ful advisability. It was found, however, that it is possible to take slips from the individual plant and root them after the manner of geranium slips. This is preferably accomplished in a greenhouse but it is probable that the operation could be successfully performed in the open if proper precautions were taken. By this means several hundred individual plants may be secured from a single plant during one season and a plot obtained which is of sufficient size to justify its practical isolation, either by its distance from other plots or by lateral screenings so that the dangers from cross-pollination would be reduced to a minimum. It would appear from this that two years' time could be saved by the adoption of this method where for any reason but a single individual of a plant is at hand and it is desired to increase the stock for field tests. The effect of the continued inbreeding upon the vigor of the individuals when but one or a few mature plants are used is a matter yet to be determined but it has been thought best to make this method at once available to those who are interested in the work. It is not unlikely that this method can be applied to the clovers and other forage plants where for any reason the flowering or seeding habits are such as to present difficulties to the practical breeder.

As the ideas presented are largely suggestive in character, it is hoped that the discussion will bring out interesting and helpful points.

SHEEP BREEDING FOR MOUNTAIN REGIONS.

By B. C. BUFFUM, *Laramie, Wyoming.*

If there is any branch of animal industry in which systematic improvement is needed and in which such improvement promises large returns, it is in the great range sheep business of the arid region. In magnitude, the sheep industry of the mountain region is second to none. The sales of wool and mutton in the United States in a year are only second to those of cattle and more than four times as great as the value of horses sold in the open market. The value of sheep in the intermountain region now exceeds the value of our cattle and the conditions are so favorable to sheep production that this difference must increase rather than diminish. The present conditions of sheep breeding on our western ranges, however, are almost, if not quite, as bad as that of the breeding of horses by small farmers. There is every kind of blood, all degrees of grades and cross bloods, produced by the various experiments or rather whims of the sheepmen themselves. A few years ago flock masters were content with grading up the common Mexican sheep of the West for the production of more and better wool. In recent years, the growing demand for mutton has caused the sheepmen to try many forms of breeding for the production of feeder lambs, and such crossing often results disastrously to the wool crop. Almost every mutton breed has been used to cross upon the common Merino grades and there is no uniformity of prac-

tice yet established. One man will claim he produces superior mutton lambs by the use of Cotswold sires; another prefers Lincolns; a third uses Hampshires; a fourth Shropshires; a fifth, Oxfords, and the recent discussion of the Leicesters has made many desire to try this breed. I have heard of no one using Southdown bucks for the production of his mutton lambs, and think this is rather remarkable, the only apparent reason for discarding them being their small size. Curtis states that Southdowns have been used in the South to grade up Merino flocks, and others claim the lambs are quick-maturing. A large quick-growing lamb is desired. Had it not been that crossing Merinos with the middle or long wools spoils the wool of the progeny, the promiscuous breeding would have been worse than it is. It is found that the Shropshire cross, which is the one generally used, breaks the wool, establishing a barrier which prevents continuing such breeding beyond the first cross. On this account the mutton crosses generally used are only for the production of that part of the lamb crop which is to be turned each year, grade fine wools being kept through the winter for the breeding and shearing flock. As indicated, then, a fine-wooled sheep is the one which is the most successful on our open ranges; and those, which are best covered with the densest wool without too much yolk, best withstand the sudden changes of temperature and rigors of our mountains winters.

Our occupancy of the arid regions dates back a comparatively few years. Where fifty years ago the conditions were all untried, to-day the different branches of the stock industry are well established and mixed husbandry or pure agriculture is coming into more general practice. Since the beginning of the stock industry in the mountain region there has been a gradual though marked improvement. The original Texas cattle have entirely disappeared and the original Mexican sheep, with its abbreviated blanket of wool, covering shoulders and back and weighing 2 to 3 pounds, are all gone from northern ranges. The average wool clip of our fine-wool sheep has increased until now there is obtained from 7 to 9 pounds per head (8.7 for Wyoming). While the better Merino blood has been continually fused into these flocks, natural selection and the survival of the fittest has undoubtedly had something to do with the improvement. I would strongly urge the fact, however, that, though marked improvement has taken place, the time has been short and as yet we have few if any fixed types of agriculture in the arid region and no fixed breeds of either plants or animals have become established. The work of Burbank and other breeders has given rise to the new idea that by organized effort it is feasible to produce more suitable types of crops and stock for these western farms and ranges. Some have thought the whole country could be brought under cultivation and question whether the development of soil tillage will leave room for large numbers of sheep or other stock on the range. Such belief could not be held by one who has traveled over the thousands of acres of rocky, rough, well-grassed summer range or the hundreds of miles of sage and salt bush desert which supply rich pasturage for millions of sheep.

The range we will always have with us. In the best watered States of the arid region, there is no more than enough water supply to irrigate 10 or 12 per cent of the area. If another 10 per cent is suitable for dry farming (an optimistic estimate), it still leaves vast ranges which can only be used for the growth of timber on limited areas in the mountains and the grazing of live stock in the larger untimbered lands. With the reclamation of lands and the establishment of farms and ranch homes, there is continual improvement in methods of caring for stock which is grazed either all or the greater part of the year. But few range men are left who do not have their best bucks cared for and fed through the winter on the ranch. There is continual increase in the number of flock owners who combine irrigated hay-making with their range operations, the hay being used to feed during bad storms; and a few are even adding grain to the feed of their breeding ewes on the range. Such feeding must be carefully and judiciously done, for sheep, like some men, readily take to charity and will not work for a living unless it is necessary. Injudicious feeding may spoil the sheep's rustling disposition. Properly feeding hay to range sheep to tide them over bad storms in the winter is an art learned by experience. The sheep are generally allowed to fast for a day and then are not fed enough at a time to satisfy their hunger. I know one man who feeds his breeding ewes corn on the range, giving one or two ounces per head per day. He thinks the increase in wool, in size of lambs and gentleness of the lambs in the feed lot more than pay for the expense and trouble of buying corn and hauling it 20 miles for this purpose. Such up-to-date methods are not in general use, however, for comparatively few men corral their sheep at night where hay feeding is possible and our larger flocks weather the storm as best they may. While these men are very prosperous under the present favorable conditions of the sheep industry, they are keenly alive to the importance of improvement and welcome any new practice which will bring them greater profit. Some of our flock owners have already taken up breeding operations for the improvement of their flocks. In one case a range man in southern Wyoming has gone to the trouble and expense of obtaining prize-winning fine-wool bucks from Eastern States and within ten years has increased the wool clip from at least one-third of his flock to more than 15 pounds per head, doubling the average production. This one instance illustrates the fact, that, while sheep have been domesticated so long, being perhaps the first animals to be bred and cared for by man, they are still plastic and capable of very important changes which will make them more suitable to the conditions under which they are being produced. An increase of 1 pound per head in the average wool clip would increase in value the output of Wyoming alone by three quarters of a million dollars and would increase the value of the wool of the arid region by five million dollars. Doubling the wool clip as in the case cited above would bring vast wealth to the mountain States.

There are several things which favor the work of sheep breeding in the West and which make results more certain to be speedily obtained. In their favor is the advantage of numbers and correspond-

ingly quick improvement from breeding and selection. The possibility of working with large numbers is appreciated by plant breeders and there is considerable advantage in this respect with sheep breeding over that of larger animals as horses or cattle. In the second place, sheep are greatly influenced by change in environment, this one thing producing variations which are of great importance. We find that sheep brought from humid regions into the mountain States become acclimated rather slowly. The environmental conditions are vastly different from those to which they have been accustomed. Every factor in their environment is changed, the climate is dryer with greater air movement, more sunshine and sudden changes in temperature. The soil is entirely different being dryer and richer in minerals and alkali salts. Their food consists of scanty short grasses and other forage plants which have less water, more mineral matter, more protein, greater digestibility, and less variation in their nutritive properties throughout the year. While this vegetation is more nutritious it is also more scant and difficult to obtain than the foods upon which they were raised. The exercise involved in getting over sufficient ground produces a tax on the constitution to which they must become accustomed. They are in the open, without protection of trees, fences, and buildings. All these conditions produce profound changes and act upon the sheep as they do upon plants, inducing variations which are marked and which may be put to some use in breeding and selection. We find, for example, that Rambouillet sheep taken from the humid East to our high, dry ranges, lost physical condition at first; and, as pointed out by Prof. Shepperd in his paper before this Association last year, they lose size if the range conditions are not the best. This loss of condition seems to be brought about by the increase in the growth of wool and the greater tax on the system resulting from unusual exercise. They take a year or more to learn the new conditions and hold their own with the natives. Then there is marked variation in the amount of wool. The nitrogenous grasses favor wool production, the cool climate increases its growth and the dryness along with lack of fat in the foods decreases the amount of yolk in the wool. The offspring of these sheep are given larger bone because the mineral elements are abundant, and, where the ranges are good enough so starvation does not take place in winter or summer; these same nitrogenous foods produce large growth of body. The cold storms and other untoward weather conditions, destroy those which do not possess the proper constitution and temperament and all these factors tend to make range sheep more suited to their environment. These so-called slow variations can be taken much advantage of in intelligent selection, and it is more than probable that this breaking up of old life habits and producing such tendency to vary may secure important mutations in individuals which would help the breeder who would take advantage of them.

If I were to outline a general plan for sheep breeding experiments, I would suggest the following considerations: (1) We should possess a fairly definite idea of the most desirable type of range sheep; (2) we should take account of the available material with which we could

work to produce this type; and (3) we must consider the method of breeding necessary to secure the desired end.

From all the data I can gather the most desirable type of range sheep may be described as one which is dual-purpose in a measure, carrying the largest possible amount of fine dense wool, and having a frame for flesh capable of making a good cross with some mutton type for the production of the best feeder lambs so the owner will find ready market at the best prices for his surplus increase and be able to dispose of his old ewes and wethers for feeders. The body must be as large as possible, without coarseness, for such a sheep would have large surface for growth of wool and would produce a large-bodied, thrifty lamb for mutton purposes. The body must be well covered with wool of even density and fineness, the wool extending over the under parts and down the legs to the feet that they may not chill when lying on the cold ground or snow, but the wool should not cover the face to such an extent as to cause wool blindness. The body should be square and blocky but the legs must be long enough to enable the sheep to walk from 4 to 6 miles per day over the range for its food. On the sage-brush ranges, the leggy sheep will lose less wool, but legginess must not be carried to the extreme. The low blocky sheep with just leg development enough seems to have the best endurance. It has been suggested that the law of correlation of parts makes it difficult to get wool on the legs without too much on the face; that the fine-wooled sheep naturally has a drooping rump and a "cat ham," and that legginess cannot be made to go with good fleshing qualities; but carried out in moderation, none of these objections need discourage us in our attempt to produce a suitable type. The feet must be good, with hoofs hard and thick enough to stand the wear of range travel. It is found that the Merino, which has been accustomed to nomadic ranging for two or three thousand years at least, has good feet while some of the mutton breeds or their crosses are apt to get foot-sore on mountain ranges. A desirable quality in our range sheep is a tendency to flock well instead of wandering off alone and thus giving the breeder work and causing the owner loss.

The ewes should be good mothers. It seems that the more highly civilized sheep become, the more apt they are to desert their lambs. Our ideal sheep should only give birth to a single lamb. An orphan or a twin on the range is a total loss. Our ideal sheep should be early-maturing but this quality should not take the place of longevity for the most profitable sheep must be able to stand range conditions and remain productive from seven to nine years. The value of an old sheep like that of an old horse is measured largely by the character of its teeth. The teeth of our quick-maturing mutton breeds on the range begin to spread apart early. Drawing the short dry grasses between them wears them down so they break and old age sets in correspondingly early.

That such an ideal type of sheep does not now exist on our ranges is obvious; but the possibility of producing a breed which approaches it, makes an organized attempt of vast importance. It is not probable that such a breed will be the outcome of the breeding carried on by

practical sheep men. It is also impossible to produce it in the pastures and barns of the East. The breeding and selection must be done on the open range where the sheep are subject to the influence of range environment and here the work must be under complete control in charge of men capable of judging and selecting, and carried on for a sufficient period of time to insure results. I believe the larger number of animals used, the more certain can the type wanted be produced. Animals as near the desired type as possible to obtain should be selected and crossed within the breed to purebred sires. It is my opinion that, to produce the improvements sought, it would not be necessary to do crossing outside the breed. There are so many types of fine-wool sheep, all Merinos, that selection for crossing within the breed will be all that is necessary to produce the type desired.

Some improvement has already come about on our ranges by the use of the large-bodied, deeply wooled Rambouillets of more pronounced mutton type along with judicious use of the Delaine to increase the fineness of wool. Some of the California Rambouillets seem especially good in size and some of the Von Homeyers and Franco-American Merinos are good in their wool covering. However, the wool on their faces stops the improvement in grading with them by some of our large range men at about 7 pounds of wool per head because of the blindness which occurs with the heavier-wooled sheep. Some of our best sheepmen think they can well afford to run the sheep through a shute two or three times during the winter to shear the wool from around the eyes and also supply their breeders with pocket scissors with which to treat blindness on the range.

Enough has already been done by our sheepmen to indicate something of the rapidity with which important improvement may be made by crossing and selection. There is already available material, widely scattered it is true, but still available from which individual selections could be made. A breeding flock selected in this manner would give a sound basis upon which to begin organized and systematic breeding for the ultimate production of a typical pure breed of range sheep. It would appear that in order to establish the desired breed it would be necessary to accumulate a breeding flock by selecting the most promising range ewes from different portions of the mountain region and carefully mating to properly selected sires. Of course in such an attempt, the sheep must be owned and the conditions controlled by an experiment station or by the Government for a sufficient period of years.

The object would be to produce mutations in the offspring whose prepotency must be proved by further breeding until finally it may be possible to select a single individual from among all those which have been used in the work as the progenitor of the new breed or type. Should these mutations be found to follow Mendel's law it may be necessary to continue breeding and rigid selection for a few years.

Obviously, we cannot expect to produce mutations for each of the characteristics I have mentioned as desirable in a range sheep and combine them all in one individual. Our foundation flock could be

selected with many of the qualities already fixed and we could confidently expect to secure a combination of the more important points.

Along with this breeding for type, there should be experiments in crossing for the production of the feeder lamb, for the raising of mutton has become almost, if not quite as important on our ranges as the production of wool. A few years of such work should produce a sheep hardy enough to withstand range conditions better than our present nondescript fine wools, large enough to produce good mutton and better mutton crosses and yielding fifteen pounds or more of wool per head. This would treble the value of the range sheep and make it possible for many more to enter into this industry with smaller flocks which could be better cared for and continually improved. Such breeding would be done with a definite object in view and the sheepman would have the advantage of that stability and certainty which only comes from pure blood through the heredity of improvements which have become fixed. There is no question that a suitable range breed could be produced which would be worth millions of dollars to the industry.

CORRELATION OF CHARACTERS IN PLANT BREEDING.

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WHAT IS CORRELATION?

In the practical work of plant breeding the investigator must handle a large number of plants, and it thus becomes important at as early a date as possible to be able to judge of the probable quality of the product in order to discard some of the numerous individuals. It is doubly important to be able to judge of the nature of the product early, when it is necessary to interbreed different individuals, as is frequently the case in the fixation of variable hybrids. It is well known that certain characters are more or less related to each other in certain plants and are inherited together, acting similar to a unit character in this respect. All practical animal or plant breeders have come to recognize cases of this kind. When they find a certain character present in an individual, they are almost certain to find another character present which is correlated with it. With the introduction of the unit character idea, correlation, which is a well established phenomenon, becomes more interesting and requires interpretation according to our new understanding of character inheritance.

Correlation is used rather loosely by botanists and plant breeders and is frequently used to refer to widely different phenomena. The writer distinguishes four kinds of correlation, which the breeder should recognize. These four correlation groups he has termed Environmental, Morphological, Physiological, and Coherital.