

Factors affecting survival of range sheep in the U.S. and characterization of sheep in Indonesia
by Subandriyo

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal Science
Montana State University
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Abstract:
Survivability and birth weight of range sheep were studied using lamb records of purebred Rambouillet, Targhee and Columbia sheep born from 1960 to 1982 at the Red Bluff Research Ranch near Norris, Montana. Least squares method for unequal subclass numbers was used to analyze survivabilities and birth weight. Heritability of survivabilities and birth weight were estimated based on paternal half-sib correlation. Year, type of birth, and birth weight generally were the important sources of variation for survivability. Birth weight was an important source of variation and had a curvilinear relationship with survivability. Year, type of birth, sex, age of dam and birth date were the important sources of variation for birth weight. Heritability was low for survivability and moderate for birth weight. Pooled heritability estimates for survivability at 60 d, 120 d and from 60 d to 120 d were .14,.12 and .06, respectively. The pooled heritability estimate for birth weight was .29. Moderate positive genetic correlations were found between birth weight and survivability at 60 d and 120 d, and low genetic correlation was found between birth weight and survivability from 60 d to 120 d.

Growth characteristics and ewe performance traits of Indonesian sheep were studied using data from two sources: the Research Institute for Animal Production station and from the villages, all located in West Java province. Village data were from Javanese thin-tailed sheep (JTT) obtained from Garut (GAR), Ciburuy (CIB) and Cirebon (CIR), representing high, medium and low elevation areas. Data from the station represented JTT and fat-tailed (FT). Least squares method for unequal subclass number was used to analyze those data. Repeatability for ewe performance traits were estimated using intraclass correlation and heritability of postnatal weights and growth were estimated using paternal half-sib correlation. Among the three locations GAR had the heaviest sheep, followed by CIB and CIR. Under experiment station conditions JTT were heavier than FT. Type of birth was the most important source of variation for growth characters. Growth curves indicated that under experiment station conditions sheep grew faster than under village conditions. JTT and FT are relatively prolific sheep. At the villages, GAR had the highest average litter size (1.67) followed by CIB (1.52) and CIR (1.15). At the experiment station JTT and FT had similar size litters (2.00 and 1.95). However, mortality was quite high, and high mortality was associated with multiple-born lambs. Lambing intervals both at the experiment station and villages were similar (259.3d and 252.4d). Repeatability study indicated that ewe weights were highly repeatable, but livabilities, litter weights, and lambing interval were lowly repeatable. Heritability of postnatal growth indicated that subsequent weights after birth and preweaning average daily gain were more highly1 heritable than birth weight.

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A thesis submitted in partial fulfillment
of the requirements for the degree

of

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in

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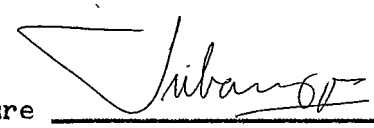
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ABSTRACT

Survivability and birth weight of range sheep were studied using lamb records of purebred Rambouillet, Targhee and Columbia sheep born from 1960 to 1982 at the Red Bluff Research Ranch near Norris, Montana. Least squares method for unequal subclass numbers was used to analyze survivabilities and birth weight. Heritability of survivabilities and birth weight were estimated based on paternal half-sib correlation. Year, type of birth, and birth weight generally were the important sources of variation for survivability. Birth weight was an important source of variation and had a curvilinear relationship with survivability. Year, type of birth, sex, age of dam and birth date were the important sources of variation for birth weight. Heritability was low for survivability and moderate for birth weight. Pooled heritability estimates for survivability at 60 d, 120 d and from 60 d to 120 d were .14,.12 and .06, respectively. The pooled heritability estimate for birth weight was .29. Moderate positive genetic correlations were found between birth weight and survivability at 60 d and 120 d, and low genetic correlation was found between birth weight and survivability from 60 d to 120 d.

Growth characteristics and ewe performance traits of Indonesian sheep were studied using data from two sources: the Research Institute for Animal Production station and from the villages, all located in West Java province. Village data were from Javanese thin-tailed sheep (JTT) obtained from Garut (GAR), Ciburuy (CIB) and Cirebon (CIR), representing high, medium and low elevation areas. Data from the station represented JTT and fat-tailed (FT). Least squares method for unequal subclass number was used to analyze those data. Repeatability for ewe performance traits were estimated using intraclass correlation and heritability of postnatal weights and growth were estimated using paternal half-sib correlation. Among the three locations GAR had the heaviest sheep, followed by CIB and CIR. Under experiment station conditions JTT were heavier than FT. Type of birth was the most important source of variation for growth characters. Growth curves indicated that under experiment station conditions sheep grew faster than under village conditions. JTT and FT are relatively prolific sheep. At the villages, GAR had the highest average litter size (1.67) followed by CIB (1.52) and CIR (1.15). At the experiment station JTT and FT had similar size litters (2.00 and 1.95). However, mortality was quite high, and high mortality was associated with multiple-born lambs. Lambing intervals both at the experiment station and villages were similar (259.3 d and 252.4 d). Repeatability study indicated that ewe weights were highly repeatable, but livabilities, litter weights, and lambing interval were lowly repeatable. Heritability of postnatal growth indicated that subsequent weights after birth and preweaning average daily gain were more highly heritable than birth weight.

INTRODUCTION

Total lamb production by a flock of sheep at weaning depends on the individual performance of each lamb and the number of lambs reaching weaning age. The latter depends on preweaning lamb survivability, conception rate and lambing rate. Lamb survivability is particularly important when lambs are raised under range conditions where high mortality has been observed. High preweaning lamb mortality not only reduces the total weight of lamb meat and wool produced, but also reduces potential genetic gain by limiting selection in breeding flocks, since fewer replacement animals are available. In addition, ram and management costs per unit of lamb produced are increased.

Several non-genetic factors have been associated with lamb mortality. One important factor is the effect of ewe age. The ewe age effect appears to be mediated through the effect on lamb birth weight as well as more highly developed mothering instincts in older ewes. Type of birth and sex of lambs are other important factors associated with lamb survivability. Lambs born in large litters usually have relatively low survivability. Higher mortality in multiple-born lambs also appears to be associated with light birth weights. Females tend to have higher survival rates than males.

The possibility of improving lamb survivability by genetic means is apparent since breed differences in lamb survival exist, and outbred lambs are generally more viable than inbred lambs. However, evidence for the existence of useful genetic variance affecting lamb survival rates within breeds is limited. Present evidence suggests

that heritability of survivability is low.

A better understanding of the genetic and non-genetic factors associated with lamb survivability is needed. Quantitative information regarding these factors is essential to the development of improved sheep management procedures for survival rates. Successful management procedures to improve survival will enhance production levels and economic returns from sheep production enterprices. Quantitative estimates of the factors affecting lamb survival under range conditions is an objective of this study.

Sheep in Indonesia are an important source of meat production, second only to chickens. They are particularly important in the villages. The total number of sheep in the country at present is about 4.2 million. In 1969-71 the number was 3.2 million (F.A.O.,1982). Thus the sheep population has increased substantially in recent years. Sheep are mostly concentrated in Java. Sheep numbers there represent approximately 80% of the total population, and of those almost 50% are concentrated in West Java (Sabrani et al., 1982).

The most prevalent types of sheep are Javanese thin-tailed (JTT) and fat-tailed (FT). The JTT are mostly found in the humid areas of West and Central Java, while FT are raised mostly in drier areas, for example in East Java and Madura. Sheep of both breeds carry some wool, but the small amount of wool on many animals, presence of some nearly woolless animals, and the very high incidence of kemp fibers in most fleeces suggests mixed wool and hair sheep ancestry. The wool is usually cut off and thrown away. These sheep under village conditions are usually kept in small herds by small holder farmers. A typical

farm has about 4 to 5 head. Sheep production is mostly a traditional semi-intensive system of back yard farming. The purposes of raising sheep are for meat, cash, saving and producing manure, and in the case of the Garut, for fighting rams as well.

Both types of sheep are reported capable of lambing more than once a year, with high incidence of multiple birth and high average litter size. Preweaning mortality is high. Production level for body weight is usually low with high variability from one location to another. Sabrani et al. (1982) reported that adult body weight ranged from 15 to 28 kg. Detailed data on characterization of these breeds are limited. The second objective of this study was the analyses of data to characterize production parameters under experiment station and village conditions for sheep in Indonesia.

LITERATURE REVIEW

Factors associated with preweaning survival rates

Preweaning lamb mortality is a major source of economic loss and lowered productivity in the sheep industry. Not only is the total weight of lamb meat and wool reduced, but also reduced selection intensity results because fewer replacement animals are available. Studies indicate that lamb mortality is high and variable between breeds and between flocks within breed in many countries.

Slee (1981) noted that typical mortality in British farms varied from less than 5% to over 40%, while in New Zealand the average mortality was slightly lower, ranging from 5-25% (Hight and Jury, 1970b; Meyer and Clarke 1978). Perinatal mortality in Australia was reported from 17.7% to 35% (Khalaf et al.,1979b). In the United States some workers reported similar preweaning mortality (Venkatachalam et al.,1949; Smith,1977).

Several workers have noted preweaning lamb mortality occurs within a few days after birth. Venkatachalam et al.(1949) working with Cotswold, Oxford, Hampshire, Southdown, Shropshire and Rambouillet in Michigan reported that approximately 71% of lamb deaths occured within two weeks after birth. Similar results were reported by Purser and Young (1964) in a study of Blackface and Welsh Mountain sheep in the United Kingdom. They observed 70% of lamb death losses occured within 14 d after birth. Hoversland et al. (1957) working with white face sheep in Montana reported 55.1% of lamb death occured within 5 d of age. Safford and Hoversland (1960), in a study based on autopsy data,

found that of deaths from birth to 45 d 56% and 73% of lambs died within the first 3 and 5 d of life, respectively. The major causes of death in this study were pneumonia, 16%; starvation, 13.8%; no visible lession, 15.8%; stillbirth, 14.3%; and dysentry, 11.8%. In addition delayed parturition, prepartum death, liver rupture, enterotoxaemia, haemorrhagic enteritis, umbilical haemorrhage and navel infection were classified as other significant causes of death. Wiener et al. (1983) in a study on Scottish Blackface, Cheviot and Welsh mountain breeds and the crosses among these breeds found that a majority of death before 24 h of age involved dystocia or delayed parturition, while later in life infectious disease and non-infectious disease became important causes.

A maternal effect on lamb viability is further substantiated by ewe age at lambing. Hight and Jury (1970b) in a study of Romney and Border Leicester and Border Leicester x Romney flocks in New Zealand indicated that lamb survival rate increased with increasing age of dam both for single and multiple born lambs. However, McDonald (1966) reported that perinatal mortality rate was highest among the lambs of young and aged ewe. Bichard and Cooper (1966) in a study of lowland flocks of Clun Forest sheep noted lamb mortality rates of 23.3%, 16.6%, and 12.9% from 1-,2-, and 3-yr-old and older dams, respectively. Earlier, Purser and Young (1959) in a study of two hill flocks indicated that the mortality rate of lambs from ewes at first lambing was double that of lambs from mature ewes in the same flocks. It was also reported that lamb mortality decreased with age of dam to 14.3% for lambs from 4- to 6-yr-old Welsh ewes. They discussed the

important relationship of parity of dam or age of dam with respect to livability of lambs, and pointed out that parity had greater effects on livability than age of dam. Gunn and Robinson (1963) working with Cheviot and Blackface in Scottish hill farms also reported that 2-yr-old ewes had higher mortality in both single and twin-born lamb. Wiener et al. (1983) found highly significant differences among parity of dams, with the first parity having the highest mortality. This was partly accounted for by birth weight, which was significantly lower for lamb born to first parity ewes.

Lax and Turner (1965) in a study of Merino lambs in two different environments, indicated that ewe age at lambing had a greater effect in the poor environment than in the better environment. Dickerson et al.(1975) in a study on Finn sheep and domestic crossbred, however, indicated that age of dam effect on survival rates was less prominent at birth than at the ages of 4 and 10 wk.

High lamb mortality in lambs from young ewes was explained by Purser and Young (1964). They indicated that young ewes tended to have lambs with lower birth weight, more stillbirths, but only few losses due to difficult lambing. However, McDonald (1966) in the autopsy of 390 lambs reported that high mortality among lambs from young and aged ewes was mostly associated with high incidence of lambs dying from dystocia and starvation, respectively. Similar results were reported by McMillan (1983) in a study on primiparous Romney ewes. He found that dystocia was the single largest cause of death within 3 d after birth and accounted for about 13 lambs/100 lambs born (mean mortality rates to weaning was around 30%). On the other hand, Hewson and

Verkaik (1981) in a study on Blackface hill sheep indicated that pain and shock of prolonged parturition in primiparous ewes inhibited maternal instinct.

Malik and Acharya (1972a) and Galal et al.(1974) reported that weight of ewes at lambing had significant effect on survivability of lambs as well. They noted that lambs with heavier mothers had better chance of surviving than those with lighter mothers, and the effect on livability was significant between birth to 120 d of age and between 15 to 90 d of age.

Ewe lambs consistently survived better than ram lambs. This has been reported by several workers (e.g. Hoversland et al.,1957; Lax and Turner,1965; Galal et al.,1974). Galal et al. (1974) reported that the effect of sex was highly significant at 7 d of age and significant at 60 and 120 d of age. Lax and Turner (1965) reported differences between survival rates of females and castrate males or entire males based on the proportion of lamb weaned to lamb born. They found differences of 3% and 4%, respectively. Other studies show differences in survivability between the sexes (table 1).

The effect of sex of co-twin was reported by Burfening (1972) in range Rambouillet, Targhee and Columbia breeds in Montana. He found that sex of lamb's co-twin significantly affected lamb losses from birth to 60 d of age. Lamb losses were 5.3% higher when a lamb was born co-twin to a male than when it was born co-twin to a female. He also reported that lamb losses were higher from birth to 60 d and birth to 120 d of age in males born as singles. A similar relation between sex and single-born lamb-losses has been reported by Gunn and

Robinson (1963) in Cheviot and Blackface lambs in Scottish hill farms. The differences in death losses between females born as singles and males born as singles varied from 1% to 8%, according to the farm. They noted that there was a greater frequency of difficult birth among males.

TABLE 1. SEX EFFECT ON SURVIVABILITY

Author	Ewe lambs	Ram lambs	Comments
Atkins (1980a)	78.8	77.6	Various breeds, Australia
Bradford et al.(1974)	91.0	82.0	Prolific breeds, U.K.
Hoversland et al.(1957)	80.1	76.5	White face,Montana, U.S.A.
Johnson et al.(1982)			
Single	86.6	81.7	Various breeds, New Zealand
Multiple	80.5	78.2	
Meyer and Clarke (1978)	85.2	82.7	Various breeds, New Zealand
Smith (1977)	64.0	59.7	Various breeds, Nebraska, U.S.A.
Venkatachalam et al. (1949)	76.0	66.0	Various purebreds, Michigan U.S.A.

An effect of birth weight on livability has been documented by several workers, and it is a common observation that lambs with smaller weight at birth had smaller chances for surviving. The physiological basis for this has been reviewed by McCutcheon et al.(1981) who explained that small lambs are susceptible to starvation and exposure primarily because: (1) higher ratio of surface area to volume, hence rate of heat loss per unit body weight in small lambs is higher than for large lambs; (2) since the metabolism per unit body weight of lambs is constant over a range of weights, small lambs cool

more quickly in less severe environment than do large lambs; (3) low level of body reserves in extreme cases. In addition, Alexander (1964) indicated that the insulation of the coat also may be low, because the density of secondary wool fibers is related to birth weight.

Phillips and Dawson (1937) reported 13.8% and 4.9% lower survival for male and female lambs, respectively, in the lower half compared to upper half of the birth weight distribution. Hoversland et al. (1957) reported that lamb mortality rapidly decreased as birth weight increased up to 3.6 kg, reached a maximum at 5.4 kg, and increased, in the case of male lambs, when birth weight was greater than 5.4 kg. On the other hand, McMillan (1983) in a study on Romney flocks, reported an optimum range of 3.3 to 4.1 kg of birth weight that gave minimum death losses. Purser and Young (1964) indicated the minimum death losses was achieved slightly above the mean. However, Shelton (1964) reported that minimum death loss was attained slightly below the maximum birth weight. From those last two studies, it should be pointed out that the later study was based on the fall born lambs, with typically low birth weight. Absolute birth weight may not be as important as birth weight expressed as a percent of dam's weight.

When death loss was regressed on birth weight, Shelton (1964a) obtained a reduction of 6.1% in mortality for each .454 kg increase in birth weight. Galal et al.(1974) reported an improvement of 8%, 9% and 11% of lamb livability per kg birth weight increase at age of 7, 60, and 120 d, respectively. Atkins (1980a) found an increase in birth weight of 1.2 kg from the overall mean to the optimal birth weight. Wiener et al.(1983) in a recent study found an increase of 11.6%

survival rates as birth weight increased 1 kg.

Comparisons between single-born lamb and twin-born lambs have been reported by several workers, who have indicated that twin-born lambs suffer higher mortality than do singles. Venkatachalam et al.(1949) found an average mortality of 35% for twins as compared to 20% for singles. Smith (1977) found differences in viability of multiple-born and single-born lambs of 4.2, 6.9, 7.7, and 2.5% at age of dam 2, 3, 4, and 5 yr, respectively. However, Johnson et al.(1982) found that multiple-born lambs had 5% lower survival than single-born lambs, with this effect accounting for a further 2.5% of variation in survival. McMillan (1983) in a recent study indicated the mortality of twin-born lamb was 39.2% as compared to 33% for single-born lambs. However, Phillips and Dawson (1937) found no differences in mean mortality between single- and twin-born lambs, inspite of 18% lower birth weight for twins.

Purser and Young (1964) and McMillan (1983) pointed out that single-born lamb mortality was due more to dystocia because of high birth weight, while twin-born lamb mortality was caused by starvation because of low birth weight. Hight and Jury (1970b) in an autopsy of 60% of the dead lambs from their study reported that 44.6% of single lambs died of dystocia and 15.1% from physiological starvation. However, of the multiple-born lambs autopsied, 16% died from dystocia and 41.7% from starvation. Of the remaining deaths, 11.6% were accounted for by infection and 10.3% by prenatal death.

Effects of high multiple birth on survivability is not as well known, except that large litter size is associated with high mortality

because of low birth weight. Bradford et al.(1974) in a study involving Finnish Landrace, Oxford Down, Border Leicester, Southdown, Tasmanian Merino and Welsh Mountain sheep reported that mortality increased in both sexes when litter size was increased. In this study which involved artificial rearing of many lambs, including all lambs in excess of two per litter, mortality was strongly associated with the depressed birth weight of larger litters. It was observed that for breeds other than Finnish Landrace, mortality of male lambs born in litter sizes of 3, 4, and 5 was on average 26%. This was more than twice the corresponding value for female lambs (11%), whereas in Finnish Landrace, lamb mortality was about 8% in both sexes. A study by Hinch et al. (1983) on Booroola flocks in New Zealand reported that triplet- and quadruplet-born lambs had lower probability of surviving compared to singles or twins of equal birth weight. Starvation resulting from mismothering of lambs born in litters of 3 or 4 was considered a possibility.

Cold exposure is another factor that causes death in lambs; consequently differences in response to cold would affect lamb viability. McCutcheon et al.(1981) and Slee (1981) explained that cold exposure depletes the energy reserves by causing an elevated metabolic rate which may exceed five times that of the resting metabolic rate, in addition to depressing suckling drive of hypothermic lambs. Cold exposure became more severe, causing lethal hypothermia and probably increased susceptibility to early postnatal hypothermia of lambs in which dystocia had damaged the central nervous system.

Samson and Slee (1981) studied under laboratory conditions 265 lambs of 10 breeds and found the major factors affecting cold resistance were breed and place of origin (hill breeds perform best), birth weight (heavier lambs were more cold resistant), skinfold thickness (thicker skin conferred greater cold resistance), and rate of recovery from hypothermia during cold exposure (feral breed tended to recover fastest). Under field conditions body temperature of newborn lambs also showed breed differences in the ability to resist hypothermia (Sykes et al.,1976). Mountain breeds tended to show greater resistance to hypothermia in the field during cold weather than other breeds, particularly the Finnish Landrace, Southdown, and Merino (Sykes et al.,1976; Slee,1981).

Part of the variation in cold resistance between breeds was also associated with coat type, independent of birth weight (Slee, 1978). From a study under laboratory conditions he reported that lambs with heavier and longer coats exhibited greater resistance. He also noted that closely clipped lambs still showed breed differences, but to a smaller extent. On the other hand, Purser and Karam (1967) in a study under field condition reported that lambs with fine coats suffered higher mortality as compared to intermediate and hairy lambs, particularly under harsh environment conditions at lambing. In this particular study they found the mortality of fine coat lambs was 13%, as compared to 5 % for lambs with intermediate and hairy coats. This indicates that coat type of lambs has a relationship with loss of body heat and energy reserves under cold temperature.

Birth date within year is related to some extent to survival rates. Hight and Jury (1970b) reported that lambs born earliest had lower survival rates. However, Dickerson et al.(1975) found no significant effect of birth dates within year on survivability.

Breed differences on survivability in the field have been documented by several workers (e.g. Venkatachalam et al.,1949; Sidwell et al.,1962; Atkins,1980a). Atkins (1980a) in a study of Border Leicester x Merino (mated inter se) (BLM), Corriedale, Polwarth, South Australian Merino (S.A.Merino) and Peppin Merino found variability in survival rates between breeds in multiple-born lambs. No difference in single-born lamb livability was found between breeds (survival rates ranged from 80.7 to 86.4 lambs weaned per 100 lambs born), but significantly different breed effects in multiple born lamb were reported. In this study, they found that S.A.Merino and Polwarth had significantly lower survival rates for multiple-born lambs (mean survival rates 65.0 and 69.5%, respectively) than other breeds (mean survival rates ranging from 76.8 to 80.4%). Sidwell et al.(1962) in a study of purebred Hampshire, Shropshire, Southdown, Merino and a strain of Columbia-Southdale in Maryland indicated that among those breeds there was little difference in livability in terms of lambs weaned of live lambs born; however, Merinos showed the highest viability (83.9% vs 75.1 to 83.9%). On the other hand, Sidwell and Miller (1971a) in a study of Hampshire, Columbia-Southdale, Targhee, Suffolk, Dorset and some crosses indicated that among the purebred breeds Columbia-Southdale had the highest number of lambs weaned of lambs born alive (83.8% vs 76.9 to 83.1%). Meanwhile Smith (1977)

working with Suffolk, Hampshire, Rambouillet, Dorset, Targhee, Corriedale, Coarse wool and some crosses in Nebraska, indicated that among the purebreds, Hampshire and Corriedale had the highest mortality rates (44.5% and 44.9%, respectively), while coarse wool and Targhee had the lowest (32.0 and 33.4%, respectively). Venkatachalam et al.(1949), in a study of Costwold, Oxford, Hampshire, Southdown, Shropshire and Rambuillet in Michigan, classified the first three as heavy breeds and the second three as light breeds, found that heavy breeds had significantly higher mortality (38.3 to 42.2%) compared to the light breeds (18.0 to 20.6%). Meyer and Clarke (1978) also found that the breed with lightest birth weight had the higher viability.

In addition to the effect of body weight and cold resistance, breed differences in survivability also involve maternal and lamb behaviour. Slee (1981) in a study on some mountain, feral, and lowland breeds indicated that feral breeds (Boreray, Blackface, and Soay) followed by mountain breeds (Cheviot, Scottish Blackface and Welsh) and the Oxford (lowland breed) had consistently lower mortality, earlier postnatal suckling and earlier development of an effective maternal bond. However, most of the lowland breeds (Southdown, Finnish Landrace, and Border Leicester) were correspondingly slow to suckle, slow to demonstrate maternal bond and suffered high mortality.

A deleterious effect of inbreeding has been noted by several workers. Galal et al.(1981), with inbreeding level of 0 to 45% (majority below 25%), reported that inbreeding of lambs increased mortality, but the most highly inbred class of lambs did not have the highest mortality. Wiener and Hayter (1975) in a study of Scottish

Blackface, Cheviot, and Welsh Mountain breeds and the crosses among them indicated that inbreeding of lambs (approximately 25%) reduced survival by about 8 lambs per 100 born. The effect was greatest for Blackface lambs and negligible in Cheviot and Blackface x Welsh lambs. However, Doney (1957) in his study with Peppin Merinos, with relatively few ewes losing lambs after birth, found no effect of inbreeding of the dam on lamb survival. Meanwhile, Doney (1966) in a further study on Blackface sheep found an effect of inbreeding both of dam and lambs on lamb survival. Deleterious effects of inbreeding both of dam and lambs on survival were also reported by Wiener et al.(1983) and Macleod et al.(1983) in a study on the same flock which indicated that inbreeding of 25 to 59% would increase mortality by increasing weak lambs, reducing birth weight, and increasing the incidence of infectious disease especially respiratory diseases. From these series of studies they suggested that crosses of inbred lines would decrease lamb mortality.

Finally, evidence for the existence of useful genetic variance affecting lamb survival rates within breed is limited. According to Piper et al.(1982) lamb survival is an all-or-none variable when treated as a trait of the lamb, therefore the heritability of viability cannot be determined from offspring-parent analysis, because dead lambs leave no offspring, but can be estimated from the variation in mean survival between half-sib groups of lambs. Piper and Bindon (1977) cited by Piper et al.(1982) in a study on two flocks of random-bred Merino found the heritability of survival from birth to 7 d of age to be .02 and birth to weaning .05, while for the second flock

(4160 lambs and 232 d.f. for sires) the estimate was slightly negative. Similar low estimates of heritability were found by Smith (1977) in a study on some purebred (Suffolk, Hampshire, Rambouillet, Dorset, Targhee, Corriedale and Coarse Wool) at Clay Center, Nebraska. Based on the paternal half-sib method he estimated the heritability of preweaning mortality to be .06, with a positive genetic correlation between mortality and dystocia (.45) and vigor (.16), but a negative genetic correlation with birth weight (-.28). Low estimates of heritability of survival rates were also found by Fogarty et al.(1982) in a study on some purebred and synthetic lines of sheep. Using the paternal half-sib method and individual records and mean records, they found the heritability of neonatal survival to be .02 and .10, respectively, and of postnatal survival to be .07 and .15, respectively. This study indicates that individual records give lower estimates of heritability. They also reported genetic and phenotypic correlations between neonatal and postnatal survival of .78 and .08, respectively. On the other hand Shelton and Menzies (1970) studying two Rambouillet flocks in Texas obtained heritability estimates of .13 and .19, respectively. Malik and Acharya (1972a) found heritability estimates in Indian sheep of .10 and .26 for survival rates between birth and 14 d and between 15 d and weaning, respectively.

Considering low heritability estimates and the increase of generation interval in progeny testing programs for choosing replacement sires, it means that there is limited opportunity for improving lamb livability by direct selection within breeds. An alternative approach would be an indirect selection program to change

the traits that are closely related to livability such as birth coat, resistance to cold exposure and skin thickness.

Factors associated with growth characters

Birth weight. Variation in birth weight is known to be affected by genetic differences between lambs, by environmental influences, and by accident of development. These effects are mediated entirely or in part through the dam (Chapman and Lush, 1932; Bradford, 1972a). Wallace (1948) demonstrated a large effect of maternal nutrition in late pregnancy on birth weight of both single and twin lambs, and he noted that lambs from low plane ewes weighed only 50 to 60% as much as lambs from ewes on a high plane of nutrition. Khalaf et al.(1979a) in a study of Scottish half-bred ewes found similar results for twins and triplets, but found no effect of dam's plane of nutrition on singles. Twin and triplet lambs born from the low plane nutrition ewes weighed 19% and 26% less than those from ewes on the high plane of nutrition, respectively. Dahmen et al.(1978) in a study of Panama and Finnish Landrace x Panama ewes on different planes of nutrition found no differences between single or between triplet born lambs associated with plane of nutrition, but they found a significant difference between twin born lambs from dams on high and low planes of nutrition.

An effect of age of dam on birth weight has been reported by several workers, and a curvilinear relationship is the general pattern found in most studies (Blackwell and Henderson, 1955; Hohenboken et al.,1976a). Vesely and Peters (1964) indicated that 2-yr-old ewes bore lighter lambs than older ewes, and the birth weight showed a slight

increase for each year increase in age of dam up to 6 yr. Nelson and Venkatachalam (1949) reported that mature ewes produced lambs with 10% heavier birth weight than 2-yr-old ewes. Chopra and Acharya (1971b) in Indian sheep found that ewes 5 yr of age and older produced heavier lamb at birth while 2-yr-old ewes produced the lightest. Alrawi et al.(1982), however, in a study on Awassi sheep found that age of dam did not affect birth weight significantly.

In most studies there is evidence that lambs born from the larger litters had lower birth weight. Vesely and Peters (1964) and Abdel Azis et al.(1978) found that type of birth had the largest influence on birth weight. Nelson and Venkatachalam (1949) found that twin-born lambs weighed 22% less than single lambs. Bichard and Cooper (1966) in a study of lowland flock sheep found that twins and triplets were 20% and 30% lighter, respectively, than singles. Fitzhugh and Bradford (1983) in a study of hair sheep reported the range of birth weights to be 1.8 to 3.3 kg. The average weights of twins, triplets and quadruplets as a percentage of single weights were: for Pelibuey- twins 81, triplet 63 and quadruplets 52%; for Virgin Island sheep - 87, 87, and 68%; and for Barbados Blackbelly - 93, 80, and 70%. Dickinson et al.(1962), in a study from an egg transfer experiment concluded that twins are expected to be 78% and triplets 62% of the mean weight of singles.

An effect of sex of co-twin on the sex differences in birth weight of twins was reported by Donald and Purser (1956), such that the difference between males and females in unlike sex pairs was greater than that in like sex pairs. A similar result was reported by

Burfening (1972) in range Rambouillet, Targhee and Columbia sheep. He found that lambs co-twin to a female were significantly heavier than lambs born co-twin to a male. The greatest difference in birth weight between males and females occurred in the mixed sex litters (.34 kg) as compared to the difference (.08 kg) between males and females born in like sex litters.

Chopra and Acharya (1971b) in a study on Indian sheep over two periods reported that year differences during the second period contributed the largest source of variation and were responsible for about 14% of the total variation. Abdel Azis et al. (1978) reported that year effects only contributed 7.8% of the variation. However, Gjedrem (1967), Dass and Acharya (1970) and Buvanendran et al.(1981) indicated that year did not significantly influence birth weight. It was suggested that year to year variation in pasture and in supplementary feed available was responsible for the differences observed.

Season of lambing is another source of variation that should be considered in accelerated lambing systems or in continous breeding system. A significant effect of season has been demonstrated by several workers (Chopra and Acharya,1971b; Malik and Acharya, 1972b; Bhadula and Bhat, 1980). Malik and Acharya (1972b) indicated that lambs born from March to April (spring) were .14 kg heavier than those born from September to October (autumn). However, Bhadula and Bhat (1980) found that lambs born from December to May were heavier than those born during the remainder of the year. Buvanendran et al. (1981) in a study in Nigeria noted that lambs born during the dry season were

lighter at birth than those lambs born during the wet season. An effect of season was reported by Shelton (1964a) in Texas, U.S.A. and Gould and Whiteman (1971) in Oklahoma, U.S.A., who found that fall-born lambs had lighter birth weights than those born in spring. It was suggested that the manifestation of fetal dwarfing was caused by high temperature (Shelton, 1964b) and possibly exerting its effect via the placenta (Alexander, 1968). Bhasin and Desai (1967) and Khan and Bhat (1981) demonstrated that season was not an important source of variation in birth weight.

Postnatal growth. Postnatal growth is the major factor influencing weaning weight. The rate of postnatal growth is influenced by the quantity of milk produced by ewes, especially the first half of lactation (Hunter, 1957). deBaca et al.(1956) found that lamb growth was essentially linear from birth to 135 d of age. However, Harrington et al.(1958) in a study of range sheep concluded that lamb growth from birth to 120 d of age could be linear or curvilinear depending upon the condition of the year. Hunter (1957) reported that the growth curve was linear the first 3 mo, but curvilinear from birth to 8 mo of age. Gould and Whiteman (1971) found that growth rate was linear from birth to 70 d of age, and curvilinear from birth to 168 d of age. Wilson (1983) noted that growth rate in hair sheep was linear from birth to 6 mo of age and curvilinear from birth to 12 mo of age.

An effect of number of lambs reared and age of dam on postnatal growth has been demonstrated in several studies. Of the different environmental factors for which weaning weights are frequently adjusted, type of birth has the greatest effect. Bradford (1972a)

reviewed several studies which indicated that the estimates of the difference in weaning weight between ages of 100 to 150 d ranged from about 3 to 8 kg. The differences were less under farm flock conditions, where ewes, and often lambs, were fed supplement during the suckling period, than under range conditions. Osman and Bradford (1965) found that in adjusting weaning weights within a flock multiplicative corrections were superior to additive.

In most studies there is evidence that weight of lambs born twin but reared as singles is intermediate between twins and singles. Bichard and Cooper (1966) who studied three different ages (21, 42 and 112 d of age) found differences between singles and twins of 5.5, 8.28, 11.05 kg and 2.65, 5.83, 8.08 kg, respectively. Carter et al.(1971) reported preweaning daily gain and 120 d weight of singles, twins and twin reared as singles to be 278, 230, 250 g and 39.8, 33, 35 kg, respectively. Similar results were reported by Sidwell et al.(1964) and Sidwell and Miller (1971b).

An effect of type of birth itself without considering numbers of lamb reared has been documented by several workers as well, and usually lambs from large litter size have lower postnatal growth. Nelson and Venkatachalam (1949) reported that twin lamb weighed 7% less than single lambs at weaning. Dickerson et al.(1975) found that twin and triplet lambs gained less than singles to 10 wk of age (-3.7 and -3.9 kg), thus weighed less at 10 wk (-4.5 and -5.4 kg). However, deBaca et al.(1956) found a difference of 7.7 kg in American sheep and Alrawi et al.(1982) found a differences of 1.8 kg in Awassi sheep between twins and singles lambs. Martinez (1983) in a study of 3

breeds of hair sheep in Venezuela indicated that while breeds did not affect preweaning daily gain (birth to 90 d), type of birth was a significant effect. He found that triplets and twins gained less than singles (97 and 93 g vs 113 g), thus, at weaning (90 d) twin-born lambs weighed 86% of the weight of singles, triplets weighed 79% of single weight and 92% of twin weight. Patterson (1983) in a study on Barbados Blackbelly in Barbados found that at weaning, twins weighed 81% as much as singles, triplets 72% and quadruplets 64%.

With respect to age of dam, ewes lambing at 2 yr of age usually raise lambs much lighter than mature ewes. Bradford (1972a) indicated that differences due to age of dam may be nearly as great as that between twins and singles, and was often confounded with lambing date. Two-yr-old ewes usually rear significantly lighter lambs than those in 3 to 5 or 6 yr range, though the difference appears dependent upon the proportion of mature weight at 2 yr (Osman and Bradford, 1965). Ewes above 5 or 6 yr of age tend to wean lighter lambs than the 3-to 5-yr-old group (Sidwell et al.,1964; Mavrogenis and Louca, 1979; Bhat et al.,1981). This suggested that the relationship between age of dam and postnatal growth is curvilinear (Blackwell and Henderson, 1955; Hohenboken et al., 1976b; Mavrogenis and Louca, 1979).

Quantitative estimates in performance differences of lambs born from young and mature ewes have been reported in some studies. Ten percent differences between lambs reared by 1- and 2-yr-old dams and 3- and 4-yr-old dams has been reported by Buvanendran et al. (1981). Nelson and Venkatachalam (1949), on the other hand, found differences of 5% between lamb reared by mature and 2-yr-old ewes. Hazel and

Terrill (1945) and Vesely and Peters (1964) indicated that mature ewes weaned 2.8 kg and .82 to 1.4 kg heavier lambs than 2-yr-old ewes, respectively. Patterson (1983) in a study of Barbados Blackbelly sheep in Barbados found that ewes less than 19 mo, 19 - 35 mo, and more than 35 mo of age weaned lambs weighing 10.8, 11.8 and 9.9 kg, respectively.

Sex has a significant influence on postnatal growth in most studies. Ram lambs usually grow faster and weigh more at weaning than ewe lambs. Nelson and Venkatachalam (1949) reported that ram lambs were 5% heavier than ewe lambs. Hazel and Terril (1945) and Blackwell and Henderson (1955) found differences of 3.8 kg and 2.0 kg, respectively. Harrington et al. (1958) reported differences of 2.3 kg at 135 d of age. Eikje (1971) in a study on Norwegian sheep at approximately 42 d weight and weaning weight in 5 locations found the differences between males and females of .54 to 1.20 kg and 3.22 to 3.80 kg, respectively. Dickerson et al. (1975) in a study on Finnish Landrace and domestic crossbred indicated that ram lambs gained .9 kg and weighed 1.1 kg more at weaning (70 d) than ewe lambs. A difference due to sex of lamb of 1.62 kg was found in Awassi sheep (Alrawi et al.,1982), and 1.80 kg in Indian sheep (Dass and Acharya, 1970). Bradford (1983) in a study on hair sheep found that ram lambs gained faster than ewe lambs from 7 - 30 d (86 vs 72 g), but relatively the same from 30 - 90 d (44.2 g vs 44.6 g). In terms of weight at 30 and 90 d of age he found that males were heavier than females, although the differences were small (4.6 kg vs 4.1 kg at 30 d and 7.9 kg vs 7.1 kg at 90 d). Nevertheless, some studies also indicated that sex had no

effect on postnatal growth (Malik and Acharya, 1972b; Abdel Azis et al.,1978; Bhadula and Bhat, 1980; Buvanendran et al.,1981).

Malik and Acharya (1972b) demonstrated that year and season were the major source of variation, whereas sexes, breed and ewe weight did not significantly affect lamb weaning weight. Year effect as an important source of variation was also reported by Blackwell and Henderson (1955); Karam (1959), Vesely and Peters (1964), Sidwell et al.(1964), Gjedrem (1967), Chopra and Acharya (1971b), and Dass and Acharya (1970). This indicated that weather conditions affected the quality and quantity of feed supply, and either directly or indirectly affected the flock's general state of health (Blackwell and Henderson, 1955; Chopra and Acharya, 1971b).

An effect of season on postnatal growth in most of the studies parallels the effect of season on birth weight. Studies in Indian sheep indicated that lambs born from December to May had heavier preweaning gain and weaning weight than lambs born at other months (Malik and Acharya, 1972b; Bhadula and Bhat, 1980,1981; Khan and Bhat, 1981). Malik and Acharya (1972b) found that lambs born in February and March weaned heavier by 3.9 kg than those born in September to October. Bhadula and Bhat (1980) reported lambs born from December to May were 1 kg heavier than lambs born in other months, but the differences were not significant. Gould and Whiteman (1971) found that fall born lambs gained less than spring born lambs (.33 vs .30 kg/d), thus weighed 2.54 kg less at weaning (70 d). Karam (1959) found that summer born lambs in an Egyptian sheep were .70 kg heavier than winter born lambs at 4 mo. However, Abdel Azis (1978) in a study on Merino

flocks in Egypt indicated that the effect of season on weaning weight was opposite to the effect of season on birth weight. Lambs born from May to October (summer) were significantly heavier than those born from November to April (winter). They elucidated that May to October lambs were born to ewes which suffered from unfavorable conditions especially those lambs born late in the season. As lambs grew older, the weather became mild and the lambs and their mothers had access to new pasture.

Of all sources of variation affecting postnatal growth, birth weight was the most influential (deBaca et al, 1956; Harrington et al.,1958). deBaca et al.(1956) found that the inclusion of birth weight in the model reduced residual variation. In this particular study they found an increase in weaning weight of 1.14 to 2.71 kg for each .454 kg increase in birth weight. Harrington et al.(1958) reported that birth weight accounted for 34 to 44% and 23 to 33% of the variation at 45 and 135 d of age, respectively. They found .68 to 1.18 kg and 1.20 to 1.36 kg increase in 45 and 135 d weight for each .454 kg increase in birth weight, respectively. Gjedrem (1967) in a study on Norwegian sheep also found that birth weight significantly affected 14 d, 28 d, 42 d and weaning weight. In this particular study the regression coefficients of these weights on birth weight were 1.49, 1.86, 2.35, and 3.40 kg/kg, respectively. Farid and Macharachian (1978) reported that the regression of weaning weight on birth weight was highly significant (b = 1.42 kg/kg), but the regression for preweaning daily gain (b = 5.15 g/kg) was not significant.

Postweaning growth. Postweaning growth, as in preweaning growth, is also affected by some non-genetic factors. Mavrogenis and Louca (1979) in a study on Awassi, Cyprus fat-tailed, Chios sheep and their crosses at 10, 15, and 20 wk of age and in postweaning gain from weaning (5 wk) to 20 wk of age indicated that sex, type of birth, and breed were the major factors that affected postweaning growth. They noted that age of dam had no effect on postweaning growth rate. It was suggested that lamb growth potential after weaning may be independent of maternal effects. Non-significant effects of age of dam on postweaning growth rate and postweaning weight were also reported in several studies (Chopra and Acharya, 1971b; Bhadula and Bhat, 1980,1981; Alrawi et al.,1982). However, Khan and Bhat (1981) found that age of dam affected 6 mo weight, but not growth rate to slaughter and slaughter weight.

As in the case of postnatal growth, sex is an important source of variation in postweaning growth. Ram lambs grow faster and are heavier than ewe lambs. Bhadula and Bhat (1980) and Alrawi et al. (1982) indicated that the effect of sex became more pronounced with advancing age. However, Martinez (1983) reported that sex had no significant effect on 6 mo weight. Differences of 3.3 to 6.9 kg have been noted from Awassi sheep between ram lambs and ewe lambs at 6 mo weight (Bhat et al., 1981; Alrawi et al., 1982), and Bhadula and Bhat (1980) found differences of 4.1 kg and 8.1 kg between ram and ewe lambs of Indian sheep at age of 6 and 9 mo.

With regard to type of birth effects, Mavrogenis and Louca (1979) indicated that single lambs were heavier than those from multiple

births, but no differences were found in growth rate after weaning between lambs from different size litters. Martinez (1983) found similar results, in addition to a significant breed effect. In this study they found that triplets weighed 85% of the weight of singles, and twins weighed 94% of singles.

Season is another source of variation that should be considered in postweaning growth. The effect of season in Indian sheep was similar to that found for postnatal growth. Lambs born from March to May were heavier than those born in September to November (Malik and Acharya, 1972b; Khan and Bhat, 1981). However, Gould and Whiteman (1971) indicated that fall born lambs gained faster after weaning at 70 d of age and reached market weight 6 d earlier than spring born lambs.

Yearling weight. Yearling weight is another important measurement of sheep productivity. This trait is closely related to future production, and it is thought to be more closely related to those traits than is weaning weight.

Yearling weight, as was true for postnatal and postweaning growth, also is affected by non-genetic factors. Several studies indicated that sex is the most important source of variation (Chopra and Acharya, 1971b; Dass and Acharya, 1970; Malik and Acharya, 1972b; Alrawi et al.,1982). Some other non genetic factors such as type of birth, and year of birth also affect yearling weight (Karam, 1959; Malik and Acharya, 1972b; Alrawi et al., 1982).

Chopra and Acharya (1971b) in a study on Indian sheep indicated that yearling rams weighed 10.5 kg more, which was about 40% heavier,

than yearling ewes. Karam (1959) in an Egyptian sheep study indicated that yearling rams were approximately 5 kg heavier than yearling ewes. Similar results were reported by Alrawi et al (1982) who found differences of 4 kg. Abdel Azis et al. (1978), however, in a study on a Merino flock under Egyptian conditions found that yearling rams weighed almost the same as yearling ewes (33.0 vs 32.9 kg).

Type of birth is another important source of variation. Phillips et al. (1940) in a study on Rambouillet and Corriedale indicated that singles are heavier than twin on average throughout the first year. Hazel and Terrill (1946a) in a study of yearling ewes found that single lambs were 2.72 kg and .23 kg heavier than twins and twins raised as singles, respectively. Karam (1959) and Alrawi et al. (1982) found small differences between singles and twins at one-year of age, but the differences were significant (.93 kg and 1.6 kg, respectively). Abdel Azis et al. (1978) found that type of birth had no effect on yearling weight.

Year differences in yearling weight reflect variation in feeding and disease condition as well as differences in genetic composition of the flock. Hazel and Terrill (1946) in two years study found a difference of 3.13 kg. Karam (1959) in an 11-yr study found that yearling weight fluctuated from 29 kg to 41.8 kg. On the other hand Abdel Azis et al. (1978), in a 3-yr study, found that yearling weight fluctuated from 32.2 to 34.4 kg.

Malik and Acharya (1972b) indicated that season of birth effects on yearling weight and pre- and post-weaning growth were similar. Lambs born in March to April were heavier than those born in September

to October. Similar results were reported by deFiguiredo et al. (1983) in a study on Brazilian hair sheep, in which it was found that lambs born during the dry season consistently were lighter than those born during the rainy season. These differences tended to decrease from 100 to 360 d of age. In this particular study they found differences due to season of 2.7 kg at 100 d and 1 kg at 360 d of age. However, Karam (1959) found an opposite effect of season of birth on yearling weight as compared to weaning weight. He found that lambs born during winter season weighed slightly but not significantly more than those born during the summer. In this study he found that summer born lambs at weaning weighed 19.6 kg, while winter born lambs weighed 18.9 kg. However, at yearling age he found that summer born lambs weighed 35.5 kg and winter born lambs 36.1 kg. He elucidated that the differences were due to the differences in feed availability from weaning to yearling age.

Phenotypic correlation. It is important to know the degree of association between growth traits. Farid and Macharachian (1978) in a study on Iranian fat-tailed sheep reported highly significant phenotypic correlations between birth weight and weaning weight, preweaning daily gain, body weight at feedlot and total feedlot daily gain. The correlation coefficients were .45, .28, .48 and .23, respectively. Highly significant correlations between weaning weight and subsequent weights in the feedlot, were also found ranging from .48 to .95.

Shelton (1964a) also found highly significant correlation between birth weight, rate of gain to 120 d and yearling weight. Correlations

ranged from .48 to .98.

Dass and Acharya (1970), mostly found significant, positive correlations between birth weight, gain in the first month, gain in the second month, gain in the third month, gain in the fourth month, weaning weight and yearling weight. The correlations ranged from .001 to .69, with the low and non-significant correlations between birth weight and gain in the fourth month (r = .001), gain in the third month (r = .04) and yearling weight (r = .07).

Mavrogenis et al. (1980) found positive correlations among birth weight, weaning weight, 4 different weights up to 20 wk, daily gain from birth to weaning and daily gain from weaning to 20 wk of age. The coefficients of correlation were in the range from very low to high (.08 to .92). In this particular study the lowest correlation was between birth weight and average daily gain from weaning to 20 wk of age (r = .08), followed by weight at 5 wk and gain from weaning to 20 wk of age (r = .13), birth weight and daily gain from weaning to 20 wk of age (r = .15) and between birth weight and gain from birth to weaning (r = .18).

High phenotypic correlations between birth weight and subsequent weights were reported by Martin et al. (1980) in a synthetic line of sheep. The correlations ranged from .43 to .83. Similar high phenotypic correlations among birth weight and subsequent weights up to weaning were also reported by Gjedrem (1967) in Norwegian sheep. In this particular study he found a correlation ranging from .29 to .90, with the lowest between birth weight and weaning weight.

Ragab et al. (1953), also found high phenotypic correlations

between birth weight, weaning weight and marketing weight. The correlation ranged from .48 to .86, with the lowest between birth weight and marketing weight.

Low estimates of phenotypic correlation were reported by Karam (1959) among birth weight, weaning weight and yearling weight. In this study the correlation ranged from .21 to .32 with the lowest between birth weight and yearling weight.

Similar low estimates of phenotypic correlations were also reported by Khan and Bhat (1981) between birth weight and 6 mo weight and slaughter weight. The correlation ranged from .02 to .16.

Genetic correlation. Mavrogenis et al. (1980) reported that the genetic correlation between birth weight and subsequent weight and gain were low (r_g = .16 to .21). In this particular study they also found low genetic correlation between remaining weights and gains (r_g = .19 to .25). Chopra and Acharya (1971a) estimated the genetic correlation between birth weight and weaning weight to be .10.

However, consistently high genetic correlation among weights at different ages were reported by Gjedrem (1967) and Martin et al. (1980) .42 to .97 and .62 to 1.04, respectively. Alrawi et al. (1982) also found consistently high genetic correlation among preweaning growth traits. In their study they found genetic correlation in the range of .46 to .71. Thrift et al. (1973) also reported high genetic correlations between weight and gain (r_g = .40 to .98), however, some correlations were negative (r_g = -.34 to -.81).

Heritabilities of growth characters. Nelson and Venkatachalam (1949) in a study of 5 breeds reported the heritabilities of birth

weight and weaning weight as .61 and .33 respectively. Ragab et al. (1953) in a study on Ossimi sheep reported estimates of the heritabilities of birth weight (.34), weaning weight (.10) and marketing weight (.29). Hazel and Terrill (1946b) in a study on weaning traits of range sheep reported .17 as the heritability of weaning weight. Blackwell and Henderson (1955), in a study on 4 breeds of sheep under farm flock conditions found the heritability of birth weight and weaning weight of .33 and .07, respectively. Karam (1959) reported the heritabilities of birth weight and weaning weight of Rahmani sheep to be .16 and .18, respectively. Chopra and Acharya (1971a) reported the heritabilities of birth weight and weaning weight of .10 and .22, respectively.

Bichard and Yalcin (1964) in a study of heritability of weight of crossbred lamb from birth to 15 wk of weight found that the heritabilities were low, ranging from .02 to .10. Gjedrem (1967) estimated the heritabilities of weight at birth, 14 d, 28 d, 42 d, and weaning weight as traits of lamb to be .12, .12, .12, .13, and .18, respectively. When the heritabilities were classified as characteristics of dam, he reported values of .17, .21, .22, .20, and .12, respectively. Martin et al. (1980) estimated the heritabilities of weight at birth, 4 wk, 8wk, 12 wk, and 16 wk, based on paternal half sib analysis to be .17, .24, .22, .23, .23, respectively. When the estimates were based on the regression of offspring on dam, the heritabilities were .24, .20, .18, .23, .28, respectively.

Mavrogenis et al. (1980), on the other hand, in a study on Chios sheep reported the heritabilities of birth weight, weaning weight (35±2 d), body weight at 5 wk, 10 wk, 20 wk, average daily gain from birth to weaning and average daily gain from weaning to 20 wk of age to be .13, .36, .34, .63, .66, .35, and .56, respectively. This suggested that postweaning growth was more highly heritable than preweaning growth. However, Dass and Acharya (1970) who estimated the heritabilities of birth weight, gains at the first, second, third and fourth months and weaning weight found estimates of .45, .12, .33, 1.11, .67, and .68, respectively. Thrift et al. (1973) in a study of some crossbreds found the heritabilities of birth weight, gain from birth to weaning (70 d), weight at 70 d, gain from weaning to market weight and market weight of .10, .09, .10, .23, .21, respectively. Heritability of .14, .73, .29 was found for birth weight, weaning weight and gain from birth to weaning (Alrawi et al., 1982).

Ercanbrack and Price (1972), in a study on Crossbreds, Rambouillets, Targhees and Columbias, reported heritabilities of birth weight, weaning weight, average daily gain from birth to weaning of .12 to .31, .15 to .45, and .14 to .39, respectively.

Osman and Bradford (1965), however, in a study of two different environments (high level flock management and low level flock management) found the heritabilities of birth weight and 120 d weight of .45 and .40 in high management flock and .19 and .19 in low management flock.

This review suggests that genetic variation was influenced by breed, method of estimation and management.

Factors associated with ewe performances

Economic returns in sheep production are strongly related to the frequency and number of lambs born (Dickerson et al., 1972), weight of lambs weaned and to other measures of reproductive efficiency (Sidwell and Miller, 1971a). Several genetic and nongenetic factors affect those traits. Therefore, better understanding of those factors will enable the producer to manage the influences which reduce reproductive efficiency.

Litter size. Reeve and Robertson (1953) reviewed factors that influenced multiple births in sheep and concluded that non-genetic factors such as age of ewe, earliness of lambing, body weight of ewes and level of nutrition prior to at mating had profound effect on frequency of multiple births. They also concluded from the available evidence that there might be breed differences in incidence of multiple births, but the genetic fraction of individual variation was small.

With regard to the effect age of ewe, most studies that cover a wide range of breeds in many different countries, show a similar pattern of a rise with age of ewe to a maximum followed by a fall for number born, number weaned, ewes lambing per ewe joined, and lambs weaned per lamb born (Turner, 1969). Litter size or number of lambs born per ewe lambing also increases with age of ewe to a maximum at age of 4 to 8 yr and then declines, but sometimes only very slightly (Reeve and Robertson, 1953; Belic, 1954; Ragab and Asker, 1957; Karam, 1957; Yalcin and Bichard, 1964; Forrest and Bichard, 1974a; Rottensen

and Ampy, 1971; Maijala, 1967; Arnold and Charlick, 1980; Amir et al., 1981). Mason (1980) in a study on Indonesian sheep, however, reported that litter size increased up to the third parturition but little thereafter. Turner (1969) explained that in flocks with a high average level of reproduction, ewes reach their maximum performances and start to decline at an earlier age than in flocks with low average level.

Reeve and Robertson (1953) concluded that maximum rate of twinning was in the middle rather than at beginning of the lambing season. Later studies also showed similar results (Ragab and Asker, 1954; Karam, 1957; Maijala, 1967; Land et al., 1969; Glimp, 1971; Tempez and Boaz, 1973; Amir et al., 1981).

Martinez (1983) in a study on hair sheep (tropical breed) that could lamb year around under tropical conditions in Venezuela found that litter size was higher during the rainy season than in the dry season. Similar results were reported by Bradford et al. (1983) for Barbados Blackbelly in Barbados. They found the smallest seasonal litter size followed mating during the dry season, with the largest size following mating during the earlier part of the wet season, which probably represented a flushing effect. They also found no evidence of reduced litter size due to out-of-season mating which was characteristic of seasonally fertile breeds including those with relatively long breeding season. Similar results were also reported by Stagnaro (1983) in a study of West African and Criollo sheep in Venezuela. Reproductive performance was much higher for matings in the rainy season than those in dry season. Under temperate conditions

(California), hair sheep (Barbados Blackbelly) also demonstrated year around lambing; however, the greatest frequency was in spring and winter. Litter size, averaging 1.53 in first lambing ewes and 2.11 in later lambings, was higher in winter (Levine and Spurlock, 1983).

There is evidence in most studies that litter size increases with increasing body weight. Killen (1967) studying Border Leicester x Merino ewes indicated that ewes with higher body weight at mating had the higher ovulation rate. This suggested that ewe with higher body weight should have larger litter size. Similar results were reported by Gunn and Doney (1979) who found in Cheviot hill country that potential of lambing rate increased by increasing body condition. Wiener (1967) in a study of five British breeds, reported that the ewes with multiple birth at first lambing weighed 2.2 kg heavier at time of first mating than those producing singles. Laster et al. (1972) in a study on 19 breed groups reported highly significant effects of ewe weight at breeding on lambs born per ewe exposed and percent lambs born per ewe lambing. There was an increase of 1% in number of lambs born per 2.8, 3.2 kg increase in ewe weight at breeding, respectively. Recent study by Atkins (1980b) in 5 Australian breeds demonstrated that an increase of 5 kg body weight at breeding would increase ewes lambing per ewe joined by 2.6% and ewes bearing multiples per ewe lambing by 7.3%. This represented an increase of 9% in lambs born per ewe joined for a 5 kg increase in body weight at breeding. Stagnaro (1983) in a study on hair sheep also found that ewes which were heavier at first service had higher lambing rates. In this particular study he found litter size of 1.13 and lambing rate

of .93 for sheep weighing more than 26 kg and litter size of 1.06 and lambing rate of .67 for ewe with weight less than 18 kg. The differences were significant.

Reeve and Robertson (1953) in reviewing flushing effect on multiple birth concluded that level of nutrition at or before mating and changes in the level of nutrition may have considerable effect on frequency of multiple births. Killen (1967) found that a high level of nutrition during flushing period increased the ovulation rates in ewes, and the effect was independent of the effect of body weight at mating. However, Coop (1966) in a study of Border Leicester x Romney ewes crossed with Southdown rams found that ewes with high live weight in the prebreeding flushing period had higher twinning rates than those of low weight. The twinning response to higher live weight was 6% per 4.54 kg weight difference.

Evidence of breed differences in litter size has been reviewed by Bradford (1972b). Based on studies of prolific and less prolific breeds under temperate region conditions he concluded that breed means ranged from little above one to above three, and differences between breeds under uniform environmental conditions exceeded a two-fold range.

There is a paucity of information concerning breed comparisons of tropical breed under the same environment. Maule (1977) who reported the study of Bodisco et al. (1973) in Venezuela indicated that there were litter size differences among the hair sheep breeds, Barbados Blackbelly, West African and Criollo. The average litter sizes were 1.45, 1.43, and 1.13, respectively. Recent study of litter size in

hair sheep in different tropical locations was reviewed by Fitzhugh and Bradford (1983) and a summary is presented in table 2. They concluded that there were substantial differences among breeds, both for average and distribution of litter size. They also pointed out that, among hair sheep, Barbados Blackbelly had the highest average litter size and greatest variability.

TABLE 2. LITTER SIZE OF HAIR SHEEP

Breed	No.	Range	Mean
Pelibuey and West African	2673	1.14 - 1.43	1.24
Barbados Blackbelly	3580	1.35 - 2.10	1.84
Virgin Island	129	1.44 - 1.82	1.61
Santa Inez, Morada Nova, Blackhead Persian and Brazilian Somali	138	1.04 - 1.76	1.08
Forest	1233	1.11 - 1.46	1.22
Peul, Touabire, Yankasa, and Uda	604	1.02 - 1.44	1.12

Source: Fitzhugh and Bradford (1983).

Litter size of Indonesian sheep has been reviewed by Mason (1980) and the results are presented in table 3. He concluded that the prolificacy may not look spectacular compared with the Finnish Landrace and Chios breeds, but with a lambing interval of 8 mo, the lambing rate per annum should average 2.72 for Javanese thin-tailed and 2.34 for Fat-tailed which amply bears out the estimate of 200 - 220 lambs per 100 ewes per year. Comparison among Indonesian sheep under a high plane of nutrition has been reported by Obst et al. (1980). A summary of the results are presented in table 4 and are

somewhat higher than the study presented by Mason (1980). This presumably is due to different environmental conditions. Bradford (1972b) indicated that a difference of 50 to 80% may be found in the performance of the same breed between poor and good environments.

In addition to breed differences, genetic effect on litter size was also mediated through the effects of type of birth of ewe and inbreeding. Belogradskii (1940) who worked on Romanov sheep found that ewes born as singles, twins, triplets, and quadruplets produced litter sizes of 1.95, 1.89, 1.96, and 2.12, respectively. Although these results show little difference in litter size associated with litter size of the dam the correlation clearly indicates heritable differences. Reeve and Robertson (1953) in reviewing the report of Marshall and Potts (1921) concluded that twin-born ewes were 4.7% more prolific than single-born ewes, but this difference could not be considered significant. The lambing rate of twin born ewes was higher and they produced .12 more lambs per year than single-born ewes according to Desai and Winters (1951). The tendency for twin born ewes to be more prolific than single-born ewes also was reported by Ragab and Asker (1954) and Karam (1957). Hanrahan (1976) working with Galway sheep compared select ewes belonging to the top 3.4% of population with a Galway control population found the superiority of selected ewes to be .099 lamb/year ($p<.025$).

Inbreeding depression on reproduction rates, particularly number of lambs born, was noted by several workers. Glembockii (1956) stated that lambing rates were lower and percentages of abortion greater for inbred than outbred sheep. Doney (1966) working with Scottish

Blackface sheep noted that the percentage of lambs born of ewes mated was 52% for inbred compared to 90% for non-inbred. A later study by Wiener and Hayter (1975), with 5 British breeds, found that on the average, litter size was reduced by .16 lambs when ewes were mated to their sons to produce inbred lambs compared with matings to unrelated rams. Lax and Brown (1968) working with Merinos, found that the dam's inbreeding had a substantial effect on number of lambs born. In this study a negative change of .009 in number of lamb born per ewe joined per 1% increase in inbreeding was found.

TABLE 3. LITTER SIZE OF INDONESIAN SHEEP

Breed	No.	Percentage of birth 1	2	3	4	Mean	Range in means
Local thin-tailed	1559	76.3	21.6	2.0	0.1	1.26	1.04-1.60
Javanese thin-tailed (JTT) - Priangan	222	36.5	49.1	11.3	3.2	1.81	1.45-2.07
Fat-tailed (FT)	132	50.8	43.2	5.3	0.8	1.56	-
JTT x FT	55	47.3	40.0	10.9	1.8	1.69	-

Source: Mason (1980).

TABLE 4. LITTER SIZE OF JAVANESE THIN-TAILED (JTT) AND FAT-TAILED (FT)

Breed	No.	Number 1	2	3	4	5	Litter size
JTT - Garut	197	43	39	21	2	1	1.86
JTT - Bogor	178	62	38	12	1	0	1.58
FT - Madura	72	22	14	6	1	0	1.67

Source : Obst et al. (1980).

Litter size weaned. Litter size weaned is determined by the litter size of lambs born alive and their mortality. Non-genetic factors influence litter size weaned similar to their influence on mortality (Jakubec, 1977).

Percent of lambs weaned of lambs born alive or lambs born has been reported by several workers under temperate condition. Sidwell et al. (1962) working with Hampshire, Shropshire, Southdown, Merino and Columbia-Southdale noted that percent lambs weaned of live lambs born was 81.9%, 79.6%, 81.4%, 83.9%, and 75.1%, respectively. Vesely and Peters (1965) studying Rambouillet, Romnelet, Canadian-Corriedale, and Romeldale found that the average percents of lambs weaned were 83.7%, 85.3%, 80.7% and 78.3%. Similar values were also reported by Hight and Jury (1970a) in a study on Romney and Border Leicester x Romney ewes. They found that the ratio of number of lamb weaned per ewe present at lambing was .71, .89, .96, and .97 for 2-, 3-, 4-, and 5-yr-old ewes, respectively. Laster et al. (1972), however in a study on 19 breed groups found the lamb weaning rate at 70 d per ewe lambing was 91%.

There is a paucity of information about litter size weaned or lamb mortality of tropical breeds. Fitzhugh and Bradford (1983) in a review of hair sheep indicated that death losses were substantial in a majority of the flocks, average losses exceeded 25%. They indicated that the factors of critical importance to lamb survival in this study were nutritional and physiological status of ewes. In this review they noted that improving nutrition of ewes during pregnancy reduced lamb mortality from 23% to 11%; for lamb born to primiparous ewes (1- to 2-yr-old) mortality was 37% compared to 18% for mature ewes; and under

African village condition, 22% of ewes with lambing intervals of less than 7 mo aborted or produced stillborn lambs compared to no abortions or stillbirths for ewes with lambing intervals greater than 7 mo.

High mortality rates of Indonesian sheep were reported by Obst et al. (1980). The percentages of lambs weaned of lambs born of JTT-Garut, JTT-Bogor and FT-Madura were 61.3%, 75.3%, and 61.1%, respectively. Fletcher et al.(1982) in a comparison between BLM and JTT ewes in the same place and the same management as the previous authors also found high mortality from birth to weaning. They reported lamb mortality from first, second and third lambings to be 18%, 44%, and 54% for BLM and 15%, 45% and 47% for JTT, respectively. Subandriyo et al. (1981) also reported high mortality rate on JTT-Garut under station conditions. They noted 197% lamb born and 132% lamb weaned on the basis of ewes lambing. Under Indonesian village conditions 162% born and 119% weaned of JTT-Garut was reported by Bell and Inounu (1982).

Lambing interval. Variation in lambing interval is affected by the variation in length of postpartum anestrus, length of time from parturition to exposure to a ram and rate of conception at first and subsequent estruses after parturition (Fitzhugh and Bradford, 1983). The gestation period is relatively constant. Shelton (1972) in a study of two small flocks of mature Rambouillet ewes which were run continously with rams over 3 yr in Texas indicated that season of the year had the major effect on interval from lambing to remating. Ewes lambing in the summer or fall had the shortest interval to remating, and those lambing in the winter had the longest. Lactation appeared to

have only a limited effect on remating as 43.5% of the ewes rebred before their lambs were weaned. In this study the average lambing interval was 240.8 d or approximately 8 mo. Arnold and Charlick (1980) who studied Peppin Merino found that lambing intervals varied widely; the average was 284 d and of 50% ewes conceived within 100 d of parturition.

Levine and Spurlock (1983) in a study of Barbados Blackbelly in California found that 35% of the lambing intervals were between 181 and 200 d in length, 22.5% between 201 and 220 d, 12.5% between 221 and 240 d, 9.5% between 241 and 260 d and 8.5% between 261 and 280 d. Only 12% of lambing intervals fell outside the range of 181 to 280 d; 3.5% were less than 181 d and 8.5% were greater than 280 d. In this study there was little difference in subsequent average lambing interval for ewes with single lambs or with twins (219.2 vs 221.1 d), but lambing interval was greater for ewes that had triplet (238.4 d). Lambing interval was also dependent upon the successive parities. The longest interval (241.7 d) occured between first and second lambing and the shortest was between second and third lambing (204.9 d). Dettmers (1983) in a study in Nigeria noted that mean lambing interval ranged from 234 to 248 d. Lambing interval was longer between first and second parity (277 d), but as parity advanced and ewes aged, lambing interval decreased to 213 d, between parity 7 and 8. Stagnaro (1983) working with hair sheep in Venezuela, found that incidence of estrus was related to rainfall. High incidence of estrus was found following high rainfall. He also noted that duration of postpartum anestrus was also affected by the number of lamb suckled.

Bradford et al. (1983) found the lambing interval of Barbados Blackbelly ranged from 158 to 520 d with a modal class of 190 to 195 d. This indicated a normal postpartum anestrus for these sheep of 40 to 45 d. It was also noted that the interval following twin births was longer than that following birth of singles. Season of year was reported to affect postpartum period in Pelibuey sheep in Mexico (Valencia and Gonzalez, 1983). They found the shortest postpartum period in June to August (40 to 75 d) and the longest postpartum period in January to May (80 to 115 d).

Mason (1980), reviewing Indonesian sheep data, stated that a lambing interval of 8 to 9 mo was most usual. In quoting the study of Natasasmita (1968), he stated that JTT had service period of 56 d which represented a lambing interval of 206 d. Under experiment station conditions in which ewes were run with rams continously except for 2 wk postpartum the lambings per year for JTT-Garut, JTT-Bogor and FT-Madura was 1.85, 1.83, 1.46, respectively (Obst et al., 1980). This resulted in lambing intervals of 197, 199 and 250 d, respectively. Subandriyo et al. (1981) calculated a parturition interval of 297 d or 1.23 parturition per year based on hand mating system under experimental station conditions. However, in a study of the village conditions, Knipscheer and Soedjana (1982) reported that only 61% of the ewes available lambed in a 12-mo period. Similar results were quoted by Bell and Inounu (1982). They concluded that the major problems were the difficulty and expense of obtaining rams, poor utilization of rams, timeliness of breeding, and lack of the technical understanding or the incentives necessary to manage for higher

reproduction rates.

Litter weight. Litter weight, particularly of the litter at weaning, is an important trait in sheep production. It combines and summarizes in one trait several different aspect of ewe reproduction (fertility and litter size) and of offspring growth (ewe milking and mothering ability and lamb gowth rate and survival). Thus it is an important biological and economic measure of ewe productivity (Martin and Smith, 1980).

Various non-genetic effects on litter weight have been reported by several workers. Fahmy (1982) in a study on various non-genetic effects on Oxford and Suffolk sheep and their crosses noted that age of ewe was a highly significant source of variation in litter weight at birth and and weaning. Litters from 2-yr-old ewes were significantly lighter at birth and at weaning than those from older ewes. The heaviest litters at birth and weaning were those from 5-yr-old ewes. Litter from 6-yr-old ewes and older were markedly lighter at birth than those from all other age groups. Age of sire had little effect on litter weight at birth and weaning. Similar results were reported by Goot and Maijala (1977) in a study on Finnish Landrace under accelerated lambing (2 lambings per year). In this particular study they found that age of ewes significantly ($p<.01$) affected the litter weight at 150 d of age from the first lambing period in the year, and accounted for 10 % of the total variance. The 4-yr-old ewes in this study produced the heaviest litters (96.6 kg) and 2-yr-old ewes the lightest (72.1 kg). Ponzoni et al. (1979) in a study on Corriedales in Uruguay also found that age of ewe had a significant

effect on weight of lambs weaned. They reported that 2-year-old ewes produced the lightest (13.3 kg), while 6-yr-old ewes produced the heaviest (20.6 kg). Vesely and Peters (1965) in a study of 4 breeds under range condition also found that age of dam was an important source of variation in weight of lamb weaned per 100 ewes bred, in addition to year effect. Two-yr-old ewes were inferior to middle-aged ewes. Age of dam and year effects on average pounds of lambs weaned per ewe also were reported by Basuthakur (1970).

In a study of management condition on litter weight Hohenboken et al. (1976a) found that hill pasture management resulted in lower prolificacy but greater survival to weaning and more kilogram of lambs weaned per ewe lambing and per ewe joined than a lowland system.

Mavrogenis (1982), working with Chios sheep, found that litter size at birth affected litter weight at birth and litter weight at weaning, in addition to herd and parity effect. He reported that litter weight at birth was 4.47 and 7.55 kg, respectively, for singles and twins. Litter weight at weaning was 12.9 and 23.4 kg. Black (1982) reported the highest litter weight at weaning was from multiple-born lambs. In his study of high fertility sheep in New Zealand, live weight weaned per ewe was 34.2, 58.8 and 73.5 kg for single-born, twin-born, and triplet-born lambs, respectively.

With respect to litter weight at birth Donald and Russell (1970) estimated the regression of litter weight of newborn lambs on the live weight of ewes at mating from 15 breeds after conversion of group means of ewes and lambs to natural logarithms. The regression coefficients estimated from this study were: .72 for single lambs, .74

for twins, and .77 for triplets. These values were not significantly different from each other. Based on these estimates they indicated that the ratio between litter weight of singles, twins and triplets was similar among ewes of different weight. The ratio was 100:160:185. A similar ratio (100:164:165) was found by Phillips and Dawson (1937); Dickinson et al. (1962) reported the ratio of 100:156:186; and Yalcin and Bichard (1964) in a study at two different locations obtained ratios of 100:158:185 and 100:159:199. In a prolific breed, the Finnish Landrace, the ratio of litter weight was 100:184:263:300 (Donald and Russell, 1962).

Evidence of breed differences was reported by Sidwell and Miller (1971c) working with Hamphshire, Shropshire, Columbia-Southdale, Targhee, Suffolk, and Dorset. Breed, age of ewe and year by age of ewe interaction were important sources of variation. The Targhee breed weaned the heaviest litters (35.3 kg) and the Dorset was the lightest (15.6 kg). Vesely and Peters (1965) also noted breed differences among Rambouillet, Romnelet, Canadian Corriedale and Romeldale for weight of lambs weaned per 100 ewes bred. They found that Rambouillet weaned the heaviest (33.5 kg) and Romeldale the lightest (29.5 kg). Similar results of breed differences in total lamb weigt was also noted by Wiener and Hayter (1975), Basuthakur (1970) and Fahmy (1982).

Basuthakur (1970) noted that type of birth of ewe and sire had an effect on lamb production, even though differences were not significant. In the Columbia breed he found superiority of lamb production when both ewe and sire were born twin. However, in Targhees he found that lamb production was lower when both ewes and sires were

born as twin as compared to the lamb production of ewes born as singles and ram born as twins.

Phenotypic correlation. Forrest and Bichard (1974b) in a study of a lowland sheep flock found that that the phenotypic correlation between body weight and reproductive performance was small but positive. In this study the correlation between body weight and average litter size was .16 and between body weight and number of lamb born per ewe present at lambing was .10. Purser (1965) in a study on Blackface and Welsh ewes found positive phenotypic correlations between live weight and litter size (r=.23 and .25, respectively).

Martin et al. (1980) in a study of a synthetic line of sheep found that premating weight was positively and highly correlated with litter traits, but the correlation between post lambing weight and litter traits were low; some were negative. The correlations of premating weight with number born alive, number weaned, litter weight at birth, litter weight at 4, 8 and 12 wk were .23,.23,.48,.15,.17, and .15. However, phenotypic correlations between post lambing weight and those litter traits were -.12, -.12, .00, .03, .03, and -.02, respectively.

High correlations between body weight at breeding with ewes lambing per ewe joined (r=.46), ewes bearing multiple lambs per ewe lambing (r=.90), and lambs born per ewe joined (r=.78) was reported by Atkins (1980b).

However, Newton and Fenlon (1979) who worked with Masham ewes found that the correlation between mating weight and litter weight was low but positive. The correlation in two flocks were .10 and .08,

respectively.

High correlations among litter traits were reported by Martin et al. (1980). The phenotypic correlation ranged from .34 to .95 among number born alive, number weaned, litter weight at birth, litter weight at 4, 8 and 12 wk. Eikje (1975) in a study on Norwegian sheep also found high phenotypic correlation among number of lambs born, number of lambs in spring and number of lambs at weaning. The correlation ranged from .67 to .93. Fogarty et al. (1982) from a study of five breeds and two synthetic lines reported mostly high postive correlations among litter size, neonatal survival, postnatal survival, lambs weaned per ewe joined. The correlation ranged from .13 to .94. The phenotypic correlation between litter size and postnatal survival was -.20, and the correlation between postnatal survival and neonatal survival was .08.

Genetic correlation. Forrest and Bichard (1974b) found that litter size at the genetic level was more strongly related to body weight (r_g=.21) than number lamb born per ewe mated and present at lambing (r_g=-.04). Strong genetic correlations between litter size and body weight were reported by Purser and Karam (1965). Estimates of the genetic correlation in Blackface and Welsh ewes, respectively, were .44 and .78.

Martin et al. (1980) estimated genetic correlations between premating weight and postlambing weight and litter weight at birth, litter weight at 4, 8, 12 wk. The correlation ranged from .38 to .88 between premating weight and litter weight at the four different ages, and .17 to .44 between postlambing weight and the four litter weights.

All had high standard errors. Low genetic correlations were found between number of lambs weaned and premating and postmating weight in this study (r_g=.02 and r_g=-.01, respectively). Estimates of genetic correlations among litter traits (number lambs weaned, litter weight at birth, litter weight at 4, 8 and 12 wk) ranged from .40 to 1.53. The standard errors were large.

Fogarty et al. (1982), who worked with 5 breeds and 2 synthetic lines, found negative genetic correlation between litter size and neonatal survival, postnatal survival, weight at weaning per ewe joined (r_g=-.30, -.32, and -.02) and low genetic correlation between litter size and lambs weaned per ewe joined (r_g=.04). However, the genetic correlations among the rest of the traits were high (.49 to 1.60), though the standard errors were relatively high.

Heritability. The relative magnitude of genetic variation of ewe performances is indicated by the heritabilities of the traits. Low estimates of heritability of litter size have been reported by several workers : -.01 and .06 (Martin et al., 1980), .04 (Ragab and Asker, 1951), .07 (Desai and Winters, 1951), .06 and .08 (Eikje, 1975), .08 (Forrest and Bichard, 1974b; Hanrahan, 1976), .11 (Rendel, 1956), .12 (Clarke and Hohenboken, 1983), .10 and .14 (Shelton and Menzies, 1970), .14 and .16 (Purser, 1965), .11 and .16 (Fogarty et al., 1982), .19 (Young et al., 1963), .27 (Karam and Ragab, 1958). Similarly, low estimates of heritabilities were also found for number of lambs weaned: .00 (Clarke and Hohenboken, 1983), .03 (Eikje, 1975), .05 (Purser, 1965), .09 (Young et al.,1963), .00 and .02 (Martin et al., 1981).

Martin et al. (1980) noted that heritability of litter weight was low to moderate. In this study they obtained heritability estimates of litter weight at 4 different ages ranging from .07 to .24 using sire component estimates (paternal half-sib) and -.08 to .21 using dam-daughter regression. For weight of lambs at various ages as a component of ewe productivity, Gjedrem (1967) reported heritability estimates of .23 to .25 and for weaning weight the estimate was .17. Eikje (1975) obtained heritability estimates for spring and weaning weight as ewe traits of .14 and .12 using variance component analysis and .06 and .09 using regression estimates. Clarke and Hohenboken (1983) who worked with crossbred ewes estimated the heritabilities of litter weight in April and litter weight at weaning to be -.02 and -.05, respectively.

Repeatability of ewe performance. Lush (1945) defined the repeatability of a characteristic as the degree of likeness among repeated records. It includes all variation due to permanent differences between ewes, and thus measures the accuracy of predicting future production on the basis of past production. It contains both genetic and environmental components of variation.

Ewe weight was highly repeatable in most studies. Newton and Fenlon (1979) working with Masham ewes in two flocks found the repeatabilities of mating weight to be .53 and .52. High estimates of repeatability of ewe weight were also reported by Buvanendran et al. (1981) in a study on Nigerian sheep and their crosses with exotic breeds (r_e=.48). Yalcin and Bichard (1964) in a study of crossbred ewes in two places reported repeatability estimates of .57 and .48.

Kishore et al. (1982) who worked with crossbred ewes (75% exotic and 25% native inheritance) also reported high value of repeatabilities of weight at mating and weight at lambing. They reported repeatability estimates of .81 and .54, respectively. Clarke and Hohenboken (1983) working with crossbred ewes, as well, found repeatability estimates of .61. Repeatability estimates of .62 and .74 were reported by Martin et al. (1981) for premating ewe weight and ewe weight 8 wk after lambing, respectively.

Low estimates of repeatability of litter size have been noted by several workers. Eikje (1975) reported the repeatability for number of lambs born to be .05. Similar low estimates was reported by Rendel (1956) in a study on four breeds in Sweden. Yalcin and Bichard (1964) in a study on crossbred ewes in three places also reported that the repeatability of litter size was low, the values ranged from .04 to .12. Shelton and Menzies (1970) in a study on two flock of Rambouillets reported the repeatabilities of .12 and .15. Similar results (r_e = .15) were reported by Forrest and Bichard (1974b). Notter (1981) who studied 1/2 Finn x 1/2 Rambouillet and 1/4 Finn x 3/4 Rambouillet also reported repeatabilities of .17 and .16, respectively. A somewhat higher repeatability estimate (.19) of litter size was reported by Clarke and Hohenboken (1983). Breed differences in repeatability were reported by Purser (1965) who obtained repeatability estimates of .24 for Welsh ewes and .19 for Blackface ewes.

Differences of repeatability estimates using different methods of estimation were reported by Young et al. (1963) working with Merino in Australia. They found the repeatability of .05 and .10 using analysis of variance and regression methods, respectively. Fogarty et al. (1982), based on intra-class correlation and pooled regression methods, found estimates of .08 and .16, respectively. Martin et al. (1981) reported repeatability ranging from .03 to .09 with an average of .07.

Relatively high repeatability of litter size was reported by Lewer and Allison (1980) in Merino and Booroola x Merino ewes. They reported the repeatability was .20 and .35, respectively. High estimates of repeatability of litter size were also reported by Goot and Maijala (1977) in Finnish Landrace, using correlation between litter size at first and second lambing (r_e=.30). These results suggest an increase in repeatability in flocks with a range of 1 to 4 or more than in those with predominantly singles and twins.

For number of lambs weaned Young et al. (1963) reported repeatability of .08 in Australian Merino. Martin et al. (1980) estimated repeatability of number lambs weaned to range from -.07 to .10. Similar low estimates of repeatability were reported by Purser (1965) in Blackface (.07) and Welsh (.10) ewes. Yalcin and Bichard (194b) reported litter size reared up to 10 - 12 wk to be .08, .10, and .04, from three different locations. Similar results were reported by Clarke and Hohenboken (1983) who obtained a repeatability estimate of .08.

There are two different criteria to measure rearing ability or mortality as ewe traits. Piper et al. (1982) indicated that rearing ability may be defined for an individual lambing ewe as the ratio of the number of lambs reared of lamb born. However, some studies treated rearing ability as an "all-or-none character", by using "weaned at least one lamb born" versus "wean none".

Shelton and Menzies (1970) in a study of two Rambouillet flocks obtained estimates of .06 and .10 for repeatability of rearing ability defined as weaning at least one lamb versus weaning none. Fogarty et al. (1982) using neonatal survival and postnatal survival which were essentially weaning at least one lamb versus none found repeatability estimates of .15 and .03 using intraclass correlation and pooled regression for neonatal survival. Corresponding values for postnatal survival, respectively were .11 and .02.

Piper et al. (1982), studying a Merino flock at Armidale, Australia demonstrated that rearing ability was repeatable. They estimated the repeatability on the basis of ratio of lambs weaned of lambs born. The estimates of adult (>2-yr-old) ewes were .16 and .15 in the two flocks. If the 2-yr-old lambing only was used as the prior record, the corresponding estimates of repeatability were .05 and .12. They concluded from this study that 2-yr-old record may be a poorer predictor than later records, and these estimates indicated that significant gain in current flock performance could be achieved by culling ewes on the basis of rearing ability.

Martin et al. (1981) estimated the repeatability of litter weight at birth, at 4, 8 and 12 wk. The estimates were .25, .17, .11 and .08,

respectively. This suggested that repeatability decreased with advancing age, because of declining maternal effect. Blackwell and Henderson (1955) also reported a similar tendency. They found the repeatability of birth weight and weaning weight was .20 and .08, respectively. Buvanendran et al. (1981) in analyzing the data of Nigerian sheep and their crosses with exotic breeds also found decreasing repeatability with advancing age. Repeatability estimates of birth weight, 3 mo and 6 mo weights were .25, .21, and .09, respectively. However, Yalcin and Bichard (1964b) found that the repeatabilities of lamb weight at 7 different ages were similar; the repeatability for lamb birth weight, lamb weight at 42, 63, 76, 84, 115 d, and lamb weight at weaning (125 d) was .18,.19,.20,.21,.19,.19, and .17, respectively. Newton and Fenlon (1979) in a study on Masham ewes, however, found repeatability estimates of litter weight to be .34 without correction to litter size, and .28 when corrected to mean birth weight.

Eikje (1975) studying Norwegian sheep estimated the repeatability of weaning weight to be .16. However, Fogarty et al. (1982) found estimates of .05 and .12 using intraclass correlation and pooled regression, respectively.

There is a paucity information on estimates of repeatability of lambing interval. Kishore et al. (1982) reported the repeatability of lambing interval to be .18.

MATERIALS AND METHODS

Factors associated with lamb survival

The data for this study were those records regularly collected at the Red Bluff Research Ranch of the Animal and Range Sciences Department, Montana Agricultural Experiment Station near Norris, Montana (latitude 45.6° N and longitude 111.6° W). These data included the records of Rambouillet, Targhee and Columbia lambs born during the years 1960 to 1982.

Management practices and data collection. All animals were managed as range ewes herded on range areas of the station and on high mountain National Forest Service allotments. They were gathered and brought to the station head quarters only during breeding, lambing, shearing and data collection times. All ewes were mated in November and December and the lambs were born in April and May. The ewes were pen-mated in single-sire groups of 20 to 40 each for approximately 20 d and then mass mated to Blackface rams for 15 d. During the breeding season mixed hay and alfalfa hay were supplied in addition to continuously flowing water. At the end of the breeding season, the ewes were herded together on the range until the start of lambing season. Hay was also provided whenever snow cover was too deep for grazing or sufficient feed was not available on the range, generally 5 d a year. Shed lambing was practiced.

Shortly after parturition ewes and lambs were placed in a 1.9 m^2 lambing pen and kept about 24 h or more depending upon the condition of the lamb and mothering ability of the dam. Then both the dam and

her lamb(s) were moved to small pens where 5 to 10 animals can be kept at a time and maintained for 5 to 6 d prior to putting them in a larger group.

At birth the number of lambs born, the sex and birth weight of the lambs were recorded. The lambs were ear tagged, docked and some males were castrated at this time as well. Shearing was conducted in April just prior to lambing.

Ewes and lambs were then moved back to the low foothill range where they grazed until the first week in July, when they were weighed at approximately 60 d of age, and then trucked to the high mountain National Forest Service allotment. During the first weeks of September when the lambs were approximately 120 d of age, they were weighed, weaned and moved back to the station.

Traits analyzed. Traits analyzed in this study were survivability at approximately 60 d (SURV60), survivability at 120 d (SURV120), survivability between 60 to 120 d (SURV60120) and birth weight. In the analyses survival traits were defined as "all-or-none characters". A "one" code indicated the lamb was alive and a "zero" code indicated the lamb was not alive at the particular age. All data studied were limited to that from lambs born alive and which had birth weight records. Lambs with missing birth weight were excluded. Data from artificially reared and grafted lambs were also excluded.

Survivability data were analyzed by methods of least squares for unequal subclass number as described by Harvey (1977).

Analytical model. The primary model used in this study was :

$$Y_{ijkl} = U + Z_i + S_{ij} + F_k + e_{ijkl}$$

where Y_{ijkl} was the survivability observations, U was general mean, Z_i was the year effect considered as fixed, S_{ij} represented random nested effect of sire within year, F_k was another set of fixed effects and e_{ijkl} was the residual error assumed to be randomly and normally distributed. The model assumed that interaction of random and fixed effects were unimportant. Set of fixed effects (F_k) fitted in the study were the effect of sex (male and female), type of birth (single, twin, and triplet), age of dam (2-yr-old to 6 yr or older), and significant two way interaction. Significant two-way interactions were determined by preliminary analysis. Three-way and higher order interaction were assumed to be unimportant.

The model as described was first applied to analyze the data for breeds separately, then the data from the three breeds were combined in one analysis. For the combined analysis Z_i in the model was considered as cross classified breed-year, and S_{ij} represented the random effects of sires nested within breed-year.

Data were also analyzed using the same model, but birth weight within type of birth was included as a continous variable (covariate), in order to assess the effect of birth weight on survivability. Birth weight as a response variable was also analyzed using the same model.

Distribution of observation for each breed according to year of birth, type of birth, age of dam at lambing and sex is displayed in table 5.

TABLE 5. NUMBER OF LAMBS BY BREED, YEAR OF BIRTH, TYPE OF BIRTH, AGE OF DAM AT LAMBING, AND SEX SUBCELL FOR SURV60, SURV120 AND SURV60120

	Rambouillet		Targhee		Columbia	
	SURV60 SURV120	SURV60120	SURV60 SURV120	SURV60120	SURV60 SURV120	SURV60120
Year						
60	301	241	246	219	172	149
61	315	244	249	211	164	145
62	431	328	209	180	134	115
63	272	222	270	220	150	126
64	302	226	305	259	103	87
65	189	146	314	275	73	59
66	207	175	292	253	...	...
67	220	196	349	316	81	69
68	187	168	340	298	76	60
69	233	213	376	340	156	137
70	238	215	343	294	252	220
71	294	257	316	287	289	257
72	286	244	275	241	244	220
73	287	258	252	224	233	154
74	249	234	227	205	161	142
75	289	243	211	186	158	135
76	227	183	234	188	176	130
77	185	165	153	144	140	124
78	228	203	154	137	112	96
79	279	214	167	133	124	81
80	265	208	192	145	139	104
81	249	188	128	105	87	68
82	250	204	146	122	48	34
Type of birth						
1	2,563	2,249	2,250	2,071	1,352	1,192
2	3,297	2,654	3,388	2,850	1,839	1,466
3	123	72	110	61	81	54
Age of dam						
2	1,397	1,127	1,432	1,176	768	585
3	1,390	1,158	1,363	1,177	720	608
4	1,277	1,077	1,148	1,043	671	580
5	1,040	887	926	819	566	472
6+	879	726	879	767	547	467
Sex						
Male	2,894	2,398	2,804	2,402	1,653	1,368
Female	3,089	2,577	2,944	2,580	1,619	1,344
Total	5,983	4,975	5,748	4,982	3,272	2,712

To evaluate breed differences in survivability the following model was applied:

$$Y_{ij} = U + F_i + e_{ij}$$

where: Y_{ij} was the survivability observations; U was the general mean, F_i was set of fixed effects, and e_{ij} was residual error assumed to be randomly and normally distributed. Set of fixed effects (F_i) fitted were breed, year, type of birth, age of dam, sex and interaction between type of birth and age of dam.

Heritability and genetic correlation estimates. Estimates of heritability were calculated based on

$$\sigma_s^2/\sigma_t^2$$

where σ_s^2 was the estimate of sire variance component and σ_t^2 was the total variance component estimated from the sum of among sires (σ_s^2) and within sire (σ_w^2) variance components.

Genetic correlation between two traits were computed by dividing "family" covariance component estimates for two traits by geometric mean of the two "family" variance component estimates.

Performance of Indonesian sheep

The data for this study were obtained from two sources: the Research Institute for Animal Production (RIAP) station and from the villages. The villages and station are located in West Java province, within latitude 6 - 8° S and longitude 106 - 109° E.

Management practises and data collection at the station. The RIAP sheep experiment station is located at Cicadas, Bogor, West Java province latitude 6.3o S, longitude 106.8o E at an altitude of

approximately 65 m. The station receives annual precipitation of about 2592 mm. The rainy season was experienced from October to April and dry season was the rest of the year.

There were approximately 125 breeding females in the flock of which approximately 60% were Javanese thin-tailed (JTT) and 40% were Fat-tailed (FT). JTT were in the flock started in 1978 and purchased from Garut, West Java. The FT were purchased from Grati, East Java and entered the flock in 1981.

All of the sheep were confined in wooden barns, and cut and carry forages were supplied. The primary forage until mid-1980 was Brachiaria decumbens, and after that period a mixture of Pennisetum purpureum with small amounts of Panicum maximum and Setaria sp. was provided. Supplementary feeding was also practiced using a concentrate ration composed of rice bran, coconut oil meal, corn and mineral mix. The concentrate ration was given approximately at a rate of 400 g/d for adults and 250 g/d for lambs.

The ewes were hand mated at first estrus after lambs were weaned. Ewes which lost their lambs before weaning were bred as soon as they showed estrus. However, this breeding management was practiced only until early 1981. After that period, pen mating in single sire groups was practiced in a small flock of approximately 10 ewes for one ram. Ewes were run continuously with the ram except during nursing periods. Ewes that lost their lambs were put in the breeding flock as soon as possible.

Lambs were ear tagged at birth and their sex, type of birth, dam, sire and weight (within 12 h) were recorded. Navels were treated with

tincture of iodine solution. Docking and castrating were not practiced. Lambs were weighed weekly until they were weaned at ages ranging from 12 to 13 wk according to their condition.

Weaned lambs were then raised in pens and fed with forages and concentrate ration as described. Ewe lambs and ram lambs were separated into different pens at 5 mo. From weaning to 12 mo of age lambs were weighed biweekly.

Young ewes were bred at approximately 19 kg or at 1 yr of age if they had not achieved the standard weight by that age. Weight of ewes were also recorded at biweekly intervals.

For this study the JTT data were collected from late 1978 to early 1982, and the FT data were collected from mid-1981 to early 1982.

Management practices and data collection in villages. Data from the villages were collected from smallholder farms in three locations (Garut (GAR), Ciburuy (CIB) and Cirebon (CIR)). Those three locations represented high elevation, medium elevation and lowland area, respectively. The number of small holder farms monitored were 29 for GAR, 29 for CIB and 15 for CIR. The environment of those three areas is presented in table 6. The breed type in those areas was JTT sheep kept in small flocks. Average flock size was about 4 to 5 head. Management, however, varied greatly. Sheep in GAR were confined in slatted floor houses and fed exclusively cut and carry grasses and crop residues. At CIB, sheep were housed similarly and were fed cut and carry grass, but were sometimes allowed to graze under rubber trees in the nearby plantation. Sheep in CIR were also confined, but

they grazed regularly on salt or fish pond levees along the coast. A severe worm problem was identified at CIR.

At GAR, ewes were hand mated. There were two decisions to breed after lambing, determined by estrus behavior characteristics and by time from parturition that ranged from 7 to 16 wk. The ram was usually allowed to mate the ewe three or four times (Bell and Inounu, 1982). A similar breeding system was conducted in CIB area. However, in CIR pen mating and mass mating were practiced. Therefore, information concerning the sire of the lambs was unknown in CIR.

TABLE 6. ENVIRONMENT OF CIR, CIB, GAR

	CIR	CIB	GAR
Latitude (° S)	6.8	6.8	7.2
Longitude (° E)	108.5	106.7	107.9
Elevation (m)	0-4	450	600-700
Topography	level	undulating	hilly
Soil texture	silt loam	n.a.	sandy
Precipitation (mm/yr)	1,128	4,500	2,000
Average temp.(° C)	28	23	25
Cultivated land (ha)	811	n.a.	1,495
Uncultivated land (ha)	269	n.a.	679
Rainfed rice field (ha)	755	127	259
Dry land (ha)	56	13	1,236
Estate (ha)	0	46	0
Communal pasture (ha)	14	16	0
Forrest (ha)	0	0	433

Source: Knipscheer and Soedjana (1982).
n.a.=not available.

Lambs were weaned at approximately three months of age. There was paucity of information about age at first breeding, but in a study that was based on a single visit some ewes at 1 yr of age (1 pair of

permanent teeth) already had lambs (Sitorus and Subandriyo, 1982). This indicated that ewes were bred under 1 yr of age.

This study was part of the monitoring program for the village project of Small Ruminant Collaborative Research Support Program - Research Institute for Animal Production (SR-CRSP/RIAP). Data were collected and monitored by SR-CRSP/RIAP staff who lived in the villages where the study was conducted. Monthly visits and recording was applied to obtain the data. The data from CIB were collected from mid-1980 to the late 1982; in CIR the data were collected from mid-1981 to late 1982; however, in GAR the data were collected from mid-1981 and terminated in the beginning of 1982 because of the eruption of a volcano near the area where the study was carried out.

Growth characters analyzed. Under station and village conditions data sets of the following weights were analyzed: birth weight (BW); weight at 30 d (W30); weight at 60 d (W60); weaning weight which was taken at fixed age of 90 d (WWT), weight at 120 d (W120); weight at 150 d (W150); weight at 180 d (W180); weight at 270 d (W270); and yearling weight (YWT). These data were obtained by linear interpolation between weights recorded before and after the particular age in question.

Average daily gains were analyzed from birth to weaning at 90 d (PREWG), and gain from weaning at 90 d to 180 d (POSTWG). Average daily gain (g/d) was calculated as the difference between corresponding weight at two different ages divided by the difference between two corresponding ages.

Growth characters were analyzed by least squares methods for unequal subclass number as described by Harvey (1977).

Ewe performances analyzed. Sets of data under station and village conditions for these traits were: litter size (LSIZE); litter size weaned (LSWEAN); neonatal survival (NSURV); livability at 30 d (LIV30); livability at 60 d (LIV60); livability at 90 d (LIV90); litter weight at birth (LTWTB); litter weight at 30 d (LTWT30); litter weight at 60 d (LTWT60); litter weight at 90 d (LTWT90); weight at mating (MTWT); postpartum weight (PPWT); and lambing interval (LINT).

Traits analyzed were defined as follows:

1. Litter size was number of lambs born at birth (including still birth).
2. Litter size weaned was number of lambs alive at weaning (90 d of age).
3. Neonatal survival was the proportion of lambs alive at birth divided by number of lambs born.
4. Livability at 30, 60, and 90 d were defined as number of lambs alive at the corresponding age divided by the number of lambs alive at birth.
5. Litter weight at birth was the sum of lamb birth weights (kg) in each litter.
6. Litter weight at 30, 60, and 90 d was the total weight of lambs (kg) from a particular ewe at the corresponding age.
7. Lambing interval (d) was measured by interval between two parturitions.

8. Weight at mating was the ewe weight approximately 5 mo before parturition.

9. Postpartum weight was the ewe weight at approximately 1 mo after parturition.

Ewe performance data were analyzed by least squares methods for unequal subclass number (Harvey, 1977).

Analytical model. The general model used to analyze growth characters and ewe performances was:

$$Y_{ij} = U + F_i + e_{ij}$$

where: Y_{ij} was growth characters or ewe performance observations, U was the general mean, F_i were sets of fixed effects that included discrete or continous variables, and e_{ij} were residual errors assumed to be randomly and normally distributed.

Analytical procedures for growth traits. The distribution of observations for growth characters under station conditions is displayed in table 7, classified according to independent variables studied. Two way interactions and linear and quadratic regression of growth traits on age of dam at lambing (in month) and birth weight were also included in the analyses.

The number of records obtained under village conditions are presented in table 8 classified by the independent variables studied. The linear and quadratic regressions of growth traits on birth weight and two way interactions were included in the analyses. Only the two way interactions and covariates found to be significant ($p<.1$) in preliminary analyses are reported.

Growth curve. Growth curves using the equation $W = a A^b$ were derived from the following data: least squares means from the analysis of weights at different ages for lambs, least squares means for mating and post partum weights of ewes at different ages in the village data, and simple means for mating and postpartum ages and weights of ewes in the station data. The data, corresponding ages and weights, were transformed to natural logarithms and the linear regression of ln W on ln A was computed for JTT sheep under village conditions and for JTT and FT sheep under experiment station conditions. These equations ($\ln W = \ln a + b \ln A$) were transformed to the exponential form : $W = a A^b$.

Analytical procedures for ewe performance. The distribution of observation for ewe performance traits under station conditions are shown in tables 9 and 10 classified according to independent variables studied. Two way interactions and linear and quadratic regression of ewe performance traits on ewe age (in month) at lambing (ewe age at mating for mating weight) included in the analysis.

The number of records obtained under village conditions are presented in tables 11 and 12, classified by the independent variables studied. Two way interactions were included in the analyses. As in the growth characters, two way interactions found to be significant ($p<.1$) in preliminary analyses are reported.

TABLE 7. NUMBER OF LAMBS IN EACH BREED, SEX, TYPE OF BIRTH, YEAR AND MONTH OF LAMBING SUBCELL FOR GROWTH CHARACTERS UNDER STATION CONDITIONS

Variable	BW	W30	W60	WWT PREWG	W120	W150	W180 POSTWG	W270	YWT
Breed									
JTT	298	168	166	158	149	131	116	74	54
FT	51	32	31	29	24	...[a]	...[a]	...[a]	...[a]
Sex									
F	201	103	101	97	93	71	61	37	23
M	148	97	96	90	80	60	55	37	31
Type of birth									
1	78	57	57	56	53	40	35	15	12
2	132	84	82	76	68	49	44	31	24
3	84	37	36	35	33	25	21	13	7
4+	55	22	22	20	19	17	16	15	11
Year									
1979	93	28	28	28	28	28	28	26	23
1980	68	46	46	46	45	43	41	33	24
1981	188	126	123	113	100	60	47	15	7
Month									
J	24	16	16	9	9	4	4	4	4
F	14	10	10	10	10	9	9	8	4
M	32	14	14	14	14	14	14	11	10
A	18	5	5	5	5	5	5	5	4
M	11	7	7	7	7	6	6	5	1
J	8	6	6	6	6	5	4	3	1
J	26	19	19	19	18	14	14	12	8
A	33	19	18	17	16	16	15	1	...[a]
S	62	39	38	37	36	32	23	6	6
O	57	33	32	31	30	11	9	8	7
N	41	18	18	18	14	7	7	7	5
D	23	14	14	14	8	8	6	4	4
Total	349	200	197	187	173	131	116	74	54

[a] No observation.

TABLE 8. NUMBER OF LAMBS IN EACH LOCATION, SEX, AGE OF DAM AT LAMBING, TYPE OF BIRTH, YEAR AND MONTH OF LAMBING SUBCELL FOR GROWTH CHARACTERS UNDER VILLAGE CONDITIONS

Variable	BW	W30	W60	WWT PREWG	W120	W150	W180 POSTWG	W270	YWT
Location									
CIB	277	224	199	189	164	144	123	63	32
CIR	58	44	34	30	25	20	18	14	9
GAR	92	84	76	65	62	41	16	...[a]	...[a]
Sex									
F	234	184	162	151	131	110	85	42	22
M	193	168	147	133	120	95	72	35	19
Year									
1980	29	23	23	23	19	16	11	3	...[c]
1981	181	155	145	138	126	120	105	61	...
1982	217	174	141	123	106	69	41	13	...
Age of dam[b]									
1	55	47	43	42	38	28	21	15	7
2	210	181	159	145	129	108	74	33	17
3	98	72	63	60	51	42	37	17	12
4+	64	52	44	37	33	27	25	12	5
Type of birth									
1	173	152	130	118	102	85	70	36	20
2	208	173	152	141	128	103	75	38	21
3+	46	27	27	25	21	17	12	3	...[d]
Month									
J	53	43	37	35	35	32	13	6	1
F	48	38	36	35	35	22	19	10	3
M	26	20	20	20	15	9	8	2	1
A	17	13	13	10	9	9	8	3	1
M	25	22	17	12	11	7	7	2	2
J	27	23	22	22	21	20	16	9	5
J	37	29	29	26	25	14	12	8	7
A	48	39	31	31	20	18	14	6	3
S	42	33	38	24	22	19	13	6	5
O	43	36	24	19	17	17	16	10	6
N	34	32	30	28	21	21	16	7	5
D	27	24	22	22	20	17	15	8	2
Total	427	352	309	284	251	205	157	77	41

[a] Only CIB and CIR analyzed.
[b] Age of dam at lambing : 1=temporary teeth and 2-tooth, 2=4-tooth, 3=6-tooth, and 4=full mouth.
[c] Year effect was combined.
[d] Combined with twin-born lambs.

TABLE 9. NUMBER OF EWES IN EACH BREED, YEAR OF LAMBING, NUMBER LAMBS BORN AND MONTHS OF LAMBING SUBCELL FOR LITTER SIZE (LSIZE), LITTER SIZE WEANED (LSWEAN), WEIGHT AT MATING (MTWT), POSTPARTUM WEIGHT (PPWT) AND LAMBING INTERVAL (LINT) UNDER STATION CONDITIONS

Variable	LSIZE	LSWEAN	MTWT	PPWT	LINT
Breed					
JTT	182	105	98	114	100
FT	46	32	25	33	13
Year					
1979	37	...	...	6	35
1980	35	35	49[a]	35	20
1981	101	102	74	106	58
1982	55	...[c]	...[c]	...[c]	...[c]
No. born					
1	...	63	...	65	40
2	...	49	...	51	39
3	...	17	...	21	23
4+	...	8	...	10	11
Month					
J	12	8	3[b]	12	4
F	6	6	11	6	5
M	18	4	16	4	17
A	17	3	28	3	10
M	8	4	22	4	5
J	5	4	12	4	3
J	31	13	9	13	12
A	22	17	11	17	8
S	33	32	6	32	16
O	34	23	3	25	16
N	18	12	1	14	12
D	24	11	1	13	5
Total	228	137	123	147	113

[a] Year of mating.
[b] Month of mating.
[c] Not available.

TABLE 10. NUMBER OF EWES IN EACH BREED, NUMBER OF LAMBS BORN, YEAR AND MONTH OF LAMBING SUBCELL FOR LITTER WEIGHTS AND LIVABILITIES UNDER STATION CONDITIONS

Variable	LTWTB	LTWT30	LTWT60	LTWT90	NSURV	LIV30	LIV60	LIV90
Breed								
JTT	108	108	108	105	108	108	108	105
FT	33	33	33	32	33	33	33	32
No. born								
1	64	64	64	63	64	64	64	63
2	51	51	51	49	51	51	51	49
3	17	17	17	17	17	17	17	17
4+	9	9	9	8	9	9	9	8
Year								
1980	35	35	35	35	35	35	35	35
1981	106	106	106	102	106	106	106	102
Month								
J	12	12	12	8	12	12	12	8
F	6	6	6	6	6	6	6	6
M	4	4	4	4	4	4	4	4
A	3	3	3	3	3	3	3	3
M	4	4	4	4	4	4	4	4
J	4	4	4	4	4	4	4	4
J	13	13	13	13	13	13	13	13
A	17	17	17	17	17	17	17	17
S	32	32	32	32	32	32	32	32
O	23	23	23	23	23	23	23	23
N	12	12	12	12	12	12	12	12
D	11	11	11	11	11	11	11	11
Total	141	141	141	137	141	141	141	137

TABLE 11. NUMBER OF EWES IN EACH LOCATION, NUMBER BORN, EWE AGE AT LAMBING, YEAR AND MONTH OF LAMBING SUBCELL FOR LITTER SIZE (LSIZE), LITTER SIZE WEANED (LSWEAN), WEIGHT AT MATING (MTWT), POSTPARTUM WEIGHT (PPWT) AND LAMBING INTERVAL (LINT) UNDER VILLAGE CONDITIONS

Variable	LSIZE	LSWEAN	MTWT	PPWT	LINT
Location					
CIB	198	184	139	197	70
CIR	51	47	28	51	13
GAR	57	48	45	57	...[a]
Year					
1980	29	28	18	28	15
1981	132	131	143	132	56
1982	145	120	51	145	12
No. born					
1	...	168	...	182	51
2	...	97	...	109	32
3+	...	14	...	14	...[b]
Ewe age[d]					
1	56	54	31	55	22
2	145	132	102	145	33
3	65	62	45	65	22
4+	40	31	34	40	6
Month					
J	31	30	13[c]	31	6
F	34	33	17	33	9
M	18	18	25	18	7
A	18	16	17	18	7
M	16	11	20	16	1
J	22	22	19	22	4
J	26	25	11	26	6
A	33	33	31	33	8
S	28	23	28	28	11
O	32	21	10	32	8
N	26	25	6	26	8
D	22	22	15	22	9
Total	306	305	212	305	83

[a] Not available.
[b] Combined with twin-born lambs.
[c] Month of mating.
[d] Ewe age at lambing: 1=temporary and 2-tooth, 2=4-tooth, 3=6-tooth, and 4=full mouth.

TABLE 12. NUMBER OF EWES IN EACH LOCATION, NUMBER OF LAMBS BORN, EWE AGE AT LAMBING, YEAR AND MONTH OF LAMBING SUBCELL FOR LITTER WEIGHTS AND LIVABILITIES UNDER VILLAGE CONDITIONS

Variable	LTWTB	LTWT30	LTWT60	LTWT90	NSURV	LIV30	LIV60	LIV90
Location								
CIB	185	184	175	171	198	198	189	186
CIR	51	51	48	47	51	51	48	47
GAR	55	55	51	46	57	57	53	49
Year								
1980	19	19	19	19	29	29	29	29
1981	127	127	126	126	132	132	131	131
1982	145	44	129	119	145	145	130	122
Ewe age[a]								
1	46	46	45	44	56	56	55	55
2	143	142	135	131	145	145	137	133
3	62	62	58	58	65	65	62	62
4+	40	40	36	31	40	40	36	32
No. born								
1	173	172	163	158	182	182	173	169
2	104	104	97	92	110	110	103	99
3+	14	14	14	14	14	14	14	14
Month								
J	31	31	31	31	31	31	31	30
F	33	33	32	32	34	34	34	34
M	14	14	14	14	18	18	18	18
A	14	14	14	12	18	18	18	16
M	16	16	13	10	16	16	13	12
J	21	21	21	21	22	22	22	22
J	25	25	25	24	26	26	26	25
A	32	32	32	32	33	33	33	33
S	27	27	25	22	28	28	26	24
O	31	30	21	20	32	32	22	21
N	25	25	24	24	26	26	25	25
D	22	22	22	22	22	22	22	22
Total	291	290	274	264	306	306	290	282

[a] Ewe age at lambing: 1=temporary and 2-tooth, 2=4-tooth, 3=6-tooth, and 4=full-mouth.

Repeatability of ewe performance traits. Under station conditions, repeatability of ewe performance traits was estimated from JTT data. Repeated observations were only available for JTT, except for litter size which were available both for JTT and FT. Hence, two models were applied to estimate of ewe variance components. The model used to estimate ewe variances in litter size was:

$$Y_{ijkl} = U + B_i + A_{ij} + F_k + e_{ijkl}$$

where : Y_{ijkl} is observed litter size (number born) at birth, U is the general mean, B_i is the breed effect considered to be fixed, A_{ij} is random nested effect of ewes within breed, F_k is another sets of fixed effects, and e_{ijkl} is the residual error assumed to be randomly and normally distributed. Interaction between random and fixed effect is assumed to be unimportant (Harvey, 1977).

For other ewe performance traits the model applied to estimates ewe variance components was:

$$Y_{ijk} = U + A_i + F_k + e_{ijk}$$

where: Y_{ijk} is the ewe performance traits observation, U is the general mean, A_i represents the random effect of ewes, F_k is the fixed effects, and e_{ijkl} is the residual error assumed to be randomly and normally distributed.

Under village conditions repeat observations were not available for GAR. Therefore, repeatability of ewe performance traits were estimated only from CIB and CIR data. The model applied to estimate ewe variance components was:

$$Y_{ijkl} = U + L_i + A_{ij} + F_k + e_{ijkl}$$

where Y_{ijkl} is the ewe performance traits observation, U is the

general mean, L_i is the effect of location, A_{ij} is random nested effect of ewes within location, F_k is the fixed effects, and e_{ijkl} is the residual error assumed to be randomly and normally distributed. Interaction between random and fixed effects was assumed to be unimportant (Harvey, 1977).

Fixed effects, both under experiment station and village conditions, were fitted for factors that affected ewe performance traits in the previous section. Two way interaction and covariates were also fitted when significant in the preliminary analysis ($p<.1$). Number of observations of each ewe performance traits is presented in table 13.

TABLE 13. NUMBER OF OBSERVATIONS OF EWE PERFORMANCE TRAITS FOR ESTIMATING REPEATABILITIES

Traits	Experiment station			Village		
	JTT	FT	No. ewe[a]	CIB	CIR	No. ewe[b]
LSIZE	182	46	115	198	51	168
LSWEAN	105	..	74	184	47	164
MTWT	98	..	74	139	28	122
PPWT	114	..	75	197	51	168
LINT	100	..	55	...	..	...
LTWB	108	..	75	185	51	164
LTWT30	108	..	75	184	51	164
LTWT60	108	..	75	175	48	160
LTWT90	105	..	74	171	47	160
NSURV	108	..	75	198	51	168
LIV30	108	..	75	198	51	168
LIV60	108	..	75	189	48	164
LIV90	105	..	74	186	47	164

[a] Number of ewes in two breeds.
[b] Number of ewes in two locations.

Repeatability was estimated based on:

$$\sigma_e^2/[\sigma_e^2 + \sigma_w^2]$$

where σ_e^2 is the estimated variance component due to differences among ewes and σ_w^2 is the variance component due to differences between records on the same ewe. Standard errors of repeatability estimates were calculated according to the formula of Turner and Young (1969).

Heritability estimates of preweaning growth characters. Under station conditions heritability estimates of preweaning growth characters were estimated both for JTT and FT, since sire information was available for both breeds. In the village data no sire information was available for CIR, hence, estimates of heritability were obtained only from CIB and GAR. Sires variance component estimates were derived from the following model

$$Y_{ijkl} = U + A_i + S_{ij} + F_k + e_{ijkl}$$

where: Y_{ijkl} is the preweaning growth character observation, U is the general mean, A_i represented the fixed effect of breed (exp.station) or location (village), S_{ij} represented random effect of sires nested within breed (exp. station) or location (village), F_k represented sets of fixed effects; and e_{ijkl} is the residual error assumed to be randomly and normally distributed. Interaction between random and fixed effects was assumed to be negligible. The fixed effects fitted were similar to factors affecting preweaning growth characters in previous section, but birth weight was not fitted as a covariate. Two way interactions and covariate (ewe age at lambing for exp. station) were only fitted when significant ($p<.1$) in preliminary analysis. Number of observations for each trait analyzed is presented in table 14.

Heritability estimates and genetic correlations were computed using formula described by Harvey (1977).

TABLE 14. NUMBER OF OBSERVATIONS OF PREWEANING GROWTH CHARACTERS ANALYZED FOR HERITABILITIES

Traits	Experiment station			Village		
	JTT	FT	No.Sires[a]	CIB	GAR	No.Sires[b]
BW	249	31	11	202	46	32
W30	144	23	11	160	40	30
W60	142	22	11	140	39	30
W90	142	22	11	131	32	30
PREWG	142	22	11	131	32	30

[a] Number of sires in two breeds.
[b] Number of sires in two locations.

RESULTS AND DISCUSSION

Survivability and birth weight of range lambs

Preweaning survival rates. Preweaning survival rates ranged from 74.1% to 78.4% with a mean of 75.8% for the three breeds from birth to 60 d of age and ranged from 68.9% to 74.8% with the mean of 71.8% from birth to 120 d of age. SURV60120 ranged from 92.9% to 95.1% with an average of 94.4% (table 15).

TABLE 15. LEAST SQUARES MEANS FOR SURV60, SURV120, SURV60120 BY BREED

Breed	No.	SURV60 (%)	SURV120 (%)[a]	No.	SURV60120 (%)
U	15,003	75.8± .9	71.8± .9	12,669	94.4± .7
Rambouillet	5,983	75.0± .9	71.6±1.0	4,975	95.1± .7
Targhee	5,748	78.4± .9	74.8±1.0	4,982	95.1± .7
Columbia	3,272	74.1±1.0	68.9±1.1	2,712	92.9± .7

[a] No. observation equal to SURV60

Mortality rates found in this study were typical of those reported by several workers: Slee (1981) reported the mortality ranged from 5 to 40% on British farms; Hight and Jury (1970b) and Meyer and Clarke (1978) reported death losses of 5 - 25% in New Zealand; and Khalaf et al. (1979b) reported mortality rates from 17.7 to 35% in Australia. Death losses observed in this study were less than that reported by Venkatachalam et al. (1949) who found average mortality of 28.6% in Michigan; and Smith (1977) who found mortality ranged from 32 to 44.9% in Nebraska. However, it should be pointed out that this study was based on lambs born alive. Most of the death losses occured

in the first 60 d. This was in agreement with the finding of Venkatachalam et al. (1949); Purser and Young (1964); Hoversland et al. (1957); and Safford and Hoversland (1960) who reported that preweaning death losses usually occured within a few days after birth.

Breed differences in SURV60, SURV120 and SURV60120 (table 15) were highly significant as indicated by the analysis of variance in appendix table 60. Targhees were superior, followed by Rambouillets and Columbias. Previous studies reported by Sidwell and Miller (1971a) and Smith (1977) indicated breed differences in lamb mortality.

The superiority of Targhees over Rambouillets and Columbias parallels the order of birth weight of those three breeds. General means and standard errors of birth weight of Targhees, Rambouillets and Columbias in this study were 4.41±.05 kg, 4.38±.05 kg and 3.97±.09 kg, respectively (table 25). Breeds with heavier birth weight tended to have higher survivability. This result is contrary to the finding of Venkatachalam et al. (1949) and Meyer and Clarke (1978) who reported that breeds with lightest birth weights had higher survival rates.

The analysis of variance (table 16) of the survivability data shows that year differences were significant sources of variation in SURV60, SURV120 but year effects were a significant source of variation in SURV60120 only in the Rambouillets. This reflected that after 60 d of age year by year variation in death losses tended to be less important. An analysis in which the data for the three breed were combined (table 16) shows a significant breed-year effect.

TABLE 16. ANALYSIS OF VARIANCE FOR SURV60, SURV120 AND SURV60120

Source of variation	df	Mean squares[a] SURV60	SURV120	df	Mean squares[a] SURV60120
		Rambouillet			
Year (Y)	22	10,885.5**	14,696.0**	22	2,084.8**
Sires/Y	257	1,735.4**	2,140.0**	253	508.9**
Type of birth (TB)	2	77,733.4**	91,161.4**	2	2,187.3**
Age of dam (AD)	4	813.0	2,483.4	4	1,926.6**
Sex	1	1,079.7	791.4	1	11.5
TB x AD	8	2,804.5*	3,955.7**	8	970.4*
Regression BD[b] linear	1	278.3	3,333.6	1	2,661.3**
Residual	5,687	1,310.5	1,503.7	4,683	393.0
		Targhee			
Year (Y)	22	4,686.4**	5,686.3**	22	462.9
Sires/Y	141	1,418.2**	1,705.8**	140	318.5
Type of birth (TB)	2	100,875.1**	116,336.2**	2	1,809.7*
Age of dam (AD)	4	3,282.2*	4,742.6**	4	761.8+
Sex	1	3,072.1+	1,887.4	1	66.0
TB x AD	8	8,341.1**	7,458.3**	8	570.9
Regression BD[b] linear	1	29.5	2,957.2	1	2,760.8**
Residual	5,568	1,064.0	1,297.7	4,803	374.4
		Columbia			
Year (Y)	21	8,718.7*	9,580.6*	21	1,430.4
Sires/Y	95	5,018.8**	4,902.1**	94	1,006.2**
Type of birth (TB)	2	42,754.0**	56,526.8**	2	2,386.9*
Age of dam (AD)	4	1,213.7	959.4	4	119.0
Sex	1	1.8	15.1	1	127.2
TB x AD	8	4,673.7**	3,411.7*	8	162.8
Regression BD[b] linear	1	4,230.4+	1,068.2	1	1,430.4
Residual	3,139	1,191.2	1,515.3	2,580	561.8
		Three breed combined			
Breed-year (B-Y)	67	8,894.7**	11,085.3**	67	1,457.9**
Sires/B-Y	493	2,302.2**	2,578.9**	487	554.7**
Type of birth (TB)	2	227,140.3**	266,524.2**	2	5,030.3**
Age of dam (AD)	4	4,014.0**	6,507.9**	4	772.5
Sex	1	3,338.2+	2,137.3	1	127.8
TB x AD	8	13,107.9**	12,028.8**	8	205.7
Regression BD[b] linear	1	296.8	2,804.2	1	6,681.9**
Residual	14,426	1,190.4	1,428.2	12,098	422.5

[a] Mean squares x 10^4.
[b] BD = birth date.
** ($p<.01$), * ($p<.05$), + ($p<.1$).

Least squares means for SURV60, SURV120 and SURV60120 are presented by years for each breed in appendix table 61. Variation between years in SURV60 probably reflects variation in weather and health conditions in the different years. Slee (1981) reported that lamb mortality in certain circumstances such as severe weather, may exceed 40%. Obst and Day (1968) found that sudden short-term changes in weather may produce very large changes in mortality, for instance from 15% to 91% in Merino lambs on Kangaroo islands.

Type of birth was generally found to be an important source of variation in lamb survivability (table 16). When birth weight was included in the model as a covariate (appendix table 62) type of birth appeared to have a smaller effect than when birth weight was excluded from the model (table 16). This suggests that part of the influence of type of birth on survival is mediated through its effect on individual lamb birth weight, therefore, by adjusting to a constant birth weight the effect of type of birth is deminished statistically.

Least squares means for SURV60, SURV120 and SURV60120 are displayed in table 17. Multiple-born lambs consistently have lower survivability than single- or twin-born lambs. Lambs born in larger litters were generally lighter in weight and probably less vigorous. Starvation probably occurs more frequently in multiple-born lambs. Although, the number of observation was small, Columbias tended to be superior in survivability of triplet-born lambs.

The effect of sex was an unimportant source of variation in SURV60, SURV120 and SURV60120. However, if birth weight was included in the model sex appeared to assume a greater effect on SURV60 and

SURV120, except for the Columbias ($p<.1$) (appendix table 62). This suggests that by including birth weight in the model the variation between sexes was increased. This may be due to the curvilinear relationship between birth weight and survivability and some degree of overlapping between birth weights of ram and ewe lambs.

TABLE 17. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SURV60, SURV120 AND SURV60120 BY TYPE OF BIRTH AND BY BREED

Type of birth	No.	SURV60 (%)	SURV120 (%)[a]	No.	SURV60120 (%)
		Rambouillet			
Single	2,563	90.3±1.5	87.4±1.7	2,249	96.7± .9
Twin	3,297	79.1±1.3	75.3±1.6	2,654	94.9± .9
Triplet	123	60.8±4.6	55.2±5.0	72	89.0±3.2
		Targhee			
Single	2,250	93.4±1.3	90.5±1.4	2,071	96.9± .6
Twin	3,388	82.0±1.1	78.0±1.2	2,850	95.2± .6
Triplet	110	50.5±4.1	45.5±4.5	61	90.1±3.3
		Columbia			
Single	1,352	88.3±4.2	84.5±4.0	1,192	95.5±1.9
Twin	1,839	77.0±4.1	71.2±4.0	1,466	92.4±1.9
Triplet	81	66.1±6.8	62.7±7.3	54	95.5±4.9
		Three breeds combined			
Single	6,165	90.7±1.2	87.4±1.2	5,512	96.3± .6
Twin	8,524	79.3±1.1	74.8±1.2	6,970	94.3± .6
Triplet	314	57.3±2.7	52.7±3.0	187	91.9±2.0

[a] No. observation equal to SURV60

Although not significant, the differences between males and females tended to be in favor of the ewe lambs except for the Columbias and for SURV60120 (table 18). Results of this study are contrary with most of the findings in previous study which indicated

that the differences in survivability between ewe lambs and ram lambs ranged from 2.5% to 10% (Venkantachalam et al., 1949; Hoversland et al., 1957; Bradford et al.,1974; Smith, 1977; Meyer and Clarke, 1978; Atkins, 1980a; and Johnson et al.,1982).

TABLE 18. LEAST SQUARES MEANS FOR SURV60, SURV120 SURV60120 BY SEX AND BY BREED

Sex	No.	SURV60 (%)	SURV120 (%)[a]	No.	SURV60120 (%)
			Rambouillet		
Male	2,894	76.3±1.9	72.2±2.1	2,398	93.6±1.3
Female	3,089	77.2±1.9	73.0±2.1	2,577	93.5±1.3
			Targhee		
Male	2,804	74.5±1.7	70.7±1.8	2,402	94.2±1.1
Female	2,944	76.0±1.7	71.9±1.8	2,580	93.9±1.1
			Columbia		
Male	1,653	77.1±4.4	72.8±4.4	1,368	94.7±2.4
Female	1,619	77.2±4.4	72.7±4.4	1,344	94.2±2.4
			Three breeds combined		
Male	7,351	75.3±1.3	71.2±1.4	6,168	94.2± .8
Female	7,652	76.3±1.3	72.0±1.4	6,501	94.0± .8

[a] No. observation equal to SURV60

Age of dam was not an important source of variation for SURV60 and SURV120 for Rambouillets and Columbias, but was an important source of variation for the Targhees ($p<.05$ for SURV60 and $p<.01$ for SURV120) and three breeds combined in one analysis ($p<.01$ for both SURV60 and SURV120). Again, if birth weight was included in the model the effect of age of dam became less important, particularly for the Targhees and in analysis of three breeds combined (appendix table 62).

This suggests that the effect of age of dam accounted for only part of the variation in survival associated with birth weight. However, there is variation in three breeds studied.

The effect of age of dam in the Targhee breed and three breeds combined in one analysis for SURV60 and SURV120 in this study is agreement with the finding by Purser and Young (1959), Gunn and Robinson (1963), Bichard and Cooper (1966), Hight and Jury (1970b) and Wiener et al. (1983). That the effect of age of dam appeared to be less important when birth weight was in the model is in agreement with the finding of Galal et al. (1974) in a study on some purebred and crosses under semi-arid conditions and Hinch et al. (1983) working with Booroola Merino in New Zealand. Both authors found that the relatively small age of dam effect was completely explained in terms of lamb birth weight.

For SURV60120 age of dam was not found to be an important source of variation except for Rambouillet ($p<.01$). In the combined analyses age of dam was not an important source of variation regardless of whether birth weight was in the model or not. This indicates that maternal influence is generally reduced at later age (60 d of age), although there is variation in different breeds studied. There was no general pattern of the effect age of dam on SURV60, SURV120 and SURV60120, except the tendency for improving survivability with advancing age of dam (table 19).

TABLE 19. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SURV60, SURV120 AND SURV60120 ACCORDING TO AGE OF DAM BY BREED

Age of dam	No.	SURV60 (%)	SURV120 (%)[a]	No.	SURV60120 (%)
			Rambouillet		
2	1,397	74.7±5.3	72.1±5.7	1,127	95.9±3.5
3	1,390	76.8±4.4	66.6±4.8	1,158	83.3±3.2
4	1,277	78.8±2.7	75.9±2.9	1,077	96.6±1.8
5	1,040	74.6±2.5	71.0±2.8	887	93.8±1.9
6+	879	78.8±2.5	77.4±2.8	726	98.2±1.7
			Targhee		
2	1,432	66.7±4.7	58.6±5.2	1,176	85.3±3.9
3	1,363	72.8±2.7	70.2±2.9	1,177	97.1±2.2
4	1,148	79.4±2.2	75.6±2.4	1,043	94.4±1.6
5	926	76.5±3.6	73.7±4.0	819	96.9±2.7
6+	879	81.0±2.4	78.5±2.6	767	96.6±1.6
			Columbia		
2	768	69.5±8.2	64.2±8.9	585	92.7±6.2
3	720	74.9±5.7	71.8±5.9	608	96.1±3.8
4	671	82.7±5.4	77.1±5.5	580	93.3±3.5
5	566	80.1±4.8	75.7±4.8	472	94.4±2.7
6+	547	78.4±4.8	75.0±4.8	467	95.9±2.7
			Three breed combined		
2	3,597	69.8±3.3	64.2±3.6	2,888	91.6±2.4
3	3,473	73.3±2.2	68.7±2.4	2,943	93.2±1.6
4	3,096	79.0±1.8	74.9±1.9	2,700	94.7±1.2
5	2,532	77.5±1.8	73.4±1.9	2,178	94.4±1.2
6+	2,305	79.4±1.7	76.9±1.8	1,960	96.9±1.1

[a] No. observation equal to SURV60

A statistically significant interaction between type of birth and age of dam was found for SURV60 and SURV120 for Rambouillets, Targhees, Columbias and three breeds combined in one analysis, and Rambouillets for SURV60120 (table 16). The reasons for this interaction is not clear. It may be due to increasing survivability associated with increasing age of dam and to the fact that twin- and

triplet-born lambs tended to have higher survivability in mature ewes than in 2-yr-old ewes. In single-born lambs survivability increased slightly with increasing age of dam. There is also great disparity in frequency of triplet births compared to singles and twins. The distribution of types of birth over ages of dam may have been highly disproportionate (figure 1).

The linear regression of survivability on birth dates indicates that generally birth dates had no significant effect on SURV60 and SURV120, but it had a significant effect on SURV60120, except for the Columbias. This suggests that birth date and birth weight were related in these data. The regression coefficients (table 20) show that Rambouillet and Targhee lambs born later in the season tended to suffer higher mortality than lambs born early in the season. For the Columbias, however, lambs born in the beginning of the season suffered more mortality from birth to 60 d and 120 d than lambs born later in the season.

TABLE 20. REGRESSION COEFFICIENT AND STANDARD ERRORS OF SURV60, SURV120 SURV60120 ON BIRTH DATE BY BREED

Breed	Regression coefficients (%/day) SURV60	SURV120	SURV60120
Rambouillet	-.031±.07	-.109±.07	-.116±.04**
Targhee	-.012±.07	-.124±.08	-.128±.05**
Columbia	.212±.11+	.107±.13	-.136±.09
Three breed combined	.023±.05	-.070±.05	-.123±.03**

** ($p<.01$), + ($p<.1$).

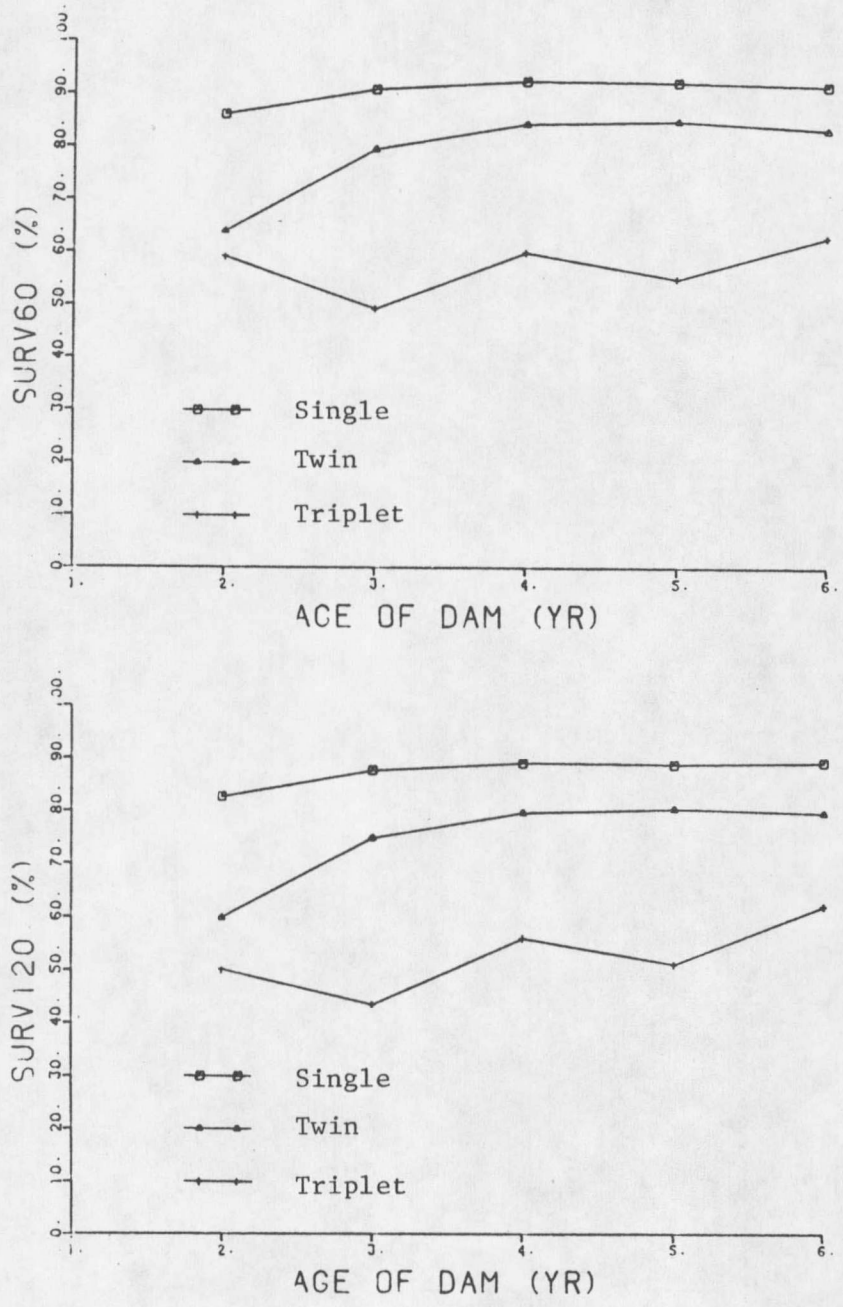


FIGURE 1. INTERACTION BETWEEN AGE OF DAM AND TYPE OF BIRTH FOR SURV60 AND SURV120 (BASED ON THREE BREED COMBINED ANALYSES)

The linear and quadratic regressions of survivabilities on birth weight (appendix table 62) generally show this to be an important source of variation for SURV60 and SURV120, but an unimportant source of variation for SURV60120. Also, birth weight had more influence on SURV60 than SURV120. In the combined analyses (appendix table 62) residual variation was reduce about 9.3% for SURV60, but only 7.8% for SURV120 compared to the analyses without birth weight in the model (table 16). The effect of birth weight on survivability was more important in Columbias than in the Rambouillet and Targhees. Birth weight in the corresponding breeds accounted for 12.2%, 9.8% and 7.6% of the variation in SURV60 and 9.9%, 8.5% and 6.2%, respectively, for SURV120.

The linear and quadratic regressions coefficients of SURV60 and SURV120 on birth weight within each type of birth are presented in table 21. Based on those coefficients prediction equations were computed as described by Harvey (1977) and are shown in table 22.

The curves showing the relationship between survivability and birth weight at 60 d and at 120 d, by breed, are presented in figure 2. In general, survivability increased dramatically with increasing birth weight up to approximately 5 - 6 kg. There were small breed differences in the birth weights for maximum survival. Birth weights that gave the highest predicted maximum SURV60 for Rambouillets, Targhees and Columbias were 6.0 kg, 4.9 kg, and 5.0 kg, respectively; and 5.8 kg, 4.9 kg, and 5.0 kg, respectively for SURV120. On the average (based on the combined analyses) the birth weights that give maximum SURV60 and SURV120 were 5.4 kg and 5.3 kg, respectively.

TABLE 21. REGRESSION COEFFICIENTS OF SURV60 AND SURV120 ON BIRTH WEIGHT (BW) AND BIRTH WEIGHT WITHIN INDIVIDUAL CLASS TYPE OF BIRTH BY BREED

Covariates, individual class covariates	Mean BW (kg)	Regression coefficients SURV60 linear (%/kg)	SURV60 quadratic (%/kg^2)	SURV120 linear (%/kg)	SURV120 quadratic (%/kg^2)
Rambouillet					
		**	**	**	**
BW	4.54	13.6 ± 2.2	-4.7 ± 1.2	12.0 ± 2.4	-4.8 ± 1.3
BW/TB		*	+	*	*
Single		15.1 ± 1.0	-5.6 ± .6	15.4 ± 1.1	-5.3 ± .7
Twin		11.3 ± 1.2	-7.2 ± .8	10.8 ± 1.2	-7.6 ± .8
Triplet		14.5 ± 6.4	-1.3 ± 3.4	9.8 ± 6.9	-1.6 ± 3.7
Targhee					
		n.s.	**	n.s.	**
BW	4.65	4.8 ± 3.1	-7.3 ± 1.5	3.9 ± 3.5	-7.4 ± 1.7
BW/TB		n.s.	**	n.s.	**
Single		8.2 ± 1.0	-2.9 ± .6	8.6 ± 1.2	-2.8 ± .7
Twin		7.2 ± 1.0	-6.8 ± .6	7.5 ± 1.1	-6.6 ± .7
Triplet		.8 ± 9.2	-12.3 ± 4.4	-4.5 ±10.3	-12.7 ± 4.9
Columbia					
		**	**	**	**
BW	4.30	14.5 ± 3.4	-10.1 ± 2.2	14.0 ± 3.9	-10.1 ± 2.5
BW/TB		n.s.	**	n.s.	**
Single		11.2 ± 1.2	-4.8 ± .7	11.7 ± 1.4	-4.6 ± .8
Twin		12.1 ± 1.3	-8.5 ± .9	13.3 ± 1.5	-8.1 ± 1.1
Triplet		20.3 ±10.1	-17.1 ± 6.6	17.0 ±11.5	-17.5 ± 7.5
Three breed combined					
		*	**	**	**
BW	4.53	10.3 ± 1.5	-6.2 ± .8	9.2 ± 1.7	-6.3 ± .9
BW/TB		+	**	*	**
Single		11.7 ± .6	-4.4 ± .4	12.1 ± .6	-4.2 ± .4
Twin		9.8 ± .7	-7.3 ± .4	9.9 ± .7	-7.3 ± .5
Triplet		9.3 ± 4.5	-6.9 ± 2.4	5.5 ± 5.0	-7.4 ± 2.7

** ($p<.01$), * ($p<.05$), + ($p<.1$), n.s. Non significant.

Based on these equations and using average birth weights from this study the predicted SURV60 were 92.7%, 83.6%, 99.8% and 88.3%, respectively, for Rambouillets, Targhees, Columbias and three breeds combined. The corresponding values for SURV120 were 85.3%, 76.2%, 92.7% and 82.6%, respectively. Maximum survivability occured just above the mean birth weight, with the exception for SURV120 for the Targhee which occured slightly below the mean of birth weight. This suggests that by increasing birth weight lamb survival would increase. However, this would be true only for low birth weight lambs. Survivability decreases rather markedly after optimum birth weight is reached. A substantial increase in birth weight would tend to increase mortality in the heavier weight range as well as reduce mortality in the lighter weight range. Purser and Young (1964) also found that maximum survival rates occured slightly above the mean birth weight.

The relationships between survivability and birth weight according to type of birth is shown in figure 3. The results of this study indicated that at equal birth weight multiple-born lambs have lower survivability than single-born lambs. For instance, at a birth weight of 5 kg triplet-born and twin-born lambs have SURV60 of 82.3% and 94.9% as compared to single-born lambs that have survivability of 97.1%. Similar results were reported by Hinch et al. (1983) in a study on Booroola flocks in New Zealand, who found that triplet- and quadruplet-born lambs had lower probability of surviving compared to singles or twins of equal birth weight.

TABLE 22. PREDICTION EQUATION OF SURV60, SURV120 ON BIRTH WEIGHT (BW) AND BIRTH WEIGHT WITHIN INDIVIDUAL CLASS TYPE OF BIRTH (BW/TB)

Class	Prediction equations SURV60	SURV120
	Rambouillet	
BW (all)	$Y = -76.5 + 56.4BW - 4.7BW^2$	$Y = -76.9 + 55.8BW - 4.8BW^2$
BW/TB		
Single	$Y = -256.4 + 122.5BW - 10.3BW^2$	$Y = -249.3 + 119.1BW - 10.1BW^2$
Twin	$Y = -271.2 + 133.2BW - 11.9BW^2$	$Y = -276.4 + 136.0BW - 12.4BW^2$
Triplet	$Y = -178.7 + 82.7BW - 6.0BW^2$	$Y = -167.0 + 80.0BW - 6.4BW^2$
	Targhee	
BW (all)	$Y = -98.9 + 73.0BW - 7.3BW^2$	$Y = -99.9 + 72.2BW - 7.4BW^2$
BW/TB		
Single	$Y = -190.0 + 107.9BW - 10.2BW^2$	$Y = -188.6 + 106.4BW - 10.1BW^2$
Twin	$Y = -272.1 + 143.3BW - 14.1BW^2$	$Y = -269.7 + 141.2BW - 14.0BW^2$
Triplet	$Y = -377.5 + 186.8BW - 19.7BW^2$	$Y = -372.2 + 185.8BW - 20.0BW^2$
	Columbia	
BW (all)	$Y = -155.2 + 101.5BW - 10.1BW^2$	$Y = -157.3 + 100.5BW - 10.1BW^2$
BW/TB		
Single	$Y = -298.6 + 153.9BW - 14.9BW^2$	$Y = -298.3 + 151.7BW - 14.7BW^2$
Twin	$Y = -370.0 + 186.3BW - 18.6BW^2$	$Y = -371.4 + 183.7BW - 18.2BW^2$
Triplet	$Y = -544.2 + 268.6BW - 27.2BW^2$	$Y = -540.2 + 267.8BW - 27.6BW^2$
	Three breed combined	
BW (all)	$Y = -90.0 + 66.5BW - 6.2BW^2$	$Y = -92.4 + 66.4BW - 6.3BW^2$
BW/TB		
Single	$Y = -228.7 + 118.2BW - 10.6BW^2$	$Y = -227.5 + 116.7BW - 10.5BW^2$
Twin	$Y = -279.6 + 142.4BW - 13.5BW^2$	$Y = -282.7 + 142.8BW - 13.7BW^2$
Triplet	$Y = -283.2 + 138.6BW - 13.1BW^2$	$Y = -280.5 + 139.1BW - 13.7BW^2$

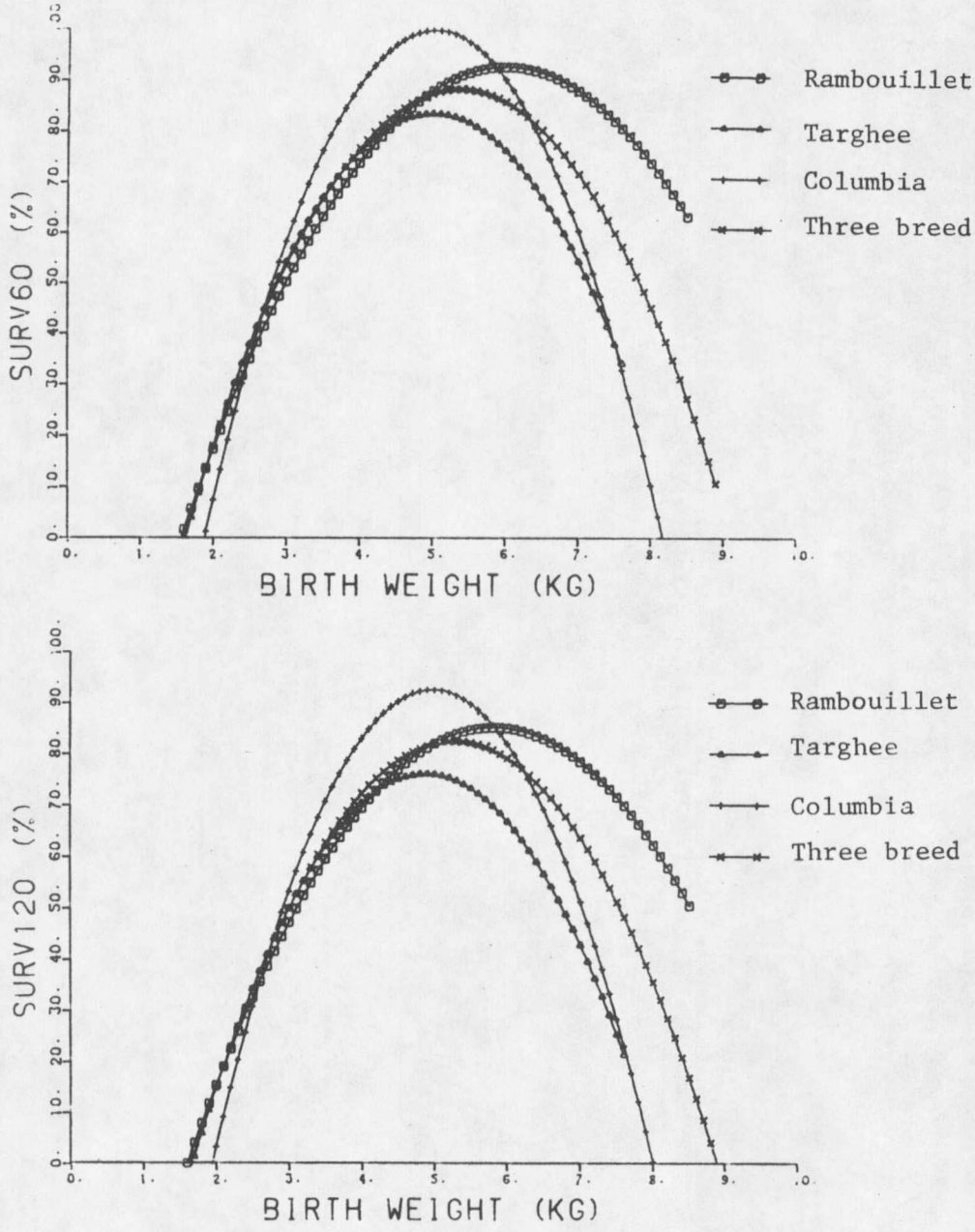


FIGURE 2. CURVE RELATIONSHIP BETWEEN BIRTH WEIGHT AND SURV60 AND SURV120 BY BREED

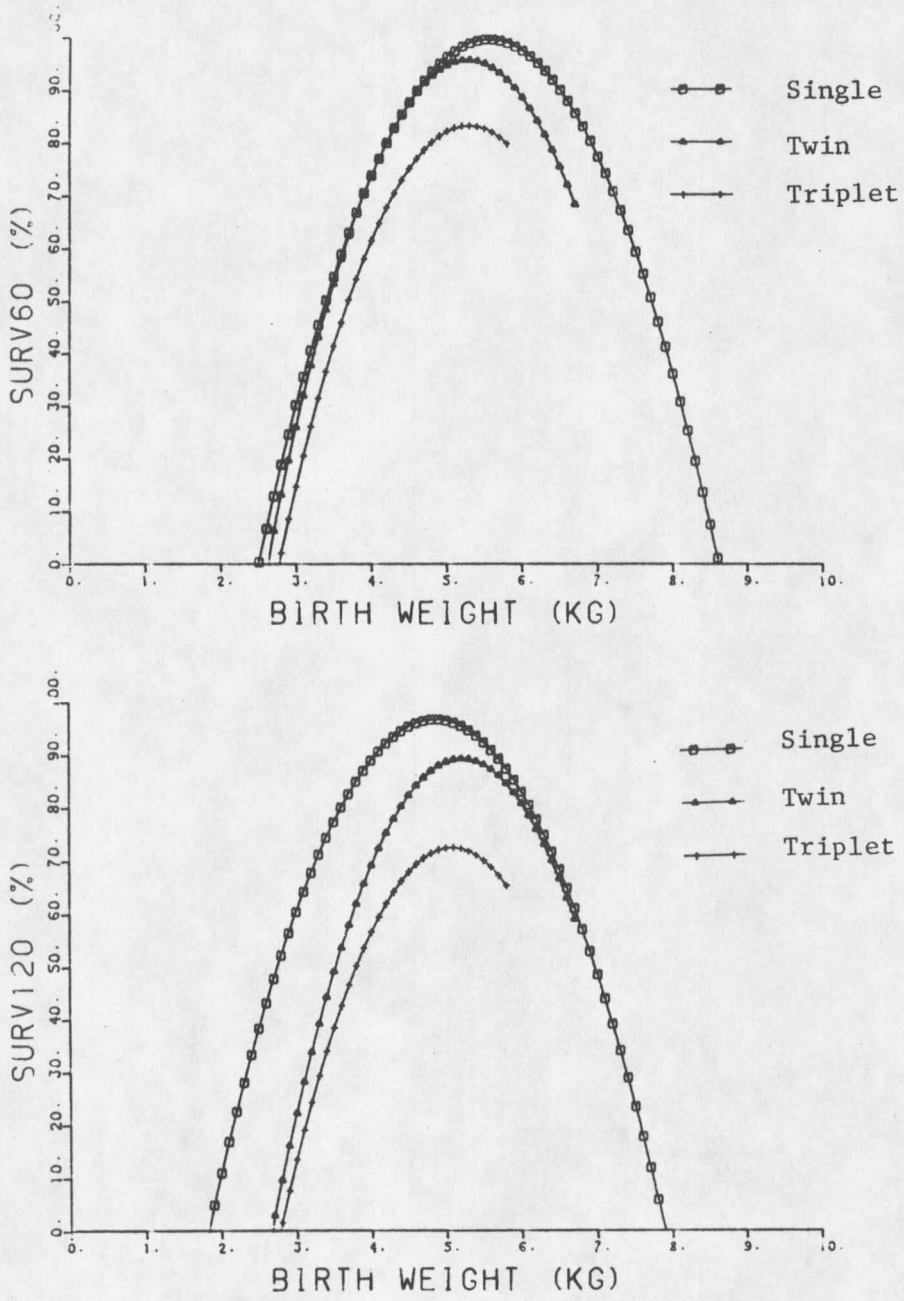


FIGURE 3. CURVE RELATIONSHIP BETWEEN BIRTH WEIGHT AND SURV60 AND SURV120 BY TYPE OF BIRTH (BASED ON THREE BREED COMBINED IN ONE ANALYSIS)

Birth weight of range sheep. The analysis of variance (table 23) shows that the differences due to year, type of birth, age of dam, sex, type of birth x age of dam interaction and linear regression of birth weight on birth date were generally significant sources of variation for birth weight. The exceptions were in the Rambouillet where age of dam was not an important source of variation, and in Columbias where the interaction of type of birth x age of dam was not significant.

Year to year variation in birth weight of Rambouillet, Targhee and Columbia breed is shown in appendix table 63. It is suggested that year to year variation in range conditions affects ewe condition and is responsible for the birth weight differences observed. Similar year by year variation in range sheep was also noted by Sidwell et al. (1964), Sidwell and Miller (1971b), Vesely and Peters (1964) and Smith (1977).

The mean birth weight for Rambouillet, Targhee and Columbia lambs was 4.38 kg, 4.41 kg, and 3.97 kg, respectively, with overall mean of 4.28 kg for those three breeds (table 24). Small differences in birth weight between Targhee and Rambouillet lambs was also reported by Smith (1977) who found the average birth weight of Targhee 4.2 kg and Rambouillet 4.1 kg and by Ercanbrack and Price (1972), but the ranking of breeds in the latter study was Targhee (4.79 kg), Columbia (4.67 kg) and Rambouillet (4.54 kg).

Least squares means of birth weight by type of birth (table 24) indicated that Rambouillet twins and triplets were 81.2% and 73.8% of

the mean birth weight of singles. The corresponding values for Targhees and Columbias were 81.1%, 69.0%, and 80.7%, 63.5%, respectively, and for the three breeds combined were 80.8% and 69.7%. This result was higher than the expected values given by Dickinson et al. (1962) who reported that twins were expected to be 78% and triplets 62% of the mean weight of singles. However, these results are similar to the study of Bichard and Cooper (1966) who reported that twins and triplets were 20% and 30% lighter than singles, respectively.

Mean birth weight according to age of dam is shown in table 24, and indicates that birth weight increases with increasing age of dam. In this study lambs produced by mature ewes were, for Rambouillets, Targhees, Columbias, 2.4%, 10.4%, and 19.8% heavier than those of lambs produced by 2-yr-old ewes, respectively. The overall percentage was 9.0%. This study was consistent with the findings of Vesely and Peters (1964) who reported that 2-yr-old ewes bore lighter lamb than older ewes, and the birth weight showed a slight increase for each year increase in age of dam up to 6 yr of age. Results of this study were also similar to the finding of Nelson and Venkantachalam (1949) who reported that mature ewes produced lambs with 10% heavier birth weight than did 2-yr-old ewes.

Ram lambs were consistently heavier than ewe lambs in this study. For Rambouillet, Targhee and Columbia, ram lambs were 6.8%, 7.2%, and 5.7% heavier than ewe lambs, respectively. Overall means from the three breeds combined indicated that ram lambs were 7% heavier than ewe lambs. These results were in the range of values reported by

Nelson and Venkantachalam (1949) and Bichard and Cooper (1966) who found that ram lambs were 5% heavier than ewe lambs, and the results reported by Dickinson et al. (1962) who found that the weight of ewe lambs was 86 - 90% of ram lambs.

Significant type of birth by age of dam interaction reflected that advancing age of dam increased birth weight, but with respect to type of birth, the increase in birth weight of lambs from larger litters with advancing age of dam is less than for singles.

The regression of birth weight on date of birth was around 9.73 g, 16.60 g, and 16.22 g per day for Rambouillet, Targhee and Columbia. In the combined analysis the regression was 13.24 g per day. This suggests that some environmental factors favored the later-bearing ewes. Ewes were brought to the station headquarters shortly before lambing season, and they received supplementary feeding, hence lambs born in early season probably had less satisfactory prenatal nutrition than those lambs born later. These results were consistent with finding of Vesely and Peters (1964) who found the regression of birth weight on date of birth was .023 kg/d.

Heritability estimates of survivability and birth weight. Heritability estimates of SURV60, SURV120 and SURV60120 were consistently low for the Rambouillet and Targhee breeds. In the Columbia breed the estimates of heritabilities of survivability were relatively high. However, in the analysis of three breed combined the estimates of heritability of survivability were low (table 25). Estimates of heritability was essentially the same by including birth weight in the model (appendix table 65).

TABLE 23. ANALYSIS OF VARIANCE OF BIRTH WEIGHT BY BREED

Source of variation	Rambouillet (kg)		Targhee (kg)		Columbia (kg)		Three breed[a] (kg)	
	df	Mean squares	df	Mean squares	df	Mean squares	df	Mean squares
Breed-Year (B-Y)	22	13.59**	22	10.57**	21	6.04**	67	14.48**
Sires/B-Y[b]	257	1.01**	141	1.46**	95	1.87**	493	1.33**
Type of birth (TB)	2	488.85**	2	515.02**	2	290.57**	2	1,309.97**
Age of dam (AD)	4	.83	4	2.35**	4	6.81**	4	7.20**
Sex	1	124.29**	1	133.39**	1	39.15**	1	289.28**
TB x AD	8	1.43**	8	1.14**	8	.53	8	1.78**
Regression BD[c] linear	1	26.64**	1	52.91**	1	24.70**	1	99.83**
Residual	5,687	.43	5,568	.44	3,139	.49	14,426	.45

[a] Three breed combined in one analysis.
[b] Sires/year for each breed.
[c] BD = birth date.
** ($p<.01$), * ($p<.05$).

TABLE 24. LEAST SQUARES MEANS AND STANDARD ERRORS OF BIRTH WEIGHT (KG) CLASSIFIED ACCORDING TO TYPE OF BIRTH, AGE OF DAM, SEX AND THE LINEAR REGRESSION OF BIRTH WEIGHT ON BIRTH DATE BY BREED

Variables	Rambouillet		Targhee		Columbia		Three breed[a]	
	No.	BW (kg)	No.	BW (kg)	No.	BW (kg)	No.	BW (kg)
U	5,983	4.38 ± .05	5,748	4.41 ± .05	3,272	3.97 ± .09	15,003	4.28 ± .03
Type of birth								
Single	2,563	5.16 ± .04	2,250	5.29 ± .05	1,352	4.88 ± .08	6,165	5.12 ± .03
Twin	3,297	4.19 ± .04	3,388	4.29 ± .05	1,839	3.94 ± .08	8,524	4.14 ± .03
Triplet	123	3.81 ± .09	110	3.65 ± .09	81	3.10 ± .14	314	3.57 ± .06
Age of dam								
2	1,397	4.30 ± .10	1,432	4.07 ± .11	768	3.43 ± .16	3,597	3.99 ± .07
3	1,390	4.31 ± .09	1,363	4.45 ± .07	720	3.79 ± .11	3,473	4.21 ± .05
4	1,277	4.38 ± .06	1,148	4.52 ± .06	671	4.12 ± .11	3,096	4.35 ± .04
5	1,040	4.43 ± .06	926	4.47 ± .09	566	4.21 ± .09	2,532	4.38 ± .04
6+	879	4.50 ± .06	879	4.54 ± .06	547	4.32 ± .09	2,305	4.45 ± .04
Sex								
Male	2,894	4.53 ± .05	2,804	4.56 ± .06	1,653	4.08 ± .09	7,351	4.42 ± .03
Female	3,089	4.24 ± .05	2,944	4.25 ± .06	1,619	3.86 ± .09	7,652	4.13 ± .03
Reg.birth weight on birth date (g/d)		9.73 ± 1.23		16.60 ± 1.51		16.22 ± 2.28		13.24 ± 0.89

[a] Three breed combined in one analysis

TABLE 25. COMPONENTS OF VARIANCE, HERITABILITIES (h^2) AND STANDARD ERRORS FOR SURV60, SURV120 AND SURV60120 AND BIRTH WEIGHT BY BREED

	Rambouillet	Targhee	Columbia	Three breed[a]
		SURV60[a]		
No. observation	5,983	5,748	3,272	15,003
No. sires	280	164	117	561
k^b	20.45	34.06	26.25	25.57
σ_{s}^2	20.78	10.40	145.83	43.47
σ_{w}^2	1,310.52	1,064.03	1,191.18	1,190.42
h^2	.06	.04	.44	.14
S.E.	.02	.02	.07	.02
		SURV120[a]		
No. observation	5,983	5,748	3,272	15,003
No. sires	280	164	117	561
k^b	20.45	34.06	26.25	25.57
σ_{s}^2	31.12	11.98	129.03	44.99
σ_{w}^2	1,503.71	1,297.66	1,515.30	1,428.18
h^2	.08	.04	.31	.12
S.E.	.02	.02	.05	.02
		SURV60120[a]		
No. observation	4,975	4,982	2,712	12,669
No. sires	276	163	116	555
k^b	17.24	29.72	21.77	21.80
σ_{s}^2	6.72	-1.88	20.41	6.07
σ_{w}^2	393.04	374.44	561.79	422.47
h^2	.07	-.02	.14	.06
S.E.	.02	.01	.04	.01
		BIRTH WEIGHT[c]		
No. observation	5,983	5,748	3,272	15,003
No. sires	280	164	117	561
k^b	20.45	34.06	26.25	25.57
σ_{s}^2	.03	.03	.05	.04
σ_{w}^2	.43	.44	.49	.45
h^2	.25	.26	.39	.29
S.E.	.03	.04	.06	.02

[a] Analysis of variance in table 16.
[b] Weighted average number records per sire within year or within breed-year for three breed combined.
[c] Analysis of variance in table 23.

Pooled heritability (within breed) estimates found in this study were .14, .12 and .06 for SURV60, SURV120 and SURV60120, respectively, and are in the range of heritability estimates found in previous studies. Previous estimates of heritability of survivability included .05 for survival from birth to weaning in Merino in Australia (Piper et al., 1982); .06 for preweaning mortality of Suffolk, Hampshire, Rambouillet, Dorset, Targhee, Corriedale and Coarse wool (Smith, 1977); .07 and .15 for postnatal survival using individual records and mean records, respectively (Fogarty et al., 1982); .13 and .19 in two Rambouillet flocks in Texas (Shelton and Menzies, 1970). Small negative estimates of heritability of survivability were found by Piper et al. (1982).

The heritability estimate for the Columbia breed in this study are clearly different from the Rambouillet and Targhee estimates. The pooled value may not be appropriate for the three sub-populations from which the data came. However, this estimate corresponds well with values reported in the literature. No reason for the higher estimate from the Columbia data is apparent, but it is doubtful if the heritability of survivability in the general sheep population is as high as the Columbia estimate suggests, and the heritability may not be that high in the Columbia breed. Additional independent estimates for this breed are needed.

Heritability estimates of birth weight found in this study for Rambouillet, Targhee and Columbia were .25, .26 and .39, respectively. The pooled heritability estimates is .29. The pooled estimate is lower than the estimates of .61 in 5 breeds (Nelson and Venkatachalam,

1949); .33 in sheep under farm flock conditions (Blackwell and Henderson, 1955); but higher than the estimates of .12 in Norwegian sheep (Gjedrem, 1967); .17 and .24 in synthetic lines (Martin et al., 1980); and .10 in crossbred lambs (Thrift et al., 1973).

The heritability estimates for birth weight in Rambouillets and Targhees were slightly lower than those reported by Ercanbrack and Price (1972) (.26 and .30, respectively) for the corresponding breeds. However, the estimate of heritability of birth weight for Columbias (.39) was higher than the value (.12) reported by those authors.

Phenotypic and genetic correlations among survivability and birth weight in range sheep. Phenotypic correlations between SURV60 SURV120 were high (table 26), ranging from .84 to .89 with pooled average of .87. Relatively low phenotypic correlations, however, were found between birth weight and SURV60 and SURV120. The correlations ranged from .20 to .28 with pooled mean of .25 between birth weight and SURV60, and from .19 to .26 with a pooled average of .23 between birth weight and SURV120 (table 26). Very low phenotypic correlations were found between birth weight and SURV60120. The range was from .03 to .06 with pooled value of .04 (table 27).

High phenotypic correlation between SURV60 and SURV120 was largerly due to the low mortality between 60 d and 120 d. Low phenotypic correlations between birth weight and SURV60 or SURV120 are largerly due to the curvilinear association between birth weight and survivability. Low phenotypic correlation between birth weight and survivability is in agreement with the value (.23) reported by Smith (1977).

Genetic correlation between SURV60 and SURV120 (table 26) ranged from .94 to 1.08 with a pooled average of .96. This means that genetic variation in SURV60 is highly correlated with genetic variation in SURV120. Similar results were reported by Fogarty et al. (1982) who reported a genetic correlation between neonatal survival and postnatal survival of .78.

Moderate genetic correlation between birth weight and SURV60 and SURV120 was found for Rambouillets and Columbias, but very low genetic correlations between the corresponding traits were found for the Targhees. However, the pooled genetic correlation is moderate as shown in table 26. Selection for birth weight should result in some genetic gain for survivability, with the exception in Targhee breed. The genetic correlation between birth weight and SURV60120 was consistently low for all breeds (table 27). Hence, selection for birth weight would result in very low genetic gain for SURV60120. Due to the curvilinear relationship selection for birth weight to improve survivability is probably not advisable.

These results are similar to the finding of Smith (1977) who found negative genetic correlation between birth weight and mortality (r_g=-.28). Differences in the sign of genetic correlation found in these results were due to the opposite parameter (survivability vs. mortality) used.

TABLE 26. COMPONENT OF VARIANCE AND COVARIANCE OF SURV60, SURV120 AND SURV60120, BIRTH WEIGHT (BW), GENETIC CORRELATION (r_g) AND PHENOTYPIC CORRELATION (r) BY BREED

	Rambouillet	Targhee	Columbia	Three breed[a]
No. observation	5,983	5,748	3,272	15,003
No. sires	280	164	117	561
k[b]	20.45	34.06	26.25	25.57
σ_s^2				
SURV60 (1)[c]	20.78	10.40	145.82	43.47
SURV120 (2)[c]	31.12	11.98	129.03	44.99
BW (3)[d]	.03	.03	.05	.04
σ_w^2				
SURV60 (1)[c]	1,310.50	1,064.00	1,191.18	1,190.40
SURV120 (2)[c]	1,503.72	1,297.66	1,515.29	1,428.20
BW (3)[d]	.43	.44	.49	.45
σ_{s12}	24.58	12.02	129.39	42.36
σ_{s13}	.27	-.0019	1.35	.41
σ_{s23}	.29	.0004	1.31	.42
Phenotypic correlation				
r_{12}	.88	.87	.84	.87
r_{13}	.26	.20	.28	.25
r_{23}	.25	.19	.27	.23
Genetic correlation[e]				
r_{g12}	.97 (.03)	1.08 (.06)	.94 (.02)	.96 (.01)
r_{g13}	.35 (.15)	-.003 (.20)	.49 (.11)	.33 (.07)
r_{g23}	.31 (.14)	.001 (.21)	.50 (.11)	.33 (.07)

[a] Three breed combined in one analysis.
[b] Weighted average number records per sire within year or breed-year for three breed combined in one analysis.
[c] Analysis of variance in table 16.
[d] Analysis of variance in table 23.
[e] Number in parentheses are standard errors.

TABLE 27. COMPONENT OF VARIANCE AND COVARIANCE OF SURV60120, BIRTH WEIGHT (BW), GENETIC CORRELATION (r_g) AND PHENOTYPIC CORRELATION (r) BY BREED

	Rambouillet	Targhee	Columbia	Three breed[a]
No. observation	4,975	4,982	2,712	12,669
No. sires	276	163	116	555
k[b]	17.24	29.72	21.77	21.80
σ_s^2				
SURV60120 (1)[c]	6.72	-1.88	20.41	6.07
BW (2)[d]	.03	.03	.04	.03
σ_w^2				
SURV60120 (1)[c]	393.04	374.44	561.79	422.47
BW (2)[d]	.35	.37	.42	.38
σ_{s12}	.04	.005	.13	.05
Phenotypic correlation				
r_{12}	.04	.03	.06	.04
Genetic correlation[e]				
r_{g12}	.08 (.17)	...[f]	.15 (.19)	.11 (.11)

[a] Three breed combined in one analysis.
[b] Weighted average number records per sire within year or breed-year for three breed combines in one analysis.
[c] Analysis of variance in table 16.
[d] Analysis of variance in appendix table 64.
[e] Number in parentheses are standard errors.
[f] Non estimable.

Growth characters of Indonesian sheep

Birth weight. Least squares analysis of variance (table 28) shows that under village conditions, location, type of birth, age of dam and sex x type of birth interaction were important sources of variation. Sex, year and month of birth were not important sources of variation. Under experiment station conditions sex, type of birth, year, month of birth and linear and quadratic regression of birth weight on age of dam are significant sources of variation. Breed differences were not significant under experiment station conditions.

General mean (U) for birth weight under village conditions was 1.97 kg, and under experiment station conditions it was 1.87 (table 29). The average birth weights in this study are typical of tropical sheep. Fitzhugh and Bradford (1983) in a study of a variety of hair sheep reported that birth weights ranged from 1.8 to 3.3 kg.

Differences in birth weight at three different locations (table 29) was as expected, with GAR having the highest birth weight followed by CIB and CIR. Sheep in GAR are larger than sheep at CIB and CIR, because in this area sheep are developed mostly for the production of fighting rams and are managed under intensive conditions. Sheep in CIR are the smallest and are managed under semi-extensive conditions in a harsher environment. Sheep in CIB are intermediate in size.

Breed differences under experiment station conditions were not significant, even though least squares means show that JTT were heavier than FT.

TABLE 28. ANALYSIS OF VARIANCE OF BIRTH WEIGHT (KG) OF INDONESIAN SHEEP UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	df	Mean squares
	Village	
Location	2	2.04**
Sex	1	.14
Type of birth (TB)	2	21.50**
Age of dam	3	2.68**
Year	2	.78+
Month	11	1.53
Sex x TB	2	1.38*
Residual	403	.32
	Experiment station	
Breed	1	.58
Sex	1	1.57*
Type of birth	3	22.50**
Year	2	.92*
Month	11	.54*
Regressions		
Age of dam linear	1	2.96**
Age of dam quadratic	1	1.62*
Residual	328	.29

** (p<.01), * (p<.05), + (p<.1)

Ram lambs are consistently heavier than ewe lambs in this study. Under village conditions ewe lambs weighed about 2 % less than ram lambs, although this difference was not significant. Under station conditions ewe lambs were about 7% lighter than ram lambs (p<.05). These results were outside the range of differences reported by Fitzhugh and Bradford (1983) who reported that ram lambs were 3 - 5% heavier at birth than ewe lambs.

TABLE 29. LEAST SQUARES MEANS AND STANDARD ERRORS OF BIRTH WEIGHT (BW) CLASSIFIED ACCORDING TO SOME MAIN EFFECTS AND COVARIATES UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	BW (kg)	No.	BW (kg)
U	427	1.97 ± .06	349	1.87 ± .07
Breed				
JTT		...	298	1.95 ± .05
FT		...	51	1.80 ± .12
Location				
GAR	92	2.11 ± .09		...
CIB	277	2.03 ± .05		...
CIR	58	1.76 ± .10		...
Sex				
Female	234	1.95 ± .07	201	1.81 ± .08
Male	193	1.99 ± .07	148	1.94 ± .08
Type of birth				
1	173	2.52 ± .06	78	2.70 ± .09
2	208	1.95 ± .06	132	2.00 ± .08
3	46	1.44 ± .11	84	1.62 ± .09
4		...	55	1.18 ± .10
Age of dam				
1	55	1.65 ± .09		...
2	210	1.99 ± .07		...
3	98	2.07 ± .08		...
4	64	2.16 ± .09		...
Reg.birth weight on age of dam				
lin.(kg/mo)		...		.013 ±.004
quad.(kg/mo^2)		...		-.0005±.0002

Least squares means of birth weight according to type of birth (table 29) show that lambs from larger litters are lighter than single-born lambs. Under village conditions the weight of twins and triplets, respectively, were 77.4% and 57.1% of single birth weight. Under station conditions birth weight of twins, triplets and quadruplets were 74.1%, 60%, 43.7% of singles. These relative weights for multiples are lower than most observation in hair sheep reported

by Fitzhugh and Bradford (1983) who found that twins, triplets and quadruplets, as percentages of singles, ranged from 81% to 93%; 63% to 87% and 52% to 70%, respectively. Dickinson et al. (1962) in a study using egg transfer also found higher estimates than this study. They concluded that twins are expected to be 78% and triplets 62% of mean weight of singles. Since undernutrition of the ewe depresses birth weights of multiples more than those of singles (Wallace, 1948), the results suggest these ewes may not have been receiving adequate digestible energy or other nutrients.

Least squares means (table 29) shows that under village conditions mature ewes produced heavier lambs than young ewes. Three- and 4-yr-old ewes in this study produced around 16.5% heavier lamb weight at birth than 1- and 2-yr-old ewes. This result is in agreement with the finding of Vesely and Peters (1964) and Chopra and Acharya (1971b) who indicated that 2-yr-old ewes bore lighter lambs than older ewes, and birth weight showed a slight increase for each year increase in age of dam up to 5- to 6-yr-old. Under experiment station conditions a curvilinear relationship between birth weight and age of dam was found. The linear and quadratic regression coefficients were .013 kg/month and -.0005 kg/mo^2, respectively. Maximum birth weight occured when ewes were approximately 39.9 mo of age. A curvilinear relationship between age of dam and birth weight was also found by Blackwell and Henderson (1955), Bhasin and Desai (1967), and Hohenboken et al. (1976b).

Year differences in birth weight under station conditions ($p<.05$) reflected variation in management year by year and the availability of

feed supply. Significant year variation was reported also by Chopra and Acharya (1971b) and Abdel Azis et al. (1978). Under village conditions year effects were not significant ($p<.1$). This suggests that there was only small variation in management and feed supply during the period studied. Gjedrem (1967), Dass and Acharya (1970) and Buvanendran et al. (1981) also found that year was not a significant source of variation.

Least squares means for birth weight by months within year show some fluctuation (appendix table 66), and suggests that season has an effect on birth weight. However, months, as a source of variation, were only important under station conditions ($p<.05$). Birth weight means month by month under station conditions shows that in June birth weight was the lowest. This is probably an effect of the dry season. Buvanendran et al. (1981) in a study on Nigerian sheep noted that lamb born during the dry season were lighter at birth than those lambs born during the wet season. However, studies reported by Bashin and Desai (1967) and Khan and Bhat (1981) indicated that season was not an important source of variation.

Postnatal growth. Least squares analysis of variance (table 30) shows that under village conditions location was an important source of variation for weight at 30 d, weight at 60 d, weaning weight and preweaning daily gain. GAR had the heaviest lambs followed by CIB and CIR as expected (table 31).

TABLE 30. ANALYSIS OF VARIANCE OF WEIGHT AT 30 D (W30), WEIGHT AT 60 D (W60), WEANING WEIGHT AT 90 D (WWT) AND PREWEANING DAILY GAIN UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	W30 (kg) df	W30 (kg) Mean squares	W60 (kg) df	W60 (kg) Mean squares	WWT (kg) df	WWT (kg) Mean squares	PREWG (g) df	PREWG (g) Mean squares
Village								
Location (L)	2	3.54*	2	12.27*	2	31.58**	2	3,767.31**
Sex	1	3.75+	1	10.40+	1	7.81	1	856.74
Type of birth (TB)	2	15.38**	2	36.86**	2	55.39**	2	6,881.31**
Year	2	.97	2	5.84	2	17.33**	2	2,095.23*
Month	11	1.22	11	6.36*	11	13.96**	11	1.706.21**
Age of dam (AD)	3	1.00	3	3.32	3	7.07	3	804.83
L x TB	3	5.41**	3	11.91**	3	20.13**	4	2,330.86**
L x Sex		n.s.		n.s.	2	14.70*	2	1,793.54*
TB x AD	6	1.88+		n.s.		n.s.		n.s.
Regressions								
Birth weight linear	1	96.28**	1	62.48**	1	39.62**		n.s.
Birth weight quadratic	1	3.44+		n.s.		n.s.		n.s.
Residual	319	1.05	283	2.83	256	4.60	257	569.33
Experiment station								
Breed (B)	1	.42	1	.51	1	5.50	1	1,099.73
Sex	1	1.86	1	10.42*	1	1.64	1	97.03
Type of birth (TB)	3	9.06**	3	23.42**	3	18.34**	3	8,057.09**
Year	2	10.14**	2	55.56**	2	69.33**	2	10,214.86**
Month	11	2.37**	11	6.22**	11	21.06**	11	2,643.60**
Sex x TB		n.s.	3	6.47*		n.s.		n.s.
B x Sex		n.s.		n.s.	1	31.78**	1	3,884.29**
Regressions								
Age of dam linear	1	11.51**	1	13.78*	1	11.82+	1	2,035.42*
Age of dam quadratic	1	5.62*		n.s.	1	8.78+	1	1,680.58*
Birth weight linear	1	23.38**	1	47.85**	1	86.87**		n.s.
Birth weight quadratic	1	6.12**		n.s.		n.s.		n.s.
Residual	177	.87	173	2.40	164	3.41	163	427.61

** ($p<.01$), * ($p<.05$), + ($p<.1$).
n.s. Non significant at the preliminary analysis ($p>.1$), hence deleted from the model.

TABLE 31. LEAST SQUARES MEANS AND STANDARD ERRORS OF WEIGHT AT 30 D (W30), WEIGHT AT 60 D (W60), WEIGHT AT WEANING AT 90 D (WWT), AND DAILY GAIN FROM BIRTH TO 90 D (PREWG) CLASSIFIED ACCORDING TO SOME MAIN EFFECTS AND COVARIATES UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	No.	W30 (kg)	No.	W60 (kg)	No.	WWT (kg)	PREWG (g)[a]
				Village			
U	352	4.46 ± .15	309	6.43 ± .23	284	8.34 ± .31	67.7 ± 3.36
Location							
GAR	84	4.66 ± .21	76	7.06 ± .31	65	9.43 ± .43	79.6 ± 4.75
CIB	224	4.66 ± .14	199	6.46 ± .20	189	8.19 ± .26	65.8 ± 2.85
CIR	44	4.06 ± .06	34	5.78 ± .43	30	7.40 ± .56	57.7 ± 6.12
Sex							
Female	184	4.35 ± .17	162	6.24 ± .25	151	8.11 ± .36	65.3 ± 3.98
Male	168	4.57 ± .16	147	6.62 ± .25	133	8.57 ± .34	70.1 ± 3.80
Type of birth							
1	152	5.22 ± .15	130	7.52 ± .24	118	9.82 ± .32	82.6 ± 3.45
2	173	4.23 ± .18	152	5.97 ± .28	141	7.84 ± .38	62.4 ± 4.13
3	27	3.93 ± .30	27	5.80 ± .42	25	7.34 ± .57	58.2 ± 6.01
Age of dam							
1	47	4.34 ± .28	43	6.32 ± .36	42	8.16 ± .47	66.9 ± 4.98
2	181	4.69 ± .17	159	6.41 ± .24	145	8.41 ± .33	68.4 ± 3.63
3	72	4.44 ± .22	63	6.81 ± .31	60	8.88 ± .42	73.2 ± 4.63
4	52	4.36 ± .26	44	6.19 ± .32	37	7.90 ± .43	62.3 ± 4.78
Reg.traits on birth weight							
lin.(kg/kg)		1.09 ± .11		.87 ± .19		.73 ± .25	...
quad.(kg/kg^2)		-.22 ± .12		...		...	...

TABLE 31. (CONTINUED)

Variables	No.	W30 (kg)	No.	W60 (kg)	No.	WWT (kg)	PREWG (g)[a]
				Experiment station			
U	200	4.95 ± .18	197	7.42 ± .26	187	9.55 ± .36	80.6 ± 3.99
Breed							
JTT	168	5.04 ± .13	166	7.52 ± .17	158	9.90 ± .23	85.5 ± 2.62
FT	32	4.86 ± .29	31	7.32 ± .44	29	9.20 ± .60	75.8 ± 6.59
Sex							
Female	103	4.85 ± .18	101	7.14 ± .28	97	9.68 ± .39	81.7 ± 4.28
Male	97	5.05 ± .20	96	7.70 ± .30	90	9.41 ± .43	79.6 ± 4.80
Type of birth							
1	57	5.96 ± .24	57	9.00 ± .34	56	10.94 ± .48	101.9 ± 4.74
2	84	4.97 ± .19	82	7.26 ± .29	76	9.24 ± .41	77.0 ± 4.51
3	37	4.74 ± .24	36	7.22 ± .37	35	9.14 ± .48	74.9 ± 5.22
4	22	4.13 ± .29	22	6.70 ± .30	20	8.88 ± .62	68.7 ± 6.37
Reg.traits on birth weight							
lin.(kg/kg)		.82 ± .16		1.15 ± .26		1.64 ± .32	...
quad.(kg/kg^2)		.35 ± .13		...		...	...
Reg.traits on age of dam							
lin.(kg/mo)		.039± .011		.029± .012		.040± .022	.518± .24
quad.(kg/mo^2)		-.001± .0005		...		-.018± .001	-.024± .01

[a] No. observation equal to WWT

Under experiment station conditions breed consistently was not a significant source of variation. Least squares means (table 31) indicated that JTT were consistently heavier than FT, although the differences was not significant. These results are as expected and consistent with the finding in birth weight. Weaning weight at 90 d (table 31) under village conditions was 8.34 kg and under experiment station conditions was 9.55 kg. Weaning weights from this study were in the range of weaning weights of hair sheep reported by Bradford (1983) who found the average weight of 7.5 kg for sheep in Senegal at 90 d, Martinez (1983) in a study of hair sheep in Venezuela reported weaning weights at 90 d that ranged from 10.2 kg to 12.5 kg, Narayanaswami et al. (1975) reported weaning weight in Indian sheep of 9.44 kg.

A sex effect on preweaning growth and weaning weight generally was not a significant source of variation (table 30), except for 60 d weight under experiment station conditions which was significant. A non-significant effect of sex on postnatal growth was reported by Malik and Acharya (1972b); Narayanaswami et al. (1975); Abdel Azis et al. (1978); Bhadula and Bhat (1980); Buvanendran et al. (1981). However, a significant effect of sex on postnatal growth was reported by Dass and Acharya (1970); Dickerson et al. (1975); and Alrawi et al. (1982).

Ram lambs usually gain faster and weigh more than ewe lambs. Similar phenomena were found in this study, with the exception of preweaning daily gain and weaning weight under experiment station conditions where ewe lambs were slightly heavier and gained faster

than ram lambs. The standard errors were high and the differences were not significant. The possible explanation for these results may be found in the important interaction ($p<.01$) between breed and sex. In one breed ram lambs were lighter than ewe lambs, but with only few observations. Ram lambs in this study were 5.1%, 6.1%, 5.7% heavier and gained 7.4% faster than ewe lambs, respectively, under village conditions for weight at 30 d, weight at 60 d, weaning weight and preweaning daily gain. For weights at 30 d and 60 d under experiment station conditions ram lambs were 4.1% and 7.8% heavier, respectively, for corresponding traits. Bradford (1983) in a study of Senegal sheep found that ram lambs were 12.2% and 11.3% heavier than ewe lambs at 30 and 90 d, respectively. Nelson and Venkatachalam (1949) found that at weaning, ram lambs were 5% heavier than ewe lambs.

Type of birth consistently affected preweaning weight, weaning weight and preweaning daily gain (table 30) under both village and experiment station conditions ($p<.01$). Lambs born in larger litters consistently were lighter in weight or gained less than singe-born lambs (table 31). These results are in agreement with most studies reported: Nelson and Venkatachalam (1949), Dickerson et al. (1975), deBaca et al. (1956), Alrawi et al. (1982), Martinez (1983) and Patterson (1983).

The average weights or gains of twins and triplets as a percentage of singles found in this study under village conditions (table 32) were: weight at 30 d - twins 81.0%, triplets 75.3%; weight at 60 d - 79.4% and 77.1%; weaning weight - 79.8% and 74.7%; and preweaning daily gain - 75.5% and 70.5%. Under experiment station

conditions the average weights or gains of twins, triplets and quadruplets as percentage of singles were: weight at 30 d - twins 83.4%, triplets 79.5%, quadruplets 69.3%; weight at 60 d - 80.7%, 80.2%, and 74.4%; weaning weight at 90 d - 84.5%, 83.5% and 81.2%; and preweaning daily gain 75.6%, 73.5% and 67.4%. With respect to weaning weight the results are similar to the values reported by Martinez (1983) that triplets weighed 79% as much as singles and twins weighed 86% as much as singles, and Patterson (1983) who found that twin weights were 81% those of singles, triplet 72% and quadruplet 64%.

Age of dam was not an important source of variation for weight at 30 d, at 60 d, at weaning or in preweaning daily gain for sheep under village conditions. However, at the experiment station the effect of age of dam was an important source of variation for weight at 30 d, at 60 d and preweaning daily gain, but unimportant for weaning weight ($p<.1$) as shown by the linear and quadratic regressions of the traits on age of dam (table 30). Under village conditions, postnatal growth usually increased with advancing age of dam up to 3 yr, and after that postnatal growth declined with increasing age of dam. The exception was in weight at 30 d where the highest average lamb weight was from 2-yr-old dams (table 31). Similar curvilinear patterns were found under experiment station conditions as shown in the regression coefficients (table 31), with the exception of weight at 60 d where the quadratic coefficient was not significant. Similar curvilinear patterns for the effect of age of dam were also found by Blackwell and Henderson (1955), Hohenboken et al. (1976b) and Mavrogenis and Louca (1979). Results of this study were similar to the pattern reported by

Patterson (1983) who found that in Barbados Blackbelly ewes less than 19 mo , 19 - 35 mo and more than 35 mo of age weaned lambs weighing 10.8, 11.8 and 9.9 kg, respectively. The non-significant effect of age of dam under village conditions for all postnatal growth, and weight at weaning under station conditions, supports the findings of Ray and Smith (1966) and Lamberson et al. (1982), that age of dam did not significantly affect weight of lamb at 90 d of age, and Wright et al. (1975), who reported that age of dam was a significant source of variation for birth weight only.

Year and months of birth were significant sources of variation for all postnatal growth traits under experiment station conditions, but under village conditions these sources of variation were only significant for weaning weight and preweaning daily gain. Month of birth was also a significant source of variation for 60 d weight. Year effect suggests that weather conditions as well as management affects the quality and quantity of feed supply, and either directly or indirectly affects the flock's general state of health, while differences among month reflect the effects of season. However, month by month means as shown in appendix table 67 did not show a general pattern. This means that season is not the only source of variability affecting growth associated with month to month variation.

Under village conditions location x type of birth interaction was generally an important source of variation for postnatal growth. This interaction was largely due to postnatal growth for larger litters decreasing sharply at GAR, while at CIB there were only small differences between litter sizes.

The effect of birth weight on postnatal growth was generally important for preweaning weight, but for preweaning daily gain the effect of birth weight was not significant either under village or station conditions (table 30). Thus, the correlation between birth weight and pre-weaning or weaning weight is apparently due primarily to the part-whole relationship, and not to a correlation between birth weight and pre-weaning growth rate. Regression of traits on birth weight (table 30) indicates that generally birth weight was linearly related to postnatal growth. Regression coefficients (table 31) indicated that increasing birth weight 1 kg will increase weight at 60 d and at 90 d by approximately .87 and .73 kg, respectively, under village conditions. The corresponding value under station conditions were 1.15 kg and 1.64 kg, respectively. However, for weight at 30 d, the relationship with birth weight tended to be curvilinear. Under village conditions the linear and quadratic regression coefficients were 1.09 kg/kg and -.22 kg/kg^2, although the quadratic term lacked significance ($p<.1$). For experiment station data the corresponding linear and quadratic regression coefficients were .82 and .35, respectively, and both were highly significant ($p<.01$). This means that as birth weight increases, the 30 d weight tends to increase at an increasing rate. In general, this study was consistent with the findings of deBaca et al. (1956), Harrington et al. (1958), Gjedrem (1967) and Farid and Macharachian (1978) who reported that the regression of postnatal growth on birth weight was highly significant. The last authors also indicated that the regression of preweaning daily gain on birth weight was not significant.

Residual correlations among birth weight, weight at 30 d, weight at 60 d, weaning weight and preweaning daily gain are presented in table 32, and most differ from zero. In both village and experiment station conditions, the correlation between two adjacent weights was high. Preweaning daily gain had a high degree of association with postnatal weight and weaning weight, but the lowest correlation with birth weight. Residual correlations from this study were similar to those reported by Gjedrem (1967) in a study on Norwegian sheep, who found the correlation between birth weight and subsequent weights to weaning ranged from .29 to .90. Mavrogenis et al. (1980) found the correlations between birth weight and weight at 5, 10, and 15 wk ranged from .38 to .88, and the correlations between average daily gain and those corresponding weights ranged from .18 to .92 with the lowest between birth weight and average daily gain from birth to weaning. A low correlation between birth weight and weaning gain ($r = .13$), and a high correlation between weaning gain and weaning weight ($r = .84$) were reported by Alrawi et al.(1982).

Postweaning growth. Least squares analyses of variance (table 33) show that under village conditions location was an important source of variation for weight at 120 d, 150 d, and 180 d and postweaning daily gain from weaning at 90 to 180 d of age. Breed did not significantly affect weight at 120 d at the experiment station. Sheep at GAR had the heaviest weight and made faster gains followed by CIB and CIR under village conditions, and JTT was heavier than FT (table 34).

TABLE 32. RESIDUAL CORRELATIONS AMONG BIRTH WEIGHT (BW), WEIGHT AT 30 D (W30), WEIGHT AT 60 D (W60), WEANING WEIGHT AT 90 D (WWT) AND PREWEANING DAILY GAIN (PREWG) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	(1)	(2)	(3)	(4)
		Village (N = 284)		
(1) BW				
(2) W30	.44**			
(3) W60	.29**	.87**		
(4) WWT	.21**	.75**	.91**	
(5) PREWG	-.04	.65**	.86**	.97**
		Experiment station (N = 187)		
(1) BW				
(2) W30	.39**			
(3) W60	.36**	.86**		
(4) WWT	.37**	.78**	.88**	
(5) PREWG	.16*	.74**	.85**	.98**

** ($p<.01$), * ($p<.05$).

Sex effect on postweaning growth was important (table 33) and least squares means (table 34) indicated that ram lambs were consistently heavier and grew faster than ewe lambs. In this study ram lambs were 10.8%, 9.3%, 19.7% heavier and grew 60.3% faster than ewe lambs for weight at 120 d, 150 d, 180 d and postweaning gain, respectively, under village conditions. Corresponding results under station conditions were 8.9%, 11.1%, 14.7%, and 22.6%, respectively. The effect of sex on postweaning growth was reported by Bhadula and

Bhat (1980), Alrawi et al. (1982) to be an important source of variation as well.

Type of birth was an important source of variation for postweaning weight, but had no effect on postweaning growth either under village or station conditions. These results were consistent with the findings of Mavrogenis and Louca (1979) who reported that single lambs were heavier than those from multiple births, but no differences were found in growth rate after weaning. Similar results were also found by Martinez (1983) who reported that type of birth had no effect on average daily gain from weaning at 90 d to 180 d of age.

Weights of twins and triplets as a percentage of singles found in this study (table 34) under village conditions were: weight at 120 d - twins 80.4%, triplets 75.3%; weight at 150 d - twins 79.5%, triplets 78.8%, and weight at 180 d - twins 85.19%, triplets 85%. However, under station conditions the average weights of twins, triplets, and quadruplets as percentage of singles were: for weight at 120 d twins 85.8%, triplets 84.3% and quadruplets 83.3%; for weight at 150 d 88.4%, 84.5% and 87.8%; and for weight at 180 d 88.4%, 80.9% and 88.5%. After weaning, specifically after 120 d of age, quadruplet-born lambs grow as fast or faster than other lambs.

The analysis of variance (table 33) shows that year and month of birth consistently affected postweaning growth under experiment station conditions, but under village conditions year and month were less important sources of variation. Under village conditions year of birth was an important source of variation only for weight at 150 d, and month of birth was an important source of variation for weight at

120 d and 150 d. Least squares means according to year and month of birth for postweaning growth (appendix table 68) indicate that the effect of year and month of birth in postweaning growth is similar to the effect on preweaning growth and birth weight. This suggests that these effects during postnatal growth still have a residual effect after weaning. This result supports the findings of Malik and Acharya (1972b) and Khan and Bhat (1981), who found that season of birth had similar effects on postweaning growth as on preweaning growth.

Age of dam effects on postweaning growth were not significant either under village or experiment station conditions (table 33). Apparently after weaning, lamb growth response quickly becomes independent of earlier maternal effects. This result is in agreement with the findings of Chopra and Acharya (1971b), Bhadula and Bhat (1980,1981), and Alrawi et al. (1982) who found that age of dam did not significantly affect postweaning growth rate and postweaning weight.

The regression of postweaning traits on birth weight indicated that birth weight significantly influenced postweaning weight at 120 d, 150 d and 180 d under experiment station conditions, but had no effect on postweaning daily gain. Under village conditions birth weight had no effect either on postweaning weight or postweaning average daily gain. Regression coefficients of postweaning weight on birth weight (table 34) under experiment station conditions indicated that by increasing birth weight 1 kg, weight at 120 d, 150 d and 180 d is expected to be increased about 1.93, 2.29, and 2.11 kg, respectively.

TABLE 33. ANALYSIS OF VARIANCE OF WEIGHT AT 120 D (W120), WEIGHT AT 150 D (W150), WEIGHT AT 180 D (W180) AND POSTWEANING GROWTH FROM WEANING AT 90 D TO 180 D (POSTWG) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	W120 (kg) df	W120 (kg) Mean squares	W150 (kg) df	W150 (kg) Mean squares	W180 (kg) df	W180 (kg) Mean squares	POSTWG (g) df	POSTWG (g) Mean squares
				Village				
Location (L)	2	47.83**	2	57.68**	2	57.44**	2	1,667.80*
Sex	1	58.45**	1	46.18*	1	90.14**	1	5,558.48**
Type of birth	2	106.28**	2	134.44**	2	62.20**	2	318.90
Year	2	17.36+	2	29.91*	2	23.85+	2	1,126.15+
Month	11	13.21*	11	24.01**	11	18.60+	11	762.70+
Age of dam	3	2.21	3	4.11	3	3.99	3	99.79
L x Sex		n.s.		n.s.		n.s.	2	1,626.62*
Sex x Year		n.s.		n.s.	2	44.31*	2	2,593.25**
Regressions								
Birth weight linear	1	24.00+		n.s.		n.s.		n.s.
Birth weight quadratic	1	n.s.		n.s.		n.s.		n.s.
Residual	228	6.58	183	8.20	133	10.06	131	448.07
				Experiment station				
Breed	1	11.91		...		...		...
Sex	1	33.76**	1	52.56**	1	109.34**	1	3,022.95**
Type of birth	3	17.82*	3	15.73*	3	27.25**	3	197.40
Year	2	168.69**	2	241.14**	2	334.33**	2	11,634.64**
Month	11	31.13**	11	43.94**	11	43.73**	11	832.56*
Sex x Year		n.s.		n.s.		n.s.	2	1,493.89*
Regressions								
Birth weight linear	1	109.94**	1	120.79**	1	89.64**		n.s.
Birth weight quadratic		n.s.		n.s.		n.s.		n.s.
Age of dam linear		n.s.		n.s.		n.s.		n.s.
Age of dam quadratic		n.s.		n.s.		n.s.		n.s.
Residual	153	4.83	112	5.39	97	5.96	96	349.05

** ($p<.01$), * ($p<.05$), + ($p<.1$).
n.s. Non significant at preliminary analysis ($p>.1$), hence deleted from the model.

TABLE 34. LEAST SQUARES MEANS AND STANDARD ERRORS OF WEIGHT AT 120 D (W120), WEIGHT AT 150 D (W150), WEIGHT AT 180 D (W180), AND POSTWEANING DAILY GAIN FROM WEANING AT 90 D TO 180 D OF AGE (POSTWG) FOR SOME MAIN EFFECTS AND COVARIATE UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	No.	W120 (kg)	No.	W150 (kg)	No.	W180 (kg)	POSTWG (g)[a]
				Village			
U	251	9.97 ± .38	205	11.42 ± .48	157	13.13 ± .67	54.3 ± 4.47
Location							
GAR	62	11.25 ± .50	41	13.07 ± .69	16	15.41 ± 1.11	64.2 ± 7.53
CIB	164	9.71 ± .31	144	11.19 ± .38	123	12.57 ± .49	52.3 ± 3.30
CIR	25	8.96 ± .65	20	9.99 ± .80	18	11.42 ± .97	46.2 ± 6.51
Sex							
Female	131	9.46 ± .41	110	10.91 ± .51	85	11.95 ± .74	41.7 ± 5.29
Male	120	10.48 ± .41	95	11.92 ± .54	72	14.31 ± .81	66.8 ± 6.12
Type of birth							
1	102	11.70 ± .39	85	13.26 ± .50	70	14.58 ± .68	53.6 ± 4.61
2	128	9.41 ± .39	103	10.54 ± .49	75	12.42 ± .69	50.7 ± 4.62
3	21	8.81 ± .71	17	10.45 ± .86	12	12.39 ± 1.16	58.5 ± 7.72
Age of dam							
1	38	9.99 ± .59	28	10.97 ± .73	21	13.35 ± 1.05	57.6 ± 7.08
2	129	10.03 ± .41	108	11.45 ± .52	74	12.79 ± .73	54.5 ± 4.94
3	51	10.24 ± .51	42	11.90 ± .65	37	13.50 ± .82	52.6 ± 5.51
4	33	9.63 ± .54	27	11.35 ± .69	25	12.89 ± .84	52.4 ± 5.65
Regression traits on birth weight linear (kg/kg)		.60 ± .32		...		...	...

TABLE 34. (CONTINUED)

Variables	No.	W120 (kg)	No.	W150 (kg)	No.	W180 (kg)	POSTWG (g)[a]
				Experiment station			
U	173	10.78 ± .40	131	12.82 ± .27	116	14.79 ± .30	53.8 ± 2.24
Breed							
JTT	149	11.30 ± .24		...		...	...
FT	24	10.26 ± .70		...		...	...
Sex							
Female	93	10.32 ± .44	71	12.14 ± .34	61	13.78 ± .37	48.3 ± 2.71
Male	80	11.24 ± .44	60	13.49 ± .36	55	15.80 ± .40	59.3 ± 3.10
Type of birth							
1	53	12.20 ± .51	40	14.22 ± .55	35	16.53 ± .60	55.9 ± 3.54
2	68	10.47 ± .44	49	12.55 ± .39	44	14.62 ± .44	53.4 ± 3.18
3	33	10.29 ± .56	25	12.02 ± .52	21	13.37 ± .60	49.0 ± 4.66
4	19	10.16 ± .76	17	12.48 ± .78	16	14.63 ± .89	56.9 ± 5.76
Regression traits on birth weight							
linear (kg/kg)		1.93 ± .40		2.29 ± .48		2.11 ± .54	...

[a] No. observations equal to W180

Residual correlations among birth weight, weaning weight, weight at 120 d, 150 d, 180 d and postweaning daily gain are tabulated in table 35. The correlations between adjacent weights were high. Birth weight was lowly correlated with postweaning gain. Postweaning gain was more highly correlated with weight at 180 d than weight at weaning. There were very low correlations between birth weight and weaning weight and postweaning weight under village conditions, and moderate correlations under experiment station conditions. This supports the previous analysis, that showed the regressions of traits on birth weight were highly significant under experiment station conditions, but not significant under village conditions. Residual correlations found in this study were similar to those reported from other studies. Khan and Bhat (1981) found low correlations between birth weight and weaning weight, 6 mo weight, slaughter weight, and growth rate to slaughter (.16, .02, .03 and .05, respectively). Mavrogenis et al. (1980) reported that the correlation between average daily gain from weaning to 20 wk and birth weight and weaning weight were quite low (being respectively, .15 and .16), but were quite high between body weight at 20 wk and average daily gain from weaning to 20 wk (.83). They also found moderate correlation between birth weight and weight at 20 wk ($r = .36$).

TABLE 35. RESIDUAL CORRELATIONS AMONG BIRTH WEIGHT (BW), WEANING WEIGHT AT 90 D (WWT), WEIGHT AT 120 D (W120), WEIGHT AT 150 D (W150), WEIGHT AT 180 D (W180), AND POSTWEANING DAILY GAIN (POSTWG) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	(1)	(2)	(3)	(4)	(5)
			Village (N=157)		
(1) BW					
(2) WWT	.19**				
(3) W120	.09	.93**			
(4) W150	.06	.88**	.96**		
(5) W180	.07	.83**	.88**	.94**	
(6) POSTWG	-.074	.36**	.53**	.67**	.82**
			Experiment station (N=116)[a]		
(1) BW					
(2) WWT	.39				
(3) W120	.37**	.91**			
(4) W150	.39**	.84**	.93**		
(5) W180	.37**	.75**	.81**	.91**	
(6) POSTWG	.09	-.07	.13	.36**	.61

[a] Only JTT data were analyzed.
** ($p<.01$), * ($p<.05$).

Nine month and yearling weight. Least squares analysis of variance (table 36) indicated that location affected weight at 270 d and yearling weight. Sheep from CIB were heavier than those from CIR. Sex was an important source of variation for weight at 270 d both in the villages and at the experiment station; however, at yearling age the effect of sex was only important under experiment station conditions. Least squares means (table 37) indicated that ram lambs were consistently heavier than ewe lambs. Under village conditions, at 270 d and yearling, ram lambs were 15.4% and 11.4% heavier than ewe lambs, and under experiment station conditions, ram lambs at the corresponding ages were 24.8% and 25.6% heavier than ewe lambs.

Significant effect of sex on 270 d weight was reported by Malik and Acharya (1972b) and Bhadula and Bhat (1980). However, Narayanaswami et al. (1975) found that the sex effect did not significantly influence weight at 9 mo. Effect of sex on yearling weight was reported by Malik and Acharya (1972b), Dass and Acharya (1970) and Chopra and Acharya (1971b). However, Abdel Azis et al. (1978) found no differences between ram lambs and ewe lambs at yearling age.

Type of birth had a significant effect on weight at 270 d in both the villages and experiment station; however, for yearling weight the type of birth effect was only significant under village conditions.

Least squares means for type of birth (table 37) showed that lambs born in larger litters are usually lighter than single-born lambs at 270 d and yearling age. Under experiment station conditions,

the average weight of twins, triplets and quadruplets as percentage of singles were, respectively: for 270 d weight - twins 84.4%, triplets 84% and quadruplets 83.1%; for yearling weight - 91.4%, 84.5%, and 83.5%. However, under village conditions the average weight of twins and triplets as percentage of singles at 270 d were 80.6% and 69.2%, respectively. For yearling weight multiple-born lambs were 69.7% of the average weight of singles. Karam (1959) and Alrawi et al. (1982) found small differences between singles and twins at 1 yr of age, but the differences were significant. However, Abdel Azis et al. (1978) found that type of birth did not significantly affect yearling weight.

Age of dam did not significantly affect weight at 270 d and yearling weight. Thus, at these ages lamb growth appears to be independent of maternal influence which has gradually been reduced with advancing age of the lamb.

Under experiment station conditions year of birth effects were only important at 270 d, and month of birth was important only in yearling weight. Under village condition years and months of birth were not significant sources of variation. However, least squares means for years and months indicated some fluctuation, but no specific pattern was found (appendix table 69). This suggests that the variation was not only due to differences in season from year to year or month to month, but also other variables such as supplementary feed and change in management could cause fluctuation in weight when the animals reached 270 d of age or yearling age at different times during the year.

TABLE 36. ANALYSIS OF VARIANCE FOR WEIGHT AT 270 D (W270) AND YEARLING WEIGHT (YWT) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	Village				Experiment station			
	W270 (kg)		YWT (kg)		W270 (kg)		YWT (kg)	
Source of variation	df	Mean squares	df	Mean squares	df	Mean squares	df	Mean squares
Location	1	97.17**	1	117.37**		...		...
Sex	1	51.05*	1	14.52	1	259.14**	1	240.60**
Type of birth	2	52.16*	1	120.67**	3	41.13*	3	32.13
Year	2	31.39+		...	2	152.37**	2	10.65
Month	11	11.11	11	11.58	11	20.31	10	49.15**
Age of dam	3	4.72	3	.92		...		...
Regressions								
Age of dam linear		...		...		n.s.		n.s.
Age of dam quadratic		...		...		n.s.		n.s.
Birth weight linear		n.s.		n.s.		n.s.		n.s.
Birth weight quadratic		n.s.		n.s.		n.s.		n.s.
Residual	56	12.09	23	13.40	56	12.17	37	16.46

** ($p<.01$), * ($p<.05$), + ($p<.1$).
n.s. Non significant in the preliminary analysis ($p>.1$), hence deleted from the model.

TABLE 37. LEAST SQUARES MEANS AND STANDARD ERRORS OF WEIGHT AT 270 D (W270) AND YEARLING WEIGHT (YWT) FOR SOME MAIN EFFECTS UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village				Experiment station			
	No.	W270 (kg)	No.	YWT (kg)	No.	W270 (kg)	No.	YWT (kg)
U	77	13.02 ± 1.38	41	14.96 ± 1.06	74	20.05 ± .60	54	25.69 ± 1.17
Location								
CIB	63	14.84 ± 1.34	32	18.32 ± 1.03		...		...
CIR	14	11.20 ± 1.68	9	11.61 ± 1.94		...		...
Sex								
Female	42	12.09 ± 1.36	22	14.16 ± 1.19	37	17.84 ± .68	23	22.77 ± 1.29
Male	35	13.95 ± 1.53	19	15.77 ± 1.41	37	22.26 ± .84	31	28.61 ± 1.49
Type of birth								
1	36	15.64 ± 1.22	20	17.64 ± 1.30	15	22.82 ± 1.12	12	28.59 ± 1.68
2	38	12.60 ± 1.12	21	12.29 ± 1.47	31	19.26 ± .83	24	26.14 ± 1.24
3	3	10.82 ± 3.62		...	13	19.16 ± 1.14	7	24.16 ± 2.04
4		...		...	15	18.96 ± 1.25	11	23.86 ± 1.92
Age of dam								
1	15	12.76 ± 1.63	7	15.06 ± 1.83		...		...
2	33	12.38 ± 1.56	17	14.75 ± 1.43		...		...
3	17	13.08 ± 1.63	12	15.43 ± 1.40		...		...
4	12	13.86 ± 1.66	5	14.62 ± 2.25		...		...

Residual correlation among yearling weight, weight at 270 d, weight at 180 d, weaning weight at 90 d and birth weight are shown in table 38. Under village conditions the correlation ranged from .26 to .92, while under experiment station conditions the correlation ranged from .21 to .87. Generally adjacent weights had a high degree of association. The residual correlations found in this study were in the range of previous studies. Karam (1959) reported that phenotypic correlation among birth weight, weaning weight and yearling weight ranged from .21 to .32. Shelton (1964a), based on a simple correlation analysis, found highly significant correlations between birth weight, rate of gain to 120 d and yearling weight; the correlation ranged from .48 to .98. Ragab et al. (1953) reported high phenotypic correlations between birth weight, weaning weight and marketing weight. The correlation ranged from .48 to .86, with the lowest between birth weight and marketing weight.

Growth curves. Equations for growth curves were derived from group mean weights and ages for JTT and FT sheep under station conditions and for JTT under village conditions. The data were transformed to natural logarithms and the linear regressions of ln W (weight) on ln A (age) were computed. These equations were then transformed back to actual weight and age to provide equations of the form $W = a A^b$.

The linear regression and transformed equations are presented in table 39. The R^2 indicated that after converting the data to natural logarithms 95.7%, 95.7% and 94.8% of the total variation of mean weight was explained by the regression on age for JTT and FT under

experiment station, and JTT under village conditions, respectively. It should be noted that the prediction equations derived here refer to growth patterns of ewes.

TABLE 38. RESIDUAL CORRELATIONS AMONG YEARLING WEIGHT (YWT), WEIGHT AT 270 D (W270), WEIGHT AT 180 D, WEIGHT AT 180 D (W180), WEANING WEIGHT AT 90 D (WWT) AND BIRTH WEIGHT (BW) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	(1)	(2)	(3)	(4)
		Village (N=41)		
(1) BW				
(2) WWT	.26			
(3) W180	.37*	.82**		
(4) W270	.59**	.53**	.75**	
(5) YWT	.58**	.44**	.61**	.92**
		Experiment station (N=54)		
(1) BW				
(2) WWT	.31*			
(3) W180	.33*	.76**		
(4) W270	.29*	.58**	.82**	
(5) YWT	.21	.51**	.64**	.87**

** ($p<.01$), * ($p<.05$).

Growth curves (figure 4) describe the growth pattern of Indonesian sheep, and show that JTT and FT under experiment station conditions grew faster than sheep under village conditions. The results also indicated that growth was essentially linear the first three months. These results are consistent with growth curves of sheep in previous studies reported by Hunter (1957) who found that growth was linear in the first three month of age, but curvilinear from birth to 8 mo of age. Wilson (1983) in a study of hair sheep noted that growth rate was linear from birth to 6 mo of age and curvilinear from birth to 12 mo of age. Gould and Whiteman (1971) found that growth rate was linear from birth to 70 d of age, and curvilinear from birth to 168 d of age; and Harrington et al. (1958) in a study on range sheep concluded that lamb growth from birth to 120 d of age could be linear or curvilinear depending upon the condition of the year that affected lamb growth.

Ewe performance traits

Ewe weight. Analysis of variance (table 40) showed that under village conditions location was an important source of variation for weight at mating. Least squares means (table 41) indicated that GAR had the heaviest mating weight followed by CIR and CIB. The last two locations ranked in different order compared to previous weights. This change was presumably due to the number of observations available and a different age composition of ewes in the data set.

TABLE 39. GROWTH CURVE EQUATIONS FOR INDONESIAN SHEEP UNDER EXPERIMENT STATION AND VILLAGE CONDITIONS

Conditions and breed	Equations		Standard Error	R^2
	Logarithmic form	Exponential form		
Experiment station - JTT	$\ln W = 1.94 + .405 \ln A$	$W = 6.959\ A^{.405}$	.0182	.957
Experiment station - FT	$\ln W = 1.86 + .424 \ln A$	$W = 6.424\ A^{.424}$	.0249	.957
Village - JTT	$\ln W = 1.81 + .385 \ln A$	$W = 6.110\ A^{.385}$	.0224	.948

W = Estimated weight

A = Age in months

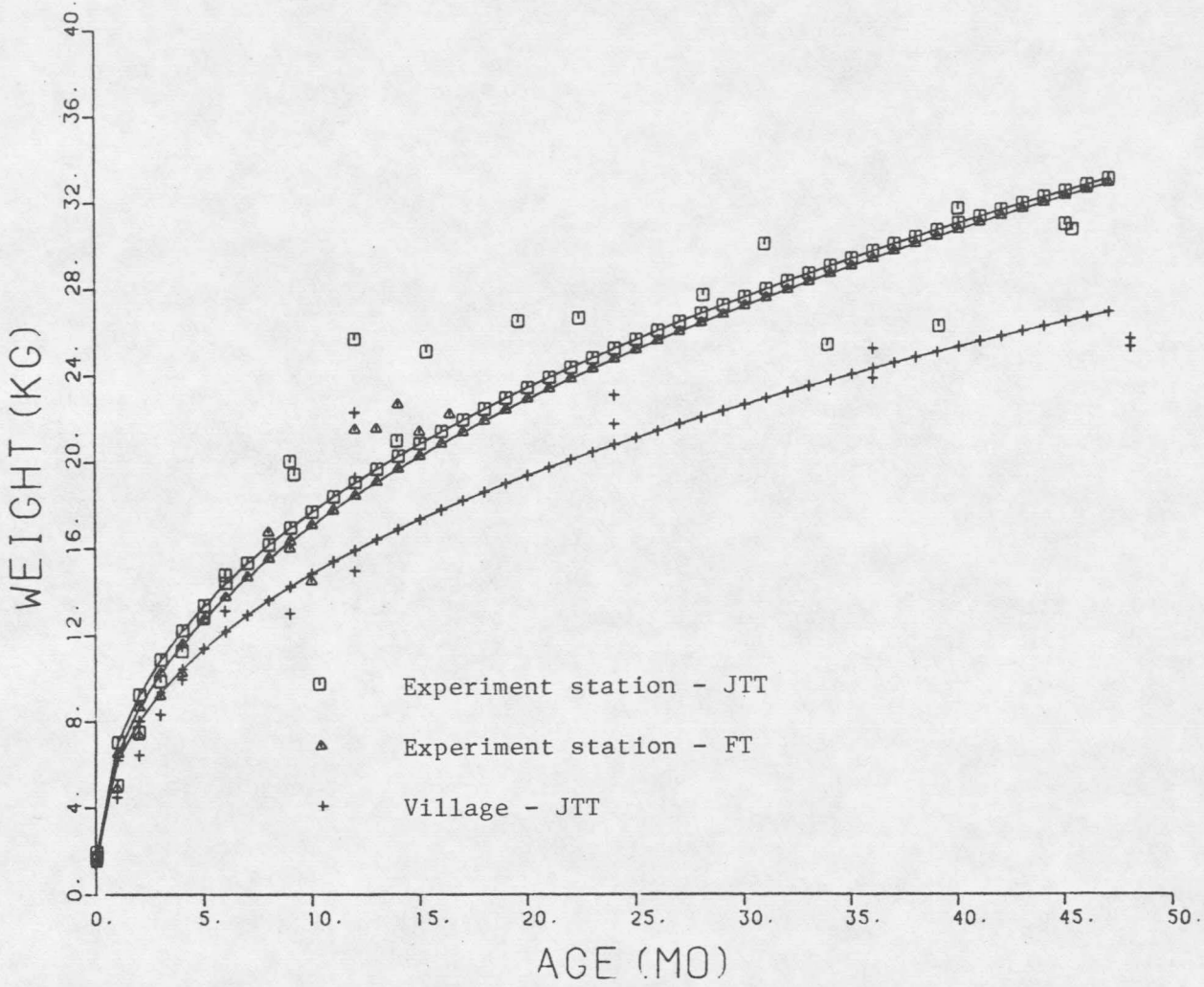


FIGURE 4. GROWTH CURVES OF JTT AND FT EWES UNDER STATION CONDITIONS AND JTT EWES UNDER VILLAGE CONDITIONS

At the experiment station, breed had no significant effect (table 40). Although there was no significance difference, least squares means (table 41) indicated that JTT ewes tended to be heavier than FT as was true for weights at other ages.

The effect of ewe age either under village or experiment station conditions was found to be important (table 40) and least squares estimates (table 41) showed that mating weight increased with advancing age from 19.31 kg at 1-yr-old to 25.32 kg at 4-yr-old and older. Under experiment station conditions mating weight tended to have curvilinear relationship with ewe age, although the quadratic regression was not significant ($p<.1$). The linear and quadratic regression coefficients were .389 kg/mo and .006 kg/mo^2, respectively.

Year effect was not significant either under village or experiment station conditions, even though there was a tendency of increased weight in the later year (appendix table 70).

Month to month variation in mating weight was significant only at the experiment station (table 40), suggesting that the fluctuation of feed supply was more variable under experiment station conditions than village conditions.

For postpartum weight, location and breed were important sources of variation under village and experiment station conditions (table 40). The ranking of postpartum weight was: ewes in GAR was the heaviest followed by CIB and CIR under village conditions and JTT was heavier than FT at the experiment station (table 42).

TABLE 40. ANALYSIS OF VARIANCE OF MATING WEIGHT (KG) AND POSTPARTUM WEIGHT (KG) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	Village df	Village Mean squares	Experiment station df	Experiment station Mean squares
		Mating weight		
Location [a]	2	156.57**	1	39.63
Year	2	12.88	1	68.44+
Month	11	17.16	11	50.04**
Ewe age	3	218.45**		...
Regressions				
Ewe age linear		...	1	730.48**
Ewe age quadratic		...	1	65.99+
Residual	193	13.98	113	19.24
		Postpartum weight		
Location (L) [a]	2	244.15**	1	145.93**
Type of birth	2	14.42	3	9.52
Year	2	34.04+	2	158.39**
Month	11	7.01	11	40.72*
Ewe age	3	107.06**		...
Regressions				
Ewe age linear		...	1	377.13**
Ewe age quadratic		...		n.s.
Residual	284	12.46	128	19.19

[a] Breed for experiment station.
** ($p<.01$), * ($p<.05$), + ($p<.1$).

As was the case for mating weight, age of ewe was an important source of variation both under village and experiment station conditions. Least squares means (table 42) showed that postpartum weight increased with increasing of age, even though there was only a small difference between ewe at 3 and 4 yr of age, under village conditions. The effect of ewe age on postpartum weight under experiment station conditions was shown by a significant linear regression (b=.158 kg/mo) of postpartum weight on ewe age (table 42).

TABLE 41. LEAST SQUARES MEANS AND STANDARD ERRORS OF MATING WEIGHT (MTWT) ACCORDING TO SOME MAIN EFFECTS AND COVARIATES UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	MTWT (kg)	No.	MTWT (kg)
U	212	22.55 ± .51	123	23.89 ± 1.13
Location				
GAR	45	24.80 ± .82		...
CIB	139	20.90 ± .44		...
CIR	28	21.95 ± .83		...
Breed				
JTT		...	98	24.96 ± 1.01
FT		...	25	22.82 ± 1.64
Ewe age				
1	31	19.31 ± .81		...
2	102	21.74 ± .55		...
3	45	23.83 ± .75		...
4	34	25.32 ± .77		...
Regression trait on ewe age				
linear (kg/mo)		...		.389 ± 0.06
quad. (kg/mo^2)		...		-.006 ± 0.003

Type of birth (litter size) was not a significant source of variation, either under village or experiment station conditions (table 40), however there was a tendency for ewes having larger litters to be heavier than ewes that had singles.

Year of lambing significantly affected postpartum weight in the experiment station ($p<.01$), but had no effect under village conditions. Ewe age composition under village conditions was constant, but at the experiment station the ewe age composition was changed such that ewes were kept in the flock until 7 yr of age. Ewe postpartum weight according to the year is presented in appendix table 71.

TABLE 42. LEAST SQUARES MEANS AND STANDARD ERRORS OF POSTPARTUM WEIGHT (PPWT) CLASSIFIED ACCORDING TO SOME MAIN EFFECTS AND COVARIATES UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variable	Village		Experiment station	
	No.	PPWT (kg)	No.	PPWT (kg)
U	305	24.18 ± .47	147	24.42 ± .98
Location				
GAR	55	26.66 ± .66		...
CIB	197	23.02 ± .42		...
CIR	51	22.88 ± .70		...
Breed				
JTT		...	114	26.08 ± .81
FT		...	33	22.76 ± 1.41
Type of birth				
1	182	23.68 ± .40	65	24.62 ± 1.07
2	109	23.67 ± .46	51	23.89 ± 1.16
3	14	25.21 ± 1.05	21	25.27 ± 1.27
4		...	10	23.90 ± 1.69
Ewe age				
1	55	22.30 ± .65		...
2	145	23.71 ± .52		...
3	65	24.95 ± .60		...
4	40	25.78 ± .72		...
Regression trait on ewe age				
linear (kg/mo)		...		.158± .04

As was the case in mating weight, month to month variation in postpartum weight was only significant in the experiment station data (table 40 and appendix table 71). Fluctuating feed supply was the major factor that affected postpartum weight.

Litter size. Analysis of variance (table 43) showed that location was an important source of variation under village conditions, while breed had no effect on litter size.

Least squares means (table 44) showed that the average litter size under village conditions was 1.44 and under station conditions was 1.97. According to the location, GAR had the largest litter size followed by CIB and CIR, while under experiment station conditions JTT and FT had almost the same litter size. The litter size of experiment station sheep was higher compared to the study reported by Mason (1980) who found that JTT-Priangan and FT had litter size 1.81 and 1.56, respectively and Obst et al. (1980) who reported that JTT-Garut and FT-Madura had litter size 1.86 and 1.67, respectively. Under village conditions the litter size was similar to these reported findings. Bell and Inounu (1982) in a study at GAR, but in different villages, found litter size average of 1.62. Sitorus and Subandriyo (1982) in a study in GAR, CIB and CIR based on one-day visits found litter size average of 1.28, 1.74 and 1.69, respectively. Obst et al. (1980) in a study of sheep similar to CIB (JTT-Bogor) found an average litter size of 1.58. These results indicate a high variability of litter size in Indonesian sheep.

Ewe age also was an important source of variation in both the villages and experiment station (table 43). Least squares means indicated that under village conditions litter size increases with advancing age of ewe (table 44). Similarly, the effect of ewe age on litter size at the experiment station is shown by significant linear regression of litter size in ewe age. Litter size increases about .021 per month increase on ewe age. These results are in agreement with previous studies that indicate that litter size and lambs born per ewe

lambing increase with age of ewe to a maximum at 4 to 8 yr and then declines, but sometimes only very slightly (Reeve and Robertson, 1953; Belic, 1954; Ragab and Asker, 1954; Karam, 1957; Yalcin and Bichard, 1964; Maijala, 1967; Rottensen and Ampy, 1971;Forrest and Bichard, 1974a; Arnold and Charlick, 1980; Amir et al.,1981). Mason (1980) in a study on Indonesian sheep, found that litter size increased up to the third parturition, but little thereafter.

Year had an important effect on litter size at the experiment station, but had no effect under village conditions. High litter size in 1979 under experiment station conditions was presumably due to the effect of flushing, because ewes were purchased in 1978 under village conditions, and after arriving at the station all the ewes received supplementary feed (appendix table 72).

Month effects were not significant in village or experiment station indicating little variation month by month in litter size born, thus the effect of season was negligible. This result was opposite to most studies of hair sheep in which season had important effects on litter size born (Martinez, 1983; Bradford et al., 1983; Stagnaro, 1983; Levine and Spurlock, 1983).

Analysis of variance (table 43) showed that number of lambs weaned was significantly affected by location under village conditions, but breed had no effect at the experiment station.

Least squares means (table 45) indicated that the mean number of lamb weaned was 1.39 and 1.47, respectively, in the villages and the experiment station. The difference between the number of lambs born (table 44) and the results shown in table 45 for number of lambs

weaned is not an accurate estimate of lamb mortality because the number of observations and the model used in each case were different. Lamb mortality will be discussed later. However, the results indicate that the proportion of lambs weaned as compared to lambs born was higher under village conditions.

TABLE 43. ANALYSIS OF VARIANCE OF LITTER SIZE BORN AND LITTER SIZE WEANED UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	Village df	Village Mean squares	Experiment station df	Experiment station Mean squares
		Litter size born		
Location/breed[a]	2	3.637**	1	.061
Year	2	.373	3	3.654**
Month	11	.636+	11	.838
Ewe age	3	.943*		...
Regressions				
Ewe age linear		...	1	10.474**
Ewe age quadratic		...	1	n.s.
Residual	287	.360	211	.875
		Litter size weaned		
Location/breed[a]	2	2.367**	1	1.751
Type of birth (TB)	2	17.621**	3	5.016**
Year	2	.739+	1	1.940*
Month	11	.216	11	.402
Ewe age	3	.122		...
Year x TB		...	3	1.351*
Regressions				
Ewe age linear		...		n.s.
Ewe age quadratic		...		n.s.
Residual	258	.309	117	.433

[a] Location in village data, breed in experiment station data.
** ($p<.01$), * ($p<.05$), + ($p<.1$).
n.s. Non significant in the preliminary analysis ($p>.1$), hence deleted from the model.

Type of birth had an important effect on number of lambs weaned both at the villages ($p<.01$) and at the experiment station ($p<.05$) (table 43). Least squares means (table 45) showed that under village conditions 82 %, 78.5% and 59.7% of singles, twins and triplets were weaned, respectively. Under experiment station conditions 68%, 61.5%, 75.3% and 42.5% of singles, twins, triplets and quadruplets were weaned, respectively. This indicates that the milk production of Indonesian sheep was only enough for raising two lambs, hence artificial rearing is recommended for lambs born in excess of two.

TABLE 44. LEAST SQUARES MEANS AND STANDARD ERRORS OF LITTER SIZE BORN (LSIZE) CLASSIFIED ACCORDING TO SOME MAIN EFFECTS AND COVARIATE UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	LSIZE	No.	LSIZE
U	306	1.44 ± .06	228	1.97 ± .11
Location				
GAR	57	1.67 ± .10		...
CIB	198	1.52 ± .05		...
CIR	51	1.15 ± .10		...
Breed				
JTT		...	182	2.00 ± .08
FT		...	46	1.95 ± .19
Ewe age				
1	56	1.28 ± .09		...
2	145	1.39 ± .07		...
3	65	1.49 ± .09		...
4	40	1.61 ± .11		...
Regression trait on ewe age				
linear		...		.021± 0.006

Ewe age had no effect either under village or experiment station conditions. However, least squares means for village data (table 45) showed that there was a tendency for a reduced number of lambs weaned with an advancing age of ewe. This result was opposite to the study of Hight and Jury (1970a) who found that number of lambs weaned per ewe present at lambing increase with advancing age. These different results probably are due to including type of birth weight in the model.

TABLE 45. LEAST SQUARES MEANS AND STANDARD ERRORS OF LITTER SIZE WEANED (LSWEAN) CLASSIFIED ACCORDING TO SOME MAIN EFFECTS UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variable	Village		Experiment station	
	No.	LSWEAN	No.	LSWEAN
U	279	1.39 ± .08	137	1.47 ± .14
Location				
GAR	48	1.65 ± .11		...
CIB	184	1.37 ± .08		...
CIR	47	1.16 ± .11		...
Breed				
JTT		...	105	1.65 ± .12
FT		...	32	1.30 ± .20
Type of birth				
1	168	.82 ± .07	63	.68 ± .13
2	92	1.57 ± .08	49	1.23 ± .13
3	14	1.79 ± .17	17	2.26 ± .36
4		...	8	1.70 ± .27
Ewe age				
1	54	1.44 ± .10		...
2	132	1.40 ± .08		...
3	62	1.33 ± .10		...
4	31	1.41 ± .12		...

Years and months of lambing at the villages showed no significant effects but at the experiment station years showed significant effects (table 43). However, least squares means indicated fluctuation year by year and month by month (appendix table 73). Estimates of the effects of years and months of lambing were associated with high standard errors.

Livability. Lamb livability as a ewe performance trait showed that breed had no effect under experiment station conditions, but location significantly affected livability at 30 and 60 d (table 46). The least squares means (table 47) indicated that death losses were high in CIR followed by CIB and GAR either at birth or at weaning age (90 d). The death losses were 7.7%, 5.3% and 2.8% at birth; 32.7%, 20.4% and 11.1% at 30 d; and 37.5%, 24.6% and 15.2% at weaning, respectively, for CIR, CIB and GAR. High death losses resulted at CIR because sheep in that area were raised under semi-extensive conditions and a severe worm problem was identified. Under experiment station conditions FT had higher mortality rates than JTT: 13.2% and 10.5% at birth; 43.5% and 33.6% at 30 d; and 49.1% and 35% at weaning at 90 d of age. Mortality under experiment station conditions compared to the village conditions was higher. This is probably due at least in part to the higher incidence of multiple births in the station. There were more weak lambs because of greater intrauterine competition and shorter gestation length in multiple birth bearing ewes compared to single bearing ewes. Other reasons include lambs born in larger litters were generally lighter in weight and probably less vigorous. Also, ewes may not have given as much individual attention to their

lambs born in a large litter. An obvious problem is the inability of ewes to suckle more than two lamb at a time, thus, all lambs in large litters are unlikely to receive equal and adequate shares of colostrum and milk (Fitzhugh and Bradford, 1983).

The overall mean lamb mortality under village conditions was 5.3% at birth, 21.4% at 30 d; 22.5% at 60 d and 25.8% at weaning at 90 d. At the experiment station death losses were 11.9% at birth, 38.6% at 30 d, 39% at 60 d and 42% at weaning at 90 d. These results indicate that high death losses mostly occured in the first 30 d of age. Approximately 82.9 % of death losses occured during this time under village conditions and 91.9% at the experiment station. These results are similar to those reported by Fitzhugh and Bradford (1983) who found postnatal death losses in a majority of the flocks exceeded 25%. Obst et al. (1980) in a study under experiment station conditions found death losses of 38.7%, 24.7% and 38.9% for JTT-Garut, JTT-Bogor and FT-Madura, respectively. Bell and Inounu (1982) under Indonesian village conditions found lamb mortality of 43%. High death losses within a few days after birth were also noted in several studies either under range conditions in temperate areas or under tropical conditions (Venkatachalam et al., 1949; Hoversland et al., 1957; Purser and Young, 1964; Fitzhugh and Bradford, 1983).

Type of birth effect was consistently significant for livability at birth, but was not significant for livability at later ages under village and experiment station conditions (table 46). Least squares means (table 47) indicated that lambs born in large litters had lower survivability than single-born lambs. At birth triplet- and

quadruplet-born lambs suffered more mortality both under village and experiment station conditions, and the effect persisted until weaning at 90 d of age. At weaning, single-, twin- and triplet-born lambs mortality under village conditions was 21.7%, 20.8%, and 34.7%, respectively. While under experiment station conditions single-,twin-, triplet-, and quadruplet-born lambs mortality was 25.6%, 38.7%, 45.7% and 58.1%, respectively. Bradford et al. (1974) in a study on some prolific breed indicated that mortality in large litters was strongly associated with depressed birth weight of larger litter. Purser and Young (1964) and Hight and Jury (1970b) indicated that multiple-born lambs suffered more mortality because of starvation.

Under experiment station conditions ewe age consistently had no effect on lamb livability; under village conditions ewe age was significant only for livability at 30 d (table 46). Significant effect of ewe age on mortality was reported by Purser and Young (1959), Gunn and Robinson (1963); Bichard and Cooper (1966); and Wiener et al. (1983), but non-significant effect of ewe age on livability was reported by Galal et al. (1974) and Hinch et al. (1983).

Years and months of lambing effects were not important sources of variation for livabilities at birth, 30 d, 60 d and at weaning of 90 d age, both under village and experiment station conditions (table 46), even though least squares means indicated fluctuation year by year and month by month (appendix table 74).

TABLE 46. ANALYSIS OF VARIANCE OF NEONATAL SURVIVAL (NSURV), LIVABILITY AT 30 D (LIV30), LIVABILITY AT 60 D (LIV60), LIVABILITY AT 90 D (LIV90) UNDER VILLAGE AND EXPERIMENT STATION CONDITION

Source of variation	NSURV (%) df	NSURV (%) Mean squares	LIV30 (%) df	LIV30 (%) Mean squares	LIV60 (%) df	LIV60 (%) Mean squares	LIV90 (%) df	LIV90 (%) Mean squares
				Village				
Location (L)	2	277.5	2	3,753.8*	2	5,167.1*	2	3,531.8+
Type of birth	2	1,361.6**	2	2,581.4+	2	701.1	2	1,063.2
Year	2	296.9	2	272.1	2	2,094.9	2	1,657.0
Month	11	153.6	11	409.3	11	1,201.1	11	1,157.4
Ewe age	3	68.1	3	2,673.4*	3	2,924.2+	3	3,556.8+
L x Ewe age		n.s.	6	3,006.2**	6	3,921.1**	6	4,309.4**
Residual	279	205.7	279	951.1	263	1,250.9	255	1,455.4
				Experiment station				
Breed	1	110.8	1	1,513.9	1	1,666.2	1	2,917.1
Type of birth	3	1,495.6**	3	2,773.6	3	3,183.3	3	3,926.3+
Year	1	.1	1	594.6	1	378.5	1	240.1
Month	11	222.6	11	1,161.4	11	1,156.9	11	1,269.5
Ewe age linear		n.s.		n.s.		n.s.		n.s.
Ewe age quadratic		n.s.		n.s.		n.s.		n.s.
Residual	124	299.1	124	1,472.9	124	1,491.7	120	1,506.6

** ($p<.01$), * ($p<.05$), + ($p<.1$).
n.s. Non significant in preliminary analysis ($p>.1$), hence deleted from the model.

TABLE 47. LEAST SQUARES MEANS AND STANDARD ERRORS OF NEONATAL SURVIVAL (NSURV), LIVABILITY AT 30 D (LIV30), LIVABILITY AT 60 D (LIV60), LIVABILITY AT 90 D (LIV90) CLASSIFIED ACCORDING TO SOME MAIN EFFECTS UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	No.	NSURV (%)	No.	LIV30 (%)	No.	LIV60 (%)	No.	LIV90 (%)
				Village				
U	306	94.7 ± 1.9	306	78.6 ± 4.3	290	77.5 ± 5.0	282	74.2 ± 5.4
Location								
GAR	57	97.2 ± 2.7	57	88.9 ± 6.6	53	90.9 ± 8.0	49	84.8 ± 8.6
CIR	198	94.7 ± 1.7	198	79.6 ± 3.8	189	77.8 ± 4.3	186	75.4 ± 4.7
CIB	51	92.3 ± 2.8	51	67.3 ± 6.6	48	63.8 ± 7.7	47	62.5 ± 8.4
Type of birth								
1	182	100.7 ± 1.6	182	86.9 ± 3.7	173	81.8 ± 4.4	169	78.3 ± 4.8
2	110	96.1 ± 1.8	110	81.3 ± 4.1	103	80.0 ± 4.9	99	79.2 ± 5.3
3	14	87.4 ± 4.3	14	67.6 ± 9.4	14	70.7 ±10.7	14	65.3 ±11.6
Ewe age								
1	56	93.3 ± 2.6	56	83.1 ± 6.9	55	84.6 ± 7.9	55	81.7 ± 8.5
2	145	94.7 ± 2.1	145	83.9 ± 4.6	137	80.5 ± 5.4	133	76.9 ± 5.9
3	65	94.5 ± 2.4	65	67.1 ± 6.1	62	63.8 ± 7.3	62	58.9 ± 7.8
4	40	96.5 ± 2.9	40	80.4 ± 7.4	36	81.2 ± 9.2	32	79.6 ±10.1
				Experiment station				
U	141	88.1 ± 3.0	141	61.4 ± 6.8	141	61.0 ± 6.8	137	58.0 ± 7.0
Breed								
JTT	108	89.5 ± 2.5	108	66.4 ± 5.5	108	66.2 ± 5.5	105	65.0 ± 5.7
FT	33	86.8 ± 4.7	33	56.5 ±10.5	33	55.8 ±10.5	32	50.9 ±10.9
Type of birth								
1	64	94.7 ± 3.1	64	74.4 ± 6.9	64	75.2 ± 6.9	63	74.4 ± 7.1
2	51	97.1 ± 3.2	51	68.0 ± 7.1	51	66.2 ± 7.2	49	61.3 ± 7.4
3	17	87.3 ± 5.1	17	56.8 ±11.4	17	55.7 ±11.4	17	54.3 ±11.6
4	9	73.4 ± 6.5	9	46.6 ±14.4	9	46.8 ±14.4	8	41.9 ±15.5

Litter weight. Analysis of variance (table 48) indicated that location, type of birth and ewe age were important sources of variation for litter weight at birth under village conditions, but year and month had no significant effects. At the experiment station type of birth, year of lambing and linear regression of litter weight at birth on ewe age were important sources of variation, while breed and month of lambing had no significant effect.

Least squares means (table 49) showed that litter weight at birth was higher under station conditions than under village conditions (4.06 kg vs 3.55 kg). This was due to higher proportion of multiple births in the station sheep than under village conditions, as well as different breed type of sheep. As was true for birth weight, GAR had heaviest litter weight at birth followed by CIB and CIR. Also, as in the case of birth weight found under experiment station conditions, JTT produced heavier litter weights at birth than FT. The differences among locations and between breeds was due in part to differences in individual birth weight and proportion of multiple birth.

Least squares means (table 49) indicated that multiple-birth lambs had heavier litter weight at birth as compared to single-born lambs. The ratio of litter weight at birth of singles, twins and triplets was 100:139:165 under village conditions; and 100:152:180:212 for singles, twins, triplets, and quadruplets under experiment station conditions. The ratios found in this study were less than ratios reported in several previous studies. The ratio of 100:164:165 was reported by Phillips and Dawson (1937); Dickinson et al. (1962) found

the ratio of 100:156:186; Yalcin and Bichard (1964a) obtained ratio of 100:158:185 and 100:159:199 in two different places; Donald and Russell (1970) reported the ratio of 100:160:185 in fifteen breeds and 100:184:263:300 in the prolific Finnish Landrace breed.

An effect of ewe age on litter weight at birth showed that advancing ewe age increased litter weight at birth under village conditions (table 49). Similarly, the effect of ewe age at the experiment station was indicated by a significant linear regression of litter weight at birth on ewe age. The regression coefficient indicated that advancing ewe age by one month would increase litter weight at birth of .017 kg. This result was consistent with the finding of Fahmy (1982) in a study on Oxford, Suffolk and their crosses, and reported that litters from 2-yr-old ewes were significantly lighter at birth than those from older ewes.

Significant effect of years of lambing at the experiment station are shown in appendix table 75. Litter weights at birth in 1980 were heavier than in 1981. This result is consistent with the significant effect of year on litter size shown in table 43.

There was no significant effect of years of lambing under village conditions, indicating that there was only small variation in number of lambs born and individual birth weight. This result is consistent with the non-significant effect of years of lambing on litter size (table 43).

TABLE 48. ANALYSIS OF VARIANCE LITTER WEIGHT AT BIRTH (LTWB), LITTER WEIGHT AT 30 D (LTWT30), LITTER WEIGHT AT 60 D (LTWT60) AND LITTER WEIGHT AT 90 D (LTWT90) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	LTWB (kg)		LTWT30 (kg)		LTWT60 (kg)		LTWT90 (kg)	
	df	Mean squares	df	Mean squares	df	Mean squares	df	Mean squares
				Village				
Location (L)	2	6.29**	2	65.53**	2	237.73**	2	398.67**
Type of birth (TB)	2	24.67**	2	117.85**	2	275.50**	2	456.72**
Ewe age	3	4.43**	3	3.33	3	2.29	3	3.78
Year	2	1.18	2	7.53	2	11.91	2	7.58
Month	11	.74	11	3.61	11	8.68	11	18.51
L x TB	3	1.76+		n.s.		n.s.		n.s.
Residual	267	178.79	269	7.04	253	16.92	243	29.85
				Experiment station				
Breed	1	.87	1	49.43+	1	80.43	1	160.56+
Type of birth (TB)	3	34.89**	3	38.61*	3	90.13*	3	145.57*
Year	1	6.03*	1	69.31*	1	253.80*	1	307.55*
Month	11	1.41	11	6.70	11	18.19	11	27.03
Ewe age linear	1	4.46*		n.s.		n.s.		n.s.
Ewe age quadratic		n.s.		n.s.		n.s.		n.s.
Residual	123	.93	124	12.64	124	31.90	120	46.37

** ($p<.01$), * ($p<.05$), + ($p<.1$).
n.s Non significant in preliminary analysis ($p>.1$), therefore deleted from the model.

TABLE 49. LEAST SQUARES MEANS AND STANDARD ERRORS OF LITTER WEIGHT AT BIRTH (LTWB), LITTER WEIGHT AT 30 D (LTWT30), LITTER WEIGHT AT 60 D (LTWT60) AND LITTER WEIGHT AT 90 D (LTWT90) CLASSIFIED ACCORDING TO SOME MAIN EFFECTS UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	No.	LTWB (kg)	No.	LTWT30 (kg)	No.	LTWT60 (kg)	No.	LTWT90 (kg)
				Village				
U	291	3.55 ± .13	290	5.73 ± .38	274	8.48 ± .60	264	10.32 ± .81
Location								
GAR	55	3.84 ± .18	55	6.96 ± .53	51	10.97 ± .84	46	13.71 ± 1.16
CIB	185	3.79 ± .12	184	5.73 ± .35	175	8.27 ± .54	171	9.96 ± .72
CIR	51	3.02 ± .20	51	4.50 ± .55	48	6.19 ± .86	47	7.30 ± 1.16
Type of birth								
1	173	2.64 ± .11	172	4.56 ± .34	163	6.39 ± .55	158	7.83 ± .74
2	104	3.66 ± .14	104	6.61 ± .37	97	9.53 ± .59	92	12.06 ± .81
3	14	4.36 ± .26	14	6.02 ± .80	14	9.53 ± 1.25	14	11.08 ± 1.66
Ewe age								
1	46	3.07 ± .17	46	5.36 ± .54	45	8.14 ± .84	44	10.26 ± 1.36
2	143	3.59 ± .13	142	5.90 ± .41	135	8.52 ± .65	131	10.65 ± .88
3	62	3.71 ± .15	62	5.76 ± .48	58	8.62 ± .76	58	10.35 ± 1.02
4	40	3.83 ± .18	40	5.89 ± .56	36	8.63 ± .90	31	10.04 ± 1.23
				Experiment station				
U	141	4.06 ± .17	141	6.60 ± .63	141	10.25 ± .99	137	12.64 ± 1.23
Breed								
JTT	108	4.19 ± .16	108	7.49 ± .51	108	11.39 ± .81	105	14.30 ± .99
FT	33	3.93 ± .26	33	5.70 ± .97	33	9.11 ± 1.54	32	10.98 ± 1.90
Type of birth								
1	64	2.52 ± .17	64	5.19 ± .64	64	7.91 ± 1.01	63	9.54 ± 1.25
2	51	3.83 ± .18	51	6.63 ± .66	51	9.72 ± 1.05	49	11.92 ± 1.30
3	17	4.53 ± .29	17	7.82 ± 1.05	17	11.76 ± 1.67	17	14.05 ± 2.03
4	9	5.35 ± .37	9	6.74 ± 1.33	9	11.60 ± 2.12	8	15.06 ± 2.72
Regression traits on ewe age linear (kg/mo)		.017±.008		...		...		...

Month by month variation had only small fluctuation both under village and experiment station conditions (appendix table 75). Season had negligible effect on number of lambs born, hence the effect on litter weight at birth was negligible.

Analysis of variance (table 48) indicated that for litter weight at 30, 60, and 90 d, location and type of birth were important sources of variation under village conditions, but ewe age, year and month had no significant effects. However, in the experiment station data type of birth and years were the important sources of variation. Breed, ewe age, and months of lambing had no significant effects.

Least squares means according to location (table 49) showed that GAR ewes consistently had higher litter weight at 30, 60 and 90 d than CIB and CIR ewes. This was due to differences in litter size, livability and individual weight at those three locations.

Under experiment station conditions, although there was no significant difference between JTT and FT, JTT tended to have higher litter weight at 30, 60 and 90 d.

Under village conditions, least squares means (table 49) for type of birth indicated that litter weight at 30, 60 and 90 d increased for twin bearing ewes then declined for larger litter size. Under experiment station conditions ewes that produced multiple births had heavier litter weight at 30, 60 and 90 d than ewes that produced single lambs. These results were similar to findings of Mavrogenis (1982) and Black (1982) who reported that ewe bearing twin lambs had heavier litter weight at weaning.

Age of ewe had no significant effect either under experiment station or under village conditions. Non-significant effects of ewe age on litter weight at 30, 60 and 90 d were contrary to the results of most previous studies. Vesely and Peters (1964), Basuthakur (1970), Goot and Maijala (1977), Ponzoni et al. (1979) and Fahmy (1982) reported that ewe age had a significant effect on litter weight at weaning; 2-yr-old ewes produced the lightest, while 6-yr-old ewes produced the heaviest.

Years and months of lambing in the villages showed no significant effects on litter weight at 30, 60 and 90 d, but at the experiment station years showed significant effects (table 48). This suggests that there was a small variation year by year or month by month on litter weight at those ages at the villages (appendix table 75). Small fluctuation year by year and month by month reflected that the mortality and individual weight of lambs are relatively constant during the period studied at the villages. However, year differences at the experiment station reflects differences in lamb weight, litter size and mortality.

Residual correlations among ewe traits are presented in table 50. Litter size born was significantly and positively correlated with litter size at weaning, and litter weight at birth, at 30, 60 d and at weaning (90 d of age). However, with respect to livabilities litter size was negatively correlated, even though some correlations were not different from zero. This indicated that large litters tended to be associated with heavy litter weights, but are associated with low survivability. This result was in agreement with previous studies as

follows: Eikje (1975) found positive phenotypic correlation among number of lambs born, number of lambs in spring and number lambs at weaning (the correlation ranged from .67 to .93). Martin et al. (1980) reported correlations ranged from .34 to .95 among number of lambs born alive, number of lambs weaned, litter weight at birth, litter weight at 4, 8 and 12 wk. Fogarty et al. (1982) indicated negative correlations between litter size and neonatal survival (-.15) and postnatal survival (-.20).

Litter size at weaning (table 50) showed mostly high positive correlations with livabilities and litter weight. The correlation ranged from .11 to .84 under village conditions and .30 to .86 under experiment station. These results supported previous studies: Martin et al. (1980) found phenotypic correlation between number of lambs weaned and litter weight at birth, at 4, 8 and 12 wk ranging from .64 to .87 and Fogarty et al. (1982) reported phenotypic correlation between lambs weaned and neonatal survival and postnatal survival of .34 and .55, and between lambs weaned and weight weaned (.94).

Positive correlations, some highly significant were found among livability and litter weight at different times. Martin et al. (1980) also found high correlations among litter weight ranging from .57 to .95. Fogarty et al. (1982) found a very low phenotypic correlation between neonatal and postnatal survival (.08).

The residual correlation involving weight at mating and postpartum weight with litter traits and livabilities were mostly low and some were negative. Some did not differ from zero statistically.

TABLE 50. RESIDUAL CORRELATIONS AMONG LITTER SIZE BORN (LSIZE), LITTER SIZE WEANED (LSWEAN), NEONATAL SURVIVAL (NSURV), LIVABILITY AT 30 D (LIV30), LIVABILITY AT 60 D (LIV60), LIVABILITY AT 90 D (LIV90), LITTER WEIGHT AT BIRTH (LTWB), LITTER WEIGHT AT 30 D (LTWT30), LITTER WEIGHT AT 60 D (LTWT60), LITTER WEIGHT AT 90 D (LTWT90), MATING WEIGHT (MTWT) AND POSTPARTUM WEIGHT (PPWT) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Village (N=185)											
(1) LSIZE											
(2) LSWEAN	.48**										
(3) NSURV	-.31**	.11									
(4) LIV30	-.16*	.48**	.26**								
(5) LIV60	-.06	.67**	.19**	.76**							
(6) LIV90	-.03	.74**	.16*	.70**	.92**						
(7) LTWB	.58**	.476**	.08	.01	.06	.08					
(8) LTWT30	.26**	.65**	.17*	.63**	.51**	.48**	.51**				
(9) LTWT60	.31**	.79**	.12	.52**	.71**	.67**	.47**	.85**			
(10) LTWT90	.29*	.84**	.08	.52**	.70**	.77**	.42**	.79**	.94**		
(11) MTWT	.10	-.14	-.01	-.07	-.11	-.16*	.12	.02	-.01	-.06	
(12) PPWT	.06	.03	-.01	.11	.09	.02	.14*	.20**	.19*	.17*	.67**
Experiment station (N=125)											
(1) LSIZE											
(2) LSWEAN	.50**										
(3) NSURV	-.20*	.30**									
(4) LIV30	-.15	.63**	.29**								
(5) LIV60	-.17	.64**	.28**	.98**							
(6) LIV90	-.20*	.64**	.33**	.95**	.96**						
(7) LTWB	.71**	.54**	.20*	.05	.02	.02					
(8) LTWT30	.26**	.81**	.34**	.75**	.72**	.68**	.42**				
(9) LTWT60	.28**	.81**	.28**	.70**	.71**	.65**	.39**	.94**			
(10) LTWT90	.28**	.86**	.35**	.70**	.71**	.70**	.43**	.94**	.96**		
(11) MTWT	.20*	.13	.10	.08	.08	.06	.25**	.18*	.23*	.23**	
(12) PPWT	-.02	.06	.15	.17	.16	.15	.17	.18*	.20*	.20*	.71**

** ($p<.01$), * ($p<.05$).

The residual correlation between mating weight and litter size at birth in these results were .10 and .20, under village and experiment station conditions, respectively. These were in the range of values from previous studies. Forrest and Bichard (1974b) reported a correlation between body weight of ewes and number of lambs born per ewe present at lambing of .10, and Purser (1965) in a study on Blackface and Welsh ewes found phenotypic correlations of .23 and .25, respectively. The residual correlations between mating weight and litter weight at birth in this study (.12 and .25, respectively for villages and the experiment station) were also in the range of correlations reported by Newton and Fenlon (1979) in a study on two flocks of Masham ewes (.10 and .08, respectively), and the findings of Martin et al. (1980) who found a phenotypic correlation of .48. However, the correlations between mating weight and postpartum weight with the other litter traits were not consistent with the correlation reported by Martin et al. (1980) who found positive correlations between mating weight and litter traits, and mostly low and negative correlations between postpartum weight and litter traits.

Lambing interval. Analysis of variance (table 51) indicated that under village conditions location, type of birth, ewe age, years and months had no significant effects on lambing interval. The experiment station data indicated that breed, type of birth, years and months were not important sources of variation, but linear and quadratic regressions of lambing interval on ewe age were significant.

Least squares means (table 52) showed that lambing interval means under village and experiment station conditions were almost the same (259.3 and 252.4 d, respectively). These results were consistent with the review reported by Mason (1980) who indicated that lambing interval of 8 to 9 mo was most usual.

TABLE 51. ANALYSIS OF VARIANCE OF LAMBING INTERVAL (D) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	Village		Experiment station	
	df	Mean squares	df	Mean squares
Location/breed[a]	1	2,552.6	1	104.4
Type of birth	1	9,190.6	3	3,417.8
Ewe age	3	4,004.8		...
Year	2	9,437.2	2	12,369.2+
Month	11	5,018.1	11	7,194.5+
Year x Ewe age	6	12,827.7+		...
Regressions				
Ewe age linear		...	1	18,226.2*
Ewe age quadratic		...	1	29,960.3**
Residual	58	6,557.2	93	4,112.9

[a] Location in village data, breed in experiment station data.
** (p<.01), * (p<.05), + (p<.1).

Even though locations were not significantly different, ewes from CIR tended to have a shorter lambing interval than ewes from CIB. The differences might be due to the differences in breeding management, which in CIB was hand mating, while in CIR pen or mass mating was applied.

An effect of the number of lambs produced by ewes indicated that ewes with large litters tended to have longer lambing interval, even though this effect lacked significance (p>.1). Similar tendency was

reported by Levine and Spurlock (1983) in a study on Barbados Blackbelly in California who found that lambing interval of ewes with singles and twins were 219.2 and 221.1 days, but for ewes with triplets the lambing interval was 238.4 days.

TABLE 52. LEAST SQUARES MEANS AND STANDARD ERRORS OF LAMBING INTERVAL (LINT) CLASSIFIED ACCORDING TO SOME MAIN EFFECTS AND COVARIATE UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	LINT (d)	No.	LINT (d)
U	83	259.3 ± 20.9	113	252.4 ± 16.2
Location				
CIB	70	268.2 ± 18.3		...
CIR	13	250.4 ± 30.8		...
Breed				
JTT		...	100	254.3 ± 10.8
FT		...	13	250.5 ± 26.3
Type of birth				
1	51	245.4 ± 20.5	40	245.5 ± 16.9
2	32	273.2 ± 27.0	39	246.9 ± 17.4
3		...	23	238.7 ± 22.0
4		...	11	278.6 ± 25.9
Ewe age				
1	22	232.5 ± 36.4		...
2	33	274.6 ± 25.3		...
3	22	249.1 ± 26.2		...
4	6	281.0 ± 41.6		...
Regression trait on ewe age				
linear (day/mo)		...		-2.10 ± 1.00
quadratic (day/mo^2)		...		.14 ± .05

Linear and quadratic regression coefficients of lambing interval on ewe age under experiment station conditions (table 52) indicated that lambing interval became shorter with advancing age of ewe until a certain age was reached than became longer after that age. Based on the linear and quadratic regression coefficients the age that had the shortest lambing interval was 32.8 months. Under village conditions the effect of ewe age at lambing had no general pattern and showed variability. Under experiment station conditions the results were similar to the findings of Levine and Spurlock (1983) who reported that lambing interval was dependent upon the successive parities with the longest interval between first and second lambing and the shortest between second and third lambing. Dettmers (1983) in a study of Nigerian ewes noted that lambing interval was longer between first and second parity, but as parity advanced and ewes aged, lambing interval decreased.

Years and months of lambing had no significant effect on lambing interval, even though there were differences in means of lambing interval year by year or month by month as shown in appendix table 76. The fluctuation yearly and monthly in the villages and the experiment station were due mostly to the variation in length of time from parturition to exposure to a ram, as well as variation in length of postpartum anestrus and rate of conception at first and subsequent estruses after parturition.

Results of the study indicated that under village and experiment station conditions ewes could lamb about 1.41 and 1.45 times a year.

Therefore, the average lamb production per ewe per year that would be produced at weaning (based on table 49) was 14.6 kg and 18.3 kg, respectively, for villages and the experiment station. However, these results are lower than the potential of Indonesian sheep, particularly JTT sheep which are relatively prolific sheep. Without considering genetic improvement for growth there are two ways to improve lamb production per ewe at weaning. These are: (1) Reduce lambing interval, and (2) Reduce lamb mortality, especially for ewes bearing multiple lambs. From these two methods for improving lamb production per ewe per year the second method is more favorable, since the lambing interval found in this study is close to the regular lambing interval that is commonly practised. Shorter lambing interval would require better feed supply and pens which are the most critical factors.

Based on the least squares means found in the study of Indonesian sheep there is some potential for improving lamb production per ewe per year as shown in table 53. Considering only changing the lambing interval to 8 mo and improving lamb survivabilities to around 81 to 85% the total production per ewe per year might be increased by 14.1% and 35.4% in the villages and experiment station, respectively. The area that merits most attention is survival of lambs born as multiples.

TABLE 53. POTENTIAL LEVELS OF PERFORMANCE FOR SOME EWE TRAITS COMPARED TO LEAST SQUARES MEANS FOUND IN THIS STUDY

Traits	Mean in this study	Possible goal	Percent increment
	Village		
Parturition per year	1.41	1.50	6.38
Livability (%)			
Singles	78.3	90.0	14.9
Twins	79.2	80.0	1.0
Triplet	65.3	67.0	2.6
Lamb production per ewe per lambing (kg)			
Singles	7.8	9.0	14.9
Twins	12.1	12.2	1.0
Triplet	11.1	11.4	2.6
Weighted average lamb production per ewe per lambing (kg)	9.5	10.2	7.8
Weighted average lamb production per ewe per year (kg)	13.4	15.3	14.1
	Experiment station		
Parturition per year	1.45	1.50	3.44
Livability (%)			
Singles	74.4	90.0	21.0
Twins	61.3	80.0	46.8
Triplets	54.3	67.0	23.4
Quadruplets	41.9	50.0	19.3
Lamb production per ewe per lambing (kg)			
Singles	9.5	11.5	21.0
Twins	11.9	17.5	46.8
Triplets	14.1	17.4	23.4
Quadruplets	15.1	18.0	19.3
Weighted average lamb production per ewe per lambing (kg)	11.3	14.8	31.0
Weighted average lamb production per ewe per year (kg)	16.4	22.2	35.4

Repeatability of ewe performance traits. Repeatability estimates of ewe weight at mating was .78 and .61 under village and experiment station conditions, respectively (table 54). Both under village and experiment station conditions the repeatabilities were typical of reported values from previous studies which included estimates of .53 (Newton and Fenlon, 1979); .48 in Nigerian sheep crosses with exotic breed (Buvanendran et al.,1981); .57 and .48 in crossbred ewes in two places in the United Kingdom (Yalcin and Bichard, 1964b); .81 in crossbred of Indian sheep with exotic breed (Kishore et al., 1982); .61 in crossbred ewes (Clarke and Hohenboken, 1983); .62 in synthetic line of sheep (Martin et al., 1981).

TABLE 54. REPEATABILITY OF MATING WEIGHT (MTWT) AND POSTPARTUM (PPWT) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS[a]

	Village		Experiment station	
	MTWT	PPWT	MTWT	PPWT
No. observation	167	248	98	114
No. ewes	122	168	74	75
k^b	1.24	1.35	1.13	1.28
σ_e^2	10.73	7.81	11.07	12.26
σ_w^2	3.07	3.64	7.03	7.59
Repeatability	.78	.68	.61	.62
Standard error	.06	.06	.18	.12

[a] Analysis of variance in appendix table 77.
[b] Weighted average number records per ewe.

Repeatability of postpartum weight (table 54) found in this study was .68 and .62, respectively, under village and experiment station conditions. As was the case in mating weight under village conditions,

postpartum weight repeatability was in the range of values from previous studies. The estimates included .54 for crossbred of Indian sheep with exotic breed (Kishore et al., 1982); and .74 in synthetic line of sheep (Martin et al., 1981).

Low repeatability estimates of litter size born (table 55) were found in this study (.22 and .12, under village and experiment station conditions, respectively). Low estimates of repeatability of litter size were also found in most previous studies. Previous estimates included .05 in Norwegian and Swedish breed (Eikje, 1975; Rendel,1956); .04 to .12 in crossbred ewes in three locations (Yalcin and Bichard, 1964b); .12 and .15 in two flocks of Rambouillet in Texas (Shelton and Menzies, 1970); .17 and .16 in 1/2 Finn x 1/2 Rambouillet and 1/4 Finn x 3/4 Rambouillet, respectively (Notter, 1981); .19 in crossbred ewes (Clarke and Hohenboken, 1983); .20 and .35 in Merino and Booroola x Merino ewes, respectively (Lewer and Allison, 1980).

TABLE 55. REPEATABILITY OF LITTER SIZE BORN (LSIZE) AND LITTER SIZE WEANED (LSWEAN) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS[a]

	Village		Experiment station	
	LSIZE	LSWEAN	LSIZE	LSWEAN
No. observation	249	231	228	105
No. ewes	168	164	115	74
k^b	1.39	1.22	1.84	1.17
$\sigma_{e_2}^2$	.073	.0012	.102	.057
σ_w^2	.261	.324	.774	.375
Repeatability	.22	.004	.12	.13
Standard Error	.13	.21	.10	.33

[a] Analysis of variance in appendix table 78.
[b] Weighted average number records per ewe.

Repeatability estimates of litter size weaned (table 55) were also low. The results were .004 and .13, respectively, under village and experiment station conditions. Previous studies also indicated low estimates of repeatability of litter size weaned. The estimates included .02 in synthetic line sheep (Martin et al., 1981); .08 in Australian Merino and in crossbred ewes (Young et al., 1963; Clarke and Hohenboken, 1983); .07 and .10 in Blackface and Welsh ewes (Purser, 1965); and .08, .10 and .04 in ewes from three different locations in the United Kingdom (Yalcin and Bichard, 1964b).

Estimates of repeatability of livability at birth (table 56) under village conditions were quite high, the experiment station estimates were low. The corresponding values were .58 and .08, respectively. However, under experiment station conditions even though the standard error was high the result was typical of repeatability of neonatal survival. Fogarty et al. (1982) found that repeatability of neonatal survival was .15 and .03 using intraclass correlation and pooled regression estimates, respectively.

Repeatabilities of livability at 30, 60 and 90 d under village conditions were .03, .13 and .11, respectively. From the experiment station data, the corresponding values were .32, .29, .27, respectively. Under village conditions the estimates of repeatabilty were typical of previous studies, while under experiment station the estimates were higher. Previous studies included .06 and .10 in two flocks of Rambouillet in Texas (Shelton and Menzies, 1970); .11 and .02 for postnatal survival estimated using intraclass correlation and pooled regression estimates, respectively (Fogarty et al., 1982);

and .16 and .15 in two Merino flocks in Armidale, Australia (Piper et al., 1982).

Repeatability of litter weight at birth (table 56) under village condition was .17, while for the experiment station data the value was .35. Compared to the previous studies, the results were in the reported range of repeatability of litter weight. Previous studies estimates were .25 (Martin et al., 1981); .20 (Blackwell and Henderson, 1955); .25 (Buvanendran et al., 1981); .18 (Yalcin and Bichard, 1964b); .34 and .28 without correction to litter size and with correction to mean birth weight, respectively (Newton and Fenlon, 1979).

Repeatability of litter weight at 30, 60 and 90 d under village conditions was .08, .14, and .08. The corresponding values under station conditions were .20, .06 and .05, respectively. These results suggest the presence of important random environmental effects. Compared to previous studies the estimates found in this study were generally lower. Previous estimates were: .17,.11 and .08 for litter weight at 4, 8, and 12 wk (Martin et al.,1981); .19, .20, .21, .19, .19 and .17 for litter weight at 42, 63, 76, 84, 115 d and at weaning at 125 d (Yalcin and Bichard, 1964b); .08 for litter weight at weaning (Blackwell and Henderson, 1955); and .16 for lamb weaning weight (Eikje, 1975).

TABLE 56. REPEATABILITY OF NEONATAL SURVIVAL (NSURV), LIVABILITY AT 30 D (LIV30), LIVABILITY AT 60 D (LIV60), LIVABILITY AT 90 D (LIV90), LITTER WEIGHT AT BIRTH (LTWB), LIITER WEIGHT AT 30 D (LTWT30), LITTER WEIGHT AT 60 D (LTWT60) AND LITTER WEIGHT AT 90 D (LTWT90) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	NSURV	LIV30	LIV60	LIV90	LTWB	LTWT30	LTWT60	LTWT90
				Village[a]				
No. observation	249	249	237	233	236	235	223	218
No. ewes	168	168	164	164	164	164	160	160
k^b	1.37	1.36	1.32	1.29	1.32	1.27	1.28	1.25
$\sigma_{e_2}^2$	140.26	36.86	187.91	179.44	.12	.68	2.79	2.63
σ_w	102.90	1,112.30	1,300.43	1,443.00	.61	7.53	16.61	28.86
Repeatability	.58	.03	.13	.11	.17	.08	.14	.08
Standard Error	.08	.15	.16	.17	.15	.18	.17	.19
				Experiment station[a]				
No. observation	108	108	108	105	108	108	108	105
No. ewes	75	75	75	74	75	75	75	74
k^b	1.19	1.23	1.23	1.21	1.22	1.23	1.23	1.21
$\sigma_{e_2}^2$	28.42	459.30	426.13	399.69	.36	2.95	2.29	2.78
σ_w	344.76	963.61	1,038.78	1,060.11	.69	11.81	35.56	51.07
Repeatability	.08	.32	.29	.27	.35	.20	.06	.05
Standard Error	.32	.22	.23	.25	.23	.26	.29	.32

[a] Analysis of variance in appendix tables 79 and 80.
[b] Weighted average number records per ewe.

Finally, the repeatability estimate of lambing interval found in this study was .04 (table 57). Low estimates of repeatability of lambing interval suggested that environmental effects such as management decisions play an important role compared to genetic effects. However, this result was lower than the estimate of Kishore et al. (1982) who reported a repeatability of .18.

TABLE 57. ANALYSIS OF VARIANCE AND REPEATABILITY OF LAMBING INTERVAL (D) UNDER EXPERIMENT STATION CONDITIONS

Source of variation	Lambing interval	
	df	Mean squares
Ewe	54	4,071.29
Type of birth (TB)	3	1,397.35
Year (Y)	2	247.03
Month	11	7,777.57+
TB x Y	6	4,473.72
Regressions		
Ewe age linear	1	794.51
Ewe age quadratic	1	15,728.69*
Residual	21	3,881.33

No. observation	100
No. ewes	55
k^a	1.37
σ_e^2	138.77
σ_w^2	3,881.33
Repeatability	.04
Standard error	.27

[a] Weighted average of number records per ewe.
* ($p<.05$), + ($p<.1$).

Heritability and genetic correlations of preweaning growth characters

Heritability. The heritability estimate of birth weight (table 58) under village conditions was high (h^2 = .63), while under experiment station conditions the estimates was low (h^2 =.13). Both at the villages and experiment station the estimates had high standard error. Under village conditions the estimate was higher than most of previous studies, while the experiment station result was in the typical range of heritability estimates. Previous estimates were .61 in 5 American breeds (Nelson and Venkatachalam, 1949); .45 in Indian sheep (Dass and Acharya, 1970); .34 in Ossimi sheep (Ragab et al., 1953); .33 in 4 breeds of sheep under farm flock conditions (Blackwell and Henderson, 1955); .16 in Rahmani sheep (Karam, 1959); .12 in Norwegian sheep (Gjedrem, 1967); .10 in Indian sheep (Chopra and Acharya, 1971a); .17 and .24 in a synthetic line of sheep (Martin et al., 1980); .13 in Chios sheep (Mavrogenis et al.,1980); .14 in Awassi sheep (Alrawi et al.,1982); .12 to .31 in crossbred, Rambouillet, Targhee and Columbia (Ercanbrack and Price, 1972); .45 and .19 in a high management flock and a low management flock, respectively.

High heritability estimates were obtained for weight at 30, 60 and 90 d of age weaning. The estimates under village conditions and experiment station conditions for corresponding weights were .69, .71, and 1.07 and .44, .59 and .84 (table 58). This suggests that with advancing age the weight at the corresponding age is more highly heritable. Although the results here are higher than previous studies, a similar tendency was reported by several workers, such as Gjedrem

(1967) who reported the heritability of weight at 14, 28, 42 d and at weaning weight as .12, .12, .13, and .18; and Mavrogenis et al. (1980) found heritability of weight in Chios sheep at 5, 10 and 20 wk to be .34, .63 and .66. With respect to weaning weight, the estimates of heritability from the experiment station data was in the range of estimates from studies of tropical sheep, such as Dass and Acharya (1970) - .67 in Indian sheep; Alrawi et al. (1982) - .73 in Awassi sheep; and Khan and Bhat (1981) - .85 in crossbred lambs of Indian sheep x Corriedale.

The heritability estimates of preweaning daily gain (table 58) was high under both village and experiment station conditions. The estimates were 1.12 and .73, respectively. The values reported here are higher than previous studies. Mavrogenis et al. (1980) reported the estimates of average daily gain from birth to weaning as .35; Thrift et al. (1973) found an estimates heritability of gain from birth to weaning of .09; Ercanbrack and Price (1972) estimated heritability of average daily gain from birth to weaning to range from .14 to .39 in Crossbred, Rambouillet, Targhee, and Columbia; Alrawi et al. (1982) in a study on Awassi sheep found the heritability of gain from birth to weaning as .29; and Dass and Acharya (1970) reported the heritability of gain of the first, second, third and fourth months to be .12, .33, 1.11, and .67, respectively.

Genetic correlation among preweaning growth characters. The genetic correlations between birth weight and other preweaning growth characters (30 and 60 d weights, weaning weight (90 d) and preweaning daily gain) were low, and in the experiment station data most were

negative (table 59). Mavrogenis et al. (1980) found that birth weight had low genetic correlation with the subsequent weight (r_g=.16 to .21), but all were positive. Low and positive genetic correlation between birth weight and weaning weight (r_g =.10) was reported by Chopra and Acharya (1971a).

High and positive genetic correlations were found between 30 and 60 d weights, weight at weaning (90 d) and preweaning daily gain. The estimates ranged from .74 to .98 and from .55 to .98, respectively, under village and experiment station conditions. The results here were consistent with the findings of Gjedrem (1967) and Martin et al. (1980) who reported estimates of genetic correlation among weight at different age (excluding birth weight) in the range of .42 to .97 and .73 to 1.04, respectively. Alrawi et al. (1982) reported that the genetic correlation between mating weight and preweaning gain was .71.

TABLE 58. HERITABILITY AND STANDARD ERRORS OF BIRTH WEIGHT (BW), WEIGHT AT 30-DAY (W30), WEIGHT AT 60-DAY (W60), WEIGHT AT 90-DAY (W90) AND PREWEANING DAILY GAIN (PREWG) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	BW	W30	W60	W90	PREWG
		Village[a]			
No. observation	248	200	179	163	163
No. sires	32	30	30	30	30
k^b	6.15	4.76	4.57	3.94	3.94
$\sigma_{s_2}^2$	.05	.26	.58	1.42	179.04
σ_w^2	.27	1.24	2.70	3.91	461.51
Heritability	.63	.69	.71	1.07	1.12
Standard Error	.25	.30	.32	.36	.36
		Experiment station[a]			
No. observation	280	167	164	164	164
No. sires	11	11	11	11	11
k^b	15.40	8.99	8.66	8.80	8.80
$\sigma_{s_2}^2$	.01	.12	.41	1.15	96.93
σ_w^2	.30	.94	2.34	4.26	433.61
Heritability	.13	.44	.60	.85	.73
Standard Error	.14	.28	.32	.36	.34

[a] Analysis of variance in appendix table 81.
[b] Weighted average number records per sire.

TABLE 59. GENETIC CORRELATION AND STANDARD ERRORS AMONG BIRTH WEIGHT (BW), WEIGHT AT 30 D (W30), WEIGHT AT 60 D (W60), WEANING WEIGHT AT 90 D (WWT) AND PREWEANING DAILY GAIN (PREWG) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	Village	Experiment station
No. observation	163	164
No. sires	30	11
k^a	3.94	8.80
σ_s^2		
BW (1)[b]	.07	.04
W30 (2)[b]	.39	.11
W60 (3)[b]	.68	.37
WWT (4)[c]	1.42	1.15
PREWG (5)[c]	179.04	96.93
σ_w^2		
BW (1)[b]	.21	.18
W30 (2)[b]	1.20	.95
W60 (3)[b]	2.54	2.38
WWT (4)[c]	3.91	4.26
PREWG (5)[c]	461.51	433.61
σ_{s12}	.033	.004
σ_{s13}	.028	-.017
σ_{s14}	.019	-.017
σ_{s15}	-.52	-.57
σ_{s23}	.49	.19
σ_{s24}	.59	.22
σ_{s25}	6.20	1.80
σ_{s34}	.97	.49
σ_{s35}	10.47	4.40
σ_{s45}	15.60	10.36
Genetic correlation and standard error ($r_{g}\pm SE$)		
r_{g12}	.21 ± .33	.07 ± .59
r_{g13}	.13 ± .35	-.15 ± .54
r_{g14}	.06 ± .34	-.09 ± .50
r_{g15}	-.15 ± .33	-.31 ± .49
r_{g23}	.94 ± .06	.95 ± .10
r_{g24}	.79 ± .13	.61 ± .35
r_{g25}	.74 ± .16	.55 ± .39
r_{g34}	.98 ± .03	.75 ± .23
r_{g35}	.95 ± .05	.73 ± .24
r_{g45}	.98 ± .02	.98 ± .02

[a] Weighted average number records per sire.
[b] Analysis of variance in appendix table 82.
[c] Analysis variance in appendix table 81.

SUMMARY

Survivability and birth weight of range sheep were studied using 15,003 lamb records of purebred Rambouillet, Targhee and Columbia sheep born during the years 1960 to 1982 at the Red Bluff Research Ranch, Montana Agricultural Experiment Station at Norris, Montana. Least squares method for unequal subclass number was used to analyze survivability from birth to 60 d (SURV60), birth to 120 d (SURV120) and from 60 d to 120 d (SURV60120), defined as "all-or-none" characters, and birth weight. The model used both for survivabilities and birth weight included random effects of sires within breed-year and the effects of breed-year, age of dam, type of birth, sex, appropriate two way interactions, linear regressions of traits on birth date. Data for each breed were analyzed separately and in a pooled three-breed analysis. Survivability data were also analyzed using the same model, but including birth weight within type of birth as an independent covariate. To evaluate breed differences, a model that included breed, year, type of birth, age of dam, sex and interaction between age of dam and type of birth was applied. Heritability of survivabilities and birth weight were estimated based on paternal half-sib correlation.

Preweaning survival rates ranged from 74.1% to 78.4% with mean of 75.8% for the three breeds from birth to 60 d of age and ranged from 68.9% to 74.8% with mean of 71.8% from birth to 120 d of age. SURV60120 was ranged from 92.9% to 95.1% with mean 94.4%. The Targhees

showed higher survivability than Rambouillets or Columbias.

Year effects were significant sources of variation for SURV60 and SURV120 but tended to be less important for SURV60120.

Type of birth was generally found to be an important source of variation in lamb survivability. When birth weight was included in the model as a covariate the effect of type of birth tended to be smaller than when birth weight was excluded from the model. Higher mortality was generally observed in lambs born twins or triplets than single-born lambs. However, variation among breed was also found.

The effect of sex was an unimportant source of variation in SURV60, SURV120 and SURV60120. However, if birth weight was included in the model sex appeared to assume a greater effect on SURV60 and SURV120, except for the Columbias.

Age of dam was not an important source of variation for SURV60 and SURV120 for Rambouillets and Columbias, but was an important source of variation for the Targhees and three breed combined in one analysis. Again, if birth weight was included in the model the effect of age of dam became less important, particularly for the Targhees and in the combined three breed analysis.

Birth date tend to have no important effect on SURV60, SURV120, but significantly effect SURV60120, except for Columbias. However, birth date assumed more important linear effect when birth weight was included in the model, except for the Columbias. Targhee and Rambouillet lambs born later in the season tended to suffer higher mortality than those born earlier. The opposite was the case for the Columbias.

The linear and quadratic regressions of survivability on birth weight showed that birth weight was an important source of variation for SURV60 and SURV120, but an unimportant source of variation for SURV60120. Birth weight in the Rambouillets, Targhees and Columbias accounted for 9.8%, 7.6% and 12.2% of the variation, respectively, for SURV60, and 8.5%, 6.2% and 9.9%, respectively for SURV120. Based on the prediction equation derived from the linear and quadratic regression coefficients and using average birth weights from this study the predicted SURV60 were 92.7%, 83.6%, 99.8% and 88.3%, respectively, for Rambouillets, Targhees, Columbias and three breeds combined. The corresponding values for SURV120 were 85.3%, 76.2%, 92.7% and 82.6%, respectively. Maximum survivability occured just above the mean birth weight, with the exception for SURV120 for the Targhee which occured slightly below the mean of birth weight. With respect to the effect of birth weight on survivability within type of birth, multiple born lambs had lower survivability than single born lambs at equal birth weight.

In the birth weight data, year, type of birth, age of dam, sex and linear regression of birth weight on birth date generally were significant sources of variation, with exception of Rambouillet where the effect age of dam was not significant. The mean birth weight of Rambouillet, Targhee and Columbia observed were 4.38 kg, 4.41 kg, and 3.97 kg, respectively. With respect to type of birth, multiple-born lambs were usually lighter in weight. Rambouillet twin and triplets were 81.2% and 73.8% of the mean birth weight of singles. The corresponding values for Targhees and Columbias were 81.1% and 69%,

and 80.7% and 63.5%, respectively, for three breeds combined were 80.8% and 69.7%. Birth weight increased with increasing age of dam. Lambs produced by mature ewes were 2.4%, 10.4% and 19.8% heavier than lambs produced by 2-yr-old ewes of the Rambouillet, Targhee and Columbia breed respectively. The overall percentage was 9.0%. Ram lambs at birth were consistently heavier than ewe lambs, and for those corresponding breeds ram lambs were 6.8%, 7.2% and 5.7% heavier than ewe lambs, respectively, and in the pooled analysis ram lambs were 7% heavier than ewe lambs. The linear regression of birth weight on birth date indicated that lambs born later in the season were heavier.

Heritability estimates of SURV60, SURV120 and SURV60120 were consistently low for Rambouillet and Targhee breeds, but in the Columbias the estimates were relatively high. The pooled estimates of heritability of survivabilities were low. The heritability estimates were .06, .04 and .44, respectively for Rambouillet, Targhee and Columbia breed for SURV60 and .08, .04 and .31 for SURV120. The corresponding value for SURV60120 were .07, -.02 and .14. Pooled heritability estimates were .14, .12 and .06, respectively, for SURV60, SURV120 and SURV60120. Heritability estimates for birth weight were .25, .26 and .39 for Rambouillet, Targhee and Columbia, respectively. The pooled heritability estimate was .29.

Phenotypic correlation between SURV60 and SURV120 was high, but between birth weight and SURV60 and SURV120 the correlations were relatively low. Very low phenotypic correlation was identified between birth weight and SURV60120.

High genetic correlation was also found between SURV60 and SURV120. The genetic correlation between birth weight and SURV60 and SURV120 was moderate in Rambouillet and Columbia, but very low in the Targhees. However, in the pooled analysis of three breed there was a moderate correlation. Low genetic correlation was also found between birth weight and SURV60120.

Results of this study clearly indicated that mostly non-genetic factors are associated with lamb survivability. However, genetic improvement in lamb survivability through selection might be accomplished by selection for traits related to survivability such as birth weight which is moderately heritable and positively related genetically to survivability.

Growth characteristics and ewe performance traits of Indonesian sheep were studied using data from two sources: the Research Institute for Animal Production station (RIAP) at Cicadas, Bogor and from the villages. Both the station and villages are located in West Java province. Village data were from Javanese thin-tailed sheep (JTT) obtained from Garut (GAR), Ciburuy (CIB) and Cirebon (CIR) representing high, medium, and low elevation areas. Data from the station represented JTT from GAR and fat-tailed (FT). Least squares method for unequal subclass number was used to analyze both growth characteristics and ewe performance traits. Growth characters analyzed were weights at birth, 30 d, 60 d, weaning (90 d), 120 d, 150 d, 180 d, 270 d, and weight at yearling, preweaning daily gain and postweaning daily gain from 90 d to 180 d of age. The data for ewe performance traits analyzed were: litter size, litter size weaned,

neonatal survival, livability at 30, 60, and 90 d, litter weight at birth, litter weight at 30, 60, and 90 d, weight at mating, postpartum weight and lambing interval. Repeatability of ewe performance traits was estimated using intraclass correlation, and heritability of postnatal growth was estimated using paternal half-sib correlation. Data from the experiment station and villages were analyzed seperately.

Location effect on growth characters was a significant source of variation at the villages in most cases. Sheep from GAR were usually heavier and grew faster than sheep from CIB and CIR. Breed was not an important source of variation at the experiment station, although there was a tendency for JTT to be heavier than FT.

Sex effect generally was unimportant in preweaning growth characters, but the effect became more pronounced for postweaning growth and yearling weight both under village and experiment station conditions. Ram lambs usually were heavier than ewe lambs. At birth ram lambs weighed 2% and 7% heavier than ewe lambs at the villages and experiment station, respectively, while at 180-day and yearling the corresponding values were 19.7% and 22.6%, and 11.4% and 25.6%, respectively.

Type of birth was generally found to be an important source of variation for growth characters both under village and experiment station conditions. Lambs born in larger litter were usually lighter than single-born lambs. At the villages, the weights and gains of twins and triplets as a percentage of the values for singles were: for birth weight, 77.4% and 57.1%; weaning weight, 79.8% and 74.7%;

preweaning daily gain, 75.5% and 70.5%; weight at 180 d, 85.2% and 85%; and weight at 270 d, 80.6% and 69.2%. The percentage of multiple-born lamb weights to the singles at yearling age was 69.7%. At the experiment station the corresponding values for average weight and gains of twins, triplets and quadruplets as percentage of singles were: 74.1%, 60% and 43.7%; 84.5%, 83.5% and 81.2%; 75.6%, 73.5% and 67.4%; 88.4%, 80.9% and 88.5%; and 84.4%, 84% and 83.1%. At yearling age the weight of twins, triplets and quadruplets as percentage of singles were: 91.4%, 84.5% and 83.5%.

The effect of age of dam on growth characters under village conditions was important only at birth, while under experiment station conditions, the effect was important for birth weight, weight at 30 d weight at 60 d and preweaning daily gain. The relationship between preweaning growth and age of dam at the experiment station tended to be curvilinear, with mature ewes producing lambs with greatest preweaning growth.

The effects of years and months of birth which reflected the management, feed supply and season variation on growth characters were not consistent under village conditions, but were mostly significant under experiment station conditions. With regard to the effect of month of birth on growth characters under experiment station conditions no seasonal pattern was found.

The regression of preweaning and postweaning growth on birth weight indicated that birth weight was positively and linearly related to pre- and postweaning weights, but had no relation to pre- and postweaning average daily gains. Under village conditions the relation

was significant up to weight at 60-day, while under experiment station conditions the relationship was significant up to weight at 180-day of age.

Residual correlation among preweaning growth characters indicated that adjacent weights were highly correlated, while birth weight was lowly correlated with other preweaning growth characters. Preweaning average daily gain was more highly correlated with weaning weight than with birth weight. Similar results were also noted in residual correlations among birth weight, weaning weight, postweaning growth characters and yearling weight.

Growth curves of Indonesian sheep under village and experiment station conditions indicated that growth was curvilinear from birth to approximately 48 month, but linear from birth to approximately 3 mo of age. The equations were $W = 6.959A^{0.405}$, $W = 6.424A^{0.424}$ and $W = 6.110A^{0.385}$ for experiment station-JTT, experiment station-FT and village sheep, respectively. Sheep at the experiment station tended to grow faster than under village conditions, and JTT sheep grew faster than FT.

Under village conditions, the effect of location was an important source of variation. The mating weight of ewes at GAR were the heaviest, followed by CIR and CIB. The last two locations changed rank relative to the previous weight data. At the experiment station, breed was an unimportant source of variation. However, JTT tended to be heavier than FT. Ewe age was an important source of variation both at the villages and experiment station. Older ewes tended to have heavier mating weight. Year and month of mating were not an important source

of variation at the villages, while under experiment station conditions month effect was an important source of variation.

At the villages, location, and ewe age at lambing were important sources of variation for postpartum weight. Type of birth, year and month of lambing showed unimportant effects. At the experiment station, breed, year and month of lambing were significant sources of variation. Type of birth had no effect on postpartum weight. The ranking of postpartum weight was GAR, CIB and CIR at the villages, and JTT and FT at the experiment station. Older ewes were heavier than younger ewes. With regard to the relationship between postpartum weight and litter weight at birth, it was found that ewes with heavier weight tended to have heavier litters at birth.

With respect to the litter size born under village conditions, location and ewe age were important sources of variation. Year and month of lambing did not differ significantly. At the experiment station, year and the linear regression of litter size on ewe age were important sources of variation. At the villages, GAR had the highest average litter size (1.67), followed by CIB (1.52) and CIR (1.15). At the experiment station, the litter size of JTT and FT were similar (2.00 and 1.95, respectively). Both at the villages and experiment station, there was a tendency for litter size to increase with advancing age of ewes.

Litter size weaned was affected by location and type of birth. Ewe age, year and month of lambing were not significant sources of variation under village conditions. At the experiment station, litter size weaned was affected by type of birth and year, while breed, ewe

age, and month of lambing were unimportant sources of variation. With respect to the effect of type of birth, 82%, 78.5% and 59.7% of singles, twins, and triplets were weaned, respectively under village conditions. At the experiment station station the weaning rates were were 68%, 61.5%, 75.3% and 42.5% for singles, twins, triplets and quadruplets, respectively.

Type of birth was a major factor affecting lamb livability at birth both at the villages and the experiment station. For livability at 30, 60 and 90 d, location tended to be the major factor affecting lamb livability at the villages, but at the experiment station none of the factors studied significantly affected lamb livability. Death losses occured mostly during the first 30 d of age. At the villages and experiment station 82.9% and 91.9% of the death losses occured during this time. With regard to the effect of type of birth, triplet- and quadruplet-born lambs suffered higher mortality both at the villages and experiment station, and the effect persisted until weaning at 90 d of age. At weaning single-, twin-, triplet-born lamb mortalities were 21.7%, 20.8% and 34.7%, respectively, under village conditions, while under experiment station conditions,single-, twin-, triplet- and quadruplet-born lambs mortality was 25.6%, 38.7%, 45.7% and 58.1%, respectively. Across the locations, death losses were higher in CIR, followed by CIB and GAR. JTT and FT had similar mortality under experiment station conditions.

In the villages, location, type of birth and ewe age were important source of variation for litter weight at birth, but year and month had no significant effect. At the experiment station, type of

birth, year of lambing and the linear regression of litter weight at birth on ewe age were important sources of variation, while breed and month of lambing had no significant effect. The location and breed effects indicated that GAR had the heaviest litter weight at birth followed by CIB and CIR, and JTT produced heavier litters than FT. The ratio of litter weight at birth of singles, twins and triplets was 100:139:165 under village conditions, and 100:152:180:212 for singles, twins, triplets and quadruplets under experiment station conditions.

For litter weight at 30, 60 and 90 d, location and type of birth were important sources of variation under village conditions, but ewe age, year and month had no significant effects. However, in the experiment station data type of birth and years were the importance sources of variation. Ewe age and months of lambing had no significant effects. GAR ewes consistently had higher litter weight at later ages than CIB and CIR ewes. JTT ewes tended to produce heavier litter at later ages than FT ewes.

Residual correlations among ewe performance traits indicated that litter size born was significantly and positively correlated with litter size at weaning and litter weight, but negatively correlated with livability, although some correlation did not differ from zero. Litter size at weaning had high positive correlations with livability and litter weight. Positive correlations, some highly significant were found among livability and litter weight at different age. The residual correlations involving weight at mating and postpartum weight with litter traits were mostly low, some were negative and some were not statistically different from zero.

At the villages, location, type of birth, ewe age, years and months had no significant effect on lambing interval, while under experiment station conditions linear and quadratic regressions of lambing interval on ewe age were the only significant source of variation. Breed, type of birth, years and month were not significant sources of variation. Both at the villages and experiment station lambing interval was similar (259.3 and 252.4 d, respectively). A study of the effect of number of lambs produced by ewes (type of birth) indicated that ewes with larger litter tended to have longer lambing interval subsequently, although the effect lacked significance. With respect to the effect of age of ewe, particularly under experiment station conditions, lambing interval became shorter with advancing age of ewe until a certain age was reached then became longer after that age. The shortest lambing interval was reached at the age of approximately 32.8 months.

Ewe weight at mating and postpartum weight were highly repeatable. At the villages the estimates of repeatability of mating- and postpartum weight were .78 and .68. Corresponding values for the experiment station were .61 and .62, respectively.

Litter size and litter size weaned were lowly repeatable. Under village conditions the repeatability were .22 and .004, respectively, while under experiment station conditions the estimates were .12 and .13, respectively.

Estimate of repeatability of livability at birth under village conditions was quite high (.58), while under experiment station conditions the estimate was low (.08). However, for livability at 30,

60 and 90 d the repeatability estimates were opposite to those for livability at birth. High estimates were found at the experiment station, and low estimates were found at the villages. The corresponding estimates were .03, .13 and .11 under village conditions, and .32, .29 and .27, respectively at the experiment station.

Repeatability of litter weight at birth, at 30, 60 and 90 d found in this study was .17, .08, .14 and .08, respectively, under village conditions, and .35, .20, .06 and .05, respectively, under experiment station conditions. This suggests the presence of random environmental effects for litter weight at 30, 60 and 90 d. A low estimate of repeatability was found for lambing interval (.04).

The heritability estimates for postnatal growth indicated that weights recorded 30 d or longer after birth and preweaning average daily gain were more heritable than birth weight. The estimates found in this study for birth weight, weights at 30 d, 60 d, weaning weight (90 d) and preweaning average daily gain were .63, .69, .71, 1.07 and 1.12, respectively, at the villages, and .13, .44, .59,.85 and .73 under experiment station conditions.

Genetic correlations between birth weight and other preweaning growth characters of village sheep (weight at 30 d, at 60 d, weaning weight at 90 d and preweaning average daily gain) were low. In the experiment station data most genetic correlations were negative. High and positive genetic correlations were found among weights at 30 d, at 60 d, weaning weight at 90 d and preweaning average daily gain.

Results of the characterization of Indonesian sheep indicated that both JTT and FT under village and experiment station conditions are relatively prolific breeds, capable of reproducing more than once a year. However, high mortality was identified as a serious problem. Therefore, in order to improve lamb production per year, reducing preweaning lamb mortality through improving management is recommended, since litter livability as a ewe traits was lowly repeatable. In addition selection for weaning weight, being high heritability, should also increase annual lamb production.

There are some similarities between the Montana and Indonesian results in lamb survivability, although there were differences in the quantitative estimates. Lamb mortality up to weaning was approximately 28% under Montana range conditions, and 26% and 42%, respectively, under Indonesian village and experiment station conditions. In both environments most death losses occured a few days after birth. Mortality from birth to 60 d was 24% under Montana range conditions and 22% to 39% under Indonesian environments. Multiple born lambs suffer more mortality than single-born lambs. Indonesian sheep were smaller at birth than the sheep raised under Montana range conditions. The average birth weights ranged from 1.8 kg to 2.0 kg in Indonesia and from 4.0 to 4.4 kg in Montana. Multiple births occured more frequently in the Indonesian sheep than in the Montana sheep.

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APPENDIX

APPENDIX TABLE 60. ANALYSES OF VARIANCE FOR SURV60, SURV120 AND SURV60120 (BREED IN THE MODEL)

Source of variation	df	Mean squares[a] SURV60	SURV120	df	Mean squares[a] SURV60120
Breed	2	24,420.7**	37,038.9**	2	4,725.3**
Year	22	16,729.3**	21,943.4**	22	2,395.7**
Type of birth (TB)	2	253,078.0**	289,050.9**	2	4,610.9**
Age of dam (AD)	4	4,081.1*	5,857.3**	4	422.3
Sex	1	4,354.7+	3,340.7	1	34.4
TB x AD	8	12,671.5**	11,703.0**	8	124.5
Residual	14,963	1,235.2	1,473.5	12,629	428.8

[a] Mean squares x 10^4.
** ($p<.01$), * ($p<.05$), + ($p<.1$).

APPENDIX TABLE 61. LEAST SQUARES MEANS AND STANDARD ERRORS FOR SURV60, SURV120 AND SURV60120 BY YEARS AND BY BREED (WITHOUT BIRTH WEIGHT IN THE MODEL)

Year	No.	SURV60 (%)	SURV120 (%)[a]	No.	SURV60120 (%)
			Rambouillet		
1960	301	72.5 ± 3.1	68.8 ± 3.4	241	94.0 ± 1.9
1961	315	70.6 ± 3.2	67.0 ± 3.6	244	93.8 ± 2.0
1962	431	69.7 ± 2.9	64.2 ± 3.2	328	91.3 ± 1.8
1963	272	72.3 ± 3.5	70.3 ± 4.0	222	96.1 ± 2.2
1964	302	67.3 ± 3.3	63.1 ± 3.8	226	93.0 ± 2.1
1965	189	69.1 ± 4.4	68.1 ± 5.0	146	97.5 ± 2.7
1966	207	77.3 ± 3.7	75.3 ± 4.2	175	96.2 ± 2.2
1967	220	83.6 ± 3.7	82.7 ± 4.1	196	97.9 ± 2.2
1968	187	83.7 ± 3.8	82.3 ± 4.2	168	96.9 ± 2.3
1969	233	86.4 ± 3.4	83.3 ± 3.9	213	95.3 ± 2.1
1970	238	82.7 ± 3.4	81.1 ± 3.8	215	96.8 ± 2.1
1971	294	81.1 ± 3.2	78.4 ± 3.7	257	95.5 ± 2.0
1972	286	80.5 ± 3.2	75.0 ± 3.6	244	92.1 ± 2.0
1973	287	84.1 ± 3.0	80.9 ± 3.3	258	95.0 ± 1.8
1974	249	86.9 ± 3.1	83.1 ± 3.4	234	94.5 ± 1.9
1975	289	77.9 ± 3.1	74.6 ± 3.4	243	94.7 ± 1.9
1976	227	74.0 ± 3.2	66.1 ± 3.6	183	88.7 ± 2.0
1977	185	81.0 ± 3.3	74.4 ± 3.7	165	91.0 ± 2.0
1978	228	82.8 ± 3.2	78.8 ± 3.5	203	94.1 ± 1.9
1979	279	70.5 ± 3.0	62.9 ± 3.4	214	88.5 ± 1.9
1980	265	72.4 ± 3.1	61.6 ± 3.4	208	84.9 ± 2.0
1981	249	66.0 ± 3.1	64.3 ± 3.4	188	96.3 ± 2.0
1982	250	72.7 ± 3.1	64.0 ± 3.4	204	87.8 ± 2.0

APPENDIX TABLE 61. (CONTINUED)

Year	No.	SURV60 (%)	SURV120 (%)[a]	No.	SURV60120 (%)
			Targhee		
1960	246	75.3 ± 2.9	68.8 ± 3.2	219	91.2 ± 1.7
1961	249	74.0 ± 3.0	70.8 ± 3.3	211	94.9 ± 1.7
1962	209	72.6 ± 3.0	67.3 ± 3.3	180	92.4 ± 1.8
1963	270	69.1 ± 2.9	66.5 ± 3.2	220	95.5 ± 1.7
1964	305	72.9 ± 3.0	69.7 ± 3.3	259	94.8 ± 1.7
1965	314	76.1 ± 2.8	72.2 ± 3.0	275	94.2 ± 1.6
1966	292	74.3 ± 2.8	70.9 ± 3.0	253	94.6 ± 1.6
1967	349	81.1 ± 2.6	79.0 ± 2.9	316	96.4 ± 1.6
1968	340	78.8 ± 2.6	76.6 ± 2.9	298	96.2 ± 1.6
1969	376	80.2 ± 2.6	76.1 ± 2.8	340	94.1 ± 1.5
1970	343	74.1 ± 2.6	72.2 ± 2.9	294	96.4 ± 1.6
1971	316	81.3 ± 2.6	77.8 ± 2.9	287	94.8 ± 1.6
1972	275	80.0 ± 2.7	76.0 ± 3.0	241	94.2 ± 1.6
1973	252	79.1 ± 2.9	74.2 ± 3.2	224	93.3 ± 1.7
1974	227	80.3 ± 2.9	76.5 ± 3.2	205	94.5 ± 1.7
1975	211	78.2 ± 3.0	73.2 ± 3.3	186	93.1 ± 1.8
1976	234	70.3 ± 3.0	65.8 ± 3.3	188	93.4 ± 1.7
1977	153	80.9 ± 3.3	77.1 ± 3.7	144	94.4 ± 2.0
1978	154	80.7 ± 3.4	78.1 ± 3.7	137	95.9 ± 2.0
1979	167	68.8 ± 3.3	64.6 ± 3.7	133	93.6 ± 2.0
1980	192	66.3 ± 3.1	60.1 ± 3.4	145	90.5 ± 2.0
1981	128	67.8 ± 3.6	62.9 ± 3.9	105	92.5 ± 2.2
1982	146	69.3 ± 3.3	64.2 ± 3.6	122	92.4 ± 2.1

APPENDIX TABLE 61. (CONTINUED)

Year	No.	SURV60 (%)	SURV120 (%)[a]	No.	SURV60120 (%)
			Columbia		
1960	172	80.5 ± 7.5	69.5 ± 7.3	149	87.0 ± 3.6
1961	164	82.5 ± 8.3	77.8 ± 8.1	145	94.5 ± 3.9
1962	134	81.2 ± 8.0	72.4 ± 7.9	115	89.6 ± 3.9
1963	150	75.1 ± 7.5	72.4 ± 7.4	126	96.3 ± 3.7
1964	103	82.1 ±10.9	78.1 ±10.6	87	95.2 ± 4.9
1965	73	72.3 ±11.0	69.4 ±10.7	59	96.1 ± 5.1
1967	81	80.5 ±10.4	81.3 ±10.1	69	100.8 ± 4.9
1968	76	75.3 ±10.5	75.5 ±10.3	60	100.1 ± 5.0
1969	156	83.9 ± 8.3	78.1 ± 8.1	137	93.4 ± 3.9
1970	252	82.7 ± 6.5	80.8 ± 6.3	220	97.7 ± 3.2
1971	289	86.1 ± 7.3	84.0 ± 7.1	257	97.7 ± 3.4
1972	244	87.4 ± 7.7	84.5 ± 7.4	220	96.8 ± 3.6
1973	233	61.9 ± 7.8	58.9 ± 7.5	154	94.9 ± 4.1
1974	161	80.8 ± 6.9	74.0 ± 6.8	142	92.1 ± 3.5
1975	158	80.7 ± 6.7	77.6 ± 6.6	135	96.1 ± 3.4
1976	176	68.8 ± 6.8	64.1 ± 6.7	130	93.2 ± 3.5
1977	140	81.6 ± 6.8	74.7 ± 6.7	124	92.1 ± 3.5
1978	112	82.2 ± 7.3	77.1 ± 7.3	96	94.0 ± 3.7
1979	124	65.3 ± 7.4	63.7 ± 7.3	81	97.6 ± 3.9
1980	139	72.1 ± 5.3	64.3 ± 5.5	104	89.3 ± 3.3
1981	87	69.9 ± 7.7	68.8 ± 7.6	68	98.2 ± 4.0
1982	48	64.1 ± 8.5	54.1 ± 8.6	34	85.8 ± 5.1

[a] No. observation equal to SURV60

APPENDIX TABLE 62. ANALYSIS OF VARIANCE FOR SURV60, SURV120 AND SURV60120 BY BREED (BIRTH WEIGHT IN THE MODEL)

Source of variation	df	Mean squares[a] SURV60	SURV120	df	Mean squares[a] SURV60120
		Rambouillet			
Year (Y)	22	5,455.0**	7,636.9**	22	1,857.4**
Sires/Y	257	1,546.5**	1,941.9**	253	507.9**
Type of birth (TB)	2	4,215.2**	7,473.0**	2	896.7
Age of dam (AD)	4	761.8	1,922.5	4	1,947.7**
Sex	1	24,267.0**	23,164.0**	1	49.7
TB x AD	8	962.4	1,889.3	8	969.5*
Regressions					
Birth weight linear	1	45,889.1**	35,602.8**	1	222.1
TB reg.lin.birth wt.	2	3,927.8**	6,169.3**	2	934.8+
Birth weight quad.	1	18,619.7**	19,559.7**	1	615.0
TB reg.quad.birth wt.	2	2,756.8+	4,482.0*	2	1,004.3+
Birth date linear	1	6,396.0*	14,879.6**	1	3,137.3**
Residual	5,681	1,182.6	1,375.9	4,677	392.0
		Targhee			
Year (Y)	22	3,234.5**	4,254.4**	22	456.4
Sires/Y	141	1,408.4**	1,708.6**	140	321.7
Type of birth (TB)	2	9,122.3**	12,891.6**	2	637.3
Age of dam (AD)	4	1,850.2	2,942.1*	4	726.6
Sex	1	17,272.9**	15,281.3**	1	.0
TB x AD	8	3,316.8**	3,038.5*	8	581.3
Regressions					
Birth weight linear	1	2,381.4	1,517.9	1	2.6
TB reg.lin.birth wt.	2	688.0	1,238.7	2	8.8
Birth weight quad.	1	23,825.0**	23,976.0**	1	53.1
TB reg.quad.birth wt.	2	11,976.4**	11,921.6**	1	243.4
Birth date linear	1	6,272.8*	16,824.1**	1	3,409.8*
Residual	5,562	983.4	1,217.4	4,797	374.3

APPENDIX TABLE 62. (CONTINUED)

Source of variation	df	Mean squares[a] SURV60	SURV120	df	Mean squares[a] SURV60120
		Columbia			
Year (Y)	21	9,304.3**	9,801.5**	21	1,289.7
Sires/Y	95	4,373.8**	4,232.7**	94	995.4**
Type of birth (TB)	2	3,176.7*	3,232.8+	2	152.0
Age of dam (AD)	4	2,026.7	1,538.8	4	149.3
Sex	1	4,735.1*	4,738.8+	1	.8
TB x AD	8	1,703.4	1,236.4	8	239.8
Regressions					
Birth weight linear	1	18,443.1**	17,499.0**	1	11.0
TB reg.lin.birth wt.	2	527.8	550.4	2	144.9
Birth weight quad.	1	21,749.1**	21,550.9**	1	4.8
TB reg.quad.birth wt.	2	6,617.8**	6,420.3**	2	377.6
Birth date linear	1	503.2	3,256.9	1	1,832.4+
Residual	3,133	1,046.1	1,365.2	2,574	560.4
		Three breed combined			
Breed-Year (B-Y)	67	6,216.5**	7,270.0**	67	1,293.9**
Sires/B-Y	493	2,054.5**	2,327.4**	487	551.8**
Type of birth (TB)	2	8,725.9**	13,764.3**	2	1,304.9*
Age of dam (AD)	4	1,061.9	2,319.3	4	715.5
Sex	1	44,409.8**	41,541.7**	1	17.2
TB x AD	8	3,038.3**	2,883.8*	8	224.9
Regressions					
Birth weight linear	1	47,825.9*	38,138.5**	1	96.8
TB reg.lin.birth wt.	2	2,738.2+	4,305.8*	2	578.9
Birth weight quad.	1	60,552.0**	62,711.1**	1	134.0
TB reg.quad.birth wt.	2	14,727.4**	17,369.6**	2	1,497.3*
Birth date linear	1	11,197.3**	31,813.6**	1	8,297.3**
Residual	14,420	1,080.0	1,316.3	12,092	421.4

[a] Mean squares x 10^4.
** ($p<.01$), * ($p<.05$), + ($p<.1$).

APPENDIX TABLE 63. LEAST SQUARES MEANS AND STANDARD ERRORS OF BIRTH WEIGHT (BW) BY YEARS AND BY BREED

Year	Rambouillet		Targhee		Columbia	
	No.	BW (kg)	No.	BW (kg)	No.	BW (kg)
1960	301	4.06±.08	246	4.13±.10	172	3.70±.14
1961	315	4.04±.09	249	4.16±.11	164	3.61±.16
1962	431	3.99±.08	209	4.08±.09	134	3.67±.16
1963	272	4.12±.10	270	3.80±.10	150	3.49±.15
1964	302	4.29±.09	305	4.51±.11	103	4.06±.21
1965	189	4.68±.13	314	4.44±.10	73	3.93±.21
1966	207	4.54±.10	292	4.38±.09		...
1967	220	4.46±.10	349	4.44±.09	81	4.11±.20
1968	187	4.72±.10	340	4.59±.09	76	4.16±.20
1969	233	4.72±.09	376	4.54±.09	156	4.07±.16
1970	238	4.49±.09	343	4.42±.09	252	4.12±.12
1971	294	4.52±.09	316	4.53±.09	289	4.06±.14
1972	286	4.57±.08	275	4.67±.09	244	4.11±.15
1973	287	4.46±.07	252	4.43±.10	233	4.12±.15
1974	249	4.68±.07	227	4.69±.09	161	4.21±.13
1975	289	4.46±.08	211	4.48±.10	158	4.17±.13
1976	227	4.22±.08	234	4.42±.10	176	3.95±.13
1977	185	4.36±.08	153	4.51±.10	140	3.91±.13
1978	228	4.45±.08	154	4.67±.11	112	4.20±.14
1979	279	4.18±.07	167	4.23±.11	124	3.83±.14
1980	265	4.39±.07	192	4.51±.10	139	3.96±.10
1981	249	4.36±.07	128	4.46±.11	87	4.11±.15
1982	250	4.10±.07	146	4.32±.10	48	3.83±.17

APPENDIX TABLE 64. ANALYSIS OF VARIANCE FOR BIRTH WEIGHT BY BREED EXCLUDING DATA FROM LAMBS DEAD AT 60 D

Source of variation	Rambouillet (kg)		Targhee (kg)		Columbia (kg)		Three breed[a] (kg)	
	df	Mean squares	df	Mean squares	df	Mean squares	df	Mean squares
Breed-year (B-Y)	22	8.82**	22	8.04**	21	5.00**	67	10.30**
Sire/B-Y[b]	253	.86**	140	1.33**	94	1.26**	487	1.09**
Type of birth (TB)	2	386.76**	2	408.15**	2	210.10**	2	1,012.90**
Age of dam (AD)	4	.59	4	1.11**	4	4.94**	4	3.95**
Sex	1	109.06**	1	117.89**	1	29.72**	1	248.82**
TB x AD	8	1.07**	8	.47	8	.48	8	.86*
Regressions								
Birth date linear	1	19.81**	1	39.99**	1	11.31**	1	69.27**
Residual	4,683	.35	4,803	.37	2,580	.42	12,098	.38

[a] Three breed combined in one analysis.
[b] Sire/year for each breed analysis.
** ($p<.01$), * ($p<.05$).

APPENDIX TABLE 65. COMPONENTS OF VARIANCE, HERITABILITIES (h^2) AND STANDARD ERRORS FOR SURV60, SURV120 AND SURV60120 BY BREED (BIRTH WEIGHT IN THE MODEL)

	Rambouillet	Targhee	Columbia	Three breed[a]
		SURV60[a]		
No. observation	5,983	5,748	3,272	15,003
No. sires	280	164	117	561
k^b	20.41	34.00	26.16	25.56
σ_s^2	17.83	12.50	127.21	38.13
σ^2	1,182.60	983.40	1,046.10	1,080.00
h^{2w}	.06	.05	.43	.14
S.E.	.02	.02	.07	.02
		SURV120[a]		
No. observation	5,983	5,748	3,272	15,003
No. sires	280	164	117	561
k^b	20.41	34.00	26.16	25.56
σ_s^2	27.73	14.45	109.61	39.56
σ^2	1,375.90	1,217.40	1,365.20	1,316.30
h^{2w}	.08	.05	.30	.12
S.E.	.02	.02	.05	.02
		SURV60120[a]		
No. observation	4,975	4,982	2,712	12,669
No. sires	276	163	116	555
k^b	17.21	29.65	21.69	21.78
σ_s^2	6.73	-1.77	20.05	5.99
σ^2	392.00	374.30	560.40	421.40
h^{2w}	.07	-.02	.14	.06
S.E.	.02	.002	.04	.01

[a] Analysis of variance in appendix table 62.

[b] Weighted average number records per sire within year or within breed-year for three breed combined.

APPENDIX TABLE 66. LEAST SQUARES MEANS AND STANDARD ERRORS OF BIRTH WEIGHT (BW) ACCORDING TO YEARS AND MONTHS OF LAMBING UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	BW (kg)	No.	BW (kg)
Year				
1979		...	93	1.80 ± .10
1980	29	2.10 ± .13	68	2.03 ± .10
1981	181	1.97 ± .06	188	1.79 ± .09
1982	217	1.84 ± .06		...
Month				
J	53	2.08 ± .10	24	1.97 ± .14
F	48	2.23 ± .10	14	2.19 ± .18
M	26	1.99 ± .13	32	1.93 ± .12
A	17	1.82 ± .15	18	1.80 ± .16
M	25	1.88 ± .13	11	1.70 ± .18
J	27	1.79 ± .13	8	1.37 ± .21
J	37	1.90 ± .12	26	2.00 ± .13
A	48	2.06 ± .11	33	1.95 ± .13
S	42	1.93 ± .10	62	2.06 ± .10
O	43	1.95 ± .10	57	1.81 ± .09
N	34	2.06 ± .11	41	1.95 ± .10
D	27	1.90 ± .12	23	1.75 ± .13

APPENDIX TABLE 67. LEAST SQUARES MEANS AND STANDARD ERRORS OF WEIGHT AT 30 D (W30), WEIGHT AT 60 D (W60), WEANING WEIGHT AT 90 D (WWT), AND PREWEANING DAILY GAIN FROM BIRTH TO 90 D (PREWG) BY YEARS AND MONTHS UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	No.	W30 (kg)	No.	W60 (kg)	No.	W90 (kg)	No.	PREWG (G)
				Village				
Year								
1980	23	4.22 ± .28	23	6.16 ± .46	23	7.92 ± .59	23	62.9 ± 6.61
1981	155	4.54 ± .16	145	6.29 ± .24	138	8.03 ± .32	138	64.4 ± 3.46
1982	174	4.60 ± .15	141	6.84 ± .24	123	9.07 ± .33	123	75.8 ± 3.65
Month								
J	43	4.29 ± .23	37	5.95 ± .40	35	7.34 ± .53	35	56.7 ± 5.89
F	38	4.22 ± .23	36	6.07 ± .36	35	7.33 ± .48	35	56.1 ± 5.36
M	20	4.15 ± .30	20	5.54 ± .47	20	6.66 ± .60	20	49.7 ± 6.62
A	13	4.80 ± .33	13	6.58 ± .79	10	8.92 ± .79	10	74.2 ± 8.82
M	22	4.45 ± .29	17	6.27 ± .49	12	8.82 ± .72	12	73.7 ± 7.89
J	23	4.46 ± .27	22	6.43 ± .45	22	9.00 ± .58	22	75.5 ± 6.43
J	29	4.07 ± .25	29	5.73 ± .41	26	7.62 ± .54	26	59.8 ± 5.99
A	39	4.74 ± .23	31	7.34 ± .40	31	9.70 ± .51	31	82.6 ± 5.71
S	33	4.68 ± .23	38	7.26 ± .37	24	9.01 ± .51	24	75.0 ± 5.70
O	36	4.52 ± .23	24	6.69 ± .42	19	8.84 ± .59	19	72.9 ± 6.60
N	32	4.50 ± .24	30	6.51 ± .37	28	8.47 ± .49	28	69.0 ± 5.45
D	24	4.60 ± .25	22	6.80 ± .42	22	8.34 ± .55	22	67.3 ± 6.11

APPENDIX TABLE 67. (CONTINUED)

Variables	No.	W30 (kg)	No.	W60 (kg)	No.	W90 (kg)	No.	PREWG (G)
				Experiment station				
Year								
1979	28	4.23 ± .28	28	6.39 ± .57	28	7.82 ± .57	28	60.7 ± 6.36
1980	46	5.77 ± .25	46	9.22 ± .37	46	11.67 ± .46	46	105.9 ± 5.16
1981	126	4.85 ± .38	123	6.65 ± .25	113	9.15 ± .42	113	75.2 ± 4.54
Month								
J	16	4.94 ± .31	16	7.10 ± .50	9	9.63 ± .75	9	82.0 ± 8.43
F	10	5.12 ± .38	10	7.39 ± .61	10	8.66 ± .76	10	72.6 ± 8.55
M	14	5.89 ± .32	14	9.38 ± .49	14	13.06 ± .63	14	120.8 ± 7.00
A	5	5.88 ± .46	5	8.68 ± .91	5	12.57 ± .91	5	115.1 ±10.18
M	7	4.50 ± .67	7	6.98 ± .67	7	8.32 ± .80	7	66.4 ± 8.94
J	6	5.12 ± .45	6	7.78 ± .71	6	9.45 ± .88	6	76.3 ± 9.63
J	19	4.46 ± .28	19	6.79 ± .71	19	9.08 ± .56	19	74.7 ± 6.21
A	19	4.73 ± .32	18	6.74 ± .41	17	8.40 ± .66	17	67.0 ± 7.31
S	39	4.28 ± .27	38	6.47 ± .41	37	8.16 ± .54	37	66.7 ± 5.99
O	33	4.75 ± .21	32	7.22 ± .32	31	9.55 ± .41	31	80.2 ± 4.50
N	18	4.84 ± .28	18	7.46 ± .43	18	8.78 ± .55	18	73.1 ± 6.13
D	14	4.87 ± .29	14	7.04 ± .47	14	8.92 ± .57	14	72.4 ± 6.29

APPENDIX TABLE 68. LEAST SQUARES MEANS AND STANDARD ERRORS OF WEIGHT AT 120 D (W120), WEIGHT AT 150 D (W150), WEIGHT AT 180 D (W180), POSTWEANING DAILY GAIN FROM WEANING AT 90 D TO 180 DAY (POSTWG) BY YEARS AND MONTHS OF BIRTH UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	No.	W120 (kg)	No.	W150 (kg)	No.	W180 (kg)	No.	POSTWG (g)
				Village				
Year								
1980	19	9.86 ± .76	16	11.17 ± .94	11	13.64 ± 1.28	11	63.7 ± 8.62
1981	126	9.43 ± .40	120	10.58 ± .46	105	12.08 ± .59	105	47.5 ± 3.94
1982	106	10.63 ± .44	69	12.50 ± .87	41	13.67 ± .87	41	51.6 ± 5.80
Month								
J	35	8.74 ± .67	32	9.06 ± .81	13	10.85 ± 1.29	13	43.9 ± 8.70
F	35	8.86 ± .61	22	9.74 ± .81	19	12.22 ± 1.06	19	54.3 ± 7.14
M	15	8.73 ± .79	9	9.39 ± 1.16	8	11.71 ± 1.44	8	61.5 ± 9.64
A	9	11.08 ± .99	9	13.15 ± 1.13	8	15.29 ± 1.39	8	75.2 ± 9.32
M	11	10.47 ± .92	7	13.24 ± 1.24	7	15.27 ± 1.47	7	61.1 ± 9.83
J	21	10.79 ± .71	20	12.46 ± .84	16	14.57 ± 1.09	16	62.1 ± 7.33
J	25	9.23 ± .67	14	11.07 ± .98	12	12.97 ± 1.25	12	49.4 ± 8.36
A	20	11.24 ± .70	18	12.72 ± .85	14	13.01 ± 1.08	14	49.0 ± 7.20
S	22	10.76 ± .65	19	12.14 ± .80	13	13.94 ± 1.11	13	51.6 ± 7.44
O	17	10.70 ± .73	17	12.08 ± .85	16	13.07 ± 1.00	16	49.1 ± 6.74
N	21	9.47 ± .66	21	10.89 ± .78	16	11.68 ± .99	16	41.8 ± 6.61
D	20	9.60 ± .68	17	11.04 ± .86	15	13.00 ± 1.07	15	52.2 ± 7.14

APPENDIX TABLE 68. (CONTINUED)

Variables	No.	W120 (kg)	No.	W150 (kg)	No.	W180 (kg)	No.	POSTWG (g)
				Experiment station				
Year								
1979	28	8.39 ± .68	28	9.24 ± .61	28	10.32 ± .66	28	24.9 ± 4.97
1980	45	13.83 ± .52	43	16.58 ± .46	41	19.31 ± .49	41	77.7 ± 3.71
1981	100	10.11 ± .41	60	12.63 ± .48	47	14.73 ± .56	47	58.8 ± 4.08
Month								
J	9	11.17 ± .91	4	11.55 ± 1.21	4	14.48 ± 1.28	4	59.3 ±10.02
F	10	10.06 ± .88	9	12.04 ± .87	9	14.31 ± .93	9	62.2 ± 7.16
M	14	14.98 ± .71	14	17.89 ± .70	14	19.43 ± .74	14	64.1 ± 5.75
A	5	14.57 ± 1.06	5	17.56 ± 1.10	5	18.83 ± 1.17	5	70.1 ± 8.93
M	7	9.73 ± .96	6	11.73 ± 1.01	6	13.03 ± 1.07	6	38.0 ± 8.22
J	6	10.00 ± 1.02	5	11.83 ± 1.12	4	13.91 ± 1.30	4	50.1 ± 9.73
J	18	9.61 ± .65	14	11.53 ± .74	14	12.78 ± .79	14	36.9 ± 6.08
A	16	9.62 ± .76	16	11.15 ± .69	15	13.32 ± .77	15	49.8 ± 5.68
S	36	8.90 ± .59	32	10.17 ± .52	23	11.13 ± .62	23	40.0 ± 4.71
O	30	10.37 ± .46	11	11.97 ± .74	9	14.18 ± .89	9	51.8 ± 6.93
N	14	10.55 ± .62	7	14.02 ± .98	7	17.07 ± 1.05	7	63.2 ± 8.30
D	8	9.79 ± .90	8	12.37 ± .90	6	14.98 ± 1.08	6	60.6 ± 8.07

APPENDIX TABLE 69. LEAST SQUARES MEANS AND STANDARD ERRORS OF WEIGHT AT 270 D (W270) AND YEARLING WEIGHT (YWT) BY YEARS AND MONTHS UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

	Village				Experiment station			
Year	No.	W270 (kg)	No.	YWT (kg)	No.	W270 (kg)	No.	YWT (kg)
Year								
1979		...		...	26	16.28 ± 1.14	23	27.10 ± 1.62
1980	3	11.01 ± 2.56		...	33	24.10 ± 0.93	24	27.77 ± 1.53
1981	61	12.19 ± 1.20		...	15	19.77 ± 1.66	7	22.20 ± 4.30
Month								
J	6	11.08 ± 2.29	1	15.90 ± 4.31	4	20.01 ± 1.97	4	25.80 ± 2.99
F	10	11.74 ± 1.92	3	10.77 ± 2.45	8	19.93 ± 1.84	4	27.66 ± 3.88
M	2	10.26 ± 3.21	1	12.66 ± 4.13	11	21.30 ± 1.45	10	19.37 ± 2.62
A	3	13.08 ± 2.72	1	14.50 ± 4.31	5	22.37 ± 1.77	4	23.36 ± 3.88
M	2	17.15 ± 3.73	2	15.39 ± 3.07	5	17.55 ± 1.71	1	21.75 ± 4.52
J	9	12.34 ± 1.91	5	15.67 ± 1.98	3	17.39 ± 2.13	1	32.77 ± 4.72
J	8	12.33 ± 2.12	7	13.94 ± 1.73	12	18.81 ± 1.48	8	24.46 ± 2.45
A	6	14.05 ± 2.30	3	14.91 ± 2.72	1	17.15 ± 3.92		...
S	6	16.54 ± 2.15	5	18.58 ± 1.77	6	17.84 ± 1.71	6	25.31 ± 2.44
O	10	13.00 ± 1.72	6	14.19 ± 1.61	8	22.15 ± 1.45	7	27.13 ± 2.40
N	7	11.94 ± 2.06	5	14.31 ± 1.98	7	25.30 ± 1.67	5	29.35 ± 2.71
D	8	12.69 ± 2.07	2	18.74 ± 3.15	4	20.81 ± 1.95	4	25.62 ± 2.76

APPENDIX TABLE 70. LEAST SQUARES MEANS AND STANDARD ERRORS OF MATING WEIGHT (MTWT) BY YEARS AND MONTHS OF MATING UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	MTWT (kg)	No.	MTWT (kg)
Year				
1980	18	22.12 ± 1.14	49	22.62 ± 1.14
1981	143	22.21 ± .45	74	25.16 ± 1.48
1982	51	23.32 ± .70		...
Month				
J	13	23.04 ± 1.21	3	20.98 ± 2.74
F	17	21.58 ± 1.11	11	19.00 ± 1.54
M	25	23.72 ± 1.04	16	21.48 ± 1.54
A	17	20.43 ± 1.09	28	23.07 ± 1.32
M	20	21.57 ± 1.06	22	20.90 ± 1.13
J	19	22.87 ± 0.93	12	21.94 ± 1.47
J	11	23.71 ± 1.21	9	24.07 ± 1.59
A	31	22.45 ± 0.84	11	26.62 ± 1.74
S	28	21.80 ± 0.80	6	27.38 ± 2.35
O	10	23.14 ± 1.28	3	26.22 ± 2.74
N	6	24.04 ± 1.61	1	23.99 ± 5.13
D	15	22.22 ± 1.05	1	31.07 ± 4.49

APPENDIX TABLE 71. LEAST SQUARES MEANS AND STANDARD ERRORS OF POSTPARTUM WEIGHT (PPWT) BY YEARS AND MONTHS OF LAMBING UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	PPWT (kg)	No.	PPWT (kg)
Year				
1979		...	6	19.50 ± 2.20
1980	28	25.17 ± .87	35	28.35 ± 1.12
1981	132	23.40 ± .49	106	25.41 ± .74
1982	145	23.98 ± .48		...
Month				
J	31	24.25 ± .81	12	24.74 ± 1.65
F	33	23.05 ± .78	6	28.78 ± 2.16
M	18	24.05 ± .93	4	27.46 ± 2.49
A	18	23.95 ± .95	3	18.25 ± 2.77
M	16	23.74 ± 1.00	4	23.82 ± 2.43
J	22	24.05 ± .92	4	21.44 ± 2.38
J	26	24.43 ± .89	13	24.41 ± 1.50
A	33	25.33 ± .82	17	23.15 ± 1.53
S	28	23.65 ± .79	32	24.28 ± 1.28
O	32	24.19 ± .77	25	24.49 ± 1.08
N	26	23.78 ± .82	14	25.57 ± 1.29
D	22	25.01 ± .88	13	27.63 ± 1.40

APPENDIX TABLE 72. LEAST SQUARES MEANS AND STANDARD ERRORS OF LITTER SIZE BORN (LSIZE) BY YEARS AND MONTHS OF LAMBING UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	LSIZE	No.	LSIZE
Year				
1979		...	37	2.45 ± .21
1980	29	1.45 ± .13	35	1.72 ± .19
1981	132	1.50 ± .07	101	1.73 ± .12
1982	145	1.38 ± .06	55	1.99 ± .16
Month				
J	31	1.76 ± .13	12	2.07 ± .29
F	34	1.46 ± .12	6	2.66 ± .42
M	18	1.75 ± .15	18	1.77 ± .24
A	18	1.14 ± .15	17	1.50 ± .24
M	16	1.50 ± .16	8	1.99 ± .35
J	22	1.30 ± .14	5	1.64 ± .43
J	26	1.40 ± .14	31	1.94 ± .19
A	33	1.50 ± .12	22	1.91 ± .22
S	28	1.50 ± .12	33	2.17 ± .21
O	32	1.47 ± .12	34	1.97 ± .17
N	26	1.29 ± .12	18	2.23 ± .23
D	22	1.25 ± .14	24	1.84 ± .21

APPENDIX TABLE 73. LEAST SQUARES MEANS AND STANDARD ERRORS OF LITTER SIZE WEANED (LSWEAN) BY YEARS AND MONTHS OF LAMBING UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	LSWEAN	No.	LSWEAN
Year				
1980	28	1.46 ± .14	35	1.72 ± .22
1981	131	1.46 ± .08	102	1.22 ± .14
1982	120	1.26 ± .08		...
Month				
J	30	1.33 ± .14	8	1.36 ± .28
F	33	1.39 ± .13	6	1.79 ± .31
M	18	1.52 ± .15	4	1.26 ± .36
A	16	1.41 ± .16	3	1.12 ± .41
M	11	1.59 ± .19	4	1.98 ± .36
J	22	1.46 ± .15	4	1.63 ± .36
J	25	1.43 ± .14	13	1.61 ± .22
A	33	1.21 ± .13	17	1.15 ± .21
S	23	1.31 ± .13	32	1.40 ± .18
O	21	1.28 ± .14	23	1.57 ± .17
N	25	1.42 ± .13	12	1.38 ± .22
D	22	1.39 ± .14	11	1.40 ± .24

APPENDIX TABLE 74. LEAST SQUARES MEANS AND STANDARD ERRORS OF NEONATAL SURVIVAL (NSURV), LIVABILITY AT 30 D (LIV30), LIVABILITY AT 60 D (LIV60), LIVABILITY AT 90 D (LIV90) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	No.	NSURV (%)	No.	LIV30 (%)	No.	LIV60 (%)	No.	LIV90 (%)
				Village				
Year								
1980	29	97.1 ± 3.5	29	77.5 ± 7.6	29	81.2 ± 8.9	29	79.7 ± 9.5
1981	132	95.1 ± 2.0	132	80.7 ± 4.4	131	80.8 ± 5.2	131	75.7 ± 5.6
1982	145	92.0 ± 2.0	145	77.6 ± 4.6	130	70.6 ± 5.4	122	67.4 ± 5.9
Month								
J	31	98.2 ± 3.3	31	78.3 ± 7.4	31	65.6 ± 8.6	30	58.9 ± 9.4
F	34	94.2 ± 3.1	34	74.6 ± 6.7	34	76.8 ± 7.8	34	74.0 ± 8.4
M	18	99.3 ± 3.7	18	76.2 ± 8.3	18	79.2 ± 9.6	18	79.0 ±10.4
A	18	90.1 ± 3.9	18	74.1 ± 8.5	18	79.9 ± 9.9	16	79.1 ±11.1
M	16	98.0 ± 4.1	16	78.4 ± 8.9	13	81.3 ±11.1	12	80.8 ±12.4
J	22	91.8 ± 3.7	22	73.0 ± 8.2	22	77.1 ± 9.4	22	77.3 ±10.1
J	26	93.5 ± 3.6	26	76.9 ± 7.9	26	83.4 ± 9.2	25	78.1 ±10.0
A	33	97.4 ± 3.3	33	76.6 ± 7.2	33	63.7 ± 8.3	33	63.1 ± 9.0
S	28	92.3 ± 3.2	28	86.7 ± 7.0	26	86.6 ± 8.2	24	81.6 ± 9.1
O	32	94.5 ± 3.1	32	81.6 ± 6.9	22	75.4 ± 9.0	21	67.4 ± 9.9
N	26	94.8 ± 3.3	26	84.5 ± 7.3	25	84.3 ± 8.5	25	75.1 ± 9.2
D	22	92.7 ± 3.6	22	82.6 ± 7.9	22	77.0 ± 9.1	22	76.8 ± 9.8

APPENDIX TABLE 74. (CONTINUED)

Variables	No.	NSURV (%)	No.	LIV30 (%)	No.	LIV60 (%)	No.	LIV90 (%)
				Experiment station				
Year								
1980	35	88.1 ± 4.3	35	58.6 ± 9.5	35	58.7 ± 9.6	35	56.1 ± 9.8
1981	106	88.2 ± 2.9	106	64.3 ± 6.5	106	63.3 ± 6.5	102	59.8 ± 6.8
Month								
J	12	91.1 ± 5.8	12	56.9 ±13.0	12	57.1 ±13.1	8	42.7 ±15.8
F	6	86.0 ± 7.9	6	83.4 ±17.6	6	83.8 ±17.7	6	82.3 ±17.9
M	4	85.1 ± 9.2	4	61.6 ±20.4	4	61.6 ±20.6	4	58.9 ±20.7
A	3	91.3 ±10.5	3	18.5 ±23.2	3	17.7 ±23.4	3	14.8 ±23.5
M	4	67.7 ± 9.1	4	66.1 ±20.2	4	66.1 ±20.3	4	64.0 ±20.5
J	4	91.5 ± 9.1	4	73.8 ±20.2	4	74.0 ±20.3	4	73.2 ±20.4
J	13	92.5 ± 5.1	13	75.7 ±11.4	13	74.8 ±11.5	13	70.9 ±11.5
A	17	88.3 ± 5.2	17	60.0 ±11.6	17	57.6 ±11.7	17	54.9 ±11.8
S	32	87.5 ± 4.2	32	61.3 ± 9.3	32	59.9 ± 9.3	32	57.4 ± 9.4
O	23	92.3 ± 4.1	23	67.0 ± 9.2	23	65.2 ± 9.3	23	61.0 ± 9.3
N	12	92.8 ± 5.5	12	55.1 ±12.2	12	55.9 ±12.3	12	56.8 ±12.4
D	11	91.3 ± 5.8	11	57.8 ±12.9	11	58.4 ±12.9	11	58.8 ±13.1

APPENDIX TABLE 75. LEAST SQUARES MEANS AND STANDARD ERRORS OF LITTER WEIGHT AT BIRTH (LTWB), LITTER WEIGHT AT 30 D (LTWT30), LITTER WEIGHT AT 60 D (LTWT60), LITTER WEIGHT AT 90 D (LTWT90) BY YEARS AND MONTHS OF LAMBING UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	No.	LTWB (kg)	No.	LTWT30 (kg)	No.	LTWT60 (kg)	No.	LTWT90 (kg)
				Village				
Year								
1980	19	3.79 ± .24	19	5.29 ± .77	19	8.40 ± 1.21	19	10.45 ± 1.62
1981	127	3.51 ± .13	127	6.14 ± .38	126	8.89 ± .60	126	10.59 ± .81
1982	145	3.35 ± .12	144	5.75 ± .37	129	8.14 ± .59	118	9.94 ± .82
Month								
J	31	3.65 ± .20	31	6.01 ± .63	31	7.94 ± 1.00	31	12.78 ± 1.93
F	33	3.89 ± .19	33	5.33 ± .60	32	8.17 ± .96	32	11.25 ± 1.51
M	14	3.58 ± .26	14	5.55 ± .81	14	8.24 ± 1.26	14	10.00 ± 1.47
A	14	3.44 ± .26	14	5.33 ± .82	14	8.32 ± 1.29	12	9.65 ± 1.34
M	16	3.47 ± .24	16	5.92 ± .77	13	9.19 ± 1.29	10	11.16 ± 1.37
J	21	3.35 ± .23	21	5.47 ± .72	21	8.51 ± 1.13	21	8.53 ± 1.43
J	25	3.45 ± .22	25	5.03 ± .70	25	8.08 ± 1.09	24	10.74 ± 1.32
A	32	3.67 ± .20	32	5.74 ± .64	32	7.57 ± 1.00	32	10.21 ± 1.38
S	27	3.67 ± .20	27	6.34 ± .62	25	9.73 ± .98	22	10.26 ± 1.14
O	31	3.26 ± .19	30	5.67 ± .60	21	8.05 ± 1.05	20	10.65 ± .88
N	25	3.67 ± .20	25	6.32 ± .63	24	9.36 ± .99	24	10.35 ± 1.02
D	22	3.49 ± .21	22	6.03 ± .66	22	8.59 ± 1.03	22	10.04 ± 1.23

APPENDIX TABLE 75. (CONTINUED)

Variables	No.	LTWB (kg)	No.	LTWT30 (kg)	No.	LTWT60 (kg)	No.	LTWT90 (kg)
				Experiment station				
Year								
1980	35	4.36 ± .25	35	7.58 ± .92	35	12.13 ± 1.40	35	14.74 ± 1.71
1981	106	3.75 ± .16	106	5.61 ± .66	106	8.36 ± .96	106	10.54 ± 1.19
Month								
J	12	4.32 ± .33	12	6.67 ± 1.20	12	9.99 ± 1.91	6	12.01 ± 2.77
F	6	4.97 ± .44	6	8.24 ± 1.63	6	12.22 ± 2.59	6	14.34 ± 3.13
M	4	3.84 ± .53	4	7.16 ± 1.89	4	11.25 ± 3.00	4	15.59 ± 3.64
A	3	2.78 ± .60	3	3.80 ± 2.15	3	6.43 ± 3.41	3	8.85 ± 4.13
M	4	4.00 ± .51	4	7.67 ± 1.87	4	11.64 ± 2.97	4	14.58 ± 3.59
J	4	3.35 ± .51	4	7.01 ± 1.87	4	10.98 ± 2.97	4	12.91 ± 3.59
J	13	4.30 ± .29	13	7.28 ± 1.06	13	12.10 ± 1.68	13	14.68 ± 2.02
A	17	4.38 ± .29	17	5.85 ± 1.08	17	8.59 ± 1.71	17	10.42 ± 2.08
S	32	4.45 ± .23	32	6.03 ± .86	32	9.14 ± 1.36	32	11.34 ± 1.66
O	23	4.09 ± .23	23	6.88 ± .85	23	10.52 ± 1.35	22	13.05 ± 1.63
N	12	4.38 ± .32	12	6.14 ± 1.13	12	10.00 ± 1.79	12	11.53 ± 2.17
D	11	3.82 ± .34	11	6.42 ± 1.19	11	10.11 ± 1.89	11	12.38 ± 2.30

APPENDIX TABLE 76. LEAST SQUARES MEANS AND STANDARD ERRORS OF LAMBING INTERVAL (LINT) BY YEARS AND MONTHS OF LAMBING UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Variables	Village		Experiment station	
	No.	LINT (d)	No.	LINT (d)
Year				
1979	...		35	279.3 ± 20.2
1980	15	257.3 ± 33.6	20	241.7 ± 23.8
1981	56	295.6 ± 20.5	58	236.2 ± 17.9
1982	12	225.0 ± 49.1	...	
Month				
J	6	206.0 ± 58.8	4	272.2 ± 36.6
F	9	259.5 ± 33.7	5	199.5 ± 35.6
M	6	218.1 ± 40.2	17	262.0 ± 22.7
A	7	297.5 ± 40.4	10	209.8 ± 25.6
M	1	268.2 ± 88.8	5	250.4 ± 32.2
J	4	292.7 ± 48.7	3	237.8 ± 41.8
J	6	287.4 ± 44.8	12	269.0 ± 23.2
A	8	213.9 ± 36.2	8	259.1 ± 30.2
S	11	290.8 ± 33.4	16	279.9 ± 22.6
O	8	276.7 ± 36.7	16	302.6 ± 19.0
N	8	231.2 ± 36.4	12	260.8 ± 22.0
D	9	269.4 ± 36.1	5	225.9 ± 34.7

APPENDIX TABLE 77. ANALYSIS OF VARIANCE OF MATING WEIGHT AND POSTPARTUM WEIGHT UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	Mating weight (kg) df	Mating weight (kg) Mean squares	Postpartum weight (kg) df	Postpartum weight (kg) Mean squares
		Village		
Location (L)	1	13.70	1	11.09+
Ewe/L	120	16.36**	166	14.18**
Type of birth		...	2	.10
Year	2	5.37	2	6.50
Month	11	2.37	11	3.96
Ewe age	3	14.92**	3	11.42*
Residual	29	3.07	59	3.64
		Experiment station		
Ewe	73	19.55**	74	23.25**
Type of birth		...	3	9.67
Year	1	30.98*	2	79.08**
Month	11	19.48+	11	15.00+
Regressions				
Ewe age linear	1	.74	1	1.02
Ewe age quadratic	1	39.00*		...
Residual	10	7.03	22	5.78

** ($p<.01$), * ($p<.05$), + ($p<.1$).

APPENDIX TABLE 78. ANALYSIS OF VARIANCE LITTER SIZE BORN (LSIZE) AND LITTER SIZE WEANED (LSWEAN) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	LSIZE df	LSIZE Mean squares	LSWEAN df	LSWEAN Mean squares
		Village		
Location (L)	1	4.586**	1	.713
Ewe/L	166	.362+	162	.325
Type of birth		...	2	.844+
Year	2	.278	2	.587
Month	11	.351	11	2.140
Ewe age	3	.130	3	.118
L x Ewe age		...	3	.392
Year x Ewe age		...	6	.628+
Regressions				
PPWT[a] linear		...	1	3.380**
PPWT quadratic		...	1	.046
Residual	65	.261	38	.324
		Experiment station		
Breed	1	.043		...
Ewe/Breed	113	.961	73	.441
Type of birth (TB)		...	3	1.093+
Year	3	1.160	1	4.026**
Month	11	.217	11	.389
TB x Year		...	3	.271
Regressions				
Ewe age linear	1	.218		...
Residual	98	.774	13	.375

[a] = postpartum weight.
** (p<.01), * (p<.05), + (p<.1).

APPENDIX TABLE 79. ANALYSIS OF VARIANCE OF NEONATAL SURVIVAL (NSURV), LIVABILITY AT 30 D (LIV30), LIVABILITY AT 60 D (LIV60), LIVABILITY AT 90 D (LIV90) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	NSURV (%)		LIV30 (%)		LIV60 (%)		LIV90 (%)	
	df	Mean squares	df	Mean squares	df	Mean squares	df	Mean squares
Village								
Location (L)	1	333.4	1	4,320.5+	1	4,411.5+	1	3,810.7
Ewe/L	166	295.6*	166	1,162.3	162	1,547.6	162	1,674.8
Type of birth (TB)	2	434.3*	2	1,218.3	2	2,174.1	2	1,976.9
Year	2	55.1	2	204.5	2	836.7	2	1,855.5
Month	11	46.3	11	739.9	11	2,071.9	11	2,489.7
Ewe age	3	149.2	3	5,091.6**	3	5,792.8**	3	4,425.6*
L x Ewe age		...	3	5,627.3**	3	6,842.4**	3	6,803.9**
Residual	63	102.9	60	1,112.3	52	1,300.4	48	1,443.0
Experiment station								
Ewe	74	378.7	74	1,530.3	74	1,564.5	73	1,543.8
Type of birth (TB)	3	455.7	3	42.4	3	74.1	3	190.9
Year	1	178.1	1	10,566.7**	1	11,454.5**	1	8,237.2*
Month	11	238.3	11	1,121.5	11	1,142.6	11	1,029.5
Residual	15	344.8	18	963.6	18	1,038.8	16	1,060.1

** ($p<.01$), * ($p<.05$), + ($p<.1$).

APPENDIX TABLE 80. ANALYSIS OF VARIANCE OF LITTER WEIGHT AT BIRTH (LTWB), LITTER WEIGHT AT 30 D (LTWT30), LITTER WEIGHT AT 60 D (LTWT60), AND LITTER WEIGHT AT 90 D (LTWT90) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	LTWB (kg)		LTWT30 (kg)		LTWT60 (kg)		LTWT90 (kg)	
	df	Mean squares	df	Mean squares	df	Mean squares	df	Mean squares
Village								
Location (L)	1	9.376**	1	49.27*	1	116.81*	1	186.06*
Ewe/L	162	.766	162	8.38	158	20.19	158	32.14
Type of birth (TB)	2	3.248**	2	17.28	2	30.97	2	34.92
Year (Y)	2	.011	2	11.73	2	6.18	2	3.75
Month	11	.808	11	10.39	11	31.21+	11	61.69*
Ewe age (EA)	3	.152	3	15.80	3	16.39	3	33.78
L x TB	1	.773		...		...		...
L X EA		...	2	16.54		...		...
Y X EA		...	6	13.32		...		...
Residual	53	.608	44	7.53	45	16.61	40	28.86
Experiment station								
Ewe	74	1.127	74	15.45	74	38.39	73	54.44
Type of birth	3	9.474**	3	7.52	3	14.20	3	14.76
Year	1	.777	1	157.74**	1	525.23**	1	617.14**
Month	11	.304	11	14.59	11	47.24	11	60.83
Regressions								
Ewe age linear	1	.057		...		...		...
Residual	17	.687	18	11.81	18	35.56	16	51.07

** (p<.01), * (p<.05), + (p<.1).

APPENDIX TABLE 81. ANALYSIS OF VARIANCE OF BIRTH WEIGHT (BW), WEIGHT AT 30 D (W30), WEIGHT AT 60 D (W60), WEANIING WEIGHT AT 90 D (WWT), AND PREWEANING DAILY GAIN (PREWG) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	BW (kg) df	BW (kg) MS[a]	W30 (kg) df	W30 (kg) MS[a]	W60 (kg) df	W60 (kg) MS[a]	WWT (kg) df	WWT (kg) MS[a]	PREWG (g) df	PREWG (g) MS[a]
Village										
Location (L)	1	.338	1	.46	1	10.854	1	34.11+	1	3,799.97+
Sire/L	30	.583**	28	2.47**	28	5.34**	28	9.51**	28	1,166.24**
Sex	1	.097	1	6.02*	1	9.86+	1	50.15**	1	4,374.41**
Type of birth (TB)	2	7.050**	2	20.72**	2	36.49**	2	53.75**	2	3,593.59**
Year	2	.394	2	.08	2	3.20	2	4.36	2	266.65
Month	11	.469+	11	1.74	11	3.41	11	5.83	11	627.06
Age of dam (AD)	3	.900*	3	.61	3	1.76	3	1.70	3	205.05
Sex x TB	2	.352	...	...	...	...	...	...	...	...
L x TB	...	...	2	6.10**	...	...	2	14.41*	2	1,009.13
AD x TB	...	...	6	1.44	...	...	...	...	...	...
L x Sex	...	...	...	...	...	...	1	13.08+	1	1,671.89+
Residual	195	.271	143	1.24	130	2.70	111	3.91	111	461.51
Experiment station										
Breed (B)	1	.041	1	1.52	1	.43	1	13.26	1	1,203.71
Sire/B	9	.451	9	1.99*	9	5.86*	9	14.41**	9	1,286.99**
Sex	1	.563	1	4.41*	1	18.45**	1	1.97	1	199.15
Type of birth (TB)	3	17.148**	3	41.59**	3	86.00**	3	126.85**	3	8,220.42**
Year	2	.221	2	19.36**	2	47.33**	2	86.32**	2	9,120.28**
Month	11	.408	11	3.16**	11	7.67**	11	19.18**	11	2,178.42**
Sex x TB	...	...	...	...	3	4.50				
Breed x Sex	...	...	...	...	...	...	1	39.72**	1	4,489.76**
Regressions										
Age of dam linear	1	.051	1	7.79**	1	10.04*	1	6.59	1	565.72
Age of dam quadratic	1	.279	1	6.98**	1	8.43+	1	20.01*	1	1,353.97+
Residual	250	.297	137	.94	131	2.34	133	4.26	133	433.61

[a] MS = Mean squares
** (p<.01), * (p<.05), + (p<.1).

APPENDIX TABLE 82. ANALYSIS OF VARIANCE OF BIRTH WEIGHT (BW), WEIGHT AT 30 D (W30), AND WEIGHT AT 60 D (W60) UNDER VILLAGE AND EXPERIMENT STATION CONDITIONS

Source of variation	BW (kg) df	BW (kg) Mean squares	W30 (kg) df	W30 (kg) Mean squares	W60 (kg) df	W60 (kg) Mean squares
			Village			
Location (L)	1	.084	1	6.18	1	18.39+
Sire/L	28	.469**	28	2.73**	28	5.23**
Sex	1	1.370*	1	10.50**	1	22.49**
Type of birth (TB)	2	4.504**	2	17.69**	2	32.68**
Year	2	.410	2	.35	2	2.82
Month	11	.338	11	.97	11	2.34
Age of dam	3	.588*	3	1.38	3	1.06
L x Sex	1	.004	1	.46	1	4.58
L x TB	2	.929*	2	4.85*	2	11.60*
Residual	111	.209	111	1.20	111	2.54
			Experiment station			
Breed (B)	1	.157	1	2.30	1	.75
Sire/B	9	.494**	9	1.92*	9	5.65*
Sex	1	.057	1	.79	1	3.22
Type of birth (TB)	3	8.794**	3	40.60**	3	85.41**
Year	2	.514+	2	19.25**	2	54.87**
Month	11	.536**	11	2.95**	11	8.43**
B x Sex	1	.005	1	.67	1	2.66
Regressions						
Age of dam linear	1	.377	1	6.12*	1	11.26*
Age of dam quadratic	1	1.088*	1	5.21*	1	11.67*
Residual	133	.184	133	.95	133	2.38

** ($p<.01$), * ($p<.05$), + ($p<.1$).

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