

SELECTION AND BREEDING PROGRAMS FOR  
IMPROVING INDIAN SHEEP

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## INTRODUCTION

India with her vast areas of uncultivated land, equitable climate, moderate rainfall, cheap labor, and a fairly good market is very well suited for sheep production. She boasts of 40.26 million sheep which produce 72 million pounds of wool, provide 400 million pounds of meat, and contribute to the fertilization of millions of acres of cultivable land. Wool and sheep products earned foreign exchange to the extent of 214 million Rupees (44.6 million dollars) in 1961-62 (Khot, 1963b).

Sheep in India occupy a very important place among the livestock industries ranking second only to cattle in numbers. However, as a producer of income the importance of sheep becomes unique, since wool accounts for the major percentage of the agricultural income to the country.

Sheep have been rightly referred to as possessing a "golden hoof" because of their ability to maintain the fertility of their pastures or to restore the productivity of the soil. They return two cash crops, namely, lambs and wool. Returns come quickly, since lambs are born yearly and are ready for market when about a year of age. The income from wool is usually obtained at a different time of year than income from lambs, thus making for a better distribution of earnings (Sharma and Kohli, 1955). Sheep rearing is important in the rural economy of the Himalayan region, since it provides occupation for thousands of flock owners and provides wool for making warm apparel for the rural weavers. Mutton is important for improving the nutritional level of the diet of the people (Khot, 1963a).

Most of our Indian sheep produce only a carpet type wool that is a mixture of varying proportions of wool and hair. The annual yield of wool averages about 2.2 pounds per head. The presence of medullated fibers is a major defect in this wool. The quality and quantity of mutton and carcass are very poor. The annual percentage of lamb crop is low.

The sheep industry in India is mostly in the hands of illiterate and poor people. At present these people are unable to breed their flocks on a scientific basis to their advantage as well as that of the country at large (Jayaraman and Buch, 1953).

The purpose of this review is to describe why the above-mentioned defects should be eliminated and how the production of the quality and quantity of wool and mutton and percentage of lamb production can be improved through selection and breeding programs.

## REVIEW OF LITERATURE

### Indian Sheep Industry

India has a very old history about its sheep and wool. In the Rig Veda, there are hymns to Pasham, the God of shepherds, and there are references to the bleaching and spinning of wool. But economic importance of the sheep industry has been greatly overlooked, because Indian sheep do not produce wool which is able to be used for the manufacture of apparel fabrics.

The sheep-raising area of India can be divided into three distinct regions, according to Khot (1963) and Kumar et al. (1963):

1. The Temperate Himalayan Region covering Kashmir, Himachal Pradesh, and the hilly districts of Punjab and Uttar Pradesh. There are about 5.20 million sheep in this region which yield 4.10 million pounds of wool with varied proportions of fine and coarse fibers. This region has good grazing facilities in the high hills. The shepherds are nomadic, poor, landless, wandering flock owners. The sheep in this region have superior fleece with a higher percentage of fine undercoat than those found in other regions. Sheep in the Garhwal district in Uttar Pradesh have a coarser wool than that in Kashmir. The flocks in Kangra, Chamba, Kulu, and Kashmir valleys produce better and finer wool.

There are three distinct breeds in Kashmir, namely, the Poonchh, the Karnah, and the Kashmir valley. The first two breeds yield a heavy and soft fleece. The Kashmir valley sheep are small, produce colored fleece, and yield a mixture of fine and coarse wool. Besides these, three more important breeds found in the Kashmir, Kangra, and Kulu valleys are the Gaddi, Bhakarwal, and Rampur-Bushair breed found in Himachal Pradesh. Some Biangi sheep from Tibet have become mixed up with this breed.

2. The dry western region which includes Rajasthan, South-east Punjab, Gujarat, and parts of Western Uttar Pradesh. Of these states, Rajasthan is the leading wool-producing state in India. Possessing about one-fifth of the total sheep population, this state produces about one-third of the total Indian wool (Narayan, 1953). There are about 12.38 million sheep in

this region which yield 44.56 million pounds of wool or 63 per cent of the total national clip. Of this, about 30 million pounds are exported.

The long-eared Lohi, the brown-faced Bikaneri, and the black-faced Marwari are the three principal breeds in this region. The Lohi breed yields a very coarse fleece, but is known for its quality mutton. The Bikaneri or Chokla breed of Rajasthan is known for its excellent carpet wool, which is long, bulky, and springy with fibers well separated from each other. The sturdy, long-faced, and well-built Marwari sheep with black face, long legs, and prominent nose is found in Rajasthan. It yields a desirable white wool.

3. The Southern Region consists of Maharashtra, Mysore, Andhra Pradesh, Madras and some parts of Madhya Pradesh. There are about 26.63 million sheep (nearly 58 per cent of total sheep population of India) raised in this region, of which 12 million sheep in the eastern part of this region yield no wool.

The chief breeds are the Nellore, the Manyas, the Bellary, the Yelaga or Tenguri, and the small Bennuri. They are all long legged, long necked, and thin bodied, with drooping hind quarters and very short tails. They are famous only for their high-quality mutton.

The drier areas have a large number of the Deccani breed, which are small, hardy animals with coarse, hairy, and colored fleece. Their wool is used by local weavers for making blankets and carpets. This breed has been improved greatly by crossing with Merino and other fine wool-producing rams. The above-

mentioned Indian sheep population, location of distinct breeds, and types of sheep are shown in Figures 1 and 2.

Professional Indian shepherds earn their livelihood by maintaining flocks consisting of from 50 to 1,000 sheep. Mixed farmers also maintain flocks of less than 50 sheep. These shepherds clip their sheep twice yearly. This wool is dry, harsh, and devoid of grease and character. It was estimated that the average growth of wool in the Bikaneri sheep is about one inch per month. The winter clip is white and the summer clip is yellow in color (Singh and Sharma, 1952).

The system of sheep breeding practiced by the Indian shepherds has been haphazard and irregular. Sheep breed before maturity and all year around. This practice was obviously unsatisfactory. The best time to obtain lambs is in the spring; therefore sheep should be bred during the autumn and early winter (Singh and Sharma, 1952).

#### Early Efforts Towards Improvement of Indian Sheep

Efforts towards the improvement of sheep in the Deccan date as far back as 1836, when a project for sheep improvement and for development of the wool industry was launched by pioneers who were officials of the East Indian Company in Bombay, Deccan, Mysore, and Nilgiris. A large number of flocks of selected sheep were stationed at Ahmednagar and near the fort of Junnar in Poona district. Fine-wooled stud rams were imported from England and Cape Colony for crossbreeding with the local sheep. The Saxon, Cape Merino, and Southdown were the main breeds of exotic sheep

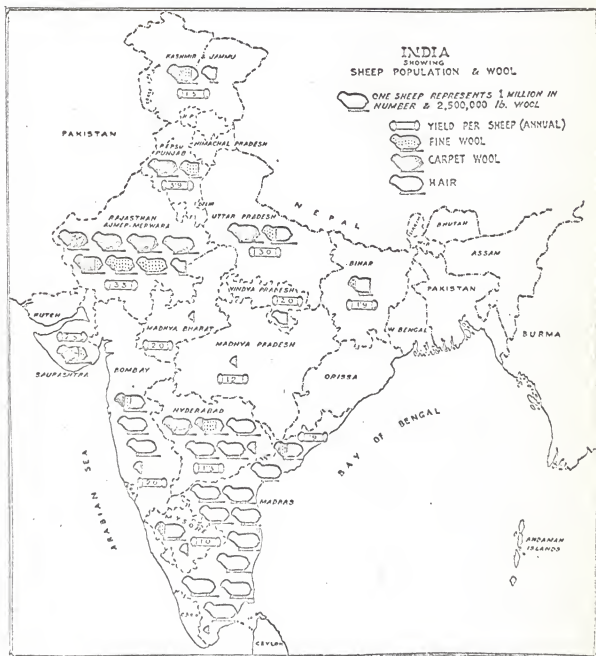


Fig. 1. India showing sheep population and wool.



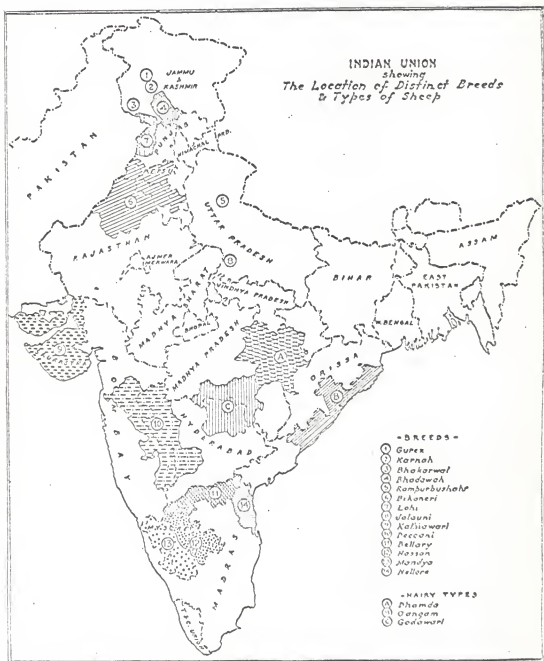


Fig. 2. Indian Union showing the location of distinct breeds and types of sheep.

used in this program. Sir George Arthur, the Governor of Bombay province at that time, took a keen interest in this work and for a time considerable progress was made with crossbreeding. The Cape Merino sheep were given preference in large scale crossbreeding, as this breed was supposed to be far superior and better adapted to this country. Red hairy sheep of India, after crossing with Southdown, became like the Southdown breed in size and wool in the second generation, and the white woolly sheep of India became like Merino and Southdown in size and wool, after crossing with Cape Merino and Southdown. It was hoped that the whole Deccan district could be converted into a fine wool-producing country. However, for some reason breeding and development of better sheep were unfortunately discontinued until the establishment of a livestock section of the Agriculture Department in the year 1919. The enthusiasm and foresight of the late Mr. E. J. Brun, the first livestock expert to the Government of India in sheep and wool improvement, bore fruit in the starting of the Sheep Breeding Research Station at Poona in the year 1937 under the auspices of the Indian Council of Agricultural Research (Khot and Deshpande, 1945; Khot and Ramchandran, 1948).

Other early efforts were initiated at Hissar Government Livestock Farm, Punjab, in 1906. The function of this farm was to develop an improved type of sheep and to establish a nucleus of pedigreed stock to breeders for the grading up of the local flocks. However, it was not successful, and it was not until 1928 that concerted efforts were made to achieve the objectives. Since 1936, selective breeding of indigenous Bikaneri sheep and

crossbreeding of Bikaneri with Australian Merinos has been in progress (Singh and Sharma, 1952).

Recent Developments Towards Improvement  
of Indian Sheep

The most important contribution in the development of Indian agriculture was due to the Indian Council of Agricultural Research established during the third decade of the twentieth century. Due consideration was given towards the improvement of sheep husbandry in the development plans. It was decided that experimental studies on the development and improvement of the indigenous breed should receive priority in the Plains areas, and that experiments in crossbreeding should be restricted to the Himalayan region and the western part of the Deccan plateau.

During the following years comprehensive plans for the establishment of Regional Sheep Breeding Stations were started and technical programs for selective breeding and crossbreeding were formulated. According to "Hindu", an Indian newspaper, January 7, 1951, the Advisory Board of the Indian Council of Agricultural Research discussed various schemes of agriculture and animal husbandry research at meetings held in New Delhi during January, 1951. One important scheme approved by the board is to make India self-sufficient in her requirements for comparatively finer types of wool which are presently imported. Under this plan, rapid development in the production of finer types of wool is envisaged both by crossbreeding with imported Rambouillet rams from the United States of America and by selective breeding to be carried out in the Sub-Himalayan region extending

from Kashmir to Uttar Pradesh and Rajasthan, Saurashtra, and the Deccan plateau covering Bombay state with substations in Mysore and Nilgiri Hills. This scheme is likely to cost about 4 lakhs Rupees (about 84 thousand dollars) over a period of five years.

For breeding pedigree sheep bearing wool of the desired standard, sheep improvement programs are being carried out under the direction of the Indian Council of Agricultural Research for breeding pedigree sheep producing wool of the desired standard. The following sheep farms were established in various parts of the country (Minett, 1950).

1. Government Sheep Breeding Farm, Banihal (Kashmir): This sheep farm lies between Jammu and Srinagar and is situated at 5,200 feet. The farm has abundant facilities for grazing and growing hay and other fodder. In November and December the ewes are mated and they lamb from April to June. The object of the farm is to test the grading up of local ewes with imported rams of Merino, Cheviot, Border-Leicester, and Wensleydale breeds.

2. Government Livestock Farm, Hissar (Punjab): Bikaneri sheep have been bred at this farm since 1928, and the object of the scheme has been to study methods of breed improvement and to gain some detailed information on feeding and pasturage, breeding, and general management. The soundness of results obtained on the farm is being tried on surrounding village flocks and approved rams are being distributed in villages for improving the local stock.

3. Government Sheep Farm, Monghyr (Bihar): It is situated near Gaya in Bihar state. At this farm breeding by selection and feeding experiments in sheep are being performed with a view to rearing and distributing rams. The intention of this farm is to breed a white sheep with superior wool.

4. Sheep and Wool Research Station, Poona: It is situated on forest land in the western part of Poona at 1,800 feet. Here the main object is to improve the wool producing capacity of the Deccan sheep through selection, crossing with the Merino, and to study the adaptability of Merino to the Deccan climate.

5. Government Livestock Research Station, Hasur (Madras): The sheep are maintained at the research station which is situated in the northwest corner of Salem District at about 3,000 feet. There has been a flock of Hasur since 1924. One of the objects is to evolve a white breed, yielding more wool of better quality, along with a heavy carcass suitable for mutton. For this purpose selected Bellary sheep have long been interbred, but since 1938 they have also been crossed with Bikaneri rams.

6. Government Sheep Farm, Orai (Uttar Pradesh): It is in district Jalaun about midway between Kanpur and Jhansi at 770 feet. The farm was started in November, 1938 and Bikaneri and local Jalauni sheep, about 100 of each breed, were introduced in the spring of 1939.

7. Government Sheep Breeding Farm, Patan-Mahsana (North Gujarat): As a part of the drive towards sheep and wool improvement in this area, the former Baroda Government established sheep breeding farm to rear improved and pedigree Pattanwadi

rams for distribution to sheep farmers in Patan Mahsana district. A wool analysis laboratory is attached to the farm to help in the selection and breeding of better wool bearing stock.

8. Sheep Farm, Ootacamund (Madras): In order to improve Nilgiri breed, this sheep farm was established in the year 1950. Selective breeding was carried on for about five years without an appreciable increase in the wool yield. The general health of the animals was found to be good and they were able to withstand the rigors of the climate very well.

In order to improve the breed, it was then considered that crossbreeding should be undertaken and the breed chosen for the purpose was Romney-Marsh. Therefore crossbreeding of the local Nilgiri sheep with imported Australian Romney-Marsh rams seems to have increased both size and wool production (Ramamurti, 1964).

9. Central Sheep and Wool Research Station, Pashulok Dehradun (Uttar Pradesh): The research station is situated at an altitude of about 1,000 feet in Doon Valley of Uttar Pradesh. The climate is very humid with 65-inch rainfall annually. The maximum temperature is  $110^{\circ}$  F. during summer and minimum temperature is  $28^{\circ}$  F. during winter. Crossbreeding work was mainly undertaken to develop a breed with more wool and a heavier carcass weight by mating indigenous sheep with exotic breeds.

Narayan (1956) stressed that India now has a better chance of rapid improvement in sheep breeding due to the recent formation of a Stud Sheep Breeding Association in Rajasthan. It helps members in buying and selling animals, in grading and marketing wool, in improving the carrying capacity of pastures, in

controlling sheep diseases, and in supplying useful information on the latest techniques employed in advanced sheep farming countries of the world. The sheep and wool improvement department will play a more effective role in putting the Association on a sounder footing.

Present Indian Government Plan to Accelerate  
Sheep Development Programs

The export value of sheep products is estimated to increase to about 35 crores Rupees (about 73 million dollars) by the end of the third five-year plan (March, 1966). During the second five-year plan 4 sheep breeding farms for the production of superior rams were started. Purebred rams were distributed to 305 sheep and wool extension centers in the established breeding tracts for the improvement of local stock. In addition to providing breeding facilities, these centers also demonstrate improved methods of shearing, grading, and marketing. In the third five-year plan 15 sheep breeding farms will be established and 17 farms expanded. In all, 2,000 to 2,500 quality rams will be supplied from these farms to flock owners; the production of wool by the end of the third five-year plan is expected to expand to approximately 90 million pounds. In view of greater demand by indigenous industry for quality wools, a large program for correct shearing as well as systematic grading is to be undertaken in Rajasthan. The plans of some states provide for loans for the introduction of sheep with a view to the development of mixed farming (second five-year plan, 1956).

### Importance of Selection

Selection is the most powerful instrument in the hands of the breeder in molding a type of animal which best suits his requirements. Selection brings about improvement of the breeding flock by retaining those animals with the most desirable characteristics and culling those with the least desirable ones (Krishna Rao, 1949).

Selection for Replacement of Ewes. Breeding ewes should be selected carefully for the establishment of new flocks. Uniformity of type along with efficient reproduction is the main desired economical characteristic of breeding flocks. Selected breeding ewes should be long in size, large framed with good conformation, sound mouth, well formed udders, roomy hind quarters, and deep and wide in chest. The back should be straight and strong. Selected ewes should be docile, well grown, healthy, and vigorous. Open white-face ewes should be preferred over sheep with heavily woolled heads. In wool producing breeds, the quality of fleece is of utmost importance because most of the wool is obtained from the ewes (Juneja, 1955, Kammlade and Kammlade, 1955, McAdams and Coppersmith, 1963).

Selection for Replacement of Rams. The importance of the sire had been realized long before the principles of scientific breeding and inheritance were well known. The selection of high producing rams is of utmost importance in any type of sheep improvement program. The selection of rams is more important because "sire is more than half the flock". Increased production should be attempted by mating rams of high producing stock



and, as far as possible, by using proven sires. The first opportunity for selection on productive value comes at weaning age. A second selection is made at yearling age at which time emphasis is placed on the same characteristics with the addition of fleece weight. Yearling traits may be somewhat more representative of breeding value than weaning traits (Krishna Roa, 1949). Staple length is important at weaning because it is the chief measure of fleece value at that age. Usually it is more economical to select as much as possible at weaning age (Terrill, 1946, Nordby, 1941).

Selected ram should be a good thick one which has quality, size, vigor, masculinity, sound mouth, good fleece, bone, and typical for his breed. This ram should be sure to fit into the type of ewe flock, active, strong and straight in the legs, evenly covered with a dense fleece. A good ram is more important than having high class ewes, because even ordinary flocks can be greatly improved by a continued use of good rams (Juneja, 1955, McAdams and Coppersmith, 1963).

Selection of sheep based on three different principles:

- (1) Selection based on the individuality--all selections of this type strictly based on individual phenotypic merit. It is referred to as mass selection. Those traits which are highly heritable or medium heritable will respond but not lowly heritable.
- (2) Selection based on pedigree. It is more useful in early age for prediction purposes. When selection is based on pedigree, the relatives should be closely related. Less than 25 per cent related relatives should not be considered.

(3) Selection based on progeny test. It is a special type of family type of selection. It should be used for breeding purposes in those traits which are lowly heritable. It is also necessary for traits that are sex limited and necessary in evaluating carcass merit. It is not needed for highly heritable traits (Rice et al., 1957).

The three most important methods of selection are: (1) Tandem method. It is the method of selection for one given merit at a time. Maximum emphasis is given on that trait. It can do more for a single trait than any other method, but it is difficult to select traits in relation to heritability and economic value. (2) Independent culling method. Several traits can be selected for a given trait. It should be two or more. Culling levels are established for each trait involved. Sheep are discarded when they do not reach the required level for any one trait. (3) Selection index method. It is the most common method, which is generally used in advanced sheep countries. It is efficient because it brings balance to economic value, heritability and genetic correlations. Maximum emphasis is given on traits which are high in economic value and heritability. Hazel and Lush (1942) reported that selection for a total score or index of net desirability is much more efficient than selection for one trait at a time. Selection for several traits by using independent culling levels for each is more efficient than tandem selection for each trait one at a time, the relative efficiency increasing with the number of traits and intensity of culling. Selection on independent culling levels is less efficient than

selection on total score.

Hazel (1943) stated that the genetic gain which can be made by selecting for several traits simultaneously within a group of animals is the product of (1) the selection differential, (2) the multiple correlation between aggregate breeding value and the selection index, and (3) genetic variability.

Hazel and Terrill (1946b) observed that standard partial regression coefficients, reflecting the relative economic importance of the various traits in the index, were as follows: face covering 0.403, neck folds 0.392, body weight 0.379, condition 0.155, staple length 0.142, and body type 0.009. The chief advantage of the selection index is that it emphasizes highly hereditary and economically important characters and provides a constant and objective basis for comparing individuals. Its disadvantages are that it is laborious to calculate and that some lambs must be culled for defects such as hairiness independently of the index.

Performance Testing Program. Performance testing is the practice of selecting animals on individual merits. The goal of performance testing is to identify the genetically superior individuals within a flock so that maximum genetic improvement can be made through their selection and breeding.

Record of performance is useful primarily to provide a basis for comparisons among sheep handled alike within a flock and not for comparing differences between flocks. Performance records are also useful for selecting the high producers and for culling undesirable animals. Maintaining production records on sheep produced in a flock helps to identify the best performing

individuals and gives information about the breeding value of the sires and dams that produced them. The performance of all individuals should be measured in order to identify those that are above average in total merit. Traits of high heritability respond more to selection than those of low heritability, and greater attention should be given to traits of higher economic value (Smith and McAdams, 1962).

Factors that determine rate of breeding improvement as a result of selection are: (1) Heritability of selected traits. (2) The amount of genetic variation, "selection differential" or "reach". (3) Number of traits selected for and genetic association among traits. (4) Accuracy of records and honest use of these in selection. (5) Number of animals from which to select. (6) Length of generation.

Differences between traits of individual sheep are due to two causes: genetic and environmental. Heritability is generally defined as the proportion of the differences measured or observed between animals that is transmitted to their offspring. In other words, it may be explained as the difference in a trait between animals which is not due to environmental effects. Theoretically, heritability for a trait may vary from 0 to 100 per cent. Heritability estimates are obtained under carefully controlled environmental conditions, with adjustments being made for known major environmental sources of variation. Heritability values may vary to some extent in different flocks due to existing genetic variability and the uniformity of the environment (Smith and McAdams, 1962).

Lush (1935) stated that the heritability is important to the breeder because it represents the proportion of the gain which is transmitted to the offspring through selected parents and is generally useful in estimating probable genetic improvement.

Hazel and Terrill (1945b) observed that the average estimates for heritability of weaning weight and staple length were  $0.30 \pm .04$  and  $0.40 \pm .05$ , respectively. Nelson and Venkatachalam (1949) found that the average heritability estimates for birth weight and weaning weight were  $0.61 \pm .09$  and  $0.33 \pm 0.12$ , respectively.

Terrill and Hazel (1946) observed that the average estimates of heritability were  $0.56 \pm .05$  and  $0.39 \pm .05$  for face covering and neck folds, respectively. Both face covering and neck folds are highly heritable when compared with other traits in weanling Rambouillets.

Hazel and Terrill (1946c) found that the average heritability of type (mutton conformation) was about  $0.13 \pm .04$ , while that for condition (degree of fatness) was about  $0.04 \pm .03$ .

Average heritability estimates for some important characteristics of sheep (Rice et al., 1957) are shown in Table 1.

Selection differential or "reach" is the difference between the selected individuals and the average of all animals in the flock from which they were actually selected. It is influenced by the proportion of the total selected, the number of traits selected for, and the prevailing variation present in the initial or total group. Selection differentials having high

Table 1. Average heritability estimates.\*

Trait	Heritability
Birth weight	.45
Weaning weight	.25
Yearling weight	.35
Multiple births	.15
Number of lambs reared	.05
Conformation	.10
Condition score	.10
Milk yield	.35
Face cover	.50
Skin folds--body	.50
Skin folds--neck	.25
Date of lambing	.35
Greasy fleece weight	.40
Clean fleece weight	.45
Staple length	.45
Fiber diameter	.40
Crimp number	.45
Marbling	.40
Fat thickness at 12th rib	.40
Rib eye area	.20
Weight of loin	.45

\*Rice et al., 1957.

values can usually be obtained in sire selection because of the relatively low proportion of males selected for breeding purposes. The progress from one generation of individual selection is equal to the individual's own record minus population average times the heritability.

Selection for a larger number of traits at one time usually results in slower progress for each trait. Genetic association may or may not exist among traits. If there is no association between traits, the traits are inherited independently. On the other hand, the genetic association between traits may be either

positive or negative. All the important traits are positive.

Traits must be measured accurately and honestly. Many traits, as body weight, length of fleece, and wool weight, can be accurately measured. Others such as face covering and conformation are harder to measure.

The larger the number of animals available the more strict the selection can be. Since sheep are not as prolific as swine, a larger percentage of the lamb crop must be selected for replacements, simply to maintain the flock size. This lowers the selection differential.

The shorter the generation time the faster the genetic improvement will be. Generation time in the sheep is longer than in swine, but shorter than in cattle. It averages about three years for sheep.

Selective Breeding Program. Buch and Jayaraman (1954b) emphasized that selective breeding can be very effectively carried out if the breeding practices are followed according to the basic principles of breeding. Breeding the flock at any time of the year or at all times in the year should be scrupulously avoided. Breeding season may begin following the monsoon in South India and Bombay Province. The Hissar Government Livestock Farm, Punjab, reported that March and April were the best suited for breeding in the northern regions.

Khot and Deshpande (1945) observed at Research Station, Poona, that the original flock on the farm had hairiness in the fleece varying from 7 to 80 per cent, but by pursuing a method of rigorous selection, it has been possible to breed a type of

sheep with insignificant hairiness in their coats.

Out of 250 ewes purchased for experimental work in regard to wool performance only 49 ewes have been retained and with their selected progeny, the farm now has a flock of 110 white-wooled Deccan sheep. They also reported that in order to test the results obtained at Research Station, Poona, in the purely rural environment and to extend the practice of selective breeding among village shepherds' flocks, a sheep breeding substation was started in 1941 at Javale in Sholapur district. A small white-wooled flock of selected Deccan sheep is maintained at this center to serve as a demonstration unit and also to enable the development of wool quality in this tract to be studied. The shepherds in the vicinity of the center, who are ready to cooperate in the development of better woolled sheep, are subsidized to enable them to maintain a white-wooled flock headed by a selected ram. These controlled flocks are now producing rams with superior fleece which are distributed among the neighboring village flocks to intensify the sheep improvement drive in the tract.

Doney (1955) observed that the weight of the first wool clip is also of value in a selection program. Simmons and Schott (1949) found that the average curl size produced in the breeding flock can be shifted by a few generations of selection. Smaller curl size is generally preferred in Karakul lambskin fur trade. Ræe (1948) observed that medullation is strongly inherited (50 to 70 per cent). Bryant (1933, 1936) was also of this opinion that the kemp is inherited and can be removed. Darling (1932)



concluded from his study that kemp could be removed from the fleece easily and the long hair could be modified. Wildman (1957) stated that kempy and non-kempy wool is a heritable characteristic and by selective breeding widely differing types of wool can be developed in the descendants of the original flock, and it is possible to stabilize the different wool types in later generations. Morley (1955) observed that the genetic correlation between face cover and fleece weights suggested that selection for fleece weight would increase "wool blindness", with possible diminution of reproductive efficiency. Selection for wools of good character would improve softness and would not decrease fleece weight. Hazel and Terrill (1946e) stressed that face covering and staple length can also be changed most rapidly by selection.

Desai and Winters (1951b) stressed that the lambing percentage rises as the age increases up to the fifth year of age and then gradually declines at an average rate of 0.1403 lamb. They also found that the daughters born to dams when young produced 0.0933 more lambs than those born to mothers when mature. It may be due to some physiological functions of dams having influence on the growing young one either in the intrauterine stage or during nursing. There are highly significant differences in the lambing averages of the ewes within the lines, emphasizing the importance of the individual ewe selection. The twin-born ewes give birth on the average to 0.12 more lambs than the single-born ewes. They also show more consistency in their higher performance throughout their productive life. The

frequency of triplet production is also higher in the twin-born group than in the single-born. Kincaid (1943), Thomson and McDonald (1955) observed that the heavier lamb at birth tended to be the heavier at weaning. According to Kincaid an average annual increase of 0.63 pound in birth weight of lambs occurred due to the influence of the selected sire.

Nanda (1947) stated that selective breeding in the Bikaneri breed leads to greater improvement in sheep stock and quality of wool than is possible by crossing of the local breed with improved Merino stock. He stressed that the use of Merino in the country has a limited scope, particularly on the plains, and it would be as paying, if not more so, on the plains to improve the quality and quantity of wool of indigenous breeds purely by selective breeding. His observations on selective breeding of Bikaneri and Lohi breeds at Hissar Government Livestock Farm, Punjab, are briefly given below.

Bikaneri and Lohi breeds can be classified into four types, namely, A, B, C, and D; according to the degree of medullation in their fleece, such that Type A has fine woolly fleeces with 0 to 20 per cent medullation. Type B has ideal carpet-type fleeces with 20 to 40 per cent medullation. Type C has coarse hairy fleeces with 40 to 70 per cent medullation. Type D has very coarse hairy fleeces with 70 and higher per cent medullation.

Attempts to increase types A and B, and to eliminate types C and D sheep, when more of A and B type rams were introduced each year, and C and D type ewes eliminated in successive years

on selection basis, over a period of three years, gave the following results:

Bikaneri Breed. Males in A increased the quality of wool from 5 to 8 per cent, and in B from 11 to 23 per cent; whereas the females in A increased from 7 to 15 per cent, but in B decreased from 22 to 18 per cent. In the case of C and D, the males increased from 36 to 50 per cent in C, but decreased from 49 to 19 per cent in D, while the females in C decreased from 38 to 41 per cent, those in D decreased from 33 to 27 per cent.

Lohi Breed. Males in A increased from 12 to 24 per cent, and in B from 12 to 15 per cent, whereas females increased from 8 to 22 per cent in A, and 14 to 20 per cent in B. The decrease effected in C and D was from 39 to 35 per cent and 39 to 26 per cent respectively in females, and from 36 to 20 per cent in males of D type only.

To start, only a small percentage of better type fleeces were available as the majority of ewes were in C and D classes. Shoulder samples of all the male progeny of the lamb's clip and of the female progeny at the second clip were tested to judge the improvement and to help in selection for future breeding. The improvement was gradual but he was successful in increasing the number of A and B type lambs each year.

Nanda and Singh (1948) reported that a program for improvement of fleece quality by selective breeding was started in Bikaneri and Lohi breeds at Hissar Sheep Farm in the year 1943-44. In five years, an appreciable improvement in the fleece quality of the flocks was accomplished with the help of an

improved system of judging fleece quality and resorting to judicious selection.

The procedure adopted for selective breeding consisted of classifying flocks of Bikaneri and Lohi ewes into A, B, C, and D types (on the same basis as Nanda, 1947, classified). More of A and B type rams were introduced each year and C and D type ewes were eliminated in successive years. This practice exhibited a gradual but distinct improvement in the new progeny with increased number of A and B type lambs each year.

They observed that in about four to five years' time, the percentage of progeny with fine type of wool increased from 6 to 30.4 per cent in Bikaneri flock and from 9.8 to 40.6 per cent in Lohi flock with a decrease in the coarse and hairy types from 41.1 to 10.8 per cent and 37.4 to 0 per cent in the two flocks, respectively. With continued selection, complete elimination of C and D types and the establishment of pure A or B type flock is now envisaged. Improvement would have been quicker had it been possible to use all A type rams from the very first year. Interbreeding of A type sheep produces a high per cent of A type of progeny, so grading up of C and D type ewes with A type rams is possible but the process is slow. It is evident that improvement of wool quality in Bikaneri and Lohi sheep is possible through careful selective breeding. Large-scale improvement in the village flocks can be undertaken, along the same lines, by establishment of breeding farms and issuing of tested rams in different localities. Singh and Sharma (1952) were able to increase the percentage of A and B type progeny in a flock from

22.8 to 81.4 per cent and decrease the percentage of D type progeny from 41.1 to 0.4 per cent during the period 1942 to 1950 through the intensive use of A type rams and the gradual elimination of C and D type sheep.

Hazel and Terrill (1945a, 1946a, 1946d), Terrill et al. (1947) and Blackwell and Henderson (1955) found that some of the environmental factors which interfere with the effectiveness of selection are sex, the age of dam, the type of birth, whether single or twin birth, and the degree of inbreeding correlation. They reported that adjustment for measurable effects of environmental factors would increase the effectiveness of selection. Ragab and Asker (1954) observed that age affected lambing percentage significantly. Ewes reached their maximum in twin births at the age of 7 to 8 years. There was a definite and significant indirect effect of sire on twinning. Nelson and Venkatachalam (1949) stressed that the variation in birth weight and weaning weight was due to differences in sex, type of birth, and age of dam. On the average, birth weights of females were 5 per cent less than males, lambs from mature ewes were 10 per cent heavier than those from 2-year-old ewes, and single lambs were 22 per cent heavier than twins. Botkin (1955) observed that ram lambs gained faster and were more efficient than ewe lambs and that efficiency can be improved essentially as much by selection for rate of gain as by selection for efficiency.

Yao et al. (1953) stated that highly heritable characters could be expected to give the most response in selection, while the characters with low heritability may be improved when line

selection and crossbreeding systems are practiced. Terrill and Hazel (1943) found heritability highest for body weight with an estimate of 40 per cent and lowest for body type score with an estimate of 12 per cent. The heritability for traits of economic importance in range sheep seems to be sufficiently high that considerable genetic progress can be achieved by careful selection for these traits. Warwick and Cartwright (1957) observed that heritability of weaning weight in lambs was high and that direct selection would be effective. Rendel (1956) stressed that the heritability of multiple birth in sheep was rather low. It appeared that heredity has a rather limited influence on fecundity in most animals.

Terrill (1951) observed that the expected progress in weaning traits from selection of sires was greater than from the selection of dams for staple length, face covering, and weight, and was generally two or three times as great for type and condition scores.

Improvement of Indian Sheep by Culling. Culling means elimination of inferior stock. Culling itself is the foundation towards building up a highly productive and almost ideal flock. Buch and Jayaraman (1954a) reported that culling is the first step towards the improvement of sheep. Every year, as each batch of female lambs reaches maturity and is to be added to the flock, the breeder can exercise his discretion in selecting the best and top ones from the flock of young ones and culling poor and uneconomic ones from the adult stock. Factors of economic importance like fertility, wool quality, body size,

quality and growth of lambs, fleece weights, etc., form the basis for culling.

The ram is actually of greater importance than the ewe, as one ram will be responsible for transmitting his characters to a greater number of his progeny, and for this reason very rigid culling has to be practiced in the case of rams. Juneja (1955) stressed that culling undesirable ewes such as those having defective udders, inferior quality wool, or poor milking qualities should be done annually. Such ewes should be replaced with selected ones at weaning time. Sheep over 6 years are generally uneconomical and should be discarded.

Hill (1921) observed that the variation in the amount of wool produced within typical range flocks is great enough to make culling a good method for increasing the average fleece weight without radically changing the type of sheep. There is a high enough correlation between a fleece produced after maturity and the weight of the subsequent fleeces produced by the same sheep to make culling effective. In fine-wooled sheep length of staple is highly correlated with fleece weight and total value.

Buch and Jayaraman (1954b) stressed that the ram plays a very important role in transmitting the qualities to the progeny, and hence all the rams showing any defective breed characters or a very high percentage of medullation should be castrated. Compulsory castration of scrub rams is necessary for improvement of sheep.

Singh and Sharma (1952) suggested that selective breeding

is more practicable, less expensive, and can easily be handled by shepherds. Nanda et al. (1946) stressed that at the present considerable possibilities to improve the quality of Indian wool and elimination of medullation is by selective breeding in sheep. The selection and culling can bring about rapid improvement in the quality of wool of the village flocks.

#### Crossbreeding Program

Since the days of Bakewell, crossbreeding has been an important tool available to breeders for improving livestock. Many new sheep breeds have been developed in recent years; some of the breeds developed in countries other than India are: Corriedale and Polwarth in Australia and New Zealand; Columbia, Targhee, Panama, and Romeldale in the U.S.A.; and Kuibishev in Russia. The only recognized crossbreed in India is the Hissardale, evolved by crossing Merino rams with Bikaneri ewes. Crossbreeding work has been conducted in India on a large scale during the last decade in Kashmir and in Bombay. According to Mudaliar (1958), crossbreeding is the cheapest, quickest, and easiest weapon in the hands of a breeder.

Raghavachari (1945) observed that wool yield is greater in the crossbreds at every stage of growth from lambs to adult and that the average body weights also favor the crossbreds. To achieve this, Bikaneri rams are mated with Black Bellary ewes at Research Station Hasur, in Madras.

Haksar (1947) pointed out that efforts made during the last 150 years to improve the local sheep by crossbreeding have been



"stray and unsustainable". He expressed the hope that successful crosses like the Hissardale can be produced by crossing Merinos with other local breeds. He observed that of the 146 sheep studied by Bombay University, 16 out of 18 sheep classed as fine were either pure Merinos or crossbred Merinos, and even among the 21 medium-quality sheep there were 3 crossbred Merinos. He advocated the introduction of Merino blood in local breeds to improve the quality of wool by making it finer and eliminating kemp and medullation. Asker et al. (1954) found that crossbreeding of the Ossimi and Rahmani breeds resulted in crossbred lambs superior to the purebred animals in weight, body measurements, and daily gain at birth, 4 months (at weaning), and 8 months of age. The Rahmani ewes produced heavier and larger crossbred lambs than the Ossimi ewes at birth and at weaning age only.

Khot and Deshpande (1945) mated a few Deccan ewes every year to a Merino ram to ascertain to what extent the fine-wooled character is inherited in the crossbred progeny. In the first generation, these sheep yield a much superior, finer grading wool, and some produce almost as fine wool as the Merino sire. All the inherent colors of the Deccan sheep appear in the progeny, although all the ewes that were mated to the Merino rams had white fleeces. The crossbred sheep yield 2 and 1/2 to 5 pounds of wool and are hardier than the Merino. They can withstand the Deccan conditions easily with careful shepherding and a cultivating class of shepherds would be in a good position to rear such a type of sheep.

Desai and Winters (1951a) stressed that the most effective

method of improving fertility would be to cross the lines under consideration with some other outstanding lines or perhaps with other breeds of known high fertility in order to bring in new genes for fertility. If no other line or breed is available that has a higher degree of fertility, it is possible that crossing with a breed of the same degree of fertility would be useful. The hope would be that the recombination of genes might prove beneficial. Rae (1952) found that the crossbreeding generally leads to increase in fertility and growth rate of the lambs.

Bywater (1945) stressed that the North (Border Leicester cross with Cheviot) ewe when mated to lowland rams was superior to Lincoln, Suffolk, Cheviot, and Kerry Hill ewes in number of lambs born, reared, and in total live weight of lambs per ewe. Phillips (1951) reported that Cheviot half-bred ewes produced 20 to 35 per cent more lambs than purebred Romney ewes. Both types of ewes were mated to Southdown rams. Lambs from the Cheviot half-bred ewes were slightly heavier at slaughter and graded slightly better than the Romney-cross lambs. Coop and Clark (1952) observed that the growth rates of the lambs by the heavy sires, Border Leicester, Dorset Horn and Suffolk, were greater than those of Southdown-cross lambs by approximately 0.09 pound live weight gain per day. The carcass weights of the lambs by the Border Leicester, Dorset Horn, and Suffolk rams were 4 pounds heavier than the Southdown. The lambs by the Rayeland and Southdown-Suffolk rams occupied an intermediate position.

Uniyal (1951) reported that an Australian Merino ram brought

by Sir Narendra Saha Bahadur was supplied to a local shepherd in 1941 with the object of determining the effects of crossbreeding with this ram on the woolen industry in Tehri-Garhwal district of Uttar Pradesh. The ram and its crosses survived well, but the local shepherds rejected both in the beginning till "Acha Dogla" (progeny of half brother and half sister) could be obtained. "Acha Dogla" was supposed to be a very good cross and it was said that it was  $7/8$  like the sire in stamina and was intelligent like the local sheep. It produced fine white wool, about 6 pounds per annum.

Another experiment was conducted at Mala Danpur Sheep Farm in Almora district of North Uttar Pradesh (Purohit, 1962). Crossbreeding with Polwarth rams at the farm and also in villages near the farm was taken up since 1956 to form a new breed for the area. Rampur-Bushair ewes were selected for crossbreeding with Polwarth rams at the farm and local Danpur ewes were selected in the rural area.  $F_1$  ewes produced more wool than the straight breeds. The annual wool yield was increased. During the period 1959-60 the yearly wool production was 2 pounds 8 ounces for the Rampur-Bushair ewes and 3 pounds 13 ounces for the  $F_1$  ewes. The wool yield in the villages was increased about four times in crossbred progeny.

Khot (1963a) reported that the results of crossbreeding work carried out in Kashmir state caused the Indian Council of Agricultural Research to sponsor in 1952 a regional scheme for establishing sheep breeding farms and for carrying out experimental breeding in the states of Jammu and Kashmir, Uttar

Pradesh, and Himachal Pradesh. A few sheep of the Rambouillet, Merino, and Polwarth breeds were obtained for evolving new breeds by crossbreeding with local types. During the last 10 years, the work of breeding productive sheep has been taken up at 4 sheep farms in Jammu and Kashmir, 3 farms in Himachal Pradesh, and 9 farms in Uttar Pradesh. At present purebred flocks of Rambouillet, Polwarth, and Spanish Merino are being maintained at these farms, along with a large number of crossbred progeny. Recently a flock of Stavropolskaya sheep from Russia has also been imported and maintained at a new farm near Srinagar in Kashmir.

The important program of making available superior rams for grading up the village flocks is accomplished by establishing sheep and wool extension centers. At each center, a few purebred or high-grade rams are maintained and loaned to flock owners during the breeding season. The work, at present, is extended to 64 centers in this region and among a quarter million sheep. The wool of the crossbred types is finer, more homogeneous, and less hairy. The crossbred sheep yield 3 to 5 pounds of wool per year compared to 2 pounds obtained from the local sheep. The Indian Council of Agricultural Research obtained experimental results from several sheep research stations in 1945 as follows: by crossing Bellary with Bikaneri sheep the wool yield can be increased by about 2 1/2 times in ewes in the first crosses. Imported Merino stock and their progeny born in Kashmir can maintain their yield and quality of wool under Kashmir climate and environment.

Gorman et al. (1942) and Haley et al. (1961) found that lambs from Rambouillet ewes and Columbia rams were heavier than those sired by Corriedale, Lincoln, or Romney rams at 140 days of age, but in character of fleece the Corriedale was highest, in length of staple produced in 12 months the Lincoln ranked highest, in pounds of grease wool produced in 12 months the Columbia ranked highest. The same type of crossing with sires of the Hampshire, Suffolk, Shropshire, and Southdown, Miller (1935) observed that lambs of larger breeds, the Hampshire and Suffolk, were 6 to 8 pounds more in weight at 3 1/2 to 4 months of age than lambs of smaller breeds such as the Shropshire and Southdown. In birth weight, the crosses ranked Hampshire, Suffolk, Shropshire, Romney, Rambouillet, and Southdown. In crossing Columbia, Corriedale, Romeldale, and Border Leicester ewes with Suffolk ram, Cassard et al. (1956) found that the Border Leicester cross lambs were heaviest, followed by Columbia cross. In lamb production performance Columbia cross ewes led, followed by the Border Leicester, Corriedale, and Romeldale crosses. Corriedale cross produced the most wool and Romeldale crosses had the lowest wool yields. Hultz et al. (1935) used rams of Hampshire, Suffolk, Lincoln, Rambouillet, Corriedale, and Southdown breeds on range ewes. They observed that the lambs sired by Suffolk rams grew fastest, followed by Hampshire, Lincoln, Rambouillet, Corriedale, and Southdown-sired lambs.

Patnaik (1944) stressed that in Orissa state, under local conditions, with nondescript sheep, the best and the easiest way of effecting their mass improvement is to create and establish

in every village economic sheep breeding units, each with a minimum of 50 selected young healthy ewes, preferably of white color and as uniform a type as possible. This should be followed by grading continuously till the sixth generation with purebred Bikaneri rams capable of transmitting their characters to the progeny and culling the male as well as the undesirable female progeny on the basis of actual records of production and disposing of them as fat stock. At the sixth generation Orissa will have a breed of sheep of her own with 98.5 per cent of Bikaneri blood and for all practical purposes, they can be considered as a pure breed.

The following recent experimental studies showed that the crossbreeding or grading up to the indigenous breed with exotic rams increased their characters in crossbred progeny. Tyagi (1965a) observed that when the Rampur-Bushair ewes were mated with Polwarth rams and the half-blood Polwarth ewes were back crossed with Polwarth rams, the crossbred had a marked advantage over the average of purebreds and Rampur-Bushair in fertility and survival rates. Heterosis was noted in fertility and survival rates which made the crossbreds better and more productive than either of the parental breeds. The crossbreds showed 15 per cent decline in annual average raw wool yield as compared with the average of purebreds, but there was an increase of 53 per cent over that of Rampur-Bushair. The increase in raw wool yield of cross breeds over that of indigenous breed showed an appreciable advantage in crossbreeding. The average body weight of crossbred ewes declined 21 per cent and 1 per cent as compared

with the average purebreds and Rampur-Bushair, respectively. Therefore it was observed that no increase was noted in body weight in crossbred ewes, as shown in Table 2.

Miller and Dailey (1951) observed the same kind of result as Tyagi by mating Shropshire, Columbia and Hampshire ewes to another breed. They found that the average total productivity of the ewe was 16 per cent more in crossbred than the purebred. The crossbred lambs were heavier and had higher livability than the purebreds. This increase in productivity was due to heterosis and rams of the larger breed. Wilkinson (1950) observed that in cross of Welsh Mountain ewes with Border Leicester and Dorset Horn rams, the Border Leicester cross was more prolific, averaging 158 per cent of lambs born alive and 154 per cent reared as against 136 per cent of lambs born alive and 129 per cent of lambs reared from the Dorset Horn and Welsh Mountain cross. The Border Leicester cross was also more uniform, although wether lambs of both crosses fattened well. Foster and Hostetler (1939) observed that when native North Carolina ewes were crossed with purebred Shropshire and Hampshire rams, the first cross Shropshire and Hampshire ewes at yearling and mature age were heavier than the native ewes but lighter than the purebred Hampshire ewes. The second cross did not show an increase in weight over the first crosses but they did show more improvement in conformation and quality. Fleeces from ewes sired by Shropshire or Hampshire rams were heavier and usually of longer staple than those from native ewes. Shropshire crosses showed more improvement in these respects than did the Hampshire crosses

Table 2. Summary of results from Polwarth and Rampur-Bushair crossbreeding.\*

Character	Polwarth	Rampur-Bushair	One-half blood Polwarth	Average of pure-bred parents	Per cent by which cross-breeds exceed average of purebreds	Per cent by which cross-breeds exceed average of Rampur-Bushair
Annual per cent fertility	48	40	95	44	+51	+55
Annual per cent adult survival	77	85	97	81	+16	+12
Annual per cent lamb survival	56	71	81	63.5	+17.5	+10
Annual average raw wool (for ewes) in pounds	7.09	2.71	4.51	4.9	-15	+53
Average body weight of ewes in pounds	91.49	60.11	59.65	75.80	-21	-1

\*Tyagi (1965a).



and their fleeces were also of higher quality, especially in fineness of fiber. The fleeces from the second cross showed improvement over those from the first crosses only in quality of fleece.

In another experimental study Tyagi (1965b) mated Bikaneri ewes with Polwarth rams. He observed a decrease in adult mortality rate of about 22 per cent and 18 per cent from the half-blood Polwarth and three-fourths blood Polwarth sheep, respectively, compared to the Bikaneri. The crossbreeds had better adaptability, but there was no improvement in the survival rate of lambs. An increase of 45 per cent in the lambing percentage of half-blood Polwarth ewes over that of Bikaneri indicated a marked increase in fertility of crossbreeds. It was concluded that there was a definite improvement in raw wool yield of half-blood Polwarth ewes compared to the Bikaneri; however, further gains were not obtained by back crossing. There was a highly significant rise, about 11.5 per cent, in the body weight of half-blood Polwarth ewes over that of Bikaneri, but the three-fourths blood Polwarth and seven-eighths blood Polwarth ewes declined in weight.

Sidwell et al. (1962) reported that the fertility, prolificacy in the ewes, livability in lambs, and overall reproductive ability were generally higher for crossbred than for purebred matings. They again reported, in 1964, that all crossbred lambs were heavier: 7 pounds for weaning weight, 0.63 pound for birth weight, and 6.5 pounds gain from birth to weaning time than purebred lambs involving the same breed. Crossbreeds always

excelled over comparable averages for purebreds for each trait. Crossbreeding improved market lamb production.

Singh and Prasad (1962) observed that when Shahabadi (plain-type Bihar sheep) sheep were mated with Bikaneri rams, the  $F_1$  Bikaneri lambs on the average were heavier at birth than pure Bikaneri or Shahabadi lambs in Bihar. Singh *et al.* (1962) reported that the Shahabadi lambs, on the average, had the highest live weight, Bikaneri lambs the lowest, and graded lambs intermediate up to 1 1/2 months of age. From the age of 1 1/2 to 3 months, the graded and Bikaneri lambs grew consistently faster than Shahabadi lambs. This indicated that environmental conditions at the Sheep Breeding Farm, Gaya in Bihar, had pronounced adverse effect on Bikaneri and graded lambs in the first 1 1/2 months of growth. Considering average daily gain to 90 days of age, it was observed that the grades grew significantly faster than the Bikaneri and Shahabadi lambs, as shown in Table 3.

Table 3. Average live weights and daily gains to 90 days of age.\*

Type of sheep	Average live weights, pounds						Average daily gain in 90 days per animal, pound
	15 days	30 days	45 days	60 days	75 days	90 days	
Shahabadi	9.57	12.86	15.70	17.84	19.46	20.83	0.178
Bikaneri	8.89	11.24	14.16	17.85	20.54	22.98	0.182
Graded ( $F_1$ )	9.54	12.21	15.11	18.10	21.55	23.62	0.217
Overall	9.45	12.29	15.17	17.97	20.69	22.39	0.199

\*Singh *et al.* (1962).

## Artificial Breeding Program

Buch and Jayaraman (1954) stressed that in order to step up the desired improvement in Indian sheep, artificial insemination may be useful. Along with the regional centers, stud ram farms may be established in suitable areas where the village flocks can be inseminated in large numbers. Artificial insemination of sheep is practicable and is capable of speeding up progress in sheep improvement, as evident from the reports from countries like Russia and South Africa where remarkable results have been achieved in this direction. For example, in Russia 14,500,000 ewes were inseminated in 1939 with the semen collected from 41,274 rams, giving an average of one ram for every 280 ewes (Ozin, 1939).

In India, preliminary investigations in artificial insemination work with sheep were carried out at the Indian Veterinary Research Institute Izatnagar, Uttar Pradesh, under a scheme of the Indian Council of Agricultural Research.

Gunn (1936), Walton (1938), and Guha et al. (1951) all reported the artificial vagina is a more satisfactory method of collecting ram semen for insemination than other methods, such as electrical stimulation.

Guha et al. (1951) inseminated 198 ewes. Of these, a number of sheep were inseminated at the Sheep Breeding Farm, Hissar, Punjab. Fractions of the total ejaculate varying from 1/2 to 1/65 were tried in inseminating ewes. Success was obtained with fractions up to 1/40. Overall percentage of pregnancy, including all animals for which pregnancy results were available, was

58.3 per cent. They emphasized that an extensive utilization of artificial insemination in sheep breeding would greatly benefit the Indian livestock industry. There is an immense scope for the adoption of artificial insemination in sheep production. The results obtained in these experiments have given encouraging indications regarding its applicability on an extensive scale.

In Russia, an average conception rate of 97 per cent has been obtained in artificially inseminated ewes (Kersin, 1937).

Keast and Morley (1949) obtained conception rates with the diluted and undiluted semen of one ram that were 47 and 60 per cent, respectively, while the other ram conception rates were 56 and 69 per cent, respectively. This data showed that the diluted semen gave results about 13 per cent below the undiluted semen. Emmens and Blackshaw (1955) observed that insemination of fresh, undiluted ram semen gave satisfactory results of 54 per cent, but dilution rates of even one in four caused a significant fall in fertility of about 20 to 31 per cent, which is not prevented by the addition of egg yolk to the medium. First et al. (1957) stressed that when frozen ram semen diluted with milk, 7 per cent glycerol, and 1.25 per cent arabinose was compared with the inseminating of 0.2 ml. of freshly collected undiluted semen in a breeding trial involving first service to 23 Hampshire ewes. They got of 12 ewes bred with frozen ram semen 17 per cent lambed with a 33 per cent lamb crop, whereas 64 per cent of 11 control ewes lambed with a 109 per cent lamb crop. First et al. (1961) observed that 46 ewes were cervically

inseminated with  $100 \times 10^6$  unfrozen sperm diluted in heated homogenized milk, yolk citrate or yolk citrate glucose urea diluter. The per cent of ewes lambing after insemination diluted in yolk citrate was 21.4, homogenized milk 46.7, and yolk citrate glucose urea 17.7. This data showed that conception rates were higher with milk diluents than yolk citrate. Moule (1962) observed that dilutions of more than 1:1 to 1:10 result in severe falls in fertility. He also stressed that fructose in standard diluents improved fertility by 4 to 7 per cent as compared with the undiluted semen, and in comparison with glucose or citrate by 5 to 8.5 per cent.

Koger (1951a) and Perry (1960) observed that 50 million or more fresh sperm per insemination were required for conception rate of more than 50 per cent.

Koger (1951b) observed that the storage of sperm in citrate egg yolk or phosphate egg yolk diluters for 24 hours resulted in a significant decrease in fertility. There was a further sharp decrease in fertility with longer periods of storage, as shown in Table 4. Emmens and Blackshaw (1955) observed that a conception rate of no more than 5 per cent could be obtained with deep-frozen semen, while undiluted fresh semen inseminated at the same time resulted in a 54 per cent lambing rate. Perry (1960) obtained a range of 17 to 45 per cent conception with ram semen stored for one to seven days. Roberts and Houlahan (1961) observed that fresh semen resulted in 75 per cent conception, while 24 hours stored undiluted and diluted semen yielded 47 and 32 per cent conception, respectively, when the

Table 4.

No. of days semen was stored	No. ewes bred	Percentage of pregnancies
0	36	52.8
1	35	45.7
2	34	32.1
3	37	18.9
4	33	9.1
5	34	0.0

semen was stored at 8 to 12° C. and diluted with the egg diluter. Guha *et al.* (1951) inseminated ewes with diluted semen with egg yolk phosphate and egg yolk citrate diluents. Semen preserved up to seven days gave success in ewes. In 198 inseminated ewes 98 were pregnant; that is, conception rate was about 48 per cent. Salamon and Robinson (1962) observed that the maximum duration of storage of ram semen with diluents was 24 hours and even this would probably result in a loss of fertilizing capacity of about 15 per cent. Aslanjan (1951) observed that the semen was diluted in yolk citrate, stored at 0° C. in thermostats and transported 20 to 1,200 km. by aeroplane. The time between collection and insemination varied from 6 to 168 hours. Of the 4,709 ewes inseminated, 93 per cent conceived and 108.6 lambs were born per 100 ewes. It is concluded that storage of ram semen for two to three days at 0° C. does not affect the conception rate.

## SUMMARY

Selective breeding is slow, but it is more practical, less expensive, and can easily be handled by the shepherds. It would be most effective in improving fleece weights in the average range flocks of sheep existing in Northern India. To bring about rapid improvement in Indian sheep, mass castration of scrub rams is necessary.

It is also necessary to adopt advanced methods of selection on a large scale for the improvement of sheep in India. Keeping performance records of individual animals in the flocks will be of great value in selecting replacement animals and for culling. In selective breeding all rams should invariably be subjected to the progeny test at the close of the breeding season and only those rams should be retained for breeding which show a high percentage of superior offspring. Selection indexes may also be useful.

Although crossbreeding is more expensive than selective breeding, it decreases the mortality rate and improves the fertility in ewes as compared with indigenous sheep. Crossbreeding of the indigenous sheep with exotic rams seems to have given a higher yield of wool and heavier lambs. Crossbreeding with improved breeds is essential in order to rapidly improve the inferior sheep found in parts of Central and South India.

In order to speed up the improvement of sheep in India, artificial insemination may be useful. Along with the regional centers, stud farms should be established in suitable areas from where the village flocks can be inseminated in large numbers.

The average yield of wool of indigenous sheep has been increased from 2.0 to 6.0 pounds per head by careful selection and crossbreeding programs. It is possible to improve the quality and quantity of wool and mutton in Indian sheep by application of advanced selection methods and careful crossbreeding.



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## LITERATURE CITED

- Asker, A. A., M. T. Ragab, and A. E. Bastawisy.  
Effect of crossing of Egyptian sheep on growth and development of lambs. *Empire Journal of Experimental Agriculture* 22:256-260, 1954.
- Aslanjan, M. M.  
The transport of semen of Ascanian fine woolled rams. *Animal Breeding Abstracts* 19:79, 1951.
- Blackwell, R. L., and C. R. Henderson.  
Variation in fleece weight, weaning weight and birth weight of sheep under farm conditions. *Jr. of Ani. Sc.* 14:831-842, 1955.
- Botkin, M. P.  
Selection for efficiency of gain in lambs. *J. of Ani. Sc.* 14:1176, 1955.
- Bryant, D. M.  
A note on the inheritance of kemp in Blackface sheep. *J. of Text. Inst.* 24:T309, 1933.
- Bryant, D. M.  
Incidence of kemp in the fleece of Scottish Mountain Blackface sheep with special reference to inheritance. *Empire J. of Exp. Agri.* 4:165-185, 1936.
- Buch, B. B., and S. Jayaraman.  
Culling--a means for improvement of sheep. *Indian Farming.* New series 3(10):24-26, 1954a.
- Buch, B. B., and S. Jayaraman.  
Improvement of Indian sheep. *Indian Vety. J.* 30:320-324, 1954b.
- Bywater, T. L.  
Crossbreeding of sheep. *Animal Breeding Abstracts* 14:150, 1945.
- Cassard, D. W., W. C. Weir, D. T. Torell, and J. E. Wilson.  
Performance of crossbred ewes. *California Agriculture* 10 (10):11-12, 1956.
- Coop, I. E., and V. R. Clark.  
A comparison of breeds of ram for fat lamb production. *New Zealand J. of Sc. and Technology* 34A:153-171, 1952.
- Darling, F. F.  
Studies on the biology of the fleece of the Scottish Mountain Blackface breed of sheep. *Z. Suscht. B.* 24(3):359-390, 1932.

- Desai, R. N., and L. M. Winters.  
The inheritance of fertility in sheep. Indian J. of Vety. Sci. and Ani. Husb. 21:191-195, 1951a.
- Desai, R. N., and L. M. Winters.  
An appraisal of factors affecting fertility in sheep. Indian J. of Vety. Sci. and Ani. Husb. 21:177-189, 1951b.
- Doney, J. M.  
Problems of Hill sheep improvement. Proc. of British Soc. of Ani. Prod., pp. 3-12, 1955.
- Ermens, C. W., and A. W. Blackshaw.  
The fertility of frozen ram semen and bull semen. The Australian Vety. J. 31:76-79, 1955.
- First, N. L., A. Seirnge, and H. A. Henneman.  
Fertility of frozen and unfrozen ram semen. J. of Animal Science 20:79-84, 1961.
- First, N. L., H. A. Henneman, and J. A. Williams.  
The influence of glycerol and various diluents on low temperature survival of ram spermatozoa. J. of Animal Science 16:1106, 1957.
- Foster, J. E., and E. H. Hostetler.  
Changes in meat and wool characteristics resulting from the use of purebred mutton rams on native ewes. North Carolina Agri. Exp. Sta. Tech. Bulletin 60, April, 1939.
- Gorman, J. A., F. S. Hultz, R. L. Hiner, O. G. Hankins, and D. A. Spencer.  
Crossbreeding for lamb and wool production. Wyoming Agri. Exp. Sta. Bulletin 254, June, 1942.
- Guha, S., M. L. Kohli, and P. Bhattacharya.  
Artificial insemination in sheep and goats at Izatnagar. Indian J. of Vety. Sci. and Ani. Husb. 21:171-176, 1951.
- Gunn, R. M. C.  
Bull. Coun. Sci. Indust. Research, Australia, No. 94, 1936.
- Haksar, R. C.  
A method of improving India's wool production. Indian Farming 8(1), 1947.
- Haley, M. J., R. C. Carter, J. A. Gaines, and C. M. Kincaid.  
The effect of breed of sire on body size of lambs at birth. J. of Animal Science 20:154-158, 1961.
- Hazel, L. N.  
The genetic basis for constructing selection indexes. Genetics 28:476-490, 1943.

- Hazel, L. N., and J. L. Lush.  
The efficiency of three methods of selection. *J. of Heredity* 33:393-399, 1942.
- Hazel, L. N., and C. E. Terrill.  
Effects of some environmental factors on weaning traits of range Rambouillet lambs. *J. of Animal Science* 4:331-341, 1945a.
- Hazel, L. N., and C. E. Terrill.  
Heritability of weaning weight and staple length in range Rambouillet lambs. *J. of Animal Science* 4:347-358, 1945b.
- Hazel, L. N., and C. E. Terrill.  
Effects of some environmental factors on fleece and body characteristics of range Rambouillet yearling ewes. *J. of Animal Science* 5:382-388, 1946a.
- Hazel, L. N., and C. E. Terrill.  
The construction and use of a selection index for range Rambouillet lambs. *J. of Animal Science* 5:412, 1946b.
- Hazel, L. N., and C. E. Terrill.  
Heritability of type and condition in range Rambouillet lambs. *J. of Animal Science* 5:55-61, 1946c.
- Hazel, L. N., and C. E. Terrill.  
Effects of some environmental factors on weaning traits of range Columbia, Corriedale and Targhee lambs. *J. of Animal Science* 5:318-325, 1946d.
- Hazel, L. N., and C. E. Terrill.  
Heritability of weaning traits in Columbia, Corriedale and Targhee lambs. *J. of Animal Science* 5:371-377, 1946e.
- Hill, J. A.  
Studies in the variation and correlation of fleeces from range sheep. *Wyoming Agri. Exp. Sta. Bulletin* 127. April, 1921.
- "Hindu."  
*Indian Vety. J.* 27:289, January 7, 1951.
- Hultz, F. S., J. A. Gorman, and S. S. Wheeler.  
Crossbreeding with Western ewes. *Wyoming Agri. Exp. Sta. Bulletin* 210, 1935.
- Indian Council of Agricultural Research.  
Facts about feeding and breeding of sheep and goats. *Indian Farming* 6(9):417, 1945.

- Jayaraman, S., and B. B. Buch.  
Selection and management of rams. Indian Farming (New Series) 3(6):20-22, 1953.
- Juneja, G. C.  
Flocks pay well if bred well. Indian Farming (New Series) 5(2):9-11, 1955.
- Kammlade, Sr., W. G., and W. G. Kammlade, Jr.  
Sheep Science. J. B. Lippincott Company, p. 149, 1955.
- Keast, J. C., and E. H. W. Morley.  
Some observations on artificial insemination of sheep. Australian Vety. J. 25:281-287, 1949.
- Kersin, I. A.  
Artificial insemination of sheep and cattle on collective farms in 1936. Animal Breeding Abstracts 5:252, 1937.
- Khot, S. S.  
Sheep rearing in the Himalayas. Indian Farming 13(1):47-48, 1963a.
- Khot, S. S.  
Towards better sheep and wool. Indian Farming 13(7):18-19, 1963b.
- Khot, S. S., and A. K. Deshpande.  
Sheep breeding and wool research in Bombay. Indian Farming 6(7):309-311, 1945.
- Khot, S. S., and K. N. Ramchandran.  
Fine woolled sheep in Nilgiris. Indian Farming 9(2):63-66, 1948.
- Kincaid, C. M.  
Influence of the sire on the birth weight of lambs. J. of Animal Science 2:152-156, 1943.
- Koger, M.  
Storage, dilution and use of ram semen in artificial breeding of sheep. Animal Breeding Abstracts 21:163-164, 1951a.
- Koger, M.  
Storage, dilution and use of ram semen in artificial insemination of sheep. New Mexico Agri. Exp. Sta. Bulletin 366, 1951b.
- Krishna, Rao, C. Lt.  
Recent advances in sheep breeding methods in the U.S.A. Indian Vety. J. 26:186-195, 1949.

- Kumar, L. S. S., A. C. Aggarwala, H. R. Arakari, M. G. Kamath, E. N. Moore, and R. L. Donahue.  
Agriculture in India, Vol. III. Animals. Asia Publishing House, London, pp. 31-32, 1963.
- Lush, J. L.  
The inheritance of productivity in farm livestock.  
Part V. Discussion of preceding contributions.  
Empire J. of Exp. Agri. 3:25-30, 1935.
- McAdams, V. E., and R. L. Coppersmith.  
Early lambs in Kansas. Circular 315, November, 1963.
- Miller, R. F.  
Crossbreeding investigations in the production of California spring lambs. California Agri. Exp. Sta. (Berkeley) Bulletin 598, December, 1935.
- Miller, R. F., and D. L. Dailey.  
A study of crossbreeding sheep. J. of Animal Science 10:462-468, 1951.
- Minett, F. C.  
Mortality in sheep and goats in India. Indian J. of Vety. Science and Ani. Husb. 20:69-103, 1950.
- Morley, F. H. W.  
Selection for economic characters in Australian Merino sheep. VI. Inheritance and interrelationships of some subjectively graded characteristics. Australian J. of Agri. Research 6:873, 1955.
- Moule, J. P.  
The semen of animals and artificial insemination.  
Published by Commonwealth Agri. Bureaux, Farnham Royal, Bucks, England, 1962.
- Mudaliar, T. V.  
Selective breeding. Indian Vety. J. 35:89-90, 1958.
- Nanda, P. N.  
Improvement of quantity and quality of wool in India.  
Indian Farming 6(1):4, 1947.
- Nanda, P. N., and Gurbax Singh.  
Improvement of wool quality by selective breeding in Bikaneri and Lohi sheep. Indian J. of Vety. Sci. and Ani. Husb. 18:195-201, 1948.
- Nanda, P. N., Gurbax Singh, and S. B. Mogra.  
A rapid field method of estimating medullation in wool and a plan for improvement of village flocks. Indian Farming 7(1):8-10, 1946.

- Narayan, N. L.  
Rajasthan will breed better stud rams. Indian Farming  
6(2):24-25, 1956.
- Narayan, S.  
Popularizing Bikaneri sheep. Indian Farming (New Series)  
3(2):22-23, 1953.
- Nelson, R. H., and G. Venkatachalam.  
Estimate of the heritability of birth weight and weaning  
weight of lambs. J. of Animal Science 8:607-608, 1949.
- Nordby, J. E.  
Sheep improvement for range production. Idaho Forester  
Vol. 23, 1941.
- Ozin, F.  
Fulfilling the State plan of grading and artificial  
insemination of sheep. Animal Breeding Abstracts  
9:224, 1939.
- Patnaik, U.  
Establishment of sheep breeding units in Orissa.  
Indian Farming 5(2):65-66, 1944.
- Perry, E. J.  
The artificial insemination of farm animals. Rutgers  
University Press, 3rd Revised Ed., p. 190, 1960.
- Phillips, T. O.  
Results of Cheviot half bred versus Romney trials. Half  
bred Cheviot cast for age ewe for fat lamb production.  
Animal Breeding Abstracts 20:354, 1951.
- Purohit, K.  
Crossbreeding with Polwarth rams in Malla Danpur (Almore),  
U. P. Indian Vety. J. 39:275-278, 1962.
- Rae, A. L.  
Modern approach to sheep breeding. Wool Palmerston,  
North New Zealand, 1948.
- Rae, A. L.  
Crossbreeding of sheep. II. Crossbreeding for lamb and  
mutton production. Animal Breeding Abstracts 20:287-299,  
1952.
- Ragab, M. T., and A. A. Asker.  
Twinning in Ossimi sheep. Empire J. of Exp. Agri.  
22:224-229, 1954.
- Raghavachari, K. V.  
Sheep development at the Livestock Research Station,  
Hesur. Indian Farming 6(12):584-585, 1945.

- Ramamurti, A.  
Performance of crossbred progeny of Nilgiri ewes with exotic rams. *Indian Vety. J.* 41:201-204, 1964.
- Rendel, J.  
Heritability of multiple birth in sheep. *J. of Animal Science* 15:193-201, 1956.
- Rice, V. A., F. N. Andrews, E. J. Warwick, and J. E. Legates.  
Breeding and Improvement of Farm Animals. New York: McGraw-Hill Book Company, Inc., pp. 380-398, 1957.
- Roberts, E. M., and P. Houlahan.  
The fertility of stored and fresh sheep semen. *Artificial Breeding of Sheep in Australia*. Published by the University of New South Wales, pp. 130-133, 1961.
- Salamon, S., and T. J. Robinson.  
Artificial insemination. I. Summary of data on the sheep. II. Semen diluent. *Animal Breeding Abstracts* 30(4), 1962.
- Second Five-Year Plan.  
Government of India (Republic). Planning Commission, New Delhi, 1956.
- Sharma, R. M., and M. L. Kohli.  
Sheep breeding in the Punjab. *Indian Vety. J.* 31:252-259, 1955.
- Sidwell, G. M., D. O. Everson, and C. E. Terrill.  
Fertility, prolificacy and lamb livability of some pure breeds and their crosses. *J. of Animal Science* 21:875, 1962.
- Sidwell, G. M., D. O. Everson, and C. E. Terrill.  
Lamb weights in some pure breeds and crosses. *J. of Animal Science* 23:105-110, 1964.
- Simmons, V. L., and R. G. Scott.  
Curl size in Kerakul lamb fur in relation to sire differences, selection and heritability. *J. of Animal Science* 8:609, 1949.
- Singh, G., and R. M. Sharma.  
Improvement of sheep and wool at the Government Livestock Farm, Hissar. *Indian Vety. J.* 28:357-362, 1952.
- Singh, O. N., and J. N. Prasad.  
Variation in birth weight of Bihar and Bikaneri sheep and their crosses. *Indian Vety. J.* 39:59-64, 1962.



- Singh, O. N., J. N. Prasad, and B. N. Sinha.  
Comparative study on growth of Bihar and Bikaneri sheep  
and their crosses. Indian Vety. J. 39:670-675, 1962.
- Smith, W., and V. E. McAdams.  
Record of performance testing program for beef cattle.  
49th Livestock Feeders' Day Report, Agri. Exp. Sta.  
(Manhattan) Bulletin 447, 1962.
- Terrill, C. E.  
Range sheep improvement through selection. National  
Wool Grower, December, 1946.
- Terrill, C. E.  
Effectiveness of selection for economically important  
traits of sheep. J. of Animal Science 10:17-18, 1951.
- Terrill, C. E., G. M. Sidwell, and L. N. Hazel.  
Effects of some environmental factors on yearling traits  
of Columbia and Targhee ewes. J. of Animal Science  
6:115-122, 1947.
- Terrill, C. E., and L. N. Hazel.  
Heritability of yearling fleece and body traits of range  
Rambouillet ewes. J. of Animal Science 2:358-359, 1943.
- Terrill, C. E., and L. N. Hazel.  
Heritability of face covering and neck folds in range  
Rambouillet lambs as evaluated by scoring. J. of Animal  
Science 5:170-179, 1946.
- Thomson, W., and I. McDonald.  
The relation of weaning weight and to birth weight of  
lambs. Proceedings of Brit. Soc. of Animal Production,  
pp. 38-44, 1955.
- Tyagi, J. C.  
The performance of Polwarth, Rampur-Bushair and their  
crossbreds. Indian Vety. J. 42:425-427, 1965a.
- Tyagi, J. C.  
The performance of Polwarth, Bikaneri and their crosses.  
Indian Vety. J. 42:200-204, 1965b.
- Uniyal, M. L., Lieut.  
Sheep and goat husbandry and its development in Tehri-  
Garhwal. Indian Vety. J. 27:355-360, 1951.
- Walton, A.  
Notes on artificial insemination of sheep, cattle and  
horses (2nd Edition). London Halborn Surgical Instrument  
Co., Ltd., 1938.

- Warwick, B. L., and T. C. Cartwright.  
Heritability of weaning weight of milk lambs. J. of  
Animal Science 16:1029, 1957.
- Wildman, A. B.  
Fleece research and wool improvement. J. of Text. Inst.  
48:359, 1957.
- Wilkinson, J. H. S.  
Welsh Mountain ewes as a source of grassland breeding  
ewes. Animal Breeding Abstracts 19:478, 1950.
- Yeo, T. S., V. L. Simmons, and R. G. Schott.  
Heritability of fur characters and birth weight in  
Karakul lambs. J. of Animal Science 12:431-439, 1953.

SELECTION AND BREEDING PROGRAMS FOR  
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by

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MASTER OF SCIENCE

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The sheep industry occupies a very important position in the Indian economy, as it brings an average of about 45 million dollars per year to the country. It is not a new industry, since sheep have been raised on Indian grasslands since time immemorial. Its importance lies in the fact that it brings money through two cash crops, namely, lamb and wool.

There are three predominant sheep raising areas in India. The temperate region includes the Himalayan mountains, Kashmir, Himachal Pradesh, the hilly districts of Punjab and Uttar Pradesh. Common breeds in this area are Poonch, Karnah, Kashmir Valley, Gaddi, Bhakarwal, and Rampur Bushair. The dry western region includes Rajasthan, Southeast Punjab, Gujarat, and parts of Western Uttar Pradesh. Common breeds in this region are Bikaneri and Lohi. The southern region consists of Maharashtra, Mysore, Andhra Pradesh, Madras, and parts of Madhya Pradesh. Common breeds of sheep are Nellore, Mandya, Bellary, and Deccani.

Most Indian sheep produce carpet type of wool (average of 2.2 pounds per head) that often contains hair and is of low quality. However, it serves as the raw material for the important carpet-weaving industry of India.

Mutton is an important source of protein in the Indian diet, but the production is low and the quality of mutton is not high.

In 1836, India initiated a program to improve wool and mutton. However, not much was accomplished until the early part of this century. Important developments were the formation of a separate livestock section in the agriculture department in

1919, a well established sheep breeding section at the livestock farm at Hissar in Punjab in 1936, and a sheep breeding station at Poona in 1937. Following this, many technical programs were started for improving wool and mutton production through selection and crossbreeding.

As indicated in a review of reports of many authors, the important feature of selection and breeding programs is the proper selection of ewes and rams on the basis of individuality, pedigree, performance testing, and progeny testing.

Selective breeding is practical, inexpensive, and is easily handled by the shepherds. It has been found to be very effective in improving fleece weights in the average range flocks of North Indian sheep. This method was applied to improve the indigenous sheep by mating with purebred of Bikaneri rams. The undesirables were culled on the basis of production records.

Performance testing is another important feature in sheep breeding programs. It involves the identification of genetically superior individuals and high producers within a flock. It is also useful for culling of undesirable animals.

Crossbreeding has attained importance in the last decade in Kashmir and Bombay. The only recognized crossbreed in India is the Hissardale, which evolved by crossing Merino rams with Bikaneri ewes.

Crossbreeding decreases mortality rate and increases fertility, lamb weight, and wool. It is a good way to improve the inferior sheep of Central and South India.

Artificial breeding in India is still in the experimental stage. It should follow the research work done on artificial breeding in Russia, Australia, the U.S.A., and South Africa.

The yield of wool of Indian sheep has been increased from 2.0 to 6.0 pounds per head by applying the described breeding programs.

It is possible to improve the quality and quantity of wool and mutton in Indian sheep by application of advanced selection methods, mass castration of scrub rams, keeping performance records of individual animals in the flocks, selection of superior offsprings, and culling of undesirable sheep.