RESPONSE OF GENETICALLY DIFFERENT GROUPS OF SHEEP TO HILL PASTURE CONDITIONS

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INTRODUCTION

Fat lamb production is one of the most promising of farming enterprises which is possible in the hill areas of Western Oregon. It is desirable that some of the factors affecting this enterprise should be investigated and each given its proper value. One such factor is the practice of giving replacement ewe lambs supplementary feed in addition to pasture during the first winter of their lives. Supplementary feeding of sheep is costly under any conditions. It is considered to be the largest single item of cost to the sheep producer. If the practice has no value the money spent for feed and labor is wasted.

Whether or not there are any breed differences in response to such feeding among the locally popular breeds would be valuable information. Some breed or breed cross might be found or developed that would be able to produce well without supplementary feeding during the first winter of their lives. If such a breed or strain could be found or developed, it would save the sheepmen of the area a considerable amount in labor and feed expense.

If such feeding were found necessary, it would be desirable to know which breed or cross would be likely to return the greatest profit per unit of feed cost.

The adaptation of the different breeds or crosses of sheep to Western Oregon hill pasture conditions generally is another item of interest to sheep raisers. The climate of the area where this experiment was conducted may be described as a mild sub-coastal type with moist, open winters, an early growing season and a dry summer. Grazing conditions during much of the year are very similar to those of the hill areas of the western part of Great Britain. Grass generally begins to grow in early March and starts to dry up in late June or early July. Lambs should be grass fat and ready for market by this time. The pasture composition and weather conditions peculiar to Western Oregon have been well described by McLeroy (54, pp.5-7).

It might appear that sheep developed in a similar area might be better adapted to this locality than some of the more common breeds. During the last two decades the Romney Marsh breed of sheep has been used extensively because of its reputation for doing well under wet and marshy conditions. The Hampshire ram has been used extensively to sire lambs which were to be sold fat off grass. During the last few years the Suffolk ram has

come into favor for this purpose. The Southdown ram has also been used for this purpose with some success. Pure-bred flocks of these three breeds and the Romney are maintained in the area.

Sheep of these four breeds would be expected to do well in Western Oregon, and in addition it was thought well to test sheep of other breeds which might not be so common in this area as these four but which had done well under similar conditions. The Cheviot and the Border Leicester are two such breeds.

Sheep of the Cheviot breed, by local standards, are rather small, active, and agile sheep. They were developed for the commercial hill lands of Great Britain. Sheep of this breed are not particularly noted for their fertility but they produce fast maturing lambs which reach acceptable conformation and market finish at a small size and at a young age. The ewes are hardy and are good mothers. They are agile and at times are discriminated against because they are rather wild and are somewhat harder to handle than are sheep of other breeds. This wildness and agility was thought to be an advantage rather than a disadvantage under hill pasture conditions here, because they might be better able to utilize feed because of roaming over the entire pasture which was inaccessible to larger, more docile sheep. It might also

enable them to avoid predators better than sheep of other breeds. Their production of wool was known to be low, but, since wool makes up only a small part of the income from sheep in this area, this fault was considered of little importance.

The Border Leicester breed of sheep is a long wooled hill breed developed in an area adjacent to that where the Cheviot breed was developed. These sheep are among the most fertile of the breeds of sheep and the ewes are superior milk producers. They are large and rather slow maturing, docile and easily handled. Their fleeces represent a greater portion of profit than fleeces of most mutton sheep. Lambs are large and are considerably older before market condition is reached than are lambs of the Cheviot breed. Their conformation also leaves something to be desired. For a market that is not too discriminating and where pounds of lamb count more than conformation and condition, the Border Leicester is well accepted.

The topography of our hill pastures is rather rugged in some places and fairly flat in others. The topography would not be a factor in production of fat lambs except for such breeds as the Southdown which might not be able to utilize some of the rougher pastures.

Certain diseases and parasites give quite a bit of trouble in this area. The denser fleeced sheep appear

to be more susceptible to fly strike, particularly in summers when there is more rain than usual. Foot rot is an ever present problem particularly in the winter when the mud becomes deep and sheep are kept in or near buildings or in small enclosures. It may be that certain breeds of sheep, because of the shape or size of the foot or for other genetic reasons, are less susceptible to this disease than sheep of other breeds. Internal parasites are rather common in Western Oregon and there is a considerable loss of money due to them. These losses are direct in some cases and indirect in others. Although the parasites may not be able to cause the death of a well nourished sheep, they may act as vectors of disease or so weaken the sheep that it falls victim to some disease to which it would not ordinarily be susceptible. Losses in weight and producing ability due to parasites may outweigh those which result from death. It may be that sheep of certain breeds have less trouble with internal parasites or that they are better able to respond to treatment than are sheep of other breeds.

Bonsma (6, p.3) says, "Climate, topography, and disease are the most important factors determining the natural possibilities for the development of any branch of animal industry. Economic factors may materially influence the production of certain commodities; thus abnormal prices may justify the production of certain

commodities under artificial conditions, but in time, as supply and demand are adjusted, this production is bound to fail when in competition with production under naturally suited environmental conditions. Hence, it is essential that the agricultural development of any locality should be directed along the lines of its natural potentialities, thus insuring a sound economic basis of production.

"Success in animal production depends largely upon the ability of livestock to produce economically the products for which they are bred, under a given set of environmental conditions. Lack of adaptability of animals to their environment leads either to failure with heavy losses or to increased costs of production in the attempt to adjust the environment to suit the animal."

The purposes of the present study were:

(1) To find out if supplementary feeding of replacement ewe lambs during the first winter of their lives had any effect on future productivity.

(2) To determine if there was a breed difference in response to supplementary feeding of replacement ewe lambs the first winter of their lives, and

(3) To determine what breeds or what combination of breeds of sheep were best adapted to fat lamb production on the hill lands of Western Oregon.

The experiment was also expected to yield certain other information which was not necessarily of direct interest to farmers but which was of interest to research workers in this field. The effects of sex, age of ewe, year, breed of ewe, breed of ram, birth type, and birth weight upon the weaning weight and quality of the lambs were important. Some light on the effects of nutrition of both ewe and lamb and other environmental factors on the weight and quality of lambs at weaning might be gleaned from such a study.

REVIEW OF LITERATURE

Supplementary winter feeding of replacement ewe lambs

The value of giving supplementary feed to replacement ewe lambs during their first winter is of interest to sheepmen who produce their own replacement ewes and to those who produce breeding ewes for sale to producers of fat lambs. Esplin, Madsen and Phillips (26, pp.3-12) investigated this problem under Utah conditions and found that the feeding of replacement ewe lambs during the first winter of their lives made a difference in their production the first year they were bred. Ewe lambs which were fed supplemental feed gained about 25 pounds from October to April, whereas comparable ewe lambs on range and without supplemental winter feed gained an average of 10 pounds. Both groups of lambs were on the same range from April until the following October, at which time they were placed in the breeding flock. At breeding time the lambs which received supplementary feed the previous winter weighed only 2 to 3 pounds more than the others. However, the lambing results of the two groups were quite different. Only 45 per cent of the "range" lambs produced offspring, whereas 65 per cent of the "fed" lambs reproduced. It was concluded that the nutritional regime during the growth period may influence subsequent reproduction

capacity.

Phillips, et al. (69, p.345) studied the same problem and although their results were not conclusive, they supported the findings of Esplin, et al. Their results indicated that the reproductive tracts of ewes which are fed their first winter develop more fully than those of ewes maintained on open range. The reproductive tracts of the "fed" ewes were larger. A higher proportion of the "fed" ewes became pregnant during their first breeding season. The difference in conception rates, however, was not statistically significant.

Roberts, Davies and Williams (74, p.32), working in Wales, measured the feasibility of wintering ewe lambs on pasture areas differing greatly in productivity. While lambs at some centers made practically no winter gain, those at other centers gained as much as 15 pounds per lamb. There was a distinct tendency for the badly wintered lambs to catch up with the others in weight in the course of the grazing season the following summer. However, poorly wintered lambs tended, when lambing a year later, to give lambs of smaller birth weight. They also exhibited less fertility than the better wintered lambs. All these workers noted these differences only during the first breeding season. Some light on the reasons for these results is afforded by the papers of

various workers who have studied the relationship of nutrition to fertility.

Flushing

Many workers have noticed beneficial results from the practice of flushing ewes before and during the breeding season (56, p.5; 55, pp.140-141, 144-145; 85, pp.15-16; 88, p.73). The results of Briggs, et al. (9, p.27), however, do not show any benefit from flushing over an eight year period in Oklahoma. It is probable that flushing is beneficial if the ewes are thin but if they are in good breeding condition, flushing appears to have little or no benefit.

Supplemental feed during gestation

Feeding supplementary feed during the latter part of gestation and during the lactation period, or giving good grazing or otherwise improving the nutrition of the ewes is apparently of benefit. Several workers have reported such benefits as an increase in the size of the lambs at birth and a better supply of milk from the ewes. Among them are Hammond (35, p.95) who reports that the size and strength of lambs at birth are affected by the state of nutrition of the ewe during the second half of pregnancy. Maynard (57, p.369) states: "Expressed arithmetically, the growth of the fetus takes place at

an increasing rate throughout the gestation period. More than half of the period elapses before the weight of the fetus equals that of its membrane, whereas, at term, the placenta makes up only about 20% of the total weight of the products of conception. Most of the growth takes place in the last third of the gestation period." Maynard (57, p.372) also says that the beneficial effects of meeting fully the current needs toward the end of the gestation period are reflected not only in more vigorous young but also in a higher potential level of milk secretion by the mother. He further says that it is during the last part of the period of gestation that the formation of secretory cells in the udder is most active. Inadequate nutrition at this time limits this process and thus lessens the milk secreting capacity that is developed.

Wallace (87, p.152) asserts that both the birth weight of the lamb and the milk yield of the ewe are profoundly affected by the level of nutrition of the ewe during the last six weeks of pregnancy. The vigor and weight of the lambs at birth are important not merely for avoiding losses, but also in enabling the lambs to take full advantage of the potential milk supply of their dams. It has been shown that the capacity of the offspring largely governs the actual yield of milk produced. Wallace also (87, p.112) states that ewes suckling twins

yield more milk than those rearing single lambs. For ewes (87, p.152) rearing singles there is a lower level of milk production and a less pronounced peak of the lactation curve as compared to those for ewes with twins. This may be due to the inability of one lamb to draw off all the milk available during the first few weeks of lactation.

Wallace (87, p.152) further states that each additional pound of milk that a lamb drinks between birth and 28 days of age was found to increase the live weight at one month by about 1/4 pound. In the following months the correlation between live weight increase and milk consumption, though still high, declines progressively, as supplementary food forms an ever increasing proportion of the lamb's diet. The level of supplemental feeding also greatly affects the growth made by the lamb, a difference of about 40 pounds in the total (TDE) from the supplementary food fed during the suckling period leading to a difference of 14-28 pounds in the weight of the lambs at weaning. There are many other workers whose work substantiates the findings of the ones quoted.

There are other workers, however, who failed to find such benefits from feeding extra feed during the last weeks of pregnancy. Coop (17, p.340) states that the high level of nutrition during pregnancy increased the

birth weight of lambs about .5 pound but had little if any influence on the rate of growth and weaning weight of the lambs irrespective of the subsequent level of nutrition. His results also show that the high level of nutrition did not reduce ewe and lamb mortality and that there was actually some evidence to the contrary when the high plane was applied early, leading to a large weight gain.

Coop found the level of nutrition after lambing to be the most important and it accounted for almost all of the differences in weaning weight of the lambs. After lambing, very few ewe losses occurred but a low level of nutrition increased lamb losses. It may be well to note that Coop obtained his different feeding levels by keeping the ewes on high quality pasture as a high level of nutrition, and by stocking heavily on poor pasture as a low level.

It is quite possible that the high level of nutrition applied by Coop caused his ewes to be too fat for best results. That it is possible to have animals too fat for best reproductive performance has been shown by quite a few researchers also. Maynard (57, pp.371-372) states that a condition of extreme fatness appears to be deleterious to reproduction. The ovaries may become so infiltrated with fat as to hinder the development of the

follicles, with a consequent irregularity or cessation of estrus which results in delay or failure in breeding. There may also be such an excessive amount of fat in the reproductive tract that, even if the egg is matured and fertilized, it may fail to reach the uterus and become implanted properly. Extreme fatness has also been noted to interfere with the production of fertile sperms in the male and lessens his desire to mate. In attributing reproductive failure to fatness, it must be recognized that, in some instances, the condition may be merely an accompaniment of some specific deficiency or other cause.

Overfatness may not be as important in sheep as it is in certain other species. In pigs, for instance, limited fed gilts reach puberty at a younger age than full fed gilts. In addition, regardless of prepuberal feed level, gilts full fed from puberty to slaughter tend to have about 25% fewer embryos than corresponding limited fed gilts. Embryo survival for full fed gilts was 32% and for the limited fed ones 57% survived (75, p.954). Christian and Nofziger (16, p.789) found that ovulation rates were slightly higher in high plane gilts. However, fertilization rates were slightly higher for low plane gilts. Their results show that gilts on a high plane of nutrition averaged 4.7 live pigs per litter and gilts on a low nutritional plane farrowed an average of

7.4 pigs per litter. Prenatal death rates were estimated at 62.9% for high plane gilts and 35.3% for low plane gilts. Hanson, Ferrin, and Aunan (38, p.919) on the other hand did not find an advantage for limited fed gilts over full fed gilts in reproductive performance. Apparently the evidence is contradictory here but the difference in results probably stem from differences in experimental conditions. "High plane", "full fed", etc. may not have meant the same thing to the different investigators.

Darroch, Nordskog, and Van Horn (20, pp.444-445) report that ewe gains reflected the influence of feeding in the breeding and early pregnancy periods. In the prebreeding and breeding periods the thin ewes showed greater response to feeding supplement than the ewes which were in good condition. During the early pregnancy period the good condition ewes gained the most. Also, feeding supplement in this period produced .37 pound more fleece. These workers reported no important effects on birth or weaning weights from their feeding treatments. Flock fertility, however, was increased by 10 and 9 per cent respectively by feeding supplement in the prebreeding and breeding periods. Good condition ewes produced 11 per cent more lambs at birth and at weaning than the thin ewes.

A different idea has been advanced by Meites (58, p.20). He says that a restricted food intake may induce resorption or abortion of the embryo during the first half of the gestation period but starvation after this period does not necessarily interrupt gestation although it may result in stillbirth or the delivery of runty offspring. This indicates, he says, that adequate caloric intake by the mother is more critical for the fetus during the first half of pregnancy, since after this period the nutritive needs of the fetus can be more easily met by drawing from maternal tissues.

In summarizing the foregoing literature it appears that adequate but not excessive nutrition is required all along the line for best results. The quality of the feeds fed and the effects of different nutrients on reproduction has also been studied rather extensively. At one time or another different workers have advanced the idea that a deficiency of some particular nutrient has caused reproductive failure. Some of these nutrients and the references cited in each case are: vitamin A and iodine (29, p.10); protein, calcium, phosphorus, and vitamin A (57, p.374); the B vitamins thiamine, pantothenic acid, riboflavin and folic acid (58, p.29) in rats; protein (79, p.164; 80, pp.172-173); protein, phosphorus and vitamin A (61, p.28).

her body by the developing young may result in permanent damage. The death of the fetus *in utero* or the birth of a weak animal, perhaps prematurely, may also occur.

Apparently, undernutrition at some stages may be more serious than at others. Asdell (2, p.130) working with dairy cattle found that when malnutrition impairs the orderly development of the reproductive tract during early life, the damage is more apt to be permanent than it is if the damage occurs after the tract has once functioned in a normal manner. This was also indicated by Phillips, *et al.* for sheep (69, p.345).

A statement made by Hart (39, p.3) is of interest at this point. He states that if sheep are maintained on a plane of nutrition that will result in continuous growth with a normal growth curve, ordinary gastro-intestinal parasites will not be able to make sufficient headway to require medication.

Nutritional-endocrine-reproductive relationships

In seasonal breeders a preponderance of evidence seems to indicate that the reproductive cycle is regulated by those environmental factors which increase or inhibit the production of gonadotropins by the anterior pituitary gland (1, p.14). One of these factors which can be altered to suit the needs of the animals produced is nutrition. Hammond (32, p.1) stated that the main

regulator of reproductive activity is recognized to be the anterior pituitary gland. Other external factors such as light, nutrition, etc., influence reproduction but they do so probably through their action in stimulating this gland. Hammond (34, p.182) asserts that the various factors which affect the number of eggs shed by the female do so mainly by means of changes in the level of follicle-stimulating hormone (FSH) circulating in the blood. The breeding season of certain species is probably controlled mainly by variations in the duration of daylight, which stimulates through nerves the output of gonadotrophic hormones from the anterior pituitary.

Maynard (57, pp.367-368) says that the sexual organs reach their full development and become functional at an age which varies with the species, the breed, and the nutrition of the individual. The development of these organs is a rather gradual process controlled by a secretion from the pituitary, the gland which also secretes a substance controlling body growth. Apparently, according to Maynard, this gland cannot provide both secretions at a maximum at the same time, and thus the development of the sex organs proceeds more rapidly as the rate of growth declines. These organs become functional before body growth is completed. If their ability to function is immediately utilized, there may be an unfavorable

effect on body development because of an undue diversion of the secretions of the pituitary from body growth to sexual activity. The lactation which follows premature breeding may cause the arrest of growth in the female.

That this arrest in growth is caused by lactation and not necessarily by pregnancy has been shown by Bogart, et al. (5, pp.370-371) in work on rats. Bogart, et al. and Asdell, et al. (3, p.25) indicate that breeding itself is a stimulus to reproduction and promotes a greater harmony between the gonads and the other endocrine organs. The latter workers also pointed out that rats bred at an early age averaged 5.8 young at a birth compared to 6.2 young for those bred at normal breeding age and only 4.9 young for rats bred late in life.

According to Hammond (30, p.7) the number of eggs which ripen in the ovaries depends on the plane of nutrition, a given quantity of FSH stimulating more follicles if the plane is high, because in this case there are more follicles with an antrum. Failure to ripen follicles occurs under conditions of phosphate deficiency or in certain species during lactation. This may be due to an inhibition of anterior pituitary secretions. The number of eggs shed which get fertilized is affected by the occurrence of still heats (blind heats) which result from a low plane of nutrition. Lack of energy nutrition

decreases the output of testosterone in the male and so sexual desire. The plane of nutrition during late pregnancy, Hammond concludes, affects the size and viability of the young at birth.

Meites (58, p.21) says that in general, underfeeding or B vitamin deficiencies reduce the secretory activity of all endocrine glands, with the exception that during severe starvation the adrenal glands increase in size and activity. The weights of the pituitary, thyroid, adrenals and ovaries were decreased in size in all underfed groups (rats) with the exception of the adrenals of the completely starved group.

The thyroid (58, p.25) profoundly influences reproductive activities. Thyroid weight was reduced in all the underfed rats, the degree depending on the severity of underfeeding. Meites (58, pp.28-29) indicated that the gonads of underfed or B-vitamin deficient rats remain responsive to gonadotropic hormones. When caloric intake was reduced, the body weights and seminal vesicle weights were correspondingly reduced, but the response of the latter to pregnant mare serum (PMS) remained the same on a 100 gram body weight basis. A reduction in protein intake also produced decreases in body growth and seminal vesicle response to PMS, but again the response of the latter to the gonadotropin was the same on a 100 gram body

weight basis.

Meites (58, p.19) states that reproduction is primarily controlled by the endocrine system, and particularly by the gonadotropic and gonadal hormones. He says that it is logical to assume, therefore, that many if not most of the actions of nutrition on reproduction are mediated through altering (1) hormone production by the endocrine glands, (2) tissue reactivity to hormone stimulation, or (3) the metabolism of hormones. Not only may nutrients influence hormone function, but the reverse may be true as well. Hormones normally help regulate the metabolism of protein, fat, carbohydrates and vitamins. Recent studies in his (Meites') laboratory have indicated that endocrine imbalances, brought about as the result of an excess or a deficiency of a particular hormone in the body, may increase the requirements for dietary factors necessary for growth and reproduction. Many other types of stresses, such as disease, toxins, physical exertions, etc., may also increase nutritional requirements for growth and reproduction.

Hammond (36, p.656) says that even after the onset of puberty is reached, there is generally a period of time elapsing before the maximum number of ova are shed at ovulation. In general, he continues, the time of submaximal fertility corresponds to the time during which

the skeleton is completing its full growth, and it therefore seems probable that some differential production between the growth hormone and gonadotropic hormones by the anterior pituitary is involved. Hammond also states that there is apparently an optimum age at which to breed young animals for the first time. If mating takes place too early, a smaller number of ova will be shed. On the other hand, if the first mating occurs late in life there appears to be greater development of the individual in general at the expense of fertility, this possibly being due to interactions between the gonadotropic and growth hormones of the anterior pituitary.

Meites (58, p.40) states that the only type of malnutrition which has conclusively been proven to impair the secretion of gonadotropic hormones by the pituitary is underfeeding or any state leading to inanition, including inadequacies of B-vitamins. He continues that there is considerable basis for the belief that the gonads and sexual activities are more easily impaired during inanition than other body functions. Some of the effects of undernutrition are probably exerted directly on the reproductive tissues, although its major action is probably through the endocrine glands. The effects of deficiencies of vitamin A or vitamin E, however, appear to be direct on the reproductive tissues <u>in utero</u>

during pregnancy, and the effects on the endocrine glands, when observed, are probably secondary in nature. Meites also thinks hormonal imbalances may impair reproductive activities.

The preponderance of information now available, according to Reineke and Soliman (72, p.78), indicates that there is a reciprocal balance among the hormones of the pituitary, the ovary, and the thyroid. Through the influence of estrogen on pituitary thyrotropin, the thyroid undergoes rhythmic fluctuations in secretion rate that in turn regulate the output of gonadotropins and also modify their action on the ovary. A rhythmic sequence of changes apparently occurs in this balance during follicular growth, estrus, and ovulation. An imbalance in this hormonal mechanism will not necessarily result in complete reproductive failure but usually leads to great irregularity. These workers further state that either hyper- or hypothyroidism results in lengthening or cessation of the estrual cycle in rats and mice and in amenorrhea in primates. Thyroidectomy has been shown to cause a reduction in the gonadotropic hormone of the pituitary. Conversely, gonadectomy results in a decrease of pituitary thyrotropin. Results in mice, rats, and rabbits indicate that pituitary FSH action is favored by hypothyroidism but the leuteinizing hormone (LH) action is favored by

hyperthyroidism.

The metabolic rate, at least in rats, is increased significantly at estrus, compared to other stages of the estrual cycle. Histologically, the thyroid also appears to be at the point of maximum activity at this stage (72, p.78). Tracer studies with I^{131} show that the iodine uptake of the thyroid is at a maximum during estrus, decreases progressively during metestrus and diestrus and reaches a minimum during proestrus (72, p.78). Experiments in ovariectomized rats show that I^{131} uptake is increased by a small, short term dose of estrogen. Larger doses for long periods have no effect. I^{131} uptake is depressed by progesterone. The adrenal glands are not needed for the effect of estrogen on I^{131} uptake to be expressed. The action of estrogen is exerted via the pituitary. Progesterone appears to operate through some other pathway (72, p.78).

It was thought for a long time that the reason for the anestrus period in sheep was the inactivity of the pituitary gland. Apparently this is not the case. Nalbandov (62, p.52) found the pituitaries of sheep to be more active during anestrus than when going through the estrual cycle. Since they are more potent during anestrus than during the estrus cycle he thinks that the nonbreeding season is due to a hormonal imbalance rather than hypophyseal inactivity. This is supported by

observations on ovarian morphology during the two reproductive phases. Kammlade, et al. (45, p.64) suggested that the nonbreeding season of sheep is caused by a shift in the ratio of FSH to LH secreted by the pituitary, during anestrus primarily FSH being secreted (as shown by ovarian activity) but very little if any LH (as shown by uterine histology, absence of heats, absence of ovulations, and induction of ovulation by exogenous LH). These workers stated (45, pp.646-655) that the pituitary is more active during anestrus than in the breeding season. More light causes more FSH. As light diminishes LH is secreted and less FSH. In late winter and early spring when sunlight increases again more FSH is again secreted than LH and the breeding season is over.

Experimental evidence in laboratory animals supports the view that physiological levels of estrogen result in a suppression of FSH and a release of LH, according to Dutt (24, p.63). Estrogens have not been shown to shorten the interval from onset of estrus to ovulation. Treating anestual ewes with estrogens has also proven to be of little value in inducing ovulation and out of season breeding. In both laboratory and farm animals progesterone has been shown to prevent ovulation and this action appears to be through a suppression of the release of LH from the pituitary gland, Dutt continues. He says

there is little doubt that the secretion of gonadotropic hormones is regulated by the sex steroid hormones.

In dairy cattle impaired nutrition seems to reduce the secretion of FSH by the anterior pituitary. This, in the young animal, prevents full ovarian development. Climatic factors may act in the same way, though in the sheep there is evidence that they regulate the release of LH, the factor causing ovulation, from the anterior pituitary. Continued secretion of FSH without change to LH secretion would seem to be the cause of cystic ovaries and mymphomania in cattle. These disorders may be a consequence of overstimulation with estrogens (2, p.130). In the sheep the production of FSH to the exclusion of LH apparently does not work this way. It may be that there is little or no estrogen in the follicles during the anestrus season.

It is known that, in some years, the sexual activity of sheep reaches a maximum earlier or later than is customary (48, p.25). Such differences, in particular areas, appear to be effects of climatic or nutritional variations involving the intensity of the sun's rays or the quantity or quality of the feed, or both.

This phenomenon was noticed by deBaca, et al. (22, p.27). They state that there is a marked year to year difference in average date of estrual onset in ewes. The

difference (11 days) exhibited by ewes on improved irrigated pasture was less than that shown by ewes on native hill pastures (25.3 days). Nutrition may thus be a factor in the earliness of estrus and consequently the earliness of the lambs.

Factors affecting the value of a breed of sheep for a particular area

Many factors affect the value of a breed of sheep for a given area. In Western Oregon one of these factors is early lambing. The earlier the lambs the sooner in the year they can be marketed and the more money is realized by the producer. Another factor, and probably the most important one is the adaptability to the conditions under which they are raised. According to Hammond (31, p.414) the chief qualities which are desired in the animal are: (a) livability, hardiness, and resistance to disease, because it is more profitable to have a comparatively unimproved animal which will live longer than a much improved one which may have only a short life; (b) a high rate of reproduction and fertility; and (c) a good growth rate, suitable body proportions for meat production and the capacity for producing large quantities of milk. Such qualities are associated with the efficient conversion of feeding stuffs into animal produce.

Cooper (18, p.11) contends that the cost of wintering

ewes is one of the largest items of expense for range sheepmen, hence the ewes must be kept on the range as much as possible or the expense of keeping them will overcome the income from them.

Bonsma (7, pp.4-5) says, "It is a well known fact that as animals grow older the velocity of growth decreases; hence the most economic gains are made when animals are very young. Obviously then, in the production of fat lambs, the largest profit will be obtained when lambs are brought to the desired degree of fatness at the time they attain their maximum growth. Hence early maturity is essential. It is not so much the actual weight as the relation between bone, muscle, and fat at a particular weight that is important. Skeletal growth takes place mainly during the first 3 or 4 months of post natal life. Muscle has a much greater rate of growth but growth becomes relatively insignificant after 9 to 12 months. Fat, on the other hand, has at first a slow rate of increase, but after 3 to 4 months exceeds that of all other parts, provided optimum conditions prevail. Unless the plane of nutrition allows for maximum development in respect to bone and muscle as well as of fat, it is very difficult, if not indeed impossible, to obtain a fat lamb which has the necessary finish and covering of fat at the weights for which there is the greatest demand on the

market. The weights and ages at which it is possible to obtain a well finished carcass will vary with different breeds of sheep according to earliness of maturity, but, under favorable nutritional conditions, fat lambs should be well finished and ready for slaughter within less than five months from birth. The object in fat lamb production should clearly be to provide for a continuously fast rate of growth, starting from birth and continuing to the time of slaughter; in other words, to aim at obtaining a full expression of the hereditary growth qualities of the breed."

Apparently, fat lamb production should be limited to areas or times when nutritional and other environmental conditions allow for maximum growth.

Crossbreds vs. purebreds for commercial production

The concensus of opinion of workers in the field of sheep production is that crossbred sheep make more money for the commercial producer than do high grades or even purebreds produced for meat. The literature on the subject is somewhat voluminous and for that reason few papers will be cited here. John Hammond (36, p.709) noticed the fact that a female will produce more young when mated to one male than she will when mated with another. This has been explained by the greater viability of the

young *in utero* especially if they are crossbred. Hammond leans to the opinion that sperm production by the male is equally, if not more, important. He says that this is certainly so in the sheep, in which species there is little fetal atrophy.

Miller and Daily (59, pp.466, 468) report that Rambouillet ewes were 27% more productive when used in crossing than Shropshire ewes mated to Shropshire rams. This greater productivity was due to more wool and faster growing lambs. They report (59, p.464) that when Columbia, Shropshire, and Hampshire ewes were used for crossing, they produced 12 to 22 percent more lamb per 100 pounds of ewe than they did when lambing purebred lambs. This increase averaged 19 per cent and was due to faster growth rate in the case of Shropshire crosses and to the greater number of crossbred lambs raised per ewe for all crosses. The Columbia and Hampshire ewes had a slightly higher lambing percentage when bred to a ram of another breed. The death loss among the purebreds was greater in all cases. Twenty-seven per cent of the purebred lambs born alive did not live to 140 days of age, compared to 19.1 per cent for the crossbred lambs. When total productivity was figured, the ewes had 16 per cent greater productivity when used in crossing, compared to ewes lambing purebred lambs. The crossbred Shropshire

and Columbia lambs scored higher than the purebreds. The Columbia's gained most from crossing. These workers pointed out that the ewes' productivity is increased most when they are mated to rams of the larger breeds. This is shown by the much greater growth rates of the Shropshire crosses compared to no increase in rate of growth for the Columbia and Hampshire crosses. The Columbia and Hampshire crosses were made to rams of smaller breeds, yet the lamb weights were as high as those of the purebreds. A possible heterosis effect is suggested. Many other workers have reported similar results.

Under some conditions, however, crossing does not show any value. Neale's work (63, p.23) shows that under the rigorous conditions of the New Mexico range country pure or grade Rambouillets gave better results when mated to Rambouillet rams than when mated to Hampshire rams. He stated that Hampshire cross lamb weights varied directly with feeding conditions and to a greater extent than did weights of Rambouillet lambs. He observed that Romney-cross lambs were very slow maturing, particularly under relatively adverse forage conditions. The Rambouillets used by Neale were apparently much better adapted to the conditions under which they were raised and crossing them to breeds obviously not adapted to

such conditions failed to show an advantage.

Ram breeds and ewe breeds for crossing

The literature is full of comparisons of breed for crossing under various conditions. A great deal of it will be cited to show the comparative value of the breeds for this purpose in other localities. However, it is probable that there is as much variation within breeds in value for crossing as there is between breeds.

Miller (60, pp.29-32) found the Hampshire to be exceeded only by Suffolk rams in weaning weight of lambs sired when bred to Rambouillet ewes. The Shropshire sired lambs ranked next to Hampshire sired lambs in weaning weight. Romney, Rambouillet, and Southdown rams were equal in this respect. The Southdown rams sired the fattest lambs at weaning. Romney and Rambouillet rams sired the least percentage of marketable lambs. Lambs from Romney rams and Rambouillet ewes were inferior both in weight and condition to those from straight run Rambouillet ewes.

Miller and Daily (59, pp.466, 468) found that Border Leicester, Hampshire, and Columbia rams sired the fastest growing lambs when mated to Rambouillet ewes. However, the Border Leicester crosses resulted in the largest total productivity and resulted in the greatest advantage over

the Purebred and Shropshire matings.

Heape (42, p.248) found a wide difference in the average fertility of different breeds of sheep. He observed that when Dorset ewes were mated to Hampshire rams they produced more lambs than when mated to rams of their own breed. He attributed this to greater viability of the crossbred embryo. Heape found that Suffolks were the most fertile sheep and that Southdowns were the least fertile.

Bonsma (6, p.6) found that in comparison with the well known British mutton breeds, the relative fertility of the Merino is remarkably low even under the best of conditions. A lambing percentage of over 80 is considered very satisfactory. Most mutton breeds, he says, have a lambing percent of over 100. Bonsma continues (6, p.7) that a fast rate of growth will depend on the hereditary earliness of maturity of the cross or breed as upon the presence of optimum nutritional conditions for the developing lamb. Experimental work at the Pretoria University Farm clearly indicates that by crossing Merino ewes to a ram of one of the British mutton breeds the earliness of maturity of the crossbred lamb is greater than that of the Merino. However, with few exceptions the milk yield of the Merino ewes is insufficient for the optimum growth of the cross bred lambs. Crossbred ewes gave considerably

more milk. Triple cross ewes gave still more.

Bonsma (7, p.29) thinks that a triple cross is necessary in South Africa to produce fat lambs if Merinos are used as foundation stock. He says that for the production of the highest quality export lamb the Border Leicester X Merino ewes mated to Southdown rams is recommended. His reasons for advocating this triangular breeding policy are found in the superior ability of the half breed for rearing a rapidly growing lamb. The half breed has the advantage of greater size, hybrid vigor, increased fertility, and superior milking qualities when compared with other maternal stock, particularly the Merino. Bonsma states (7, p.61) that the difference in the milk yield between Merinos and crossbred Merinos was highly significant. Bonsma further states (7, p.12) that hereditary breed differences in attaining maturity in respect to skeletal, muscular, and fat development will determine the suitability of particular breeds to different nutritional and environmental conditions for production of fat lambs.

Burns and Johnston (10, p.25) observed higher birth and weaning weights, greater survival rate and a larger percentage of marketable lambs sired by Suffolks rams than by Hampshire rams.

Christian and Henning (15, p.604) found a trend

showing that three breed crossbred ewes when bred to Shropshire and Southdown rams produced a higher percentage of higher grade carcasses.

Grandstaff (28, p.478) found that Romney sires produced 15.4 pounds less lamb per ewe bred than did Columbia sires.

Hammond (33, p.6) stated that the Suffolk breed is unique for it combines early maturity, good milking qualities and high fertility to a remarkable degree when used for crossing.

Hammond (36, p.708) declares, "That fertility is a racial characteristic and consequently is capable of hereditary transmission is a fact that is generally accepted. Among sheep, for example, some breeds like the Dorset Horns, Suffolks, and Half-breds (Border Leicester X Cheviot) are notoriously prolific while other varieties like the Blackfaced and Southdown are relatively infertile." Hammond further states that crosses between a fertile breed of sheep like the Border Leicester and a breed of lower fertility like the Merino give ewes with an intermediate grade of fertility.

Horlacher and Good (43, pp.197-198) found that Hampshire rams X native ewes produced lambs which gained rapidly and were ready for market at an earlier age than any others. They lacked the quality, however, of lambs

produced by Southdown X native and Cheviot X native ewes. Cheviot cross lambs grew more rapidly than Southdowns and produced a good quality carcass. The Cheviot cross ewes were hardy and were good mothers.

For Hultz, et al., (44, p.7) Suffolk sired lambs made the most rapid gains, followed by those sired by Hampshire, Lincoln, Rambouillet, Corriedale, and Southdown rams in that order.

Three breed crosses are more desirable for hothouse lamb production than two breed crosses, according to Kean and Henning (47, p.370). These workers say that Southdown rams do not sire as large a lamb as the Hampshire or Dorset rams, nor do the lambs gain as fast, but the pedigreed Southdown ram does sire lambs which have more finish and quality that sell for a higher price.

Kincaid (49, p.155) found that lambs sired by Hampshire rams averaged 1.05 pounds heavier at birth than those sired by Southdowns, the difference being highly significant.

According to Sidwell and Grandstaff (77, p.379) Columbia rams sired the heaviest lambs at weaning, followed by Corriedale, Crossbred, Navajo, and Romney rams.

At Oregon State College, Nelson, et al. (64, p.4) found that under Willamette valley conditions, Hampshire rams sired lambs which were fat and heavy when crossed

on Lincoln X Rambouillet ewes. Border Leicester rams sired lambs which were large but only moderately fat at weaning time. Cheviot cross lambs were of good finish but were small while those sired by Romney rams were as heavy as Cheviot sired lambs but were lacking in finish. Southdown rams gave a higher lambing percentage than Romney rams. The Romney rams had a smaller lambing percentage with a lower survival rate and a smaller percentage of fat lambs off grass.

A good comparison of several breeds of sheep for their performance under hill pasture conditions in Western Oregon has been made by de Baca (23). He states (23, p. 76) that Suffolk rams produced a greater percentage of pregnancy than did Southdown rams. Fewer services per conception were necessary. The average weaning age of Suffolk sired lambs was greater than that of lambs sired by Southdown rams. Ewes mated to Suffolk rams produced 15 pounds more lamb per ewe bred than those bred to Southdown rams. On the basis of equal ages, the tendency for heavy weaning weights of lambs favored the Suffolk sires but the difference was not significant. There was also a tendency for ewes bred to Suffolk rams to produce heavier lambs than those bred to Southdown rams.

Southdown sired lambs (23, pp.76-77) showed a tendency to score higher in condition and conformation than

those sired by Suffolk rams. When market grade and lamb weight were integrated, Suffolk rams sired 5.7 pounds more lamb of the Prime and Choice grades, 3.6 pounds more of Good grade, and 6.3 pounds more of utility grade lamb per average ewe than did Southdown sires.

de Baca found (23, p.77) that the average lambs from Hampshire and Border Leicester cross ewes were heavier than those from Cheviot cross and Romney cross ewes. The lambing percentages were 134, 127, 124, and 115 respectively for Hampshire-cross, Cheviot-cross, Border Leicester-cross, and Romney-cross ewes. Mortality was 6.4, 5.7, 4.8, and 14.8, per cent respectively for lambs of Hampshire-cross, Cheviot-cross, Border Leicester-cross and Romney-cross ewes. Production per ewe bred was Hampshire 98.0 pounds of lamb, Cheviot 91.4 pounds, Border Leicester 91.4 pounds and for the Romney 75.2 pounds. In pounds of lamb per 100 pounds of ewe the rank of the four breeds was Cheviot-, Hampshire-, Border Leicester-, and Romney-cross ewes. Lambs from Hampshire- and Cheviot-cross ewes scored higher in conformation and condition than those of Border Leicester-cross ewes which in turn scored higher than lambs from Romney-cross ewes. The percentages of marketable lambs (Good or better) of the total lambs dropped were: Cheviot-cross 90.9, Hampshire-cross 83.0, Border Leicester-cross 77.1, and Romney-cross 65.8.

The remainder of the total lambs within crosses either graded utility or died before weaning time. Hampshire-cross, Border Leicester-cross, and Romney-cross ewes produced lambs which scored higher in conformation and condition when they were sired by Southdown rams. The total number of pounds of marketable lamb per average ewe bred was 88.7 for Cheviot-cross ewes, 88.4 for Hampshire-cross, 77.7 for Border Leicester-cross and 62.8 for Romney-cross ewes.

Factors affecting the value of lambs

There are many factors affecting the value of a lamb and other factors affecting those factors. The year the lambs are born and raised apparently has a great deal of influence on how the lamb will succeed. Weather conditions of course will account for the greater part of any differences which may be caused by year. Apparently weather conditions have their effect on pasturage and thus upon nutrition in addition to the direct effects they have upon the animal. Differences in the performance of sheep due to year have been reported by many experimenters. Blunn (4, p.309) indicated that 14.2 per cent of the total variation exhibited by Navajo lambs was due to difference in years. This worker further stated that the differences due to year at the same

location was 37.4 per cent of the total variation among Navajo crossbred lambs. This indicates a difference in adaptability to the environment. His data indicated a breed-year interaction which further showed a difference in breed response to environment.

Sidwell and Grandstaff (77, p.379) found six measurable environmental factors which had important effects upon the weaning weights of the lambs. These were: (1) year of birth, (2) age of ewes, (3) breed of sire, (4) type of birth and rearing (twin or single), (5) sex, and (6) age of lamb at weaning. The variance attributed to each of these six factors was statistically significant.

The effects of nutrition upon birth weight, milking ability of the ewe, weaning weight, and condition and quality of the lambs has already been shown.

Kincaid (49, p.155) showed that an average annual increase of .63 pound in birth weight occurred as the ewe increased in age from 2 to 6 years. No significant departure from linearity was shown by the data. Kincaid also reported that 7.8 per cent of lamb birth weight variation was due to breed of sire.

Nichols (66, p.372) found that young ewes pregnant for the first time (18 months) gave a much smaller lambing percentage than older ewes.

The data of Bonsma (7, p.70) shows a significant difference in milk production between the first and second lactations in ewes, and that there was a gradual increase in successive lactations up to the fifth. Ewes in their fifth lactation produced 83.5 per cent more milk than they did in their first lactation. Bonsma (7, p.50) also found that the mean weight of ewes carrying ram lambs was significantly larger than that of ewes carrying ewe lambs. He states that this was entirely unexpected. There was significance at the 5 per cent level. He thought this might be due to chance. In this case, the difference between the weights of maiden ewes carrying male lambs and female lambs respectively, was far more pronounced than in the case of mature ewes. He suggested that the hormone activity responsible for the greater growth stimulus resulting in heavier birth weights for male lambs as compared with female lambs exerts a similar influence upon young ewes which are not yet fully matured when producing their first lambs. The variance due to number of parturition was highly significant, maiden ewes being considerably lighter than ewes producing their second or third lambs.

Hazel and Terrill (40, p.340; 41, p.325) reported differences due to age of ewe between weights and condition scores of the lambs produced. In all cases the

differences were in favor of mature ewes.

Koch (50, p.769) says that age of dam affects calf weaning weight through changes in udder development, milking ability, and the ability of the dam to withstand the rigors of environment.

A study of 1300 Hereford cattle on the San Carlos Indian Reservation (53, p.34) showed that when artificial insemination was used 2.37 inseminations per calf were required in animals 2 to 3 years old. Only 1.36 inseminations per calf born were required in cattle 5 to 6 years old. Fertility appeared to decline gradually after the sixth year.

Ewes born of mature dams had longer staple wool, produced more grease wool, had heavier body weight and better type and condition scores than ewes born of 2 year old ewes. Single ewes were superior to twin ewes in all traits studied (70, p.703). The age of ewe had an important effect on all traits except type and condition.

Sidwell and co-workers (78, p.461) reported differences in weights and condition scores of lambs produced by mature ewes and those produced by young ewes.

The effects of sex have been studied in many species by many workers. Hazel (40, p.340) found that ram lambs were 8.3 pounds heavier than ewe lambs at weaning. Verges (86, p.11) avers that ewe lambs are fatter than males at

the same weight. Hazel (41, p.319) showed that ram lambs were 10.8 pounds heavier than ewe lambs at weaning. Karam (46, p.606) found that wethers were 3.5 pounds heavier than ewe lambs at 25 weeks old. Phillips (67, p.11) showed that sex differences at weaning were significant even when corrected for birth weights. The rams were heavier than the ewe lambs. Hazel and Terrell (41, p.24) showed higher scores in type and condition for ewe lambs over ram lambs. They also found a difference of 11.7 pounds at weaning time between singles and individual twins. They found a difference in the same experiment between lambs of 2 year old ewes and those of mature ewes amounting to 8.7 pounds. de Baca (23, p.79) found no significant differences because of sex in any of the factors he studied. Tendencies were for males to be heavier at birth than females, and for wethers to be heavier at weaning than ewe lambs. There was also a tendency for ewe lambs to score higher than wethers in condition.

Hammond (37, p.50) presented evidence that ewe lambs mature earlier than wethers. He also stated (37, p.110) that rams have a higher dressing percentage than ewe lambs. Karam (46, p.606) showed that ewe lambs scored higher in condition than ram lambs.

In cattle, Koger and Knox (51, p.19) reported

differences in weaning weights of beef calves in favor of steers over heifers. Burris and Bogart (11, p.5) showed differences in thyrotropic hormone content of the anterior pituitary glands of heifers and steers, and that heifers and steers injected with testosterone gained more rapidly and efficiently than controls. Koch (50, p.771) demonstrated differences in weaning weights of calves due to sex. Males were heavier than females. Dawson (21, p.256) found that bulls were heavier at birth than heifers. Dahmen and Bogart (19, p.20) demonstrated sex differences in rates and economy of gains in young beef animals. Bulls gained 2.3 pounds per day and heifers gained 2.0 pounds per day during the test.

Within breeds, ewes heavier as yearlings on the average weaned more pounds of lambs per ewe during their lifetime, regardless of breed (84, p.227).

Marshall (55, pp.149-150) claims that breeding from sheep that were born as twins consistently tends to raise the average fertility within a breed.

In multiparous animals, the larger the number of fetuses the smaller the individuals tend to be, according to Maynard (57, p.370). This may be due to crowding, and there is frequently a marked difference in size among the individuals of a litter. In animals which may give birth to one or more young, multiple births do not produce so

large individuals as do single births. Stark (82, p.564) found that lambs born as singles were 20 per cent heavier than those born as twins and also they grow 20 per cent faster. Singles had better conformation, better finish, and graded higher. Hammond (35, pp.95-108) claims that singles attain their maximum growth rate during their first week after birth. It is the fifth week before twins can supplement their milk supply enough with other feeds to get to a maximum growth rate.

Lambs born as singles were from 1.92 to 2.40 pounds heavier at birth and weighed 17 pounds more at weaning than those born as twins (23, p.79). Hammond and Appleton (37, p.27) reported a 29 per cent difference between the weights of singles and those of twins.

Singles scored higher in condition and weighed 9.2 pounds more at weaning than did twins (40, p.340). Price, Sidwell and Grandstaff (71, p.1029) found that type of birth influenced weanling traits of Navajo and Navajo crossbred lambs more than did any of the other environmental factors studied. Sidwell and Grandstaff (78, p. 461) reported that singles scored higher in type and condition than twins and that ewes scored higher than rams.

There seems to be a correlation between birth weights and average daily gains in lambs of the breeds studied

(47, p.370). Phillips (68, p.19) showed a high correlation between weights early in life and subsequent weights. This worker also stated that 32 per cent of the lambs which weighed less than six pounds at birth died soon afterwards, and that single and twin lambs of the same size at birth have an equal chance for survival.

Bonsma (7, p.93) reported a correlation of .408 between birth weight and 12 week weight of lambs. He stated (7, p.48) that 24 per cent of the variation in birth weight of lambs was due to differences in weight of the ewes. He found (7, p.72) that 25 per cent of the variation in milk yield of ewes within breeds is due to differences in the body weights of the ewes. He reported a correlation of .317 between total milk yield of ewes and the birth weight of their lambs.

Cadmus (13, p.15) claimed that each pound increase in birth weight above the mean results in 2.5 to 3.5 pounds increase above the mean weight at 20 weeks, depending on the breed.

de Baca (23, pp.78-79) found an increase of 2.50 to 5.96 pounds in weaning weight for every pound increase in birth weight. Hammond (37, p.81) found a correlation of .52 for lambs weight at 20 weeks with that at one week, and a higher correlation for weight at 61 weeks with that at 20 weeks.

Nelson and Venkatachalam (65, p.609) found the heritability of lamb birth weight to be .61 and the heritability of weaning weight to be .33.

Bonsma (7, p.48) found that the birth weights of crossbreed lambs were significantly higher than those of purebred Merino lambs. This proves, he says, that the use of different rams has a very definite effect on the birth weight of lambs and that the birth weight of lambs is predetermined by hereditary growth factors as received from both sire and dam, that is, apart from environmental influences. Male lambs were significantly heavier than females. Carter and Henning (14, p.1023), however, were unable to demonstrate heterosis in birth weight. Hammond (37, p.53) also states that the dam has more influence in controlling size at birth than does the ram.

Burris and Blunn (12, p.37) showed that bulls are larger at birth than heifer calves. Dahman and Bogart (19, p.17) found that 18 per cent of the variation in economy of gains in beef calves was due to birth variations, and that the correlation of birth weight and economy of gain was .42. Krider, et al. (52, p.14) found a 5 per cent heritability of birth weight for pigs. This increased to 24 per cent at weaning.

Bonsma (7, p.49) believes that the larger size of

the male at birth is not due to a longer gestation period. This, he says, is seen by the fact that males are also larger in animals which bear litters. The birth weight of males is still significantly greater than that of females after correcting to a basis of equal gestation periods. Bonsma found no significant difference in the duration of pregnancy as a result of the sex of the offspring.

Wallace (87, p.153) states that 98 per cent of the variation in the weight gains made by individual lambs between birth and 112 days can be accounted for by the differences between them in respect to their consumption of milk and supplementary feed. Hammond (35, p.96) declares that the milk supply of the ewe is the most important factor affecting the growth rate of lambs. Bonsma (7, p.96) found significant correlations between the milk yield of the ewes and growth rate of their lambs in all cases. He states (7, p.97) that the differences in the amounts of milk consumed per pound gained in live weight as lambs get older is highly significant. There is a marked decrease as the lambs get older. This is accounted for by the increased use of other food by the lambs.

Bonsma (7, p.65) insists that individual selection for high milk production in sheep is more important than

choice of breed. He states (7, p.72) that within breeds there is a significant correlation between the live weight of ewes and their milk production, heavier ewes tending to produce more milk.

Bonsma (7, p.96) further stated that a high level of milk secretion during the first few weeks after lambing is of greater importance than persistency. Gains were more highly correlated with milk yield during the first 45 days of lactation than later. He noticed a 50 per cent difference in weight increase between lambs from high milking ewes and those from low milking ewes.

METHODS AND MATERIALS

The data were collected over a period of five years beginning in 1949. Five hundred thirty matings were made which resulted in the birth of 652 lambs. Five hundred seventy two of these lambs lived to weaning age.

The production of lamb is much more important in Western Oregon than the production of wool; consequently, this study was concerned only with lamb production.

A flock of 120 Lincoln x Rambouillet range ewes was available in 1946. These range ewes were divided into four groups, one group to be bred to good rams of each of the Romney, Border Leicester, Cheviot, and Hampshire breeds. These ewes were the foundation females from which the "first cross" ewes were obtained for this experiment. The Romney is a popular breed of sheep in Western Oregon, the Border Leicester is a long-wool hill breed, the Cheviot is a medium wool hill breed, and the Hampshire is a mutton breed. Space and money were limited and consequently the development of ewe-breed crosses was prolonged over a seven year period.

The first cross ewes resulting from mating these Lincoln x Rambouillet range ewes to rams of the four breeds previously mentioned carried 25% Lincoln breeding, 25% Rambouillet breeding, and 50% of the breeding of whichever breed of ram was used. These first cross ewes

were then backcrossed to rams of their respective sire breed to produce second cross ewes. These second cross ewes were theoretically 12½% Lincoln, 12½% Rambouillet, and 75% Hampshire, Cheviot, Border Leicester, or Romney. It was originally intended to compare the producing abilities of the first cross and the second cross ewes. However, the results were confounded by a two year age difference and by year differences. This could have resulted in a misinterpretation of results. The ewe lambs resulting from these matings were born in 1949 and 1950.

In the fall of 1950 rams of three breeds, Romney, Southdown, and Hampshire, were used. Bucks of the Cheviot and Border Leicester breeds were not used after the first two years. A comparison between the performance of rams of these three breeds was attempted but data were too scanty to show any decisive differences.

In the falls of 1951 and 1952 first cross and second cross ewes were bred to Suffolk and Southdown rams. Rams of these two breeds sired the lamb crops which were dropped in 1952 and 1953. The ewes were alloted by use of random numbers tables to each of two rams of the Suffolk and Southdown breeds by ages, by crosses, and by treatments. Different rams were used in consecutive years so that the results might show a more accurate picture of the merit of each ram breed rather than that

of the individual rams.

The ewes used in this experiment were treated exactly alike except that approximately half of each sire group was fed a supplementary ration in addition to pasture during the first winter of their lives and the other half received pasture only during this period except when snow covered the forage. Each year the replacement ewe lambs were divided within sire groups and were treated in the same way. All other environmental conditions were considered random and free from bias so that any differences in the performance of these sheep would be due to: (1) feeding or not feeding during their first winter, (2) ewe breed, (3) ram breed, (4) individual ewe productivity, (5) sex, (6) birth type, (7) age of ewe, (8) age of lamb at weaning, and (9) year.

Pasture and pen matings were made during the first four years of the experiment. The ewes were on pasture with the rams in the pasture matings. When pen matings were made, the ewes were on pasture during the day and were turned into pens with their respective rams each evening. During the breeding season the last year of the experiment hand mating was practiced. Vasectomized rams were marked with wool paint on their breasts and allowed to run on pasture with the ewes. The ewe in heat was served by these vasectomized rams and marked

on the rump with the wool paint from the breast of the buck. These marked ewes were then brought in to the breeding shed and bred to their respective fertile rams.

The ewes were tagged just prior to the breeding season in order to facilitate breeding. This treatment consisted of removing tags and wool from the dock and the area adjacent to and below the vulva. About six weeks before the lambing season the ewes were tagged or crutched again. This time the tags and wool were removed from the udder and the area near it.

Grain and hay feeding was begun about a month before the first lamb was expected and was continued until about March 10. Each ewe received 30 to 45 pounds of an oat-barley mixture and 225 pounds of hay per year in addition to natural pasture. A phenothiazine-salt mixture was available to the ewes at all times.

Each ewe had a flock number and was identified by a metal tag in each ear. As soon as a lamb was born it was also ear-tagged, and its weight recorded to the nearest tenth of a pound. Male lambs were docked and castrated with rubber rings, and the naval was disinfected with iodine. The ewe and her lamb(s) were confined in a 3' x 4' enclosure to "mother up" for a period of 12 to 36 hours depending on the strength of the lamb(s). Assistance was given in all cases of dystocia.

The flock was rotated from pasture to pasture in such a way that the lambs and ewes were on the best pasture at all times. Weighing was done at different times in order to get pasture gains from each pasture. Weights of the lambs were also taken at weaning. In 1953 the lambs were weighed as rapidly as possible each Saturday morning to obtain growth rates. All these weighings should not affect the experimental results since all lambs were subjected to the same treatment.

The lambs were weaned as they reached top condition and/or heavy market weights. Usually about three weanings were made because of the different ages of the lambs. A committee of three judges scored each lamb for condition and conformation.

The breeding season usually began about September 10 and extended into October. During the early years of the experiment the breeding season was 60 days. This was subsequently shortened to 40 days. The lambing season thus began in early February and lasted until about the last of March. The average age at weaning was 120-125 days. Most of the lambs were marketed well before July 1.

Because of the great number of variables no single analysis of the data was considered practical. Wherever enough data were comparable a factorial analysis was used. In most cases, however, more data were comparable

when simple analysis of variance with two way classification was used. The five per cent level was taken as "significant".

Ewes which were given supplementary feed in addition to pasture during the first winter of their lives are referred to as "fed" ewes. Ewes not receiving this feed are referred to as "not fed" ewes.

RESULTS AND ANALYSIS

All the data collected over a period of five years are presented in Tables 1 and 2. The data for the first two years of the study are presented in Table 1. During these two years the ewes were bred back to their respective sire breeds. These data are presented only for comparative purposes and will be used only to compare grading up of the sheep with a program of continued crossbreeding. All the data including the material presented in Table 1 are given in Table 2.

It may be seen from a comparison of the data in Tables 1 and 2 that in almost every case the birth weights, weaning weights, conformation scores, and condition scores were higher with continued crossbreeding than with grading up. Exceptions are: (1) Conformation and condition scores for Cheviot ewes that were fed the first winter of their lives, and (2) Pounds lamb per ewe bred and birth weight of lambs from Hampshire ewes that were fed the first winter of their lives. These differences will be discussed in the next chapter.

The average age of lambs at weaning was lower in every case where continued crossbreeding was practiced than where grading up was the system used. The weaning percentage was higher in every case except two for the

continued crossbreeding program. In the case of Romney and Hampshire ewes that were fed the first winter of their lives, weaning percentage was as high or higher for the groups in the grading up as for continued crossbreeding.

Since all of the data are contained in Table 2, the remainder of the discussion will be confined to the information presented there.

The data given under disposals include ewes which died, those culled and those eliminated from the breeding flock for any other reason. Thirty-three ewes not fed the first winter were eliminated, but only 28 of those receiving winter feed were eliminated for some reason. Of those kept in the experimental flock more ewes that were not fed the first winter of their lives failed to wean a lamb than was the case with the ewes that were fed.

Even though lamb mortality was slightly higher in the group that received winter feed the first winter they still weaned a higher percentage of lambs than ewes of the group not winter fed.

As noted in Table 2 the remainder of the data are not entirely comparable. A series of factorial analyses was set up which contained all of the data which were comparable. The analyses were made within sex, birth type (twins or singles), year, age of ewe, and breed of

TABLE 1

Summary of results when ewes were bred to their own sire breeds

	Cheviot		Hampshire		Border Leicester		Romney	
	Not Fed	Fed	Not Fed	Fed	Not Fed	Fed	Not Fed	Fed
Number of ewes bred	25	26	10	13	26	24	15	13
Bred ewes not weaning lambs	3	3	4	0	3	5	3	1
Number of lambs born	28	34	12	20	31	27	13	14
Number of lambs lost	4	9	3	4	6	2	1	1
Number of lambs weaned	24	25	9	16	25	25	12	13
Weaning percentage based on ewes bred	96	96	90	123	96	104	80	100
Pounds of lamb born per ewe bred	8.9	10.9	10.2	13.2	11.2	11.2	7.9	10.0
Average age of lambs at weaning (days)	128.4	128.6	129.0	131.8	136.4	135.5	139.7	133.5
Average conformation score of lambs weaned*	85.4	84.7	71.2	80.9	76.8	74.8	80.3	77.3
Average condition score of lambs weaned*	82.9	81.5	72.7	81.3	76.1	75.3	74.1	74.1
Pounds of lamb weaned per ewe bred	68.1	67.6	61.0	98.2	73.8	78.6	58.8	71.3

* Scoring was done by three men and the average of the three scores was taken.

TABLE 2

Production of Grade Cheviot, Hampshire, Border Leicester, and Romney Ewes Which Were Fed and Not Fed During the First Winter of Their Lives

	Cheviot		Hampshire		Border Leicester		Romney		Totals	
	Not Fed	Fed	Not Fed	Fed	Not Fed	Fed	Not Fed	Fed	Not Fed	Fed
Number of ewes bred	75	70	51	66	66	77	66	59	258	272
Total disposals (ewes)	10	13	5	1	17	10	1	4	33	28
Bred ewes not weaning lambs	8	7	7	10	10	10	16	8	41	35
Total number of lambs born	94	86	62	95	85	94	69	67	310	342
Total number of lambs lost	8	13	7	15	9	6	14	8	38	42
Total number of lambs weaned	86	73	55	80	76	88	55	59	272	300
Weaning percentage based on ewes bred	115	104	108	121	115	114	83	100	105.4	110.3
*Average lbs. lamb born/ ewe bred	11.2	11.2	11.5	13.1	12.6	12.2	9.9	10.2		
* Average age of lambs at weaning (days)	121.6	110.6	121.9	121.2	125.3	121.1	121.1	121.1		
*Average conformation score[1] at weaning	86.6	78.0	83.5	81.8	79.9	79.9	84.2	81.5		
*Average condition score[2] at weaning	85.1	77.8	84.5	84.1	80.0	80.5	82.6	79.9		
*Pounds lamb weaned/ewe bred	80.3	75.8	84.1	93.0	86.9	88.9	63.4	72.9		

* These figures are not directly comparable. They are confounded by year, age of ewe, breed of ram, birth type, and sex.

1 Conformation score - 95 is average of excellent, 85 is good, 75 is medium, 65 is inferior, and 55 is cull.

2 Condition score - 95 is average of prime, 85 is choice, 75 is good, 65 is utility, and 55 is cull.

ram. Analyses of variance for birth weight and weaning weight are presented in Tables 4 and 5, respectively. By use of these analyses one can compare ewe and wether lambs and feeding versus not feeding of the ewes their first winter for the effects on the birth weight and weaning weight of the lambs produced.

TABLE 3

Analysis of variance of the effects of sex and feeding on the birth weights of lambs

Source of variance	s.s.	d.f.	m.s.	F
Total	135.50	59		
Replications	95.17	14		
Sex	11.09	1	11.09	17.06**
Feed	0.00	1	0.00	0.00
S x F	1.86	1	1.86	2.86
Error	27.38	42	.65	

** Significant at 1 per cent level.

Mean birth weights for lambs from ewes not fed their first winter were 10.7 pounds for males and 9.6 pounds for females. In the group which was fed their first winter the male lambs weighed an average of 10.5 pounds and the females 9.8 pounds.

That sex of lamb influences birth weight is shown clearly in Table 3. Males were heavier at birth. Whether

the ewe was fed or not during her first winter made no difference in the birth weight of her lambs.

The effects of sex and the feeding of the ewes during their first winter are not significant at weaning although there is a tendency for males to be heavier than females and for lambs from ewes that were fed the first winter to be heavier than those from non-fed ewes (Table 4).

TABLE 4

Analysis of variance of the effects of sex and feeding on the weaning weight of lambs

Source of variance	s.s.	d.f.	m.s.	F
Total	7781.00	59		
Replications	4437.00	14		
Sex	272.73	1	272.73	3.96
Feed	179.93	1	179.93	2.61
S x F	.61	1	.61	.009
Error	2890.73	42	68.83	

Mean weaning weights of lambs from ewes not fed their first winter were 79.67 pounds for males and 75.53 pounds for females. Mean weaning weights for lambs from ewes fed their first winter were 83.27 pounds for males and 78.87 pounds for female lambs.

A different type of analysis in which more data were comparable was used to determine these effects in a comparison of the breeds. Those analyses are presented later. Analyses were made on the effects of sex of lamb and winter feeding of the ewes their first winter on age of lamb at weaning, and conformation score and condition score of the lambs. None of the findings were significant. The means only are presented in Table 5.

TABLE 5

Table of Means

Weaning age (mean)	
Lambs from non-fed ewes:	Males 126.9, Females 124.9
Lambs from fed ewes:	Males 124.3, Females 127.0
Conformation score	
Mean scores	
Lambs from non-fed ewes:	Males 82.14, Females 82.94
Lambs from fed ewes:	Males 82.05, Females 83.95
Condition score	
Mean scores	
Lambs from non-fed ewes:	Males 81.93, Females 83.60
Lambs from fed ewes:	Males 81.59, Females 82.88

There is a tendency for females to be slightly fatter at weaning.
There is no improvement in score due to feeding of ewes the first winter of their lives.

Sex had no significant effect on weaning age, conformation score, or condition score. Whether or not the ewes were fed as lambs during their first winter made no difference in so far as these three factors were concerned.

Factorial analyses of birth type and winter feeding during the first year of life were made to determine their effects on birth weight, weaning weight, conformation score, and condition score of the lambs produced. These analyses are presented in Tables 6, 7, 8, and 9.

TABLE 6

Analysis of variance of the effects of birth type of the lambs and feeding of the ewes their first winter on the birth weight of the lambs produced

Source of variance	s.s.	d.f.	m.s.	F
Total	86.26	19		
Replications	34.95	4	8.74	
Birth type	45.00	1	45.00	109.76**
Feeding	1.35	1	1.35	3.29
BT x F	.13	1	.13	.32
Error	4.86	12	.41	

** Significant at the 1% level.

Mean birth weights for lambs from ewes not fed the first winter of life were 7.7 pounds for twins and 10.9 pounds for singles. Mean birth weights for lambs from ewes winter fed their first year of life were 8.4 pounds for twins and 11.2 pounds for singles.

TABLE 7

Analysis of variance of the effects of birth type of the lambs and feeding the ewes their first winter on the weaning weight of the lambs produced

Source of variance	s.s.	d.f.	m.s.	F
Total	6629.80	19		
Replications	2793.80	4	698.45	
Birth type	1729.80	1	1729.80	12.80**
Feeding	441.80	1	441.80	
BT x F	43.00	1	43.00	
Error	1621.40	12	135.12	

** Significant at the 1% level.

Mean weaning weights for lambs from ewes not fed their first winter were 61.6 pounds for twins and 83.2 pounds for single lambs. Mean weaning weights for lambs from ewes fed their first winter were 74.0 pounds for twins and 89.6 pounds for single lambs.

TABLE 8

Analysis of variance of the effects of birth type of lamb and feeding of ewes their first winter on the conformation scores of the lambs produced

Source of variance	s.s.	d.f.	m.s.	F
Total	1117.16	19		
Replications	253.74	4	63.44	
Birth type	325.63	1	325.63	7.87*
Feeding	32.52	1	32.52	.79
BT x F	8.83	1	8.83	.21
Error	496.44	12	41.37	

* Significant at the 5% level.

Mean conformation scores for lambs from ewes not fed during their first winter were 72.5 for twins and 76.4 for single lambs. Mean conformation scores for lambs from ewes fed during their first winter were 76.4 for twins and 83.1 for single lambs.

TABLE 9

Analysis of variance of the effects of birth type of lamb and feeding of ewes their first winter on the condition scores of the lambs produced

Source of variance	s.s.	d.f.	m.s.	F
Total	1487.56	19		
Replications	488.55	4	122.14	
Birth type	349.45	1	349.45	7.81*
Feeding	67.71	1	67.71	1.51
BT x F	45.00	1	45.00	1.01
Error	536.85	12	44.74	

* Significant at the 5% level.

Mean condition scores for lambs from ewes not fed their first winter were 69.3 for twins and 80.6 for single lambs. Mean condition scores for lambs from ewes fed their first winter were 76.0 for twins and 81.3 for singles.

It may be seen from these tables that birth type (twin or single) had a significant effect on all four factors. Single lambs were significantly heavier at

birth and weaning and had significantly higher conformation and condition scores than individual twin lambs. If more data were comparable it might have been found that feeding a ewe the first winter of her life influences her subsequent production since the means were all larger for ewes that had been fed. Although the means were higher for lambs produced by ewes fed their first winter, the difference lacks significance. Feeding the ewes their first winter had no effect on conformation and condition scores of lambs produced. There was no significant difference in the ages of the lambs at weaning.

By using analysis of variance with two way classification a great many more data were comparable than with the factorial analysis. This kind of analysis was used in comparisons between the breeds in their response to winter feeding the ewes their first year. The data presented in Table 2 leads one to suspect that there might be breed differences in response to feeding as lambs. The Hampshire and Romney breeds show a rather wide difference in production per ewe bred between ewes that were fed their first winter and those that were non-fed ones. The Border Leicester ewes show a slight difference in pounds of lamb weaned per ewe bred in favor of the ewes that were winter fed the first year of life. The Cheviot

ewes, on the other hand, do not show any advantage gained by feeding. The difference in pounds of lamb per ewe bred for the ewes fed their first winter and those which were not fed may be partially accounted for by the difference in age of the lambs at weaning. However, there are other indications that feeding had little value in the Cheviot breed. There were more Cheviot ewes disposed of which were fed their first winter than unfed ones; almost as many ewes fed their first winter failed to wean a lamb as did ewes not fed; the weaning percentage of the ewes not fed was larger than that of the fed ewes; and the conformation and condition scores of the lambs produced by ewes not fed were greater than those of the lambs produced by the ewes which were fed the first winter of life.

Analyses of the data on the lambs of the Cheviot ewes showed no significant differences in birth weights, age at weaning, weaning weights, conformation scores, or condition scores of lambs from ewes not fed their first winter and those from ewes which were fed.

Cheviot sheep are rather wild, that is, they do not take handling by humans as well as do the other three breeds of ewes used in this work. In checking back on these sheep it was found that there was only a minute difference (about one-third pound) in the weights of the

sheep in the spring. The fed ewe lambs were only slightly heavier. This fact suggests that the "fed" Cheviot ewe lambs might actually not have come in for their feed. The herdsman during the first four years of the experiment stated that this was true. Consequently, there is some doubt of the validity of the comparison between the production of Cheviot ewes which were fed their first winter and those which were not fed during this time.

Analysis of the Romney lamb data also failed to show any differences in the birth weights, weaning weights, conformation scores, and condition scores of the individual lambs due to feeding of their dams the first winter. The reasons for the difference between ewes which were fed their first winter and those which were not fed in production of lamb per ewe bred must be sought elsewhere than in the lamb data. It may be seen from Table 2 that mortality was considerably higher in the lambs from ewes not fed their first winter than in those from ewes which were fed. More of the ewes which were bred failed to wean a lamb in the group which was not winter fed. However, more ewes fed their first winter were disposed of than unfed ones.

In the analysis of the lamb data for Hampshire ewes it was found that although the birth weights of lambs

from ewes winter fed the first year of life tended to be slightly higher than those of lambs from ewes which were not fed, the difference was not significant. Weaning ages were the same for lambs from the two groups of ewes. Average conformation scores of lambs from ewes fed their first winter were slightly higher than those of lambs from ewes not winter fed, but here again the difference was not significant. Mean condition scores of lambs from the ewes winter fed their first year were greater than those of lambs from ewes not winter fed but the difference lacked significance. In weaning weight, however, lambs from ewes which were winter fed were considerably heavier than those from ewes not winter fed as lambs and although the difference was not significant, the F value was very near significance at the 5% level. The analysis of variance is presented in Table 10.

TABLE 10

Analysis of variance of the effect of feeding Hampshire ewes their first winter on the weaning weight of their lambs

Source of variance	s.s.	d.f.	m.s.	F
Total	4527.37	29		
Replications	2856.87	14		
Feeding	410.70	1	410.70	4.56
Error	1259.80	14	89.99	

Mean weaning weights were 77.53 pounds for lambs from ewes not winter fed their first year and 84.93 pounds for lambs from ewes which were winter fed.

An F value of 4.60 is significant at the 5% level.

Analysis of variance of the Border Leicester lamb data again failed to show a significant difference in birth weight, conformation scores and condition scores due to winter feeding their first year. Weaning age was practically the same for the two groups. Analysis of variance of the effect of feeding on weaning weight showed a tendency toward heavier lambs for the ewes which were fed their first winter. The difference was not significant but the analysis is presented in Table 11.

TABLE 11

Analysis of variance of the effect of feeding Border Leicester ewes their first winter on the weaning weight of their lambs

Source of variance	s.s.	d.f.	m.s.	F
Total	7580.82	49		
Replications	5314.32	24		
Feeding	124.82	1	124.82	1.40
Error	2141.68	24	89.24	

Mean weaning weights were 77.5 pounds for lambs from ewes not fed their first winter and 80.6 pounds for

lambs from ewes fed their first winter.

Since Border Leicester and Hampshire ewes which were fed the first winter of life showed a tendency to wean heavier lambs than ewes of the two breeds which were not fed their first winter, it was felt that, if sufficient numbers of animals were considered, the results might be significant. Accordingly, the figures for the two breeds were pooled. The analysis is shown in Table 12.

TABLE 12

Analysis of variance of the effects of feeding Border Leicester and Hampshire ewes their first winter on the weaning weights of their lambs

Source of variance	s.s.	d.f.	m.s.	F
Total	12108.19	79		
Replications	8171.19	39		
Feeding	535.52	1	535.52	6.14*
Error	3401.48	39	87.22	

* Significant at the 5% level.

Mean weaning weights were 77.5 pounds for lambs from non-fed ewes and 82.3 pounds for those from fed ewes.

In this analysis the difference in weaning weight of the lambs due to feeding the ewes their first winter was significant.

Besides the evidence from the lamb data, there are other indications that feeding was of benefit in the

Hampshire and Border Leicester breeds. More ewes not fed their first winter than fed ewes were removed from the experimental flock in both breeds. Fourteen per cent of the bred ewes in the group fed their first winter failed to wean a lamb. The percentage of twins weaned by the Hampshire ewes which were winter fed their first year was much higher than the percentage weaned by the Hampshire ewes not winter fed. The percentage of twins weaned by the Border Leicester ewes which were fed their first winter, however, was slightly lower than that weaned by the ewes not fed their first winter. The weaning percentage of the Hampshire ewes winter fed their first year of life was considerably higher than that of the ewes not receiving feed during this period. The weaning percentage of the Border Leicester ewes fed their first winter was slightly (1 percentage point) lower than that of the ewes not winter fed their first year of life. More lambs were lost from the group of Hampshire ewes fed during their first winter than from the group not winter fed but, in spite of that, a larger percentage of lambs was raised by the ewes which were fed their first winter.

No significant effects of age of ewe upon birth weight, weaning weight, conformation score, or condition score could be shown by these data except in the

case of yearling vs. four-year-old ewes. However, there was a difference in weaning age which, if adjusted for, might account for the lack of differences due to this factor. This does not mean that there are no differences, but that such differences cannot be shown by these data. In comparison of production of yearling ewes with that of four-year-old ewes a significant difference in birth weight of lambs was found. There was no difference even in this case in the other criteria. The analysis is shown in Table 13.

TABLE 13

Analysis of variance of effect of age of ewe upon the birth weight of their lambs

Source of variance	s.s.	d.f.	m.s.	F
Total	16.92	7		
Replication	1.90	1	1.90	
Feed	.21	1	.21	.34
Age	12.75	1	12.75	20.90*
Feed X Age	.22	1	.22	.36
Error	1.84	3	.61	

* Significant at the 5% level.

Mean birth weights were 9.8 pounds for lambs from yearling ewes and 12.3 pounds for those from four-year-old ewes.

It may be seen from the number of degrees of freedom in this analysis that numbers were very small.

In comparing production of yearling ewes with that of all ewes there was no significant difference found. Means were slightly further apart for fed and unfed ewes in the yearling group but the differences were so slight that many more data would be required to show a significant difference if such a difference exists. Even this slight difference found may be accounted for by the fact that more of the poor producers among the older sheep had been culled than had been the case with yearlings.

Comparable data for the comparison of the performance of the ram breeds used are rather scanty in some cases. Some differences are shown, however, and they will be presented.

In comparing lambs sired by Hampshire rams with those sired by Romney rams, no significant difference could be shown in average birth weight, weaning weight, condition score, or conformation score. There was a tendency, pronounced in some cases, favoring the Hampshire. Greater numbers of experimental animals would probably show a real difference in all factors. However, such a difference cannot be shown by these data. Analyses are shown in Tables 14, 15, 16, and 17.

TABLE 14

Analysis of variance of birth weights of lambs sired by Hampshire rams and those sired by Romney rams

Source of variance	s.s.	d.f.	m.s.	F
Total	29.46	19		
Replications	14.30	9	1.59	
Breeds	.34	1	.34	.21
Error	14.82	9	1.65	

Mean birth weights were 10.44 pounds for lambs sired by Hampshire rams and 10.18 for those sired by Romney rams.

TABLE 15

Analysis of variance of weaning weights of lambs sired by Hampshire rams and those sired by Romney rams

Source of variance	s.s.	d.f.	m.s.	F
Total	1634.55	19		
Replications	753.05	9	83.67	
Breeds	198.45	1	198.45	2.61
Error	683.05	9	75.89	

Mean weaning weights were 84.3 pounds for lambs sired by Hampshire rams and 78.0 for lambs sired by Romney rams.

TABLE 16

Analysis of variance of conformation scores of lambs sired by Hampshire rams and those sired by Romney rams

Source of variance	s.s.	d.f.	m.s.	F
Total	462.07	19		
Replications	156.02	9	17.34	
Breeds	97.68	1	97.68	4.22
Error	208.37	9	23.15	

Mean conformation scores were 82.7 for lambs sired by Hampshire reams and 78.3 for lambs sired by Romney rams.

TABLE 17

Analysis of variance of condition scores of lambs sired by Hampshire rams and those sired by Romney rams

Source of variance	s.s.	d.f.	m.s.	F
Total	714.29	19		
Replications	326.21	9	36.25	
Breeds	139.93	1	139.93	5.07
Error	248.15	9	27.57	

Mean condition scores were 83.11 for lambs sired by Hampshire rams and 77.82 for those sired by Romney rams.

In comparing lambs sired by Hampshires with those sired by Southdown rams, there is no difference in birth

weight (F = .06). That analysis is not shown. In weaning weight lambs sired by Hampshire rams are significantly heavier than lambs sired by Southdown rams. In conformation scores and condition scores lambs sired by Southdown rams are significantly higher. Tables 18, 19, and 20 show the analyses.

TABLE 18

Analysis of variance of weaning weights of lambs sired by Hampshire rams and those sired by Southdown rams

Source of variance	s.s.	d.f.	m.s.	F
Total	1333.86	21		
Replications	788.35	10	78.84	
Breeds	204.04	1	204.04	5.97*
Error	341.46	10	34.15	

* Significant at the 5% level.

The mean weaning weights were 83.8 pounds for lambs sired by Hampshire rams and 77.6 pounds for those sired by Southdown rams.

TABLE 19

Analysis of variance of conformation scores of lambs sired by Hampshire rams and those sired by Southdown rams

Source of variance	s.s.	d.f.	m.s.	F
Total	439.01	21		
Replications	161.48	10	16.15	
Breeds	143.06	1	143.06	10.64**
Error	134.47	10	13.45	

** Significant at the 1% level.

The mean conformation scores were 87.8 for lambs sired by Southdown rams and 82.7 for those sired by Hampshire rams.

TABLE 20

Analysis of variance of condition scores of lambs sired by Hampshire rams and those sired by Southdown rams

Source of variance	s.s.	d.f.	m.s.	F
Total	726.12	21		
Replications	378.41	10	37.84	
Breeds	207.72	1	207.72	14.84**
Error	139.99	10	14.00	

** Significant at the 1% level.

Mean condition scores were 89.3 for lambs sired by Southdown rams and 83.1 for those sired by Hampshire rams.

A comparison of lambs sired by Romney rams with lambs sired by Southdown rams shows that there is no difference in birth weight (F = .06) nor in weaning weight (F = .25). In conformation score and condition score, however, lambs sired by Southdown rams are much higher than lambs sired by Romney rams. The analyses for scores are given in Tables 21 and 22.

TABLE 21

Analysis of variance of conformation scores of lambs sired by Southdown rams and those sired by Romney rams

Source of variance	s.s.	d.f.	m.s.	F
Total	1179.67	21		
Replications	513.54	10	51.35	
Breeds	471.05	1	471.05	24.14**
Error	195.08	10	19.51	

** Significant at the 1% level.

Mean conformation scores were 86.3 for lambs sired by Southdown rams and 77.1 for lambs sired by Romney rams.

TABLE 22

Analysis of variance of condition scores of lambs sired by Southdown rams and those sired by Romney rams

Source of variance	s.s.	d.f.	m.s.	F
Total	1484.82	21		
Replications	570.19	10	57.02	
Breeds	719.35	1	719.35	36.83**
Error	195.28	10	19.53	

** Significant at the 1% level.

Mean condition scores were 86.6 for lambs sired by Southdown rams and 75.2 for those sired by Romney rams.

In the foregoing ram comparisons there have been no differences in the ages of lambs at weaning. In the comparison of lambs sired by Southdown rams with those sired by Suffolk rams, however, there is a difference in age of lambs at weaning. There were more comparisons of these two ram breeds because they were the only breeds of ram used in 1952 and 1953. There are significant differences in birth and weaning weights, the lambs sired by Suffolk rams being heavier. The differences in conformation score and condition score show the lambs sired by Southdown rams to be better. There is also a significant difference in the age of lambs at weaning. Lambs sired by Southdown rams are younger. This would naturally influence weaning weight but would not necessarily

influence the other three criteria. Analyses of variance are shown in Tables 23, 24, 25, 26, and 27.

TABLE 23

Analysis of variance of birth weights of lambs sired by Suffolk rams and those sired by Southdown rams

Source of variance	s.s.	d.f.	m.s.	F
Total	153.79	69		
Replications	116.04	34	3.41	
Breeds of Ram	7.36	1	7.36	8.27**
Error	30.39	34	.89	

** Significant at the 1% level.

Mean birth weights were 10.4 pounds for lambs sired by Suffolk rams and 9.7 pounds for those sired by Southdown rams.

TABLE 24

Analysis of variance of ages at weaning of lambs sired by Suffolk rams and those sired by Southdown rams

Source of variance	s.s.	d.f.	m.s.	F
Total	10465.94	69		
Replications	5793.94	34	170.41	
Breeds of Ram	1320.23	1	1320.23	13.39**
Error	3351.77	34	98.58	

** Significant at the 1% level.

Mean weaning ages were 119.5 days for lambs sired by Suffolk rams and 111.0 days for those sired by Southdown rams.

TABLE 25

Analysis of variance of weaning weights of lambs sired by Southdown rams and those sired by Suffolk rams

Source of variance	s.s.	d.f.	m.s.	F
Total	10056.34	69		
Replications	4998.34	34	147.01	
Breeds	2765.71	1	2765.71	41.02**
Error	2292.29	34	67.42	

** Significant at the 1% level.

Mean weaning weights were 82.7 pounds for lambs sired by Suffolk rams and 70.1 pounds for lambs sired by Southdown rams. When these weights were corrected for age of lamb, however, no statistical significance was found.

TABLE 26

Analysis of variance of conformation scores of lambs sired by Southdown rams and those sired by Suffolk rams

Source of variance	s.s.	d.f.	m.s.	F
Total	2843.95	69		
Replications	899.57	34	26.46	
Breeds	1263.52	1	1263.52	63.08**
Error	680.86	34	20.03	

** Significant at the 1% level.

Mean conformation scores were 90.6 for lambs sired by Southdown rams and 82.1 for those sired by Suffolk rams.

TABLE 27

Analysis of variance of condition scores of lambs sired by Suffolk rams and those sired by Southdown rams

Source of variance	s.s.	d.f.	m.s.	F
Total	1895.03	69		
Replications	1025.65	34	30.17	
Breeds	337.92	1	337.92	21.62**
Error	531.46	34	15.63	

** Significant at the 1% level.

Mean condition scores were 89.1 for lambs sired by Southdown rams and 84.7 for those sired by Suffolk rams.

Another bit of information which would be of value is the relative value of continued crossing and grading up in commercial operations. This point could not be established because of the confounding which existed in the data. From a comparison of the data in Table 1 with those in Table 2, however, it would appear that grading up has less value in commercial sheep operations in Western Oregon. Continued crossing appears to have the advantage in almost every instance.

Comparisons were made between years where it was possible. Criteria used were birth weight and weaning weight. Conformation score and condition score were not used because in different years and with different men doing the scoring the human error was regarded as large.

The two years 1949 and 1950 were compared. There was no difference in birth and weaning weights but there was a large difference in age at weaning. In 1949 the lambs required 145.1 days to reach an average weight of 72 pounds while in 1950 this weight was reached at 121.5 days. There may have been some management differences but this indicates that there was a difference due to year.

Neither 1949 nor 1950 could be compared with 1951, 1952, or 1953 because of confounding by age of ewe and ram breed. Nineteen fifty one was compared with 1952

and no significant differences were found. Nineteen fifty one was compared with 1953 where a significant difference in weaning weight was found. The analysis is shown in Table 28.

TABLE 28

Analysis of variance of weaning weights of lambs born in 1951 and those born in 1953

Source of variance	s.s.	d.f.	m.s.	F
Total	339.87	7		
Replications	86.37	3		
Years	210.12	1	210.12	14.53*
Error	43.38	3	14.46	

* Significant at the 5% level.

Mean weaning weights were 66 pounds in 1951 and 77 pounds in 1953.

This result is probably due to chance because the sample was small and there were no differences found between 1952 and 1953 where the sample was adequate. There was also no difference found between 1951 and 1952.

DISCUSSION

A comparison of a program of grading up sheep with a program of continued crossbreeding shows clearly that a program of continued crossbreeding is superior in every trait having commercial value. The exceptions to this general statement which have already been mentioned have a rather obvious explanation. The conformation and condition scores of Cheviot lambs may be slightly improved by a second cross with Cheviot rams. This advantage is more than offset by the higher percentage of lambs weaned by first cross ewes and by the ability of first cross lambs to reach market weight and condition earlier than the second cross Cheviot lambs.

Second cross lambs of the Hampshire breed are heavier at birth than are first cross lambs. This is explained by the fact that Hampshire rams are larger than the rams that were used in continued crossbreeding in this experiment. This fact also explains why the number of pounds of lamb weaned per ewe bred is greater for Hampshire-cross ewes bred back to Hampshire rams. It is suggested that if the Hampshire-cross ewes had been crossed on rams of breeds as large as or larger than Hampshires, the results would have been reversed. This suggestion has been supported by previous work (59, pp. 466, 468).

It appears from the information contained in Table 2 that there is a breed difference in response of ewes to winter feeding during their first winter. The evidence contained in Table 2 indicates that supplementary feeding during a ewe's first winter may have little or no value in the Cheviot breed. This point was investigated further. It was found that the "fed" Cheviot lambs made only a fraction of a pound greater gain during the time they were fed than did the "unfed" Cheviot lambs. Cheviots are rather wild and do not hang around feeding places like sheep of some other breeds. This fact leads one to suspect that they may not have come in for their feed. This was confirmed by the herdsman. Another possibility was that since they were smaller than the sheep of the other breeds they may have been crowded away from the feed even if they did come in at feeding time. For these reasons some question has been raised as to the validity of comparisons made between "fed" and "unfed" ewes of this breed. Indications are rather strong that the "fed" Cheviots were not actually fed. The results of the analysis of the data on the lambs of the "fed" and "unfed" Cheviot ewes support such a conclusion. For the aforementioned reasons it is impossible to state on the basis of these data whether or not the feeding of Cheviot ewes as lambs has any value for the

commercial sheep producer.

Cheviot ewes, however, have given an excellent account of themselves in this trial whether or not they were fed as lambs. This breed should certainly be given consideration when a choice of breed is made for conditions similar to those obtaining at the Experiment Station hill pasture. They will probably return a larger margin of profit per unit of maintenance cost under relatively rigorous conditions than any other breed tried in this experiment. This is not meant to imply that any breed of sheep will be successful under too rigorous a set of conditions because any sheep must have feed to live and produce. Cheviot sheep, however, appear to be able to get more feed from poor pastures than sheep of other breeds. They are small and for this reason it should cost less to maintain them. They are also very active and for this reason they may be able to utilize feed which would be inaccessible to sheep of other breeds. Since they are small and extremely active and agile for domestic sheep, Cheviots may also be able to avoid predators and other hazards to which sheep of other breeds fall victim. The agility and relative wildness of these sheep may also be a disadvantage since they are a little harder to handle and may require better fences than sheep of the more docile breeds. Little trouble was

encountered from foot rot in Cheviot ewes during the trial and a large percentage of the lambs dropped were raised. Cheviots had a better record so far as conformation and condition of lambs at weaning time were concerned than did any other breed tried. Even though the "fed" Cheviots may not actually have been fed, the Cheviot compares favorably with the best of the other breeds in production of fat lambs. For the production of fat lambs under Western Oregon hill pasture conditions, particularly the more rigorous conditions, the Cheviot certainly has a place.

The Hampshire is an excellent breed of sheep for most localities where feeding and other conditions are fair to good. The data in this study clearly show, however, that Hampshires do not mature early enough to make it unnecessary to feed the replacement ewe lambs during their first winter. If minimum feed and other environmental conditions are to be provided for sheep, the Hampshire is not recommended. If feed and other conditions are good, however, and if supplemental feeding can be practiced during the winters and other periods when pastures are poor, the Hampshire is probably one of the best breeds for use in fat lamb production. The fertility of sheep of this breed is unsurpassed among the breeds tested. With proper environmental conditions

this should lead to high production per ewe. Under poor conditions, however, high fertility is of no advantage because the ewe is unable to care for more than one lamb. The large size of the Hampshire ewe contributes to high milk production and fast growth in her lambs. This, too, can be a disadvantage. The larger a ewe is, the more feed it takes to maintain her. Production must be high if such a ewe is to be profitable. For production to be high, feeding and other environmental conditions must be optimum. These conditions are seldom optimum on hill pastures in Western Oregon. There are certain other obvious disadvantages connected with the use of Hampshire cross ewes under the conditions of this experiment. Many Hampshire ewes show a tendency to be wooled too heavily on the face. This causes them to be unable to see approaching danger and also keeps them from being able to graze properly. Foot rot is thought to be primarily a management problem, however, the Hampshire seems to have more difficulty on account of the disease than sheep of the other breeds tested. The shape or structure of the foot may be such that a greater susceptibility is possible. Another possibility is that the Hampshire is heavier and does not see too well where it is going. Bruises and other injuries to the foot may result from these conditions. If Hampshire cross ewes are to be

used on hill pastures, the best conditions of feed and care possible should be provided. They should be checked regularly and often for foot rot and the affected ones treated. They should have the wool clipped away from the face and about the eyes. Under these conditions the Hampshire-cross ewe is suitable for hill pastures.

The Border Leicester is another British hill breed which was obtained for use in this experiment. Fertility was high in this breed and ewes of the breed were good mothers. The results of this experiment show, however, that the Border Leicester is not suitable for fat lamb production on the hill pastures of this area. These ewes produce lambs which grow fairly fast but which do not fatten at a young enough age to fit the requirements of sheepmen of this area. They are large sheep, rather slow maturing, and the lambs fatten at a large size. The lambs do not reach market condition in this locality before the pastures dry up in the summer.

The performance of Romney-cross ewes in this experiment has been disappointing. They ranked fourth among the four breeds tested in percentage of lambs born, percentage of lambs weaned, fertility, average birth weight of lambs, and in pounds of lamb per ewe bred. The conformation and condition scores of lambs weaned by Romney-cross ewes were higher than those of the Border Leicester

and about the same as those of the Hampshire and Cheviot. On direct and comparable comparison, however, the Romney ranked fourth in these factors also. There is no question as to the unsuitability of these sheep for hill pasture conditions.

It is clear from the evidence presented in the preceding chapter that feeding the ewes of certain breeds as lambs has a beneficial effect on their future production. Such feeding costs money both for feed and for labor. It seems reasonable to assume that a breed of sheep which can produce well without the outlay of extra money would be more profitable to raise than those which require considerable feeding. Apparently it is not economical to raise sheep from ewes of the Hampshire, Border Leicester, or Romney breeds without supplementary feed for the replacement ewe lambs during their first winter. The effect of such feeding on the production of the ewes apparently lasts throughout the ewe's life and indicates a permanent detrimental effect of poor nutrition at a critical time. It is not so clear whether the supplementary feeding of ewe lambs is an economical practice. Apparently there is some doubt of this, particularly in the Romney and Border Leicester breeds. The results of supplementary feeding of Hampshire ewe lambs are striking and the practice may be highly

profitable in this breed. No beneficial effect is demonstrated for feeding the ewe lambs of the Cheviot breed during their first winter.

The results of other people in the field and the results of this experiment tend to support the view that there is some damage to the reproductive tracts of unfed ewes of some breeds due to a deficiency of feed at a critical time during the development of the reproductive tracts. Results of this trial indicate that this damage is permanent. Since Cheviots are small and early maturing it may be that their reproductive tracts are sufficiently developed before the rigors of winter so that no damage from lack of feeding during their first winter is apparent. It is also possible that, due to their agility and activity, they may be able to glean more feed from poor pastures than can sheep of the other breeds tested.

Under hill pasture conditions in Western Oregon, and with the management practices necessary for marketing the lambs before pastures dry up, Hampshire cross, Romney cross, and Border Leicester cross ewes are apparently at a critical stage of growth during their first winter. The growth and development of their reproductive tracts is also apparently at a critical stage. For these breeds of ewe the feed available from pastures alone appears to be insufficient to afford either optimum growth of the

lamb or optimum development of its reproductive tract. The ewe may be able to overcome the effects of malnutrition so far as general body growth is concerned but the damage to her reproductive tract seems to be permanent. At least, the effects of the damage to the reproductive tracts seem to last for five years. The difference between the production of fed and unfed yearling ewes is slightly greater than the difference in the production of older ewes of the two groups. This is partly accounted for by the fact that poor producers are culled when rather young. This practice may completely account for the difference.

The literature previously cited indicates that a deficiency of feed at certain times may result in an endocrine upset. This is further indicated by the fact that more lambs born to ewes in the unfed group died before weaning. This may have been caused in large part by a deficiency in milk production in the ewe and this in turn may have been caused by an endocrine upset. More of the ewes in the unfed group refused to own their lambs; this also indicates an endocrine upset or imbalance. Whether such an endocrine imbalance is permanent or whether the effects of an imbalance at a particular time are permanent is a matter for conjecture.

As expected, ram lambs were found to be significantly

heavier at birth and weaning than were ewe lambs. This is in agreement with previous work. Females were slightly fatter than males at weaning but not significantly so.

Single lambs were significantly heavier at birth and weaning than individual twin lambs and also had higher conformation and condition scores.

Lambs from fed Hampshire-cross and Border Leicester-cross ewes were significantly heavier at weaning than were lambs from ewes of the two breeds which were not fed. This indicates that feeding the ewes as lambs caused a greater ability in the ewes to produce milk.

There was probably a real difference in production due to the age of the ewe. This difference could not be demonstrated, however. Nevertheless, this effect, if any, was removed from the analysis.

In comparing the value of purebred rams of the different breeds for crossing, the only good comparison is between the Suffolk and Southdown breeds. No conclusive results were obtained between the performance of Hampshire, Romney, and Southdown rams. Tendencies favored the Hampshire and Southdown over the Romney in all cases. The Hampshire was favored over the Southdown in weaning weight of lambs, and the Southdown was favored over the Hampshire in conformation and condition of lambs. Superiority of the Southdown over the Hampshire and Romney

were significant for conformation and condition.

Lambs sired by Suffolk rams were significantly heavier at birth and weaning than were those sired by Southdown rams. Southdown sired lambs ranked significantly higher in conformation and condition than did those sired by Suffolk rams.

It is at once apparent that the demands of the market should influence one in his selection of a breed of ram for use in crossbreeding. If the market is discriminating, it might be that the use of Southdown rams would be indicated. If the market were not too discriminating and if pounds of lamb were more important than quality, then the use of rams of one of the large mutton breeds would be more profitable. There are certain practical considerations, however, which must be borne in mind. If handbreeding is practiced, Southdown rams do acceptable work. For range breeding, however, the Southdown ram has certain obvious weaknesses. First, the Southdown ram is small and fat. This causes him to be unable to cover rough ground and to keep up with the ewes. This characteristic is more apparent than real, however, because the ewes in heat tend to come to the ram for service. A second weakness, however, which is very real is that many low set Southdown rams have difficulty in reaching a large range ewe for service.

The Southdown is also lacking in fertility when compared to the Suffolk or Hampshire. Consequently, the lamb crop from Southdown rams, particularly with range breeding, is likely to be smaller than it would be if Suffolk or Hampshire rams were used.

The fertility and sex drive of the Suffolk ram is unsurpassed. He is vigorous and able to get a good lamb crop regardless of the topography of the pasture. His lambs will be heavy at birth and weaning and will mature early. They lack the conformation and especially the condition of the lambs sired by the Southdown.

The Hampshire ram has been used successfully for crossing for many years by sheepmen of the west. He sires a heavy lamb at birth and weaning and a lamb which possesses acceptable conformation and condition. Again, however, the Southdown is superior in transmitting conformation and condition.

The Hampshire ram is somewhat less vigorous and has somewhat less sex drive than the Suffolk. There has also been some objection to the Hampshire ram as a crossing sheep because of the size and shape of head he transmits to his lambs. It is said that this causes a certain amount of trouble at parturition particularly in yearling ewes. There was no trouble from this cause experienced in the present study.

The Romney ram has not been satisfactory as a crossing sheep during this experiment. He lacks virility and his lambs lack the vigor and growing ability which is necessary for profitable commercial sheep production.

It may be well to point out here that it is usually not a profitable practice for a sheepman in a fat lamb producing area to raise his own replacement ewes. There may be some disagreement on this point and for that reason some of the arguments pro and con are presented.

First, a fat ewe lamb will usually sell for more money at five months of age than a yearling ewe will cost.

Second, a yearling ewe raised under range conditions should be more valuable as a producer than a home raised ewe because the unfit ones have usually been eliminated by natural selection. In connection with this point, there is a tendency for sheepmen in the fat lamb area to keep their late lambs and lambs otherwise unfit for market as replacements. Because of the greater care he gives them he is able to raise more of the unfit animals than is possible under range conditions. As a consequence, the replacements raised in the fat lamb area are inferior to their mothers and to the range yearling ewes. Another factor is that range raised ewes are usually freer of parasites and such diseases as foot rot than are home

raised ewes.

On the other hand, replacements of the breeding desired may not be available from the range. It may be necessary to obtain common range ewes and cross them on Cheviot or other rams in order to get the kind of ewes desired.

It would seem more profitable to make arrangements for replacements long enough in advance so that the range sheepman can produce the replacements of the breeding desired.

SUMMARY AND CONCLUSIONS

In summary, it is beneficial to the production of ewes of many breeds to be fed supplementary feed during their first winter. Whether or not this is an economical practice will depend on the breed, weather conditions, cost of labor, and the cost of the feed used.

Ewes with some Cheviot breeding have given better results under poor hill pasture conditions than ewes of any other breed tried.

For optimum hill pasture conditions ewes with Hampshire breeding give excellent results.

The chief weakness of Border Leicester ewes for hill pasture conditions is that their lambs do not reach market condition before pastures dry up in the summer.

Romney ewes are not as well adapted to hill pasture conditions as are the other breeds tested.

For discriminating markets the Southdown is an excellent ram for crossing on commercial ewes. Type and condition of Southdown sired lambs are unsurpassed.

For markets not so discriminating the Suffolk and Hampshire rams give best results. Their lambs are heavier at birth and weaning than are those of the other breeds tried.

The Romney ram is the least satisfactory of the ram

breeds tried for crossing.

Continued crossing seems to be superior to grading up in the production of market lambs.

Ram lambs are heavier at birth and weaning than are ewe lambs.

Single lambs are heavier at birth and weaning than are individual twin lambs and score higher in conformation and condition.

In some breeds of sheep, feeding the replacement ewe lambs their first winter leads to a more complete development of their reproductive tracts and the effects of this development last at least until the ewe is five years old. It may be permanent.

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