

Line Breeding is a breeding technique used to protect certain family traits within a family line. Line breeding is a system of breeding in which the degree of relationship is less intense than in inbreeding and is usually directed towards keeping the offspring related to some highly prized ancestor. The degree of relationship is not closer than half-brother half-sister matings or cousin matings, etc. Line breeding is a mild form of inbreeding. Here at Kind Horn Farm, we do not line breed all that much as one of our goals is genetic diversity, but we do use this strategy at times. The following article explains line breeding very well. I am providing some other links below to other excellent articles on line breeding.

[Line Breeding vs. Inbreeding](#) Excellent short article by Boyer Land and Livestock

[Breeding Strategies](#)

## ***Inbreeding And Line Breeding***

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*In the minds of the majority of persons who consider matters relating to breeding, the idea is firmly fixed that the practice of inbreeding is altogether objectionable. In general it is described as the mating of close relationships, though what is sometimes considered to fall within the term is in other instances designated by milder phrases. In really correct usage inbreeding designates the union between brother and sister or between offspring and parent, in one or more generations. Popularly considered line breeding is applied to matings of a degree of consanguinity not included in the foregoing definition. Those who advocate breeding in line fear the results of actual inbreeding, and aim to avoid the uncertainties of mixing strains or families totally unrelated though belonging to the same breed. In the minds and speech of present-day breeders, however, there is no generally recognized distinction between inbreeding and line breeding. The principle involved is the same; and the difference is one of*

degree. Most of what is commonly referred to as inbreeding is not in reality such. In order to be clear in discussing the subject as it is before our breeders today inbreeding will be considered as the mating of two animals with sufficient similarity of ancestry to make 50 per cent of the inheritance of one identical with the same proportion in its mate, the inheritance in common not being necessarily that of a single animal.

In each of the above cases A is inbred. In the first instance son and daughter of D are mated. In the second, the dam of B is full brother to the sire of C, that is, B and C are full first cousins.

Line breeding may be differentiated from inbreeding by defining it as the mating of two individuals identical to the extent of 25 per cent and less than 50 per cent of their blood. Line breeding however really implies something more; it implies a succession of sires that trace their descent in some measure to the same individual. The example on the opposite page shows typical line breeding.

In this case the descendants of the female I have been line-bred. G having two lines to I has been mated with F who is also a grandson of I and their progeny C is bred to B, another grandson of I. In no case have full first cousins been mated. The blood of I preponderates in A and yet there has been sufficient latitude to allow the selection and use of only the better individuals from the descendants of I, and so valuable characters may be thus retained, not so fully as might be if inbreeding were practiced but in a safe and useful degree.

The difference between line breeding and inbreeding is one of degree. The principle being the same it may be discussed at once for both. The popular use of the term "blood" in this connection is likely to be misleading and should be substituted by some term to designate the hereditary material itself. Also there is strong probability of error in assuming that because of the parentage mentioned that 25 per cent of the germ-plasm in B is identical with a similar proportion of the same material that entered into the make-up of C. The process typified in maturation shows that there may be a wide difference between the combination of chromosomes received, for instance, by E from J and K and that received by F from the same individuals in the sample pedigree showing inbreeding. This possibility of dissimilarity may explain the variable results observed in apparently similar instances of the mating of closely related animals.

Most states have laws forbidding the marriage of first cousins. These laws seem to be based on somewhat similar injunctions issued to the children of Israel and recorded in the book of

*Leviticus. While those laws are entirely defensible on the grounds of the dependence of a nation's strength upon the purity of the family lives of its citizens, it is not necessary to suppose them to have been originally formulated solely in the interest of the progeny. The Mosaic law precludes cohabitation in cases where no actual relationship exists. Familiar statistics regarding relationship of parents of inmates of institutions for defectives and in-sane will not be cited. In spite of the biased attitude of compilers of such data and the contradictory character of the teaching of the facts accumulated at different times and places, the impression is irresistible that to some degree at least the kinship of the parents is a considerable factor in the production of such abnormalities. Attention must be drawn to the unfairness here, and in regard to acquired characters, of assuming a complete parallelism between our domestic animals and the members of the human family. The developing period of the human infant is so much longer, the impressions bearing upon it so much stronger, and its susceptibilities so infinitely more acute, that the possibilities of environmental modifications, mental and physical, are out of all comparison to their import in organisms of lower place. Even a slight inherited predisposition to defective mentality may be fostered by continuous impressions in the home or outside life. The compensating qualities may be so dwarfed by the absence of forces essential to their development that it is quite reasonable to explain the facts as being the result of special circumstances, assisted or not by inherited leaning, which might never be suspected in the presence of counteracting environment.*

*Some of the injurious effects of inbreeding are set forth in the histories of the breeds. Thomas Bates Duchess family of Short-horns was bred very closely, probably no less because of a desire to inbreed than because of the inferior character of unrelated stock. A pedigree of one of the members of this family is shown on the opposite page.*

*The intensification of the Duchess blood is further shown in the fact that of the twenty-two bulls used with Duchess cows, The Earl (646) sired five Duchesses; Second Hubback, twelve, and Belvedere, nine. The first was out of Duchess 3d; the second had Duchess blood only through his sire and the third was wholly unrelated though himself inbred. The final condition of the family, with respect to fertility, is shown by Sanders\* in the table on page 174 which when summarized shows that up to 1849, from fifty-eight Duchess females of which the first was calved in 1808 and six later than 1841, a total of 110 calves were produced. Of the fifty-eight, twenty-four never produced calves.*

*Although the Bates Duchesses have been regarded as the striking instance of the results of close breeding, the following facts deduced from Mr. Sanders' table are worthy of study : The later Duchesses were presumably more intensely bred than the earlier ones. In the first half of the period from the birth of Duchess 1st to that of Duchess 58th, or down to 1827, twenty-eight Duchesses were produced. In the last nineteen years thirty Duchesses. The last thirty produced fifty-six calves being no less prolific than the first twenty-eight which produced*

fifty-four calves. The first twenty-eight Duchesses included twelve barren ones, the last thirty, the same number. The third Duchess had two barren daughters by different sires, so evidently the tendency to barrenness was present in the early days of the family and did not wait until after the closer breeding had been done to show it-self. Whatever may be the condition or character that causes barrenness it must have a physical basis and lend itself to intensification through close mating in the same manner as other physical qualities, but it is not shown that inbreeding originated the barrenness in the Bates Duchesses.

The claim has been quite freely made within recent years that the present type of Poland-China is much less prolific than were earlier representatives of the breed, and that some of the loss is due to the matings of related families to produce the present exceptional individuals. Conditions governing selection may be considered as sufficient to account in themselves for the result, but inasmuch as it has been stated that the facts are not really as supposed, a discussion is not out of place. Rommel\* has compiled statistics from the American and Ohio Poland-China registers comparing the average size of litters from 1892-6 with the average size of all litters registered from 1898-1902 the figures being 7.04 for the earlier time and 7.52 for the latter, thus indicating that there has been no falling off in fecundity. These figures, however, do not of them-selves invalidate the claim of decreased fecundity. At best a very small proportion of the animals registered represent the so-called showyard type against which criticisms are principally lodged. It remains to be shown statistically, that the herds of the extreme show type, in which close breeding has been most common, have retained the prolificacy of their more primitive progenitors.

The result of experiments conducted to furnish data upon the effect of inbreeding, and in which all other influences were carefully excluded, are of more than ordinary interest. Bos, a German investigator, bred a family of rats for six years without introduction of any new individuals. Young rats were bred back to their parents and females were mated with their full brothers, such being continued for thirty generations. During the first twenty generations there was a slight decrease in prolificacy. The average number of young per litter with the initial stock was  $7\frac{1}{2}$  and in the twentieth generation 6.21-36. In ten generations succeeding the average size of litters rapidly decreased to one-half the original number, and 41.18 per cent of the pairings were fruitless. An accompanying decrease of 20 per cent in size is also recorded. Breeding of mother to son and daughter to father was less injurious than breeding brothers and sisters. Though of a lower type, rats are as truly mammals as are cattle. While the ultimate results of this experiment are very striking, it is important to observe that the injurious influence on fertility was evidenced only after the twentieth generation of very close matings.

Castle and his associates have inbred the pomace-fly, (*Drocophila ampelophia*) for fifty-nine generations. Brothers and sisters were caged together and their off-spring selected in the pupa stage for pairing in other separate chambers. Where two pupae developed the same in sex a

rearrangement was made to secure the presence in each chamber of male and female from the same parents. Castle's conclusions from this work are as follows :

(1) "Inbreeding probably reduces very slightly the productiveness of *Drosophila*, but the productiveness may be fully maintained under constant inbreeding (brother with sister) if selection is made from the more productive families.

(2) "In crosses of a race of low productiveness and frequent sterility (race A) with a race of high productiveness (B) it has been found that a female of race A does not have her fecundity increased by mating with a male of race B, and conversely, a female of race B does not have her fecundity diminished by a mating with a male of race A. Hence every male not actually sterile furnishes an abundance of functional spermatozoa.

(3) "The cross-breds produced by the mating, B female with A male, are all of high productiveness.

(4) "The cross-breds produced by a mating A female with B male are usually but not always of high productiveness.

(5) "The children of both sorts of cross-breds (see 3 and 4) are some of high productiveness like race B, others of low productiveness like race A.

(6) "Low productiveness is inherited after the manner of a Mendelian recessive character in certain of the crosses made, skipping a generation and then reappearing. In other cases it has failed to reappear in generation F<sub>2</sub>, indicating its complete extinction by the cross. In a few cases it has failed to be dominated by high productiveness in generation F<sub>1</sub>. In such cases the female parent has always been of race A. Hence low productiveness (or sterility) of the female may be transmitted directly through the egg from mother to daughter, but only indirectly through the sperm, the character skip-ping a generation.

(7) "A cross between two races, one inbred for thirty or more generations and of low productiveness, the other inbred for less than ten generations and of high productiveness,

*produced offspring like the latter in productiveness, but not superior to it.*

*(8) "The same two races crossed after an additional year of inbreeding (about twenty generations) produced offspring superior to either pure race in productiveness."*

*If it be true that inbreeding contains such possibilities of evil as have in the past been attributed to it, what then was the justification of the practice in the past and to a lesser extent at the present time? It is generally believed that progeny whose parents are related are more prepotent than those resulting from the union of individuals of entirely dissimilar ancestry. This is the natural consequence of the preponderance in inbred stock of the hereditary material and tendencies possessed by the individual with which the concentration begins : not only are units of the germ plasm numerically strongest but their similarity gives a certain number greater power than an equal number from a more varied ancestry. One of the difficulties in establishing a breed is the securing- of individuals with the power to transmit the qualities of the various animals that evidence the improvement. In almost every breed inbreeding has been practiced by the founders to secure that fixity of type that entitles a class of animals to be called a breed. The pedigree of Comet, a notably successful sire and sold for \$5,000 at the dispersion sale of Charles Colling in 1810, is an interesting study.*

*Houseman states that in 1839, seven years prior to the first registration, the Sovereign blood was in the Hereford ranks what Belvedere was in those of Short-horns, and the name of Hewer parallel with that of Bates.*

*Other notable breeding animals have not been so intensely bred, but among those that stand out now as having marked eras of special progress close breeding is the rule and not the exception. In the fixing of types within breeds similar facts are observable. Amos Cruickshank, whether from choice or through compulsion, is known to have benefited greatly by the practice of in-breeding, though it must also be said that benefits were not all that can be attributed to the practice of that system in his herd.*

*The American type of Hereford is eminently more useful in America than is the English type. The progress in the evolution of that breed in this country, while effected by the concerted efforts of a number of breeders who have avoided continued mating of close relationships, has been eminently advanced by Gudgeon & Simpson under a system of in-breeding. The breeding of one of their animals that was junior champion female at the International in 1900 is given.*

*A full sister of Mischief Maker 97907, Miss Caprice 109725, was junior champion female at the 1901 Inter-national. The part played by Anxiety 4th in the making of the American Hereford and the prepotency of his descendants is commonly spoken of, but reference is seldom made to his own breeding as a probable explanation of his marked prepotency.*

*Considerable publicity has. justly been given the work of N. H. Gentry in his breeding of Berkshires. Though the matings of Mr. Gentry's animals have been by no means so close as those typified in the last tabulations he has not purchased a boar in twenty years, yet his large herd shows no evidence of impairment of size, vigor or fecundity, and has produced an unusually large proportion of prizewinners.*

*From the two types of instances presented it is evident that inbreeding contains strong possibilities in either direction, and there must be a common principle underlying both sets of occurrences. Major David Castleman has said : "Inbreeding has produced some of the finest successes and some of the most dismal failures. We sometimes use it but feel that in so doing we are playing with fire." One assumption seems justified and that one is sufficient to explain the facts, namely: that the matter of kinship is of itself not the cause of the observed effects commonly attributed to inbreeding, but that the similarity of characters of parents constitutes the seat of the pronounced possibilities of inbreeding. In other words, we may say of the cases that have resulted unfavorably that we should look, not to the kinship of blood but to the kinship of defect. Similarly we may say of the successes of inbreeding, they are attributable, not to the kinship of blood but to the kinship of superiority.*

*Knowing something of the behavior of the hereditary material, it is possible to explain the intensification of a good or a bad quality common to two parents in the same way as the development and accretion of minor congenital variations was explained in Chapter VI. As with the variations referred to, it must also be remembered that there may be in individuals inherited and recessive defects which come to notice only when intensified and aided by sympathetic matings such as may be looked for in representatives of the same family. Most of the cases of decreased fecundity in farm animals attributed to too close matings are probably due to the intensification of existing weaknesses or hindrances to reproduction.*

*It must be recognized however that there is a possibility of a measure of the same result from inbreeding in itself. It is considered by zoologists that in the lowest forms of life in which the union of two individuals is not essential to reproduction, that a greater vigor results from reproduction participated in by two individuals. In some forms individuals reproduce*

*independently for a number of generations and then conjugate. The mixing of material from separate sources appears to add vigor much as is observed in cross-breeding of larger animals. Continued mating of animals restricted to a common descent may then of itself diminish the vitality of the stock. Color is given this idea by the unusual vigor sometimes apparently present in the offspring of two pure-bred parents of different breeds. Such a cross is the extreme opposite of close mating. The same principle obtains in plants propagated by vegetative methods. Prof. Cook\* states : "The weakened vitality of old varieties of potatoes or sugar cane may be compared with the gradual weakening of aged trees or of aged men. There is a slackening of the organic energies which can be quickened only by new conjugations." It is possible in animals to so restrict and concentrate the ancestral hereditary material as to render new conjugations imperative. Pronounced injury from inbreeding fully robust animals would only come however from long continuation of the practice as shown in Bos' experiment cited earlier in this chapter. On the other hand it is possible to so dilute and dissipate the heritage of good as to lose what generations of careful breeding have built into the stock. It has been said that in the case of some of our carefully bred families of stock, the paramount question is not how much inbreeding is safe, but rather, how much outbreeding can be permitted?*

*As stated, however, most of the decreased fecundity of farm animals properly attributed to close matings must be regarded as the result of the intensification of existing tendencies rather than the lack of new conjugations. Such tendencies present in a minor degree may be strengthened into serious defects by close breeding just as may any other bad feature, or as a useful quality may be accentuated and transmitted more strongly by judicious limitation of descent. Sterility that is the out-come of inbreeding must not be regarded as a single characteristic separately transmitted as such. It is doubt-less the result of the accumulation or intensification of a number of conditions bearing unfavorably upon reproduction but not previously so strong or so combined as to constitute effective obstacles to breeding. Sterility produced by inbreeding marks the limit, and recovery can be effected only if parents or ancestors still remain to permit a retracing of the course pursued to a point of greater fecundity.*

*Success or failure with inbreeding is then clearly dependent upon selection. Ability to select necessitates not only well trained powers of observation and good judgment, but also an intimate knowledge of the individuality and ancestry of all the animals in which the breeder is directly or indirectly interested. An examination of the personal qualities and the methods of those men who have successfully practiced inbreeding will reveal in every instance the fact that they were thorough students of the individuality of every one of their animals and in no cases allowed superior lineage to blind them to the presence or seriousness of an undesirable quality or character. Inbreeding has not been practiced by any successful breeder at the commencement of his operations. The exercise of the abilities of the masters in the art has resulted in their attaining a measure of success that gives them within their own herds animals superior to any that can be purchased. Any present-day breeder who really reaches such a position cannot afford to lightly decide to set his face unalterably against inbreeding.*



*In comparing modern breeders with those of earlier times one other factor must be regarded. Popularity of strong strains and families within each of the breeds has given members and descendants thereof wide dissemination, and it is difficult to procure within these old breeds good animals so nearly unrelated and free from common tendencies as in earlier days. The fact that Scotch Short-horns were more closely bred than were English Herefords accounts for the present greater aversion of Short-horn breeders to close matings. Some advocates of inbreeding would seem to suggest that selection be based solely on descent. So long as animals are individually adapted to each other and there is no common weakness in their lineage, a degree of common relationship to superior animals is not a detriment but an advantage. Line breeding, as defined on page 168, permits concentration of type by selection from numerous descendants of a good individual and may retain the best features of that individual without the concentration of blood that may cause some minor weakness to be intensified into serious ones.*