to make further inter-breed comparisons.

All the genotypes are treated as similarly as possible. However, the management of the B1 lambs was not identical with that of the other genotypes: the synchronisation technique used with the AI may have enhanced ovulation rate and litter size. Only the ewes bearing B1 lambs were given 200 g/d concentrate for one month before lambing, and the B1 lambs were born an average of about 3 weeks before the others. Therefore B1 lambs were subjected to slightly different grazing management and parasite burdens. The major statistical analyses presented in this paper compare only the E1, H1 and S lambs born in all three seasons. Secondary analyses compare the B1 lambs with the other lambs born in March 1992.

## RESULTS

### Litter size

A large proportion of lambs were born in multiple litters. The percentages of ewes (of all four breeds in all three seasons) with litters of 1, 2, 3 and 4 lambs were 54, 38, 7 and 1%, respectively. These figures are almost identical to those reported by Iniguez et al (1991) for the same flock in 1985-1988. Overall litter size was 1.55.

The analysis of litter size for three breeds in all seasons is summarised in Table 3. Litter size was affected by breed of dam ($P<0.001$), but not by age of ewe nor season of birth. A similar picture was seen for analysis of all four breeds in March 1992, although the least squares means were higher.

Table 3. Least squares means for litter size of S and G1 ewes producing E1, H1, S lambs in all three seasons.

| | n | mean | SE |
|---|---|---|---|
| Overall mean | 517 | 1.54 | 0.028 |
| Breed of dam | | | |
| G1 | 119 | 1.78 | 0.07 |
| S | 398 | 1.46 | 0.04 |
| | | P<0.001 | |
| Age of dam | | | |
| <2 y | 120 | 1.46 | 0.07 |
| 2-3 y | 159 | 1.64 | 0.05 |
| 3-4 y | 109 | 1.65 | 0.07 |
| 4-6 y | 91 | 1.66 | 0.08 |
| >6 y | 38 | 1.70 | 0.11 |
| | | ns | |
| Season of birth | | | |
| March | 263 | 1.67 | 0.05 |
| June | 70 | 1.56 | 0.08 |
| September | 184 | 1.63 | 0.06 |
| | | ns | |

The higher litter size of the G1 dams compared to the S dams can be attributed to (i) hybrid vigour, and (ii) the higher frequency of the $FecJ^F$ gene (Bradford et al., 1986) in the Java Thin-tail breed which sired the G1 dams than in the Sumatra.

Young ewes have smaller litters than mature ewes aged two years or more. There was no reduction in litter size in the oldest ewes aged more than 6 years. The age effect on litter size followed a similar pattern in all seasons.

Litter size was highest in March, closely followed by September; the litter size in June was slightly lower. Several factors contribute to the seasonal effect. For about 6 months before the ewes were mated in October 1991, those which were not pregnant had been held open. Thus the body condition of many ewes was better than normal, and this may have lead to higher litter sizes in March 1992. Also, the most fertile ewes conceived in October 1991 and lambed in March 1992. The less fertile ewes did not conceive until 3 months later and lambed in June 1992; there is probably a correlation between ewe fertility and litter size. About 51% of the ewes which lambed in March conceived in April or May and lambed again in September or October 1992.

Weights of lambs

The analysis of three breeds in three seasons, which is summarised in Table 4, shows that average weights were 1.83 kg at birth and 8.7 kg at weaning for lambs of both sexes. For female lambs only, weights averaged 14.4 kg at 6 months and 17.9 kg at 9 months of age. Six- and 9-month weights were corrected for age to give weights at exactly 183 and 274 days of age.

Lamb weights were affected by breed of sire, sex of lamb, litter size at birth and weaning, breed and age of dam and season of birth. Individual sire had no statistically significant effect.

Male lambs were heavier than female lambs ($P<0.01$). Lambs born and reared as single lambs were heavier than those born as multiples ($P<0.001$). For more detailed analysis of the effects of type of birth and rearing, see page (9-10).

Lambs born to G1 dams were significantly heavier than lambs born to S dams at ages up to 6 months. At birth the difference was 14%; this increased to 18% at weaning suggesting that the milk production of G1 dams is superior. The difference then declined to 8% at 6 months, and to less than 2% at 9 months of age.

Age of ewe had highly significant effects on lamb weights at 0 and 3 months, but no effects on weights of older lambs. Both at birth and weaning, lamb weight increased with ewe age to a maximum in ewes aged 4-6 years. There was a slight reduction in lamb weights born to ewes aged more than 6 years.

Season of birth had no significant effect on birth weight. The seasonal differences observed in weights at 3, 6 and 9 months of age can be attributed to differences in grazing and housing management which were largely related to the number of animals in the flock. In particular the low 6- and 9-month weights for the March lambs can be attributed to crowding in the post-weaning pens.

Effect of breed of sire on weight of lambs. The average weights of the four breed groups born in March are shown in Table 5. These, together with the values from the three breed analysis in Table 4, show that

1. the ranking of average lamb weights was consistent with S < E1 < H1 < B1.
2. the average increase in weight of the crossbreds above the S was 7% for E1, 15% for H1 and 20% for B1. These differences are highly significant statistically. However, the variation within the genotypes was large compared with the difference between the means. This is demonstrated in Figure 1.

Table 4. Least squares means and standard errors (kg) for lamb weights of three breeds in all seasons. Values for birth and 3 months are for both sexes; values for 6 and 9 months are for females only.

| | Birth | | Three months | | Six months | | Nine months | |
|---|---|---|---|---|---|---|---|---|
| n | 799 | | 616 | | 275 | | 159 | |
| Overall mean | 1.83 | | 8.7 | | 14.4 | | 17.9 | |
| Breed group[1] | | | | | | | | |
| E1 | 1.73[a] | 0.05 | 8.6[b] | 0.25 | 14.3[b] | 0.5 | 18.2[a] | 0.5 |
| H1 | 1.95[b] | 0.05 | 8.9[b] | 0.26 | 15.4[b] | 0.4 | 19.9[b] | 0.5 |
| S | 1.71[a] | 0.03 | 7.8[a] | 0.17 | 12.8[a] | 0.4 | 17.0[a] | 0.6 |
| | P<0.001 | | P<0.001 | | P<0.001 | | P<0.001 | |
| Sex | | | | | | | | |
| Female | 1.74 | 0.03 | 8.2 | 0.18 | | | | |
| Male | 1.85 | 0.03 | 8.6 | 0.17 | | | | |
| | P<0.001 | | P<0.01 | | | | | |
| Type of birth (or birth and rearing) | | | | | | | | |
| 1 (11) | 2.31 | 0.04 | 11.0 | 0.18 | 16.3 | 0.4 | 19.8 | 0.5 |
| (21) | | | 8.2 | 0.29 | 14.2 | 0.5 | 18.6 | 0.8 |
| 2 (22) | 1.75 | 0.03 | 7.5 | 0.17 | 13.3 | 0.3 | 17.5 | 0.4 |
| 3 (32) | 1.33 | 0.05 | 6.9 | 0.27 | 12.9 | 0.6 | 17.5 | 0.9 |
| | P<0.001 | | P<0.001 | | P<0.001 | | P<0.001 | |
| Breed of dam | | | | | | | | |
| G1 | 1.92 | 0.04 | 9.1 | 0.22 | 14.8 | 0.5 | 18.5 | 0.6 |
| S | 1.68 | 0.03 | 7.7 | 0.15 | 13.6 | 0.3 | 18.2 | 0.4 |
| | P<0.001 | | P<0.001 | | P<0.01 | | ns | |
| Age of dam | | | | | | | | |
| <2 y | 1.53 | 0.04 | 7.4 | 0.24 | 13.5 | 0.5 | 17.7 | 0.6 |
| 2-3 y | 1.75 | 0.03 | 8.7 | 0.19 | 14.5 | 0.3 | 18.6 | 0.5 |
| 3-4 y | 1.88 | 0.04 | 8.8 | 0.21 | 14.7 | 0.4 | 18.5 | 0.6 |
| 4-6 y | 1.95 | 0.05 | 9.2 | 0.25 | 14.6 | 0.5 | 18.2 | 0.7 |
| >6 y | 1.88 | 0.06 | 7.9 | 0.35 | 13.8 | 0.7 | 18.8 | 0.9 |
| | P<0.001 | | P<0.001 | | ns | | ns | |
| Season of birth | | | | | | | | |
| March | 1.82 | 0.03 | 8.5 | 0.17 | 13.1 | 0.4 | 17.3 | 0.4 |
| June | 1.73 | 0.05 | 8.6 | 0.25 | 14.0 | 0.5 | 19.4 | 0.6 |
| September | 1.85 | 0.04 | 8.1 | 0.20 | 15.5 | 0.4 | | |
| | ns | | P<0.05 | | P<0.001 | | P<0.01 | |
| Sire within breed | ns | | ns | | ns | | ns | |

[1]Means within each column without the same superscipt are significantly different (P<0.05).

Table 5. Least squares means and standard errors (kg) for lamb weights of four breeds born in March. Values for birth and 3 months are for both sexes; values for 6 and 9 months are for females only.

| | Birth | Three months | Six months | Nine months |
|---|---|---|---|---|
| n | 488 | 391 | 163 | 156 |
| Breed group | | | | |
| B1 | $1.97^{b}$ 0.06 | $10.3^{c}$ 0.29 | $14.7^{b}$ 0.5 | $19.9^{b}$ 0.6 |
| E1 | $1.82^{ab}$ 0.08 | $8.8^{b}$ 0.37 | $13.5^{ab}$ 0.6 | $17.2^{a}$ 0.7 |
| H1 | $1.95^{b}$ 0.06 | $9.0^{b}$ 0.31 | $13.9^{ab}$ 0.5 | $19.0^{b}$ 0.5 |
| S | $1.71^{a}$ 0.05 | $7.8^{a}$ 0.24 | $12.8^{a}$ 0.5 | $16.6^{a}$ 0.6 |
| | P<0.001 | P<0.001 | P<0.05 | P<0.001 |

Means within each column without the same superscipt are significantly different (P<0.05).

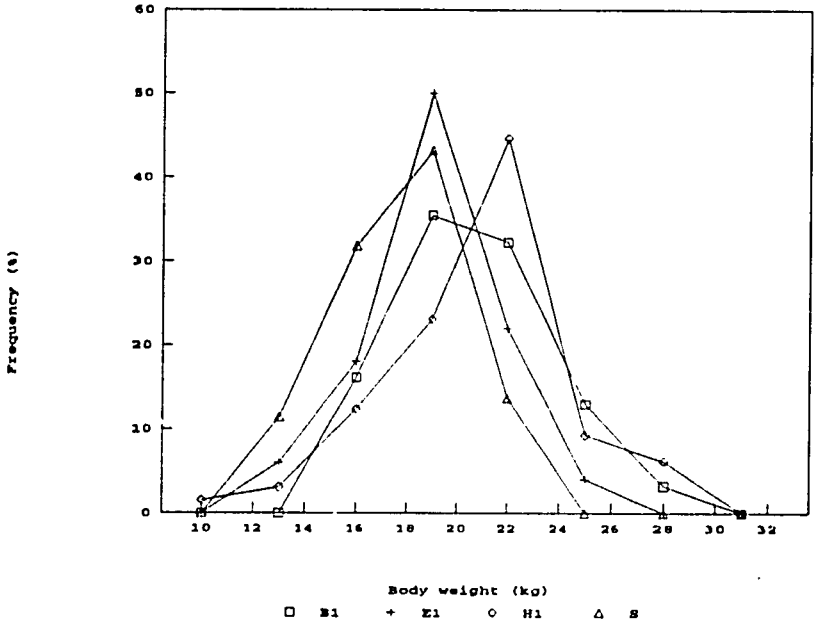


**Figure 1.** Frequency distribution of body weight in 9-month-old ewe lambs.

Effect of ewe weight on weight of lambs. In order to examine the effect of ewe weight at mating or at lambing on the weight of lambs, the analyses were repeated with the inclusion of ewe weight. The other variables included were breed of sire, sex, type of birth and rearing, breed of dam, age of dam and season of birth.

In each analysis there was a positive correlation between ewe weight and lamb weight. The results for the analysis of three breeds in all seasons are summarised in Table 6.

Table 6. Least squares estimates of regression coefficients for lamb weight on ewe weight for three breeds in all seasons. Analyses for birth and 3 months are for both sexes; values for 6 and 9 months are for females only.

| | Birth | Three months | Six months | Nine months |
|---|---|---|---|---|
| Ewe weight at mating | 0.031±0.004<br>P<0.001 | 0.23±0.02<br>P<0.001 | 0.21±0.04<br>P<0.001 | 0.24±0.06<br>P<0.001 |
| Ewe weight at lambing | 0.033±0.005<br>P<0.001 | 0.26±0.02<br>P<0.001 | 0.22±0.05<br>P<0.001 | 0.25±0.06<br>P<0.001 |

These values show that there is a strong positive correlation between ewe weight and lamb weight at all ages from birth to 9 months. Ewe weight at mating and at lambing appear to be equally good predictors of lamb weight.

Two factors are probably having an effect here. Firstly, ewes with a large frame tend to produce lambs with a high potential for growth. Secondly, ewes in good body condition are better able to support foetal growth and to produce a good supply of milk for suckling lambs.

Effect of litter size on lamb weights. A more detailed analysis of the effects of type of birth and rearing on lamb weights is shown in Table 7. This analysis also included all other variables (breed, sex of lamb, etc) in Table 4.

Table 7. Least squares means and standard errors (kg) for lamb weights of three breeds in all seasons, showing effects of type of birth and rearing.

| Type of birth (or birth and rearing) | Birth | | | Three months | | |
|---|---|---|---|---|---|---|
| | n | mean | SE | n | mean | SE |
| 1 (11) | 305 | 2.31 | 0.04 | 268 | 11.0 | 0.19 |
| (12) | | | | 1 | 8.1 | 1.94 |
| (21) | | | | 61 | 8.2 | 0.29 |
| 2 (22) | 436 | 1.75 | 0.03 | 271 | 7.5 | 0.17 |
| (31) | | | | 17 | 7.2 | 0.59 |
| 3 (32) | 117 | 1.34 | 0.05 | 31 | 7.1 | 0.42 |
| (33) | | | | 18 | 6.5 | 0.53 |
| (41) | | | | 1 | 4.0 | 0.95 |
| 4 (42) | 24 | 1.27 | 0.10 | 12 | 7.3 | 0.60 |
| (43) | | | | 4 | 5.8 | 0.99 |
| | | P<0.001 | | | P<0.001 | |

The majority of lambs (65%) were born in litters of two or more lambs. A total of 141 lambs were born in litters of 3 or 4; this is 16% of all lambs born. However, only 22 lambs were weaned in litters of 3 or 4. Most lambs in large litters died, were reared in reduced litters, or were fostered onto ewes with fewer lambs.

The weaning weight of lambs born and reared as twins averages 7.5 kg. Thus litter weight is 15 kg, compared with only 11 kg for single lambs. There is a good chance that both twins survive, and twinning is advantageous where nutrition and management are good. On the other hand litter sizes of 3 and 4 cause many problems and, unless there is a cheap and reliable way of providing milk substitute to lambs, large litters should be avoided.

## Lamb mortality

Pre-weaning mortality averaged 22.5% (from birth to 3 months), and for females post-weaning mortality (3 to 9 months) averaged 13.1%. The factors affecting lamb mortality are summarised in Table 8. For analysis three periods were considered:

1. 0-2 weeks of age. "Perinatal mortality". Lambs born dead were included in this figure.
2. 2 weeks to 3 months of age.
3. 3-9 months of age. "Post-weaning mortality". This figure is for females only, and includes the few animals that were culled for physical deformities and those that lost their identification tags or were stolen.

Table 8. Least squares means and standard errors for lamb mortality (%) of three breeds in all seasons. Values until 3 months are for both sexes; the final column is for females only.

| | 0-14 d (1) | | 0.5-3.0 months (2) | | 0-3 months (1+2) | | 3-9 months (3) | |
|---|---|---|---|---|---|---|---|---|
| n | 799 | | 799 | | 799 | | 183 | |
| Overall mean | 10.1 | | 12.4 | | 22.5 | | 13.1 | |
| Breed group[1] | | | | | | | | |
| E1 | 15.9[a] | 3.2 | 3.8[a] | 3.5 | 19.7[a] | 4.3 | 14.6[a] | 6.7 |
| H1 | 8.0[a] | 3.3 | 17.3[b] | 3.6 | 25.3[a] | 4.5 | 3.8[a] | 6.6 |
| S | 12.9[a] | 2.2 | 11.2[b] | 2.4 | 24.2[a] | 3.0 | 17.6[a] | 6.7 |
| | ns | | P<0.05 | | ns | | ns | |
| Sex | | | | | | | | |
| Female | 14.2 | 2.3 | 9.1 | 2.5 | 23.2 | 3.1 | | |
| Male | 10.4 | 2.2 | 12.5 | 2.4 | 22.9 | 3.1 | | |
| | ns | | ns | | ns | | | |
| Type of birth (or birth and rearing) | | | | | | | | |
| 1 (11) | 2.7 | 2.5 | 4.0 | 2.7 | 6.7 | 3.4 | 8.2 | 6.3 |
| (21) | | | | | | | 12.6 | 9.2 |
| 2 (22) | 9.0 | 2.2 | 14.4 | 2.3 | 23.4 | 2.9 | 10.3 | 5.0 |
| 3 (32) | 25.1 | 3.3 | 13.9 | 3.6 | 39.0 | 4.4 | 16.9 | 10.5 |
| | P<0.001 | | P<0.001 | | P<0.001 | | ns | |
| Breed of dam | | | | | | | | |
| G1 | 9.3 | 2.9 | 6.3 | 3.1 | 15.6 | 3.9 | 9.7 | 7.8 |
| S | 15.3 | 1.9 | 15.2 | 2.1 | 30.5 | 2.6 | 14.4 | 5.0 |
| | P<0.05 | | P<0.01 | | P<0.001 | | ns | |
| Age of dam | | | | | | | | |
| <2 y | 19.6 | 3.0 | 11.4 | 3.3 | 31.0 | 4.1 | 12.3 | 6.9 |
| 2-3 y | 11.4 | 2.3 | 12.2 | 2.6 | 23.6 | 3.2 | 17.2 | 6.4 |
| 3-4 y | 8.8 | 2.8 | 9.7 | 3.0 | 18.5 | 3.8 | 18.9 | 7.7 |
| 4-6 y | 12.2 | 3.2 | 0.0 | 3.5 | 11.6 | 4.4 | 3.5 | 8.7 |
| >6 y | 9.4 | 4.3 | 21.1 | 4.7 | 30.6 | 5.9 | 8.1 | 10.7 |
| | P<0.05 | | P<0.001 | | P<0.001 | | ns | |
| Season of birth | | | | | | | | |
| March | 9.3 | 2.2 | 9.1 | 2.4 | 18.3 | 3.0 | 11.2 | 4.9 |
| June | 13.7 | 3.3 | 5.5 | 3.7 | 19.2 | 4.6 | 12.8 | 7.4 |
| September | 13.9 | 2.5 | 17.7 | 2.7 | 31.6 | 3.4 | | |
| | ns | | P<0.01 | | P<0.001 | | ns | |
| Individual sire | | | | | | | | |
| | ns | | ns | | ns | | ns | |

[1]Means within each column without the same superscipt are significantly different (P<0.05).

Pre-weaning mortality, which is the sum of category 1 + category 2, is also shown in Table 8.

Mortality was affected by type of birth and rearing, breed of dam, age of ewe and season of birth. The high pre-weaning mortality of September-born lambs can be attributed to heavy rain in November and December 1992. Sex of lamb and individual sire had no statistically significant effects.

In the analysis shown in Table 8 breed had a significant effect only on mortality from two weeks to 3 months of age, when the mortality of E1 lambs was lower than that of other breeds. The least squares mean mortality rates of all four breeds in March are shown in Table 9. There were no statistically significant differences between the preweaning mortality rates of the four breeds, but after the age of 3 months, the mortality rate of the S was more than 20%, and that of the H1 was lowest.

Table 9. Least squares means and standard errors for lamb mortality (%) of four breeds in March. Values in the first column are for both sexes; the second column is for females only.

| | 0-3 months | | 3-9 months | |
|---|---|---|---|---|
| n | 489 | | 180 | |
| Overall mean | 19.6 | | 13.3 | |
| Breed group | | | | |
| B1 | 13.3 | 5.3 | 9.0 | 7.9 |
| E1 | 13.6 | 7.2 | 16.1 | 8.7 |
| H1 | 24.6 | 5.2 | 6.3 | 7.0 |
| S | 20.7 | 4.3 | 23.9 | 7.6 |
| | ns | | ns | |

Pre-weaning mortality was much higher for twins and triplets than for single lambs. This results from the greater attention received from the ewe and the greater quantity of milk consumed by single-born lambs, and also there is a direct effect of lamb birth weight on mortality rate. Inclusion of birth weight as a covariable into the analysis showed that birth weight had a very highly significant ($P<0.001$) effect on preweaning mortality, and its inclusion into the analysis did not eliminate the significance of litter size, breed of dam, age of ewe and season of birth. Figure 2 illustrates the effect of birth weight on preweaning mortality. As birth weight decreases mortality increases, and lambs weighing less than about 1 kg have little chance of survival.

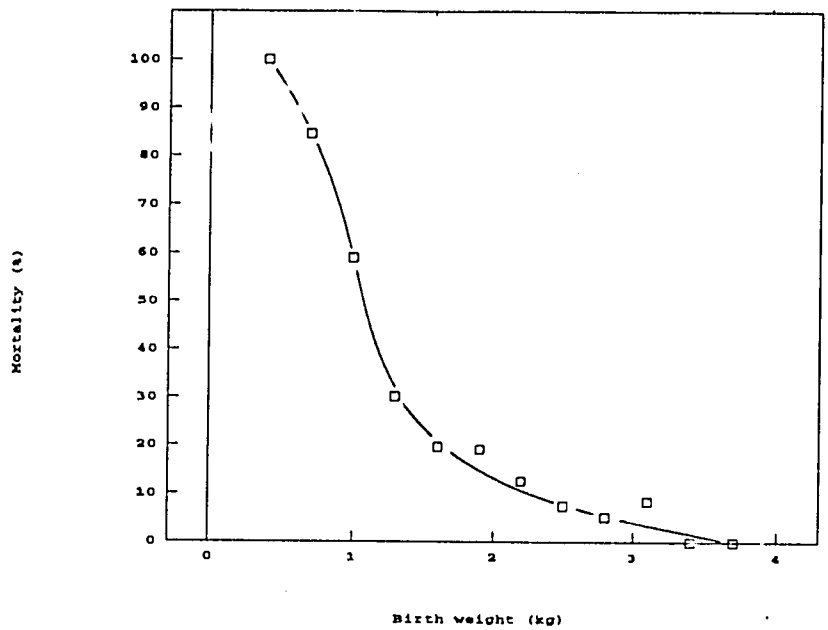


**Figure 2.** Effect of birth weight on preweaning lamb mortality.

Causes of mortality. A substantial number of lambs were born dead. In March several large single lambs and the smaller of triplets and quadruplets were still-born without any identifiable cause. In June and September, post-mortem examination of still-born lambs which were superficially normal showed accumulation of fluid in the body cavity of the lamb.

There were four main causes of death in lambs before weaning:

1. Insufficient milk consumption due to high litter size or inadequate milk production by the ewe. Undernutrition predisposes lambs to parasites.
2. Worms, particularly *Haemonchus contortus* which cause severe anaemia. Worms were most obvious in the final weeks before weaning.
3. Coccidia, which caused diarrhoea in lambs aged about 2 months.
4. Pneumonia in ewes in December 1992 when there was prolonged rain.

Wool coat

Birthcoat. The coats of lambs at birth were assessed as either straight or curly. Approximately half (48%) had curly coats, and half (52%) straight. The proportion of curly coats was 34% for E1, 38% for B1, 52% for S and 62% for H1. A chi-square test on the numbers in each category showed that this effect of breed on birthcoat type is statistically significant (Chi-square = 35.3, df = 3, P<0.001).

Wool score. Wool score is the product of wool cover (0-9) and wool length (0-9), so can range from 0 to 81. The effect of breed on wool score is summarised in Table 10. Wool scores at 3 months of age were similar for all breeds, but in older animals the scores were consistently B1 < H1 < E1 < S. B1 had the least wool, and S were the most woolly.

Table 10. Least squares means and standard errors for wool scores. Values for 3 months are for both sexes; values for 6 and 9 months are for females only.

| Breed group | Three months | Six months | Nine months |
|---|---|---|---|
| THREE BREEDS, ALL SEASONS | | | |
| n | 575 | 276 | 166 |
| Overall mean | 51.6 | 60.5 | 51.8 |
| E1 | $54.7^{a}$ 2.0 | $64.9^{b}$ 3.2 | $61.1^{ab}$ 4.4 |
| H1 | $55.9^{a}$ 2.1 | $51.9^{a}$ 2.5 | $54.0^{a}$ 4.3 |
| S | $54.7^{a}$ 1.4 | $68.0^{b}$ 2.2 | $68.7^{b}$ 4.6 |
| | ns | P<0.001 | P<0.05 |
| ALL BREEDS, MARCH ONLY | | | |
| n | 375 | 164 | 163 |
| Overall mean | 42.1 | 53.3 | 41.4 |
| B1 | $41.4^{a}$ 1.6 | $38.8^{a}$ 4.6 | $17.9^{a}$ 5.5 |
| E1 | $42.8^{a}$ 2.0 | $58.1^{b}$ 5.1 | $38.6^{b}$ 6.0 |
| H1 | $41.6^{a}$ 1.7 | $41.6^{a}$ 4.0 | $34.3^{b}$ 4.7 |
| S | $43.4^{a}$ 1.3 | $64.4^{b}$ 4.5 | $52.3^{c}$ 5.4 |
| | ns | P<0.001 | P<0.001 |

Means within each column without the same superscipt are significantly different (P<0.05).

Inclusion of birthcoat type in the analysis shown in Table 10 showed a significant effect of birthcoat ($P<0.05$). Lambs with curly birthcoats had higher wool scores at weaning (least squares mean 57.7±1.3) than those with straight birthcoats (54.7±1.3).

Effect of wool coat on lamb weights. Birthcoat type and wool score were included in the analysis of lamb weights, and statistically significant effects were found (in addition to the variables listed in Table 4).

Lambs with straight birthcoats had higher average weaning weights than lambs with curly birthcoats ($P<0.05$). The least squares means (±SE) for the 3-breed 3-season comparison were 8.09(±0.21) kg for curly coats and 8.57(±0.21) kg for straight coats.

The effect of wool score on lamb weight is summarised in Table 11. At 3 and 6 months of age, there was a positive correlation between wool score and lamb weight; bigger lambs were more woolly than smaller lambs. By 9 months the correlation had become non-significant.

Table 11. Least squares estimates of regression coefficients for lamb weight on wool score for three breeds in all seasons (Mean±SE). The analysis for 3 months is for both sexes; values for 6 and 9 months are for females only.

| Three months | Six months | Nine months |
|---|---|---|
| 0.013±0.006<br>P<0.05 | 0.029±0.010<br>P<0.01 | 0.016±0.013<br>ns |

Future plans for crossbreeding programme

Phenotypic characteristics (colour, ears and horns) of the four genotypes, behaviour and susceptibility to internal parasites are being assessed. Already we have found that the parasite burdens, as measured by nematode faecal egg counts, of the crossbred genotypes are slightly lower than those of the purebred Sumatra.

All the ewes born in March and June 1992, and ten rams from each genotype are being mated in 1993. Ewes are mated to sires of the same breed and, starting June 1993, lambs of BC, EC, HC and S genotypes will be born. The reproductive performance of the four genotypes will be evaluated on the basis of the first two lambings of the B1, E1, H1 and S ewes.

## DISCUSSION

Average litter size of the Sumatra and Garut crossbred dams was 1.55. Average weights of lambs were 1.83 and 8.7 kg at birth and 3 months. Weights of females at 6 and 9 months averaged 14.4 and 17.9 kg. There was a consistent effect of breed on lamb weight. E1, H1 and B1 crossbreds were 7, 15 and 20% heavier than Sumatra lambs.

In Tobago which has a similar climate to North Sumatra, a 6-year comparison showed that the growth of Barbados Blackbelly lambs to weaning was markedly superior to that of Virgin Island lambs (Rastogi et al, 1993). On the other hand, in New Jersey, USA, Horton and Burgher (1992) found that the growth rate of Virgin Island wethers was higher than the growth rate of Barbados Blackbelly wethers. It seems that there is considerable variation between the genetic potential of stocks of hair sheep in different parts of the tropics (e.g. Shelton, 1983). Many flocks are small and may not be typical of the general population.

In their islands of origin Barbados Blackbelly ewes are generally larger than Virgin Island ewes. The mean mature weight of B ewes in Barbados has been estimated to be 40-45 kg (Bradford et al, 1983) or 50 kg (Devendra, 1972). Weights of Virgin Island ewes in the US Virgin Islands average about 35 kg (Hupp and Deller, 1983).

Fat-tail sheep in Java are larger than Thin-tail sheep (Mason, 1978; Gatenby et al, 1988). In our Suka Damai flock the average weights of S and G1 ewes in 1992 were 22.0 kg and 25.6 kg, whereas the average for E was 26.2 and the average for H was 31.2 kg. Thus the breed differences in weights of lambs can be partly attributed to differences in mature size of the sire breed. Differences may also be due to hybrid vigour which would favour the crossbred groups.

Lamb mortality to weaning was 22.5%. This high value can be attributed to the high litter size and health problems associated with the hot-humid climate. Mortality was not significantly affected by breed of lamb.

Wool scores at 3, 6 and 9 months of age showed an effect of breed. The breeds were ranked B1 < H1 < E1 < S. Comparison with the ranking of body weights suggests that genotypes with a low wool score have high body weights. However, statistical analysis showed that for individual lambs there was a positive correlation between wool score and weight at 3 and 6 months.

## ACKNOWLEDGEMENTS

We thank the staff of the Suka Damai kandangs for their work with the animals and keeping accurate records, Mrs Michele Horne for keeping the computers functioning so we could analyse the data, and Mr Leo Batubara and Mr Setel Karokaro

for continued support of the SR-CRSP program in SBPT Sei Putih.

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