THE VALUE OF IN-BREEDING IN THE IMPROVE-
MENT OF THE DOMESTIC ANIMALS

by

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I INTRODUCTION

The value of in-breeding in the improvement of the domestic animals has been a subject for discussion ever since the origin of the improved breeds. The term in-breeding is generally used to indicate the mating of animals that are closely related, although no definite rule has been or can be established to indicate an exact degree of relationship to which the term in-breeding applies. Almost every writer upon the subject has used the term with a different shade of meaning. Why should the term in-breeding not cover all forms of breeding between related individuals? It seems to me that such terms as line-breeding, close-breeding, incestuous-breeding, etc. should fall under the general head of in-breeding. These terms certainly represent forms of in-breeding, although they may represent matings of different degrees of relationship. If we accept the term in-breeding as covering all forms of matings between related individuals, we can now define in-breeding as the mating of related animals without reference to the closeness of relationship. The most extreme type of inbreeding is continued brother by sister breeding; then follows parent by offspring and first cousin by first cousin matings.

Apparently, breeders are divided into three groups when it comes to the discussion of the good and bad effects of in-breeding. One group claims many advantages for this form of breeding when directed by proper selection, etc. A second group takes a rather neutral viewpoint; that is, they believe

there is a division line somewhere, and when this method continues beyond some certain point (very indefinite) bad results are sure to follow. A third group claims that in-breeding is dangerous, even when practiced to a slight degree.

The following are some of the more important claimed effects of in-breeding:

1.-Advantages. Breeders who have practiced this method of breeding and believe it the most efficient method of improvement at their command have the following to say in regard to its effects:

- (a) It is the most rapid method of fixing a uniform type.
- (b) It accelerates the rate of improvement.
- (c) In-bred animals are more prepotent.
- (d) In-breeding is the only method of breeding which will retain and perpetuate the valuable qualities of an exceptionally good animal.

2.-Disadvantages. Breeders who have seen bad results from this method of breeding or have been informed by their fore-fathers that it is dangerous have the following claims against this method of breeding:

- (a) It weakens the constitution, decreases size, and malformations are common.
- (b) It causes a loss of fecundity, and sterility is the final result.
- (c) It brings about an unequal proportion of males and females, Albinism, idiocy, etc.

Does it seem plausible that a question of so great importance to breeders of all classes of live stock could remain under discussion for generations without coming to some final conclusions, unless there exists some ground for an argument? Where have the advocates of in-breeding gotten their information? Have we any evidence at the present time to show that this is a good or a bad practice to follow in the improvement of our breeds? Many questions similar to the above cannot be answered, but from the abundance of literature on the subject, one comes to the conclusion that the advocates of in-breeding have gotten ~~their~~ information mostly from actual breeding trials; the advocates against inbreeding have likewise gotten much of their information from the same source. However, many of them have had the prejudice against in-breeding handed down to them by their forefathers, and they have failed to give the question due consideration themselves. Is it not true that one case showing the bad effects of in-breeding has turned thousands against this method of breeding, and, on the other hand, several cases showing the advantages of in-breeding have had but little effect upon the average breeder? This seems to be actually what has happened in the past, and few have practiced in-breeding.

Until recent years, or until the rediscovery of Mendel's Law in 1900, we knew little about the inheritance of characters which go to make up an individual animal, and consequently the blame for bad results when related animals were mated were placed upon the method of breeding; no attention was given to other conditions which probably were the direct cause ~~of~~

of the results.

It is a lamentable condition that we know so little about this method of breeding at the present time. If it is harmless and has many advantages as claimed, we are disregarding a great ~~secret~~ ^{method} in animal breeding, and spending large sums of money for the purchase of unrelated animals that could be utilized in improving the live stock industry in other ways. If it is harmful and these disadvantages are true, we should seek some means to prevent such a practice.

In this paper I shall take the stand of a neutral, and all literature and available material of value upon the subject both for and against, will be studied with a view of determining our present knowledge of in-breeding in regard to the improvement of our domestic animals.

II

REVIEW OF LITERATURE

The literature upon the subject of in-breeding is so abundant and of such a ~~variable~~ character that it is difficult to compile in a manner presentable to the reader. For convenience we may divide this array of literature into two classes; namely, scientific and popular. Trouble begins with the establishing of a division between these two main classes. How are we to determine between scientific and popular literature? It seems to me that the division between these two classes of literature is merely the opinion of an individual. One might say that scientific literature should include only actual experimental work which has been done to determine the effects of in-breeding. This would most certainly be a clear-cut division, but it would not place the proper value on the practical breeding experiments which have been run by many breeders of domestic animals. In this paper, I shall consider all experimental work and other literature of good or unquestionable origin as scientific; and literature of a more questionable origin, and the opinions of men who have drawn their conclusions from the work of others as popular. It should be kept in mind that scientific literature is of greater value than popular, and at the same time we must give this class of literature (popular) due consideration.

Under each of the above mentioned divisions, we find literature which is favorable, unfavorable, and neutral toward in-breeding. In regard to popular literature, I shall discard the greater amount of that which we know to be absolutely worthless, and has been repeated time and time again merely

to fill up space.

(a) SCIENTIFIC

Experiments of Castle (1) and His Students

The main objects of these experiments were to determine the effect of in-breeding, cross-breeding, and selection upon the fertility and variability of Drosophila. The major in-breeding experiment covered a period of $4\frac{1}{2}$ years, and carried a single series (A) through 59 generations of brother by sister matings.

Material and Methods. The organism used was the small fruit fly Drosophila-ampelophila. The parental stock came from a different source for each series used. The life cycle was found to be short (15 to 20 days), and they were kept breeding the year around at ordinary room temperature. For the first twelve generations, the food consisted of fermenting grapes, and from the twelfth to fifty-ninth generation it consisted of fermented bananas.

Brother by sister matings were carried on for 59 generations. (Following the 47th generation, cousins were allowed to mate for about two generations, and during this time no record was kept) Care was taken that all matings were between brother and sister. Pupae of the same parentage were put together, a pair in each of a number of jars (glass tumblers 8 c.m. deep and 6 c.m. wide were used during the greater part of the experiment) and covered with window glass. When the imagoes

~~M~~erged, if in any jar they proved to be of different sexes, they were left together; if of the same sex, the flies were rearranged so as to bring those of opposite sex together. Thus, each female was ultimately placed in a jar with a single male brother, and allowed to remain there during its entire subsequent life.

Pairs which produced no young by the end of 2 to 3 weeks were ^{dis}recarded as sterile, and in many cases each parent was placed with a new male to ascertain, if possible, in which of the two parents the sterility lay.

In-breeding

Series A. The A series which was in-bred (brother by sister) 59 generations were of low productiveness, compared with series M, N, and outside stock, throughout the experiment, and sterility was very common. There were periods of extremely low productiveness, followed by periods of higher productiveness, which as a rule could be attributed to lower temperatures, although this variation in productiveness did not follow any definite season of the year, and the length of time between the period of low and higher productiveness varied from time to time.

In October, 1903 (31st generation), the A series fell off very rapidly in productiveness and seemed on the verge of extinction. Four out of seven pairs were sterile, and the three fertile pairs produced in all only twelve young. At the same time, control pairs from outside were producing vigorous broods containing from 200 to 300 individuals.

But in the subsequent (32d) generation, this A series seemed to recover its normal condition, and maintained it, with some periods of fluctuation, to the end of the experiment.

The average number of young produced by the A series (fertile pairs) had never been as high as 200 until the 53d generation (winter of 1905); usually, it was under 100, and about 1 in 5 of the pairs formed had been sterile (at least between the period of the 12th and 44th generations). Control cultures made under identical conditions, but from stock not in-bred, had a productiveness two or three times as great, and showed no signs of sterility. If these were effects of in-breeding, they began to show themselves early, the small productiveness as early as the sixth generation, the partial sterility as early as the 13th generation, and probably earlier. But it was thought very improbable that the low productiveness of case A was due to in-breeding, for when the in-breeding experiment was repeated with other stock of flies, no appreciable diminution of fertility occurred.

It could not have been due to selection, conscious or unconscious, of parents of least productive broods, for it was the practice of Messrs. Carpenter and Clark "to start a number of cultures and then breed from the one which succeeded best", which would be in general the most productive rather than the least productive pair. Selection certainly has a much greater influence on fertility than does in-breeding; so that selection from the most productive pairs is able to more than affect the effects of in-breeding. Still it was not sufficient in the

experiments of Carpenter and Clark to bring the A series up to normal productiveness. This shows that low productiveness must have been present in the A stock at the beginning of the experiment and persisted throughout regardless of selection.

The following table will show the record of the A series from the 13th to 59th generation. The record of this series as shown on page 736, Proc. Amer. Academy of Arts & Sc., Vol. 41, will be divided into as nearly four equal divisions as possible to bring out more clearly the effect of in-breeding on the size of brood and the per cent of sterility. Generations not appearing; that is, from the thirteenth to fifty-ninth inclusive, indicate that the records for such generations are not complete.

Table I.

(Taken from record of A series, P. 736)

	Generations			
	15-24	26-35	36-43	50-59 (inclusive)
Average No. of pairs tested	9	10.7	10.1	5.7
" " " sterile pairs	1.5	2.8	1.0	0.1
Per cent of " "	16.5	24.5	9.9	1.7
Av. Brood for fertile pairs	44.6	76	104.7	205.5

From this table it looks as if in-breeding has absolutely no effect upon fecundity and sterility. The average productiveness for the last ten generations (50-59 inclusive) is more than four times as great as for the first ten generations (15-24 inclusive) recorded, and the per cent of sterile pairs decreased

from 16.5 to 1.7 per cent. It should be noted that the sterility for the second period is almost double that for the first period; however, this period includes the 30th, 31st, 32d, and 33d generations where sterility was unusually high.

During the early part of this experiment, from the first to the twelfth generation, it was conducted by F. W. Carpenter and no record was kept of the number of sterile pairs, or the total number of young produced by each pair (except in generation 6), attention being directed chiefly to the effects of inbreeding on variability. No variability that occurred could be attributed to inbreeding. Beginning with the thirteenth generation, the experiment was taken over by A. H. Clark, and a more complete record was kept. Clark had charge of the experiment from the 13th to 25th generation; W. E. Castle from 26th to 49th generation; and W. M. Barrows from 50th to 59th generation. An accurate record was kept from the time Clark took over the experiment to the end, with the exception of a few generations.

When sterile pairs occurred, each member was mated with new mates to ascertain in which of the two parents the sterility lay. Both males and females were found to be sterile, but in no case were both members of the same pair found to be sterile. This indicates that the sterility observed was not relative, but absolute; for an animal which was found to be sterile toward one mate was sterile toward all mates.

Series M and N. These two series were in-bred (brother by sister) for fourteen generations and proved to be much higher in productiveness than series A. The average brood never fell below 200, except in a single generation of each series, and was usually nearer 300, occasionally as high as 400 or even higher. The M series showed a few cases of sporadic sterility; the N series none whatever. The M series increased slightly in productiveness during the fourteen generations of inbreeding; the N series falling off somewhat.

When these series were divided as nearly as possible into three periods of equal length, the following average broods were obtained:

	Generations		
	1-5	6-9	10-14
M series	261	239	331
N series	322	268	244

These three experiments certainly show that in-breeding was not the cause of low productiveness and the sterility of series A, but that particular degree of productiveness may be found in stock from different parental sources.

The parental stock of the M and N series came from a different source or location than the parental stock of the A series, and were used as a control on the results of the A series previously obtained, and also to obtain a stock of known productiveness to use in crosses with the A series.

Cross-breeding

When males and females of the A series, which was of low productiveness, were crossed upon individuals of series M, N, and the stock race, all being high in productiveness, the parental females did not have their fecundity increased or diminished by the male regardless of whether he came from the low or high producing series.

The cross-breeds produced by these matings were usually of high productiveness similar to the series from which the high producing parent came; some matings being even more productive than the high producing parent, although the cross-breeds produced by mating females of the A series to males of the high producing series were not always of high productiveness. But as a rule these cross-breeds were of high productiveness, and this seems to have been the only matings where high productiveness did not dominate in the F generation. The sterility observed in these cross-breeds seemed to follow very closely with the productiveness of the broods. The per cent of sterile pairs was invariably higher among the pairs selected from small broods.

Selection. Selection was made from broods of low and high productiveness in the in-bred series A between the 30th and 43d generations. The following is the average of a number of the lowest and highest parental and filial broods considered, and also the per cent of filial pairs found to be sterile:

	Parental Broods	Filial Broods	% Filial Pairs sterile
Lowest	96	91	23
Highest	185	104	13

Other selections were made from broods more or less productive (different series) but of similar ancestry, and the following averages were obtained.

	Parental Brood	Filial Brood
Lowest	196	197
Highest	232	239

These experiments indicate that the productiveness can be more or less regulated by selection and, at the same time, sterility is much greater in pairs selected from low productive broods.

GENERAL SUMMARY OF EXPERIMENTS

By Castle (1)

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

2. In crosses of a race of low productiveness and inclined to sterility (race A) with a race of high productiveness (B) it has been found that females of race A do not have their fecundity increased by mating with males of race B, and conversely females of race B do not have their fecundity diminished by mating with males of race A. Hence, every male not actually sterile furnishes an abundance of functional spermatozoa.

3. The cross-breeds produced by mating $B\varphi$ by $A\sigma$ were all of high productiveness.

4. The cross-breeds produced by mating $A\varphi$ by $B\sigma$ were

usually, but not always, of high productiveness.

5. The children of both crosses (see 3 #4) were of both high and low productiveness.

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 failed to reappear in generation F_2 , indicating its complete extinction by the cross. In a few cases it failed to be dominated by high productiveness in generation F_1 . In such cases the female parent was always 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 skipping a generation.

7. A cross between two races, one in-bred for 30 or more generations and of low productiveness, the other in-bred 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 produced offspring superior to either pure race in productiveness.

9. In-breeding does not affect the variability of parts nor the size of individuals."

EXPERIMENTS OF W. J. MOENKHAUS (2)

These experiments were run to determine the effect of in-breeding and selection on the fertility, vigor, and sex ratio of *Drosophila Ampelophila*.

Material and Methods. Several strains (different parental source) were started at the beginning of these experiments, but only two were carried beyond the second or third generation, and these were called 6 and 7. The latter was discontinued after the tenth generation since it had been from the beginning apparently less prolific. The strain 6 was in-bred (brother by sister) for over 75 generations, and is the one on which the results of inbreeding are based.

The brothers and sisters were paired off in 8 dram shell vials within the first ten or twelve hours of their life as imagoes. The food consisted entirely of well ripened bananas and all possible precautions were taken to prevent foreign eggs from being introduced on the food. To prevent the larvae from pupating in the food, narrow strips of moist blotter or filter paper were introduced in which they seemed to be especially fond of pupating. The vials used were very satisfactory, as they could be plugged with cotton, which allowed a small amount of air to enter. The flies are strongly positive to light, so that the vials could be laid with their bottoms toward the light and the cotton plugs removed with safety for the introduction of food. The room temperature was kept as near constant as possible, varying from 60 to 80 degrees Fahrenheit.

Sterility (strain No. 6). When this in-breeding experiment first began, 5 pairs (brother by sister) were mated in each generation. Along at the fifth and sixth generation, it became more and more difficult to keep the strain alive with the five pairs of brothers and sisters that were mated each generation. The failure of an occasional pair to produce young had hitherto been attributed to the conditions of food, etc., but this no longer seemed a satisfactory explanation of all the failures to produce young. To avoid the strain from running out, and to gain a better knowledge of the cause for unproductive pairs, a much larger number of pairs were selected to breed from than had previously been used. The greatest care was taken with the food, temperature, etc., and it was soon learned that a variable per cent of the pairs were sterile. It was clear now that while in-breeding had not reduced the general vitality of the strain (so far as could be detected) thus far, there had appeared a large number of sterile pairs.

Character of the Sterility. The females of these sterile pairs were apparently productive so far as the capacity to produce eggs, and as copulation had taken place frequently between individuals of many sterile pairs, it seemed that impregnation should follow. To find an explanation of this sterility, thousands of eggs were removed from the vials and placed in other vials so that they could be observed with the microscope. They were examined after twenty-four, forty-eight, and seventy-two hours, and never was there an egg observed

which produced a larva. Eggs removed from fertile matings, under identical conditions, produced larvae within twenty-four hours. The eggs were not sectioned and examined to see whether spermatozoa entered the eggs or whether they contained partially developed larvae which failed to hatch; however, the sex at fault was determined in this strain. This was done in the following manner. After a pair by sufficient trial had proven itself infertile, the male was mated to a virgin female of a fresh strain that had not been in-bred and possessed a high degree of fertility, and the female was similarly mated with a male, usually one whose fertility had been established. Sixty-four such cases were tried and in no case did the females fail to produce young, and in no case did the males produce any. Although repeated, copulation took place. This establishes the fact that in this strain the sterility lies exclusively in the male and that the female has lost apparently nothing in fertility. Here it is interesting to note that Castle (1) found either sex to be sterile. However, Castle took no account of eggs and larvae, but merely the production of pupae, so that his sterility cannot be with certainty compared to the sterility of this experiment. These results show that when sterility occurs, it is complete for all males.

Degrees of Sterility. It was observed that pairs selected from the same brood (all brothers and sisters) had a wide variation in productiveness, ranging from complete sterility to comparatively high fertility. To test this variation of

fertility, the following experiment was carried out:

About 200 eggs from each of 17 pairs of flies were laid out as indicated in the previous experiment. Ten of these pairs had been in-bred for 17 generations while seven belonged to fresh stock that had not been in-bred. Of the ten pairs of the in-bred strains, five belonged to a strain which had arrived at a very low degree of fertility; only 36 per cent of the forty-two pairs tested were fertile. These five pairs were brothers and sisters to many of the sterile pairs considered in the preceding experiment. The other five pairs (of the ten in-bred) were from a strain which had been held by selection to a high degree of fertility; namely, 97% of the thirty-four pairs tested were fertile. Both of these strains were descended from common great-grandparents.

A comparison of the fertility of the eggs produced by these three strains were made. The comparison was made of three conditions; i.e., (1) eggs from a highly infertile, in-bred strain; (2) eggs from a highly fertile inbred strain; and (3) eggs from a presumably normal strain that had not been in-bred. Approximately the first 200 eggs of each pair were laid out in batches of about twenty to twenty-five to the vial. The number of eggs that hatched and also the number that immerged as imagoes were noted in each case. The following is the average results for ~~the 5 pairs of~~ each strain:

In-bred (low fertility) P. 130.

Table II.

Pairs:	Total eggs: placed	Total eggs: hatched	Total imagoes: emerged	% Eggs hatched	% Imagoes emerged
5	915	890	795	97.27	86.8
<u>(High fertility)</u>					
5	950	932	809	98.2	85.1
<u>Normals (not in-bred)</u>					
7	1189	1155	975	97.2	82

From this table it appears that the fertility of the eggs from the highly fertile in-bred and the highly infertile in-bred strains differ very slightly either in the per cent of eggs hatched or the per cent of imagoes emerged. This clearly brings out the fact that when infertility ~~arose~~ in this strain, it ~~arose~~ suddenly and does not present all intergradations; that is, one does not find that among a large number of brothers and sisters some pairs whose eggs partially hatch, and other pairs that range in this respect, on the one hand, to perfect fertility, and, on the other, to complete sterility. The fertility of the eggs is either of a high degree or completely lost.

In the comparison of in-bre~~eds~~ with the normals (not in-bred) in regard to the percentage of eggs hatched, no essential difference was observed. This would seem to indicate that the pairs that had not completely lost their fertility, in so far as hatching their eggs is concerned, had undergone no deterioration

whatever as a result of seventeen generations of in-breeding.

IN-BREEDING AND VIGOR

This experiment covered a period of $4\frac{1}{2}$ years, and more than 75 generations of brother by sister matings were observed. The methods of mating have previously been stated. In the early part of this experiment, the vigor of the in-bred strains 6 and 7 was tested in the following manner: (1) Their rate of reaction to light and gravity; (2) the total number of eggs produced; and (3) the percentage of eggs which hatched and emerged.

(1) The reaction of this animal toward light and against gravity is well known. To get a measure of the rate of reaction, the flies were made to travel through a blackened glass tube 16 c.m. in length. The tube was inclined about 25 degrees, and a light placed at the upper end. To make everything as uniform as possible, the two batches of flies (in-breeds and normals) were reared under the same conditions, were of the same age, temperature of the room was kept the same, and the sexes were about equal. The results were as follows: At a temperature of 27.2 deg. C., 133 normals took an average of 16 seconds to travel the distance, and 140 in-breeds took 15.4 seconds. In both groups, the males traveled the distance on an average of three seconds less time. Here again, inbreeding has not caused any injurious effects with respect to these agents.

(2) Great care was observed in counting the eggs produced by the 5 matings (only fertile pairs) up to the 9th and 10th

generations of series 6 and 7. No material reduction occurred during this period. Such variations as occurred were attributed to individual differences in the females.

(3) The data given in table I shows that no deterioration had taken place in respect to hatching and emerging qualities where in-breeding had been practiced for seventeen generations. No such exacting determinations were made during the latter part of the experiment, but Mr. Moenkhaus believed that no detrimental effects were manifested by seventy-five generations of in-breeding.

Sterility and Selection. More than 50 per cent of the males of some pairs had become sterile during the thirteenth and fourteenth generations. On the other hand, while practically all pairs showed some degree of sterility, this was observed to vary much between the different brothers and sisters of the same brood. As sterility was not wholly wanting in broods that had not been in-bred, it was very doubtful as to whether this sterility was a direct physiological result of in-breeding. In order to keep the strain alive, it was decided to determine the effect of selection.

This was done as follows: In the fourteenth generation, three fertile pairs of brothers and sisters from the same brood were isolated and mated. The offspring of each of these were paired to determine the degree of sterility. It was found that nine out of twelve pairs tested, from the pair marked A, were infertile; from another pair marked B, four pairs out of fourteen tested were infertile; and pair C threw offspring with five pairs out of fifteen infertile. Pair A showed 75 per cent of

pairs(offspring) infertile, while the pairs B and C approximately the reverse ratio. At this point of the experiment, pair C was discontinued and the descendants of pairs A and B are referred to as strains A and B.

To be sure that the strain A continued to show a low degree of fertility and the strain B a high degree of fertility without selection, a single fertile pair of each strain was tested. The pairs tested came from the fifteenth in-bred generation. Forty-seven pairs of offspring were tested from the pair coming from the A strain. Twenty-seven pairs or 57 per cent of the pairs were found to be sterile, while in strain B none of the 37 pairs tested were found to be sterile. The same process was repeated with a pair of the sixteenth generation of the two strains. Strain A showed sixty-four per cent of the forty-two pairs tested to be sterile, while strain B showed three per cent of the 36 pairs tested to be sterile.

To be absolutely positive that he was not unconsciously selecting pairs that gave the above results, and probably not representing the true state of fertility of the strains, he selected five pairs from each strain (eighteenth generation) and tested the fertility of their offspring. The following table gives the results obtained.

Table No. III

Strain A (Journal of Morphology, Vol. 22, p. 136)

	No. Pairs Tested	No. Pairs fertile	No. pairs infertile	% Pairs fertile	% pairs infertile
18 (1)	52	27	25	51	49
18 (2)	51	37	14	72	28
18 (3)	52	37	15	71	29
18 (4)	56	45	11	80	20
18 (5)	28	19	9	69	31

Average fertility for 239 pairs 69%.

Strain B.

18 (1)	15	15	0	100	0
18 (2)	14	14	0	100	0
18 (3)	19	19	0	100	0
18 (4)	22	15	7	68	32
18 (5)	23	23	0	100	0
<u>Average fertility for 93 pairs 92.5 %.</u>					

From these results, one would draw the same conclusion as did Mr. Moenkhaus,--that by selection from among the variable offspring of generation fourteen of the in-bred strain, two strains, one of low and another of high fertility have been established.

At this point, strain B was dropped, but by selection a strain of high fertility was established from strain A in two generations, which gave an average fertility for 211 pairs of 93.8%. The offspring of five pairs were tested for each generation. The sex ratio was also found to be an inherent

character and amenable to selection.

GENERAL SUMMARY OF EXPERIMENTS

(By Moenkhaus 2)

1. "Drosophila ampelophila may be in-bred (brothers and sisters) for 75 or more generations.
2. In-breeding in itself is not deleterious to the fertility or vigor of this species.
3. Infertility normally occurs to a varying degree among the offspring of any pair. Promiscuous in-breeding among such offspring may perpetuate and even intensify this character. When sterility appeared in the strain experimented with, it was always complete, appeared suddenly, and was confined to the male.
4. By the judicious selection of the brothers and sisters to be mated from a brood that shows a high degree of infertility, this infertility can be eliminated by selection, although continuing the in-breeding in the closest possible way.
5. There is a wide divergence in the fertility and productiveness among the different pairs taken in nature, but by proper selection and closest in-breeding, these may be readily brought to either a high or a low state with respect to these characters.
6. Many generations of closest in-breeding does not necessarily cause any loss in size, perfection of form, rate of reaction to light and gravity, egg production, or length of life and sex ratio.

7. Sex-ratio is an inherent characteristic of this creature, strongly transmissible and amenable to selection.

8. The female is almost wholly responsible in the transmission of sex-ratio. For if females from a strain possessing a high female ratio be mated with males from a strain possessing a low female ratio or vice versa, the offspring will show a sex ratio which is wholly or very near that of the strain from which the females were taken."

Experiment of Dr. King (3). (This experiment has not been published in full, but a synopsis of portions of it appears in the January and February issues of the Journal of Heredity,--1916) Dr. Helen Dean King of the ~~Wistar~~ Institute, Philadelphia, Pa., has carried on an in-breeding experiment with white rats for 22 generations, accompanied by careful selection and followed by excellent results.

This experiment was first started to determine whether in-breeding alters the sex ratio by increasing the number of males, as a number of investigators have claimed.

In the rat, the normal sex ratio was found to be the same as in man and cattle; namely, 107 males to 100 females. Dr. King began her work by taking from the stock animals one healthy litter of new born rats, two males and two females. During the first six generations, no selection for sex was made, the object being to get the stock well established and homogenous. No change in sex rates appeared during this period. Brother by sister mating was practiced from the start. The descendants of one pair of the rats after the 6th generation

all came from the mating of brother and sister from litters in which males invariably predominated. This she called the A or male line. The B or female line of her experiment came from the other pair of the original litter and was obtained by mating brothers and sisters from litters containing (after the 6th generation) an excess of females.

After the sixth generation, constant selection was followed for the A line in one direction and for the B line in the other direction with strict in-breeding of the animals selected. She also selected from the most vigorous broods, and avoided the mating of an individual which did not appear normal.

By the above method, it appears that the tendency to produce a disproportionate number of one sex was fixed in each line of descent. Instead of a normal ratio of 107 to 100 (which was established for this particular stock at the beginning of the experiment, by ascertaining the sex ratio in 1,000 new-born litters) Dr. King found in various generations ratios as far apart as 150 males to 100 females in the A or male producing line, and 65 males to 100 females in the B or female producing line. At the time this data was taken, about 1,000 rats were being produced each generation.

After 22 generations of in-breeding (brother by sister) Dr. King found no deterioration in any respect. The rats were larger and more fertile than the common stock. During

the six years that the experiment has been conducted, she has failed to find a single sterile individual. In the 6th in-bred generation, she produced the largest albino rat ever recorded. At the end of fifteen months, he weighed 550 grams, while the stock rats of the same age, bred without regard to consanguinity, average 320 grams.

Dr. King sums up the experiment to date as follows:

"The results so far obtained with these rats indicate that close in-breeding does not necessarily lead to a loss of size or of constitutional vigor or of fertility, if the animals so mated come from sound stock in the beginning and sufficient care is taken to breed only from the best individuals."

From Dr. King's results, in regard to sex ratio, it looks as if strains of rats can easily be established which predominate in either sex, and in-breeding has no effect unless the character be present in the stock.

Experiments of Bos, Weisman, and VonGuaita. Castle (4), Thompson (5), and Morgan (6) each give a synopsis of the in-breeding experiments of Bos, Weisman, and VonGuaita as follows:

"Bos (Biol. Centralb., ~~art~~ XIV, 1894) practiced continuous in-breeding of a family of rats for six years (30 generations). No ill effects were observed during the first half of the experiment, but in the following generations there was very marked decrease of fertility, increase of

mortality, and decrease of size. But there was no disease or abnormality which could be attributed to in-breeding. The average size of the litter in the first half of the experiment was about 7.5 and fell to 3.2 in the last half. Many pairs were found to be completely sterile, the size decreased from 8 to 20 per cent, and the mortality of the young increased from 3.9 per cent (1887) to 45.5 per cent (1892).

Weisman ("Berichte der Naturforschenden Gesellschaft zu Freiburg," 1900) in-bred a colony of mice for 8 years (29 generations). The result was a loss of fertility. In the first 10 generations, the average young per litter was 6.1; in the next generations it was 5.6; and the last nine generations, it was 4.2. This experiment was carried on for several generations by Von Guaita with similar results.

Experiment of N. H. Gentry (7). Mr. Gentry, who has in-bred Berkshire hogs for a number of years, has the following to say in regard to this method of breeding:

"In-breeding, as a rule, is very good or very bad. If you intensify the blood of animals that are good, you do good, but if they are bad, you go wrong as fast or faster than you go right in the other case. If it is true that in-breeding intensifies weakness of constitution, lack of vigor or too great fineness of bone, as we all believe, is it not as reasonable and as certain that you can intensify strength of constitution, heavy bone, or vigor if you have these traits well developed in the blood of the animals you are in-breeding with? The latter is certainly my belief and my experience.

I also believe, as do most well-informed breeders, that the in-bred animal, if a good one by inheritance from ancestors of the same quality, will, as a rule, prove the more prepotent breeder; that is, he will show improvement to a greater extent when crossed on outside families. I believe there is little or nothing to fear from kinship of animals mated, if they are suited to be mated together. I have watched results of in-breeding in my herd for years, and until I can discover some evil effects from it, and I have not yet, I shall continue to practice it. I think many breeders have made mistakes by studying pedigrees; that is comparing pedigrees with each other, rather than studying the animals."

Mr. Gentry's experiment began with the boar, Longfellow 16,835, sired by Charmar's Duke 13,360 and out of an imported sow. This sow was sired by the same boar as was the dam of Charmar's Duke. After the death of Longfellow, his best sons, grandsons, and great-grandsons were used in the herd. Mr. Gentry states that one of the largest and best boars he ever produced was by a son of Longfellow out of a daughter of Longfellow. "This boar weighed 660 pounds at 13 months and 6 days of age, with as much action, strength, vigor, and masculine development as any boar I ever saw," said Mr. Gentry.

To further substantiate his views on in-breeding, I quote the following from a letter I recently received from Mr. Gentry: "Lady Lee 50th 33,469 was the greatest sow I ever saw of any breed and so said many good judges who bred other breeds of hogs. Her full brothers, King Lee 27,500, King Lee

~~the~~ 2d 29,801, Baron Lee 4th 33,446, and Baron Lee 6th 34,246 were all among the greatest ever produced, and were all great breeders. All by Longfellow 16,835 and out of a sow (Lady Lee 7th) strongly bred in the same blood. I could mention many other famous animals produced by the same method of breeding." Notice the pedigree of Lady Lee 50th which shows the degree of in-breeding practiced in producing the famous animals just mentioned by Mr. Gentry.

Mr. A. J. Lovejay, another famous American breeder of Berkshires, attributes his success to the practice of in-breeding. He is quoted by Davenport (30) as follows:

"We are believers in quite close, even in-breeding. We find the greatest show animals are closely in-bred. Sires to half-sisters is the most common form of close breeding, though cousins, nephews, and nieces, and even brothers and sisters are bred together with great success. It of course requires good judgment in mating animals that are particularly strong in individual merit. Should each have a bad effect in any way, we should expect that to be more manifest in the offspring than in the parents, and likewise the good points would be better; so, if one mates equally good specimens, the produce will be an improvement. There is no sire of any breed so prepotent as an in-bred sire. When we get to the point where we feel the need of outside blood, we mate an imported sow with our best boar, and from this litter we select a boar to use upon the get of his own sire from other sows in the herd; that is, we breed this boar to his own half-sisters."

Pedigree of Lady Lee 50th 35469

BRED BY

M H Trenchy
Tobacco, Mo

19360

Charmers Black

Black of Hawthorn
11361

Thorn 4th 1017
Selling C. 11358

For 3891
Black Tail (8042)
Wigard I 11355
Wigard II 11352

Royal Charmers
9082

For 3891
Charmers II
9080

Ridgale 388578
Charmers 4428

For 3891

Charmers 3889

For 3885
Ridgale 57198

Murrie Lee

14606

Charmers II
8034

Wigard II 2001
Charmers 4448

Lady Knight III
10192

For 3887
Wigard II 2001
Charmers 4448
Wigard II 2001
Charmers 4448

For 3891

16835

Model Black

17397

Perfection
14681

Black of Hawthorn
11143
Wigard II
14680
Wigard II 11142
Wigard II 3891
Black Tail 8042

Lady Lee 7th
25107

For 3891

16847

Charmers Black
13360
Charmers 10191

Wigard 4th 10188
Wigard 9822

For 3891

21602

For 3891

Charmers Black
13360

Experiments of Cornevin. Charles Cornevin (8)

practiced in-breeding with cattle, sheep, and fowls for many years without injury, but his experiment with swine was unfavorable to this method of breeding. He in-bred his Hollander Cattle for twelve years, Jersey cattle for twelve years, and Merino sheep for eleven years without observing any evidence of degeneracy. He in-bred Yorkshire and Essex swine for a number of years, and found that they became too fat and sterility or decrease of fecundity was the result. Pigeons regularly in-breed in the closest manner, according to Cornevin; that is, brother mates with sister. He also states that this is often the case of swans, geese, ducks, and guinea-fowls. He pursued in-breeding for eleven years with guinea-fowls and geese, and there was no perceptible change of color, weight, or fecundity. His rabbits were in-bred for several generations. Their offspring became white to a large extent, or developed a strong tendency to albinism.

From these experiments, he drew the conclusion that in-breeding did act on all animals alike, and one could not assert for all species, that it was wholly harmless.

Bize (9) found by breeding together brother and sister of the Yorkshire breed of swine that in two years the in-breeding resulted in a loss of 61.6 pounds in weight at twelve months of age. He then crossed the Yorkshire breed with a French breed (Croannais) and

found that the offspring were larger than the Yorkshires, although not as large as the Croannis breed.

Experiments of Wright and Nathusius (11). Mr. John Wright crossed the same boar with his daughter, granddaughter, and great-grand-daughter, and so on for seven generations. The result was that in many instances the offspring failed to breed; in others, they produced few that lived; and of the latter, many were idiotic, not having enough sense to suck, and when attempting to move could not walk straight. The best sow produced during the whole seven generations was one in the last stages of descent, but the litter consisted of this one sow. This sow failed to breed to her sire, yet bred at the first trial to a stranger in blood. It seems that

in Mr. Wright's experiment, long continued and extremely close in-breeding did not affect the external form or merit of the young; yet, the mental powers, general constitution, and the reproductive functions of many were seriously affected.

The experiment of Nathusius as quoted by Darwin⁽¹²⁾, p. 101.

"He imported from England a pregnant sow of the large Yorkshire breed, and bred the product closely in-and-in for three generations: the result was unfavorable, as the young were weak in constitution, with impaired fertility. One of the latest sows which he esteemed a good animal produced, when paired with her own uncle (who was known to be productive when paired with sows of other breeds), a litter of six, and a second time a litter of only five weak pigs. He then paired this sow with a boar of a small black breed, which he had likewise imported from England; this boar when matched with sows of his own breed, produced from seven to nine young. Now the sow of the large breed which was so unproductive when paired with her own uncle, yielded to the small black boar in the first litter twenty-one, and in the second litter 18 pigs; so that in one year she produced thirty-nine young."

In-breeding Cattle. Bakewell, who is recognized as the foremost early improver of livestock, "cared not about distant or near affinities in his experiments with Long Horn cattle and Leicester sheep," says Mac Donald (13). Manly Miles (14) also mentions the methods of breeding adopted by Mr. Fowler and Mr. Bakewell. The pedigree of Shakespeare given by Miles (p 148) shows the extent to which in-and-in breeding was

Pedigree of (Longhairs)

Shakespeare

BRED BY

Wm. Faulkner

England

Son of Mrs -

Jenny

Thompson

Westmoreland Place

Old County

A County Cur -

-

D

Westmoreland Place

Thompson

Old County

Daughter of D

Old County

Westmoreland Place

Thompson

Old County

Daughter of
Thompson

A County Cur -

practiced by those who were most successful in improving the Long~~Horn~~ breed. Shakespeare was the most famous animal ever bred by Mr. Fowler and his sire D represents one of Bakewell's improved Longhorns. Yanott, ^[(15) - p. 199] says that Bakewell's cattle, after a long period of close breeding, acquired a delicacy of constitution with common management, and the propagation of the species was not at all certain. Miles also mentions the "high-bred" (meaning in-bred) Devon cow, Eveleen 5th (466), formerly owned by the Michigan Agricultural College. According to Miles, she was an exceptional individual; being a regular breeder, a good milker, and remarkable for her feeding qualities and sound constitution. (Miles, 14, p. 148) "Her dam traces to Forester thirty times, to Sillifant ten times, to Hundred Guinea seven times, and to Quartly's Prince of Wales three times in eight generations. Her sire within the same limits traces to Forester twenty-one times, to Sillifant twenty times, to Hundred Guines thirteen times, and to Quartly's Prince of Wales five times." Quartly's Prince of Wales (105) was also closely bred in the blood of Hundred Guinea (56) and Sillifant (120). (Pedigree taken from Miles' Stock Breeding p. 149)

Chillingham Cattle. (Darwin, 12, p. 97) "The half-wild cattle, which have been kept in British parks probably for 400 or 500 years, or even for a longer period, have been advanced by Culley and others as a case of long-continued inter-breeding within the limits of the same herd without

Pedigree of ~~Edward~~

Quarth's Prince of Wales (105)
RED

Quarley, Eng

Quarley Prince

(156)

Quarley (120)

Quarley (192)

Quarley Albert
(102)

Quarley
(115)

Quarley (120)

Quarley

Quarth's Prince of Wales
(105)

Quarley
(116)

Quarley Prince
(156)

Quarley (120)

Quarley (192)

Quarley

any consequent injury. With respect to the cattle at Chillingham, the late Lord Tankerville owned that they were bad breeders. The agent, Mr. Hardy, estimates that in the herd of about fifty the average number of animals, ^{annually} slaughtered, killed by fighting, and dying is about ten, or one in five. As the herd is kept up nearly to the same average number, the ~~annual~~ rate of increase must be likewise about one in five. The bulls, I may add, engage in furious battles, of which the present Lord Tankerville has given me a graphic description, so that there will always be rigorous selection of the most vigorous males. I procured in 1855 from Mr. D. Gardner, agent to the Duke of Hamilton, the following account of the wild cattle kept in the Duke's park in Lanarkshire, which is about 200 acres in extent. The number of cattle varies from sixty-five to eighty; and the number annually killed (I presume by all causes) is from eight to ten; so that, the ~~annual~~ rate of increase can hardly be more than one in six. Now in South America, where the herds are half wild and therefore offer a nearly fair standard of comparison, according to Azara, the natural increase of the cattle on an estancia is from one third to one fourth the total number, or one in between three and four; this, no doubt, applies to adult animals fit for consumption. Hence, the half-wild British cattle which have long inter-bred within the same herd are far less fertile. Although in an open country like Paraguay, there must be some crossing between the different herds, yet even, according to Azara, the inhabitants believe that the occasional introduction of

~~of~~ animals from distant localities is necessary to prevent degeneration in size and diminution in fertility." Darwin attributes the apparent loss of size and lessened fertility of the cattle in the Chillingham and the Duke's park as due to close breeding rather than to less favorable conditions of life.

Aberdeen Angus Cattle In-bred. In the early development of Aberdeen Angus breed of cattle, in-breeding was practiced to some extent, but not to the same degree it was used in building up the Shorthorn foundation stock. Mr. Hugh Watson, who was to the Aberdeen Angus breed what the Colling brothers were to the Shorthorns, followed the breeding methods of the early improvers of the Shorthorns. Macdonald and Sinclair (16) state that his methods of breeding were to mate the best with the best regardless of relationship. ^[29]-p. 214] Plumb states that Watson in-and-in bred and produced a more early maturing, heavier-fleshed, blockier type that dressed out better than ever before. The following is a very good example of Watson's method of breeding, quoted from the Transactions of the Highland and Agricultural Societies of Scotland (17):

"Jack I, or better known as Old Jack (calved in 1842) was the greatest bull bred by Hugh Watson, Keillor, Scotland. Old Jack's pedigree, when traced back to 1808 or six generations, we find only six ancestors instead of sixty-four. Here he traces back to the two bulls Bannatyne Sandy and Tarnty Jack, with which Watson started breeding in 1808. His father

Grey-breasted Jack, was also his grandfather, and his dam's dam was also her grand-dam. Old Jack was a great show animal, and is regarded as the foundation sire of the following families: Ballindalloch Eriean, Pride of Aberdeen, Favourite and Princess."

Mr. ~~Mac~~Combie of Tillyfour, Scotland, was also among the earlier improvers who developed a wonderful herd between 1830 and 1880. His practice was to breed from close affinities, but according to Macdonald and Sinclair (16) (p. 93), he made the following statement in regard to inbreeding:

"In-and-in breeding may be pursued for a time, until the type is developed, but to continue to breed in-and-in is not only against my experience, but I believe against nature."

Although ~~Mac~~Combie did not believe in continued close breeding, we find that some of his best animals were very closely bred. Windsor 202, Charlotte 203, Lola Montes 208, Bloomer 201, and Black Jock of Tillyfour 365 were all in-bred animals and were among the most famous Aberdeen Angus of their day. Many of the later herds of Scotland were made famous by the use of these animals and their descendants. The foundation animals of the herd of Sir George Macpherson Grant were closely descended from the Watson and McCombie ~~Cattle~~ cattle.

The pedigrees of the above animals as presented here are not complete, but they illustrate McCombie's practice of in-breeding. Here again, as in the case of the Shorthorn and Hereford ~~Cattle~~ cattle, in-breeding has been the method of

Pedigree of Windsor 202

BRED BY

Mr. McQuinn
Highland, Scot.

Flowerd 44

Victor 46

Jeon Ann
206

Annice 51

Queen Milder
348

Annice 51

Wells

and Annice's
Black May.

Annice 51

Julia 671

Travelling

Captain 97
Black May 766

Annice 51

(above)

Queen of Bedouin

Captain 97

29

Black May 766

Victor

and Annice's
Black May.

Captain 97

Queen of Bedouin

29

Black May

766

(16) - P. 485

Windsor 202

Pedigree of *Charlotte 203*

BRED BY

Mrs. M. C. C. C.
High four, set.

August 45

Old Jack I

Young Buckles
Jack 21

Old Haverhill

Old Haverhill

Charlotte 203

(U) - P. 482 + 483.

Lala Mouto

208

[Brewer 201]

Musick 44

Panama 51

Victor
Lord Panama's
Beck May

Panama 51

Julia 671

Tucuma

Victor
Lord Panama's B.M.
Capt. Twin
Beck May 766

Panama 51

Victor
Lord Panama's
Beck May

Queen Mink

348

Queen of
Beck May 766

Capt. Twin 97

Pedigree of Black Jack of Tillyfau 365
 Tillyfau 365
 Sired by
 Mr. Wm. Cantle,
 Tillyfau, Oct.

Hutton
 228 (not found)

Black Jack of Tillyfau 365
 "A famous sire of
 prize winners and
 Col. Fraser's best of
 Cattle Fraser, Oct."
 (16) - p 145.

[Sliding of Tillyfau 1165]
 Sire of Fraser 578

[Sire of Cheekam
 581]

Hutton 228

Charlotte 203

Regus 46

Old Jack I

Old Jack I
Old Jack I

See Mutt

Thursd 44

Thursd 51

208

Queen Mutt

Queen Mutt 51

Queen Mutt 51

breeding adopted in developing or establishing the Aberdeen Angus breed.

In-breeding Guinea-pigs and Rabbits: Castle (4--p 148) gives an interesting account of the origin of a polydactylous race of guinea-pigs. This race was built up by the closest in-breeding of individuals, descended from one individual. To quote from Castle,--"This race has now been in existence for ten years, and it consists of one of the largest and most vigorous strains of guinea-pigs I have ever seen. It shows no indications of diminished fertility."

Huth (18--pp 277-287) inbred rabbits (brother by sister) for many generations, and found not the slightest indication of albinism (claimed by Aube and others). The size increased but there was a loss of fecundity. He did not attribute this loss of fecundity to in-breeding, because he made no selection for fertility, and there was no evidence to show that this character was not introduced accidentally. His original stock was composed of a pair of unrelated silver-grey rabbits,--knowing nothing of their ancestors. White rabbits appeared occasionally in the first few generations, but these were discarded and the silver-grey coat became more constant.

In-breeding Sheep. Mr. Miles (14--p 150) and Mr. Huth (18--p 253) state that in-breeding is quite generally practiced by sheep breeders. "The Merino sheep bred by the late Edwin Hammond present a remarkable example of close breeding. They were bred in-and-in by Col. Humphreys up to the period of Mr. Atwood's purchase. Mr. Atwood bred his entire flock from one

ewe, and never used any but pure Humphreys rams. Mr. Hammond has preserved the same blood entirely intact, and thus, after being drawn beyond all doubt from an unmixed Spanish Cubana, they have been bred in-and-in in the United States for upwards of sixty years. The pedigree of the ram Gold Drop, for which Mr. Hammond refused \$25,000 is an example of his close breeding."

American Saddle Horse in-bred. W. A. Anderson (19)

states that so far as is known to him, but one earnest and intelligent attempt has been made to evolve a pure bred type of saddle horse, and he relates with interest the experiment of J. Gano Johnson of Montgomery County, Kentucky.

Johnson selected three great sires to furnish the foundation material for his new horse; Indian Chief, Harrison Chief, and Wilkes. All three sires were of the light harness type, rather than the saddle conformation, but in the great speed of Wilkes the soundness, strength, and action of Harrison, and the intelligence and refinement of Indian, he believed that he had the essential elements to make a great breed of fine horses. His stud was established in the early eighties and by the judicious use of the blood of these three animals and their descendants, there has come a great type of horse. The mares first used did not possess the desired qualities; so, he practiced in-breeding in order to produce mares which would breed true to the desired qualities. "One of these, Queen, traces through Whirlwind to Indian Chief and Geo. Wilkes, while his sire, Red Cloud, was by Indian Chief and out of the dam of Wilson's King. This beautiful

Pedigree of *Good Wharf*

BRED BY

Charles Hammond

115

California

Superlatos

11 Grand Sire 3d.

11 Grand Sire 3d.

Old Whiskey { *Old Greeny*
11 Grand Sire 2nd
11 Grand Sire 3rd
11 Grand Sire 4th
11 Grand Sire 5th
11 Grand Sire 6th
11 Grand Sire 7th
11 Grand Sire 8th
11 Grand Sire 9th
11 Grand Sire 10th
11 Grand Sire 11th
11 Grand Sire 12th
11 Grand Sire 13th
11 Grand Sire 14th
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11 Grand Sire 85th
11 Grand Sire 86th
11 Grand Sire 87th
11 Grand Sire 88th
11 Grand Sire 89th
11 Grand Sire 90th
11 Grand Sire 91st
11 Grand Sire 92nd
11 Grand Sire 93rd
11 Grand Sire 94th
11 Grand Sire 95th
11 Grand Sire 96th
11 Grand Sire 97th
11 Grand Sire 98th
11 Grand Sire 99th
11 Grand Sire 100th

Superlatos

(1st place)

Beauty

Old Queen

Long Walk

Old Greeny
Greened Sire
Old Black
1st Old Sire

Old Greeny

Wharls

Old Black
1st Sire Found
Old Black
1st Old Sire

Long Walk

Lawrence Sire

Young Martin

Wharls
11 Grand Sire

Old Queen

Old Black

Greened Sire

1st Old Sire

Good Wharf
"Stock Breeding by
Miles" p. 152.

in-bred mare, Queen, was mated with Wilson's King, son of Harrison Chief. The colt from this mating, Golden King, proved valuable both as a show horse and as a sire. The half brother of Golden King, Claud King, by Wilson's King out of May Chief by Harrison Chief is scarcely less famous than Golden himself." The descendants of this new type of horse are now numerous in Kentucky and other states.

Anderson (20) also mentions the close breeding of the saddle-bred colt which won first prize at the Kentucky State Fair, Louisville, Sept. 1916. "This colt was sired by Roosevelt and its dam was by Roosevelt. The second dam was by Bourbon King; Roosevelt was also by Bourbon King (Son of Harrison Chief). A brother was mated to his sister and then back to the daughter of that sister and himself. The product of this last mating was good enough to win in a ring of the best."

IN-BREEDING VS. CROSS-BREEDING IN THE PLANT KINGDOM

Plant Experiments by Darwin. Charles Darwin (12), ^(pp. 108, 109) in his plant breeding experiments, found that plants which were cross-pollinated produced more seed in the parental generation, and the F₁ hybrids were more vigorous and produced more seed (being cross-pollinated each generation) than plants grown from self-fertilized seed. His experiments were with flowering plants that could easily be handled in pots. Species belonging to fifty-two genera were tested and all gave the same results. He always placed one plant derived from self-fertilized

seed and one from cross-fertilized seed in the same pot so that each had the same chance for growth, etc. The same method was used for the parental stock, where one plant was cross-fertilized and the other self-fertilized. All precautions were taken to protect plants from bees or other insects that would interfere with self-pollination. No attempt was made to ascertain the prolonged effect of a single cross. Plants were selfed or crossed each generation and continued for a number of generations.

Experiments with Indian Corn (Zea Mays) and Oats (Avena Sativa). After several years of corn breeding, Mr. Shull (21) comes to the following conclusions in regard to the self-fertilized and the cross-fertilized corn plant:

1. "The progeny of every self-fertilized corn plant is of inferior size, vigor, and productiveness. As compared with the progeny of a normally cross-bred plant derived from the same source. This holds true when the parents are above the average conditions as well as when they are below it.

2. The decrease in size and vigor which accompanies self-fertilization is greatest in the first generation, and becomes less and less in each succeeding generation until a condition is reached in which there is, presumably, no more loss of vigor.

3. A cross between plants belonging to two self-fertilized families results in a progeny of as great vigor, size, and productiveness as are possessed by families which had never

been self-fertilized. The yield per acre of the F_1 hybrid is greater than the F_2 ."

Hayes, H. K. and East, E. M. (22) found that five out of seven crosses between different varieties of corn gave an increase of from 7 to 44 bushels per acre over the parental stock in the F_1 generation. They found that in-breeding decreased the yield, but that this bad effect was not continuous; that is, the evil was greater for the first in-bred generation and gradually approached zero as the variety was separated into pure-lines. Carrier (23) found that when different strains of Boone County white corn were crossed that the increased yield in the F_1 generation varied from 13.8 to 35.3 per cent, and crosses between common varieties gave increased yields in the F_1 generation varying from 12.8 to 77 per cent over the parental varieties.

Dr. Love (24) in his experimental work with hybrid oats at Cornell University found that some crosses proved beneficial in the F_1 generation, while others were indifferent; but on the average (for five years) the hybrids yielded more grain than selections. The hybrids gave an average yield of 50.14 bushels against 46.09 bushels per acre for selections. Oats is a self-fertilizing plant under normal conditions.

All Crosses Not Successful. Macdonald (13)^(p-268) claims that all crosses are not successful, and he cites the cross of the Kylloe cattle on the Hebrides Islands as an example of an unsuccessful cross. He states that when these cattle were crossed with other breeds, they became more delicate, lost their symmetry, and were not suited to the climate and pasture.

(p. 413)
Macdonald^(p. 413) quotes Mr. Spooner's opinion on cross-breeding as follows:--"There is a direct pecuniary advantage in judicious cross-breeding; it increases size, brings about a disposition to fatten and early maturity. Although the benefits are more evident in the first cross, after which, on pairing the cross-bred animals, the defects of one breed or the other, or the incongruities of both, are perpetually breaking out.

In following the pure or in-and-in breeding, the danger to be apprehended is not so much from any defects arising from the principle of consanguinity, but from the breeding from stock having bad qualities."

Guyer (25) takes up Inter-racial Marriages and concludes that they are detrimental; quotes Agassiz on this point as follows:--"Let anyone who doubts the evil of the mixture of races and who is inclined from mistaken philanthropy to break down all barriers between them come to Brazil. He cannot deny the deterioration consequent upon the amalgamation of races, more widespread here than in any other country in the world, and which is rapidly effacing the best qualities of the white man, the Indian, and the negro, leaving a mongrel, nondescript type, deficient in physical and mental energy."

Of the American mulatto, one not infrequently meets with the assertion that he is on the average inferior mentally, morally, and physically to either the white or the negro race.

Doctor J. B. Taylor (26) states that, "It is demonstrated by well-attested facts that these hybrids of black and white are vastly more susceptible to certain infections; their moral as well as physical stamina is lower than that of either race."

According to the report of John W. Titcomb (27), chairman of committee on breeding fish, the experiments on crossing of allied species at several stations of the United States Bureau of Fisheries has been very disappointing. The F_1 hybrids are low in vitality, death rate exceedingly high, and many are deformed.

Darwin (28) found in his experiment with the common morning glory (*Ipomoea purpurea*), which was bred both crossed and self-fertilized for ten generations, that there appeared a plant in the sixth in-bred generation which was more vigorous than the crossed plants, although the morning glory was very sensitive to close breeding throughout the experiment. He self-fertilized this plant which he called "Hero" and found that its descendants proved just as vigorous, strong, and prolific. Descendants of "Hero" were crossed with a distinct stock, but the plants from this cross did not prove equal to the descendants of Hero. Darwin remarked, "Hero transmitted to its offspring a peculiar constitution adapted to self-fertilization." It appears, therefore, that Hero and its descendants have varied from the common type not only in acquiring great power of growth and increased fertility when subjected to self-fertilization, but in not profiting from a

cross with a distinct stock."

DISCUSSION OF SCIENTIFIC LITERATURE

We have abundant evidence in the literature cited, that in-breeding per se does not affect the size, variability of parts, productiveness, sterility, vigor and sex-ratio of the small fruit fly Drosophila. The experiments carried on by Castle and Moenkhaus with this small creature are the most thorough tests of long continued in-breeding we have on record.

The experiments conducted by Castle might be criticised because there were too many changes made in the men actually conducting the work, and in some instances the data is not as complete as it should be. Changing of men conducting an experiment of this nature is more than likely to bring about variations in the results, but at the same time if these men were perfectly reliable, I dare say that the changes were rather beneficial. When one man runs a long continued, tedious experiment, he is very liable to form an opinion (after carrying on the work for two or three years) of just what the final results are going to be, and overlook slight variations which would be readily noticed by a man who had not spent so long a period on the same experiment. The experiments of Moenkhaus seem to have been carefully planned and well carried out. Regardless of criticism against either the experiments of Castle or Moenkhaus, their results are almost identical.

The only noticeable differences in their results were the periodical variations of the size of broods in Castle's experiments, which failed to occur in the experiments of Moenkhaus; and Castle found both sexes to be sterile, while Moenkhaus found only males to be sterile.

Productiveness was found to be amenable to selection by both of these investigators, and that the percentage of sterility followed very closely the size of broods,-- the smaller the brood, the greater the per cent of sterility. Sex-ratio was also found to be an inherent character and strongly amenable to selection by Moenkhaus.

Do these experiments with the *Drosophila* apply to our domestic animals? This is a question the writer cannot answer. Although the results in regard to productiveness and sex-ratio are similar to those found by Dr. King in her experiment with rats. She found that in-breeding did not decrease size, vigor or fertility during twenty-two generations of brother by sister matings, and that the sex-ratio was amenable to selection. Size, vigor, and fertility seemed to be increased rather than decreased, and in no instance has she observed a single sterile individual. Here again the same old question is asked: Can experiments with rats be applied to our domestic animals? Since rats are warm blooded animals and inherit various characters in the same manner as our domestic animals, I see no objection to the

application of such experiments to our domestic animals. Gentry's experiment with swine also leads one to believe that good as well as bad qualities can be stimulated by in-breeding.

On the other hand, Bos, Weisman, and Von Guaita found that long continued in-breeding of a family of rats produced an increase in the rate of mortality, decrease of fertility and size. King used strict selection for the most vigorous individuals, but it is not stated whether these investigators practiced selection or not. If they bred from inferior individuals, we are aware of the results, regardless of whether they in-bred or cross-bred. I merely mention this fact here, because we cannot attach a vast array of evil results to in-breeding when the animals so bred are themselves inferior. Every practical breeder recognizes the value of selecting the very best animals for breeding stock, if he is to achieve success. So it is with in-breeding; judicious selection must be practiced in order to determine whether or not in-breeding per se produces evil results.

Cornevin had good success in in-breeding cattle, sheep, and fowls, but his experiments with swine and rabbits led him to believe that in-breeding did not act on all animals alike. His swine became too fat, and sterility was common. His rabbits developed a tendency to albinism. To attribute fat to in-breeding is

ridiculous. If a breeder can make an animal become fat by in-breeding, we should reduce the amount of high priced feeds fed these days, and do more in-breeding. We are aware of the inheritance of the coat color or the pigmentation of animals, and to assume that in-breeding per se produces albinism, etc. is just as erroneous as to assume that this method of breeding makes an animal fat. All biologists agree that breeders cannot create new hereditary material (germ plasm--chromosomes), but they can cause recombinations of the material at hand, and in-breeding is the quickest method which will bring about these recombinations and allow segregation to take place.

John Wright believed in-breeding the cause of sterility, weakened constitution, and idiocy in his experiment with swine, although he acknowledged that after breeding sire to daughter, granddaughter, great-granddaughter, and so on for seven generations that the best individual was produced in the last litter. This litter consisted of only one pig, and she failed to breed when mated to her sire, but produced a litter to the first mating to a stranger in blood. Was this last sow not subjected to in-breeding even a longer period than other individuals in his experiment, and yet she was the best individual of the whole family and was not sterile. If in-breeding per se is injurious to swine, can we see

why it does not act on all individuals alike? This last sow produced by Wright is merely proof that in-breeding was not the cause of the former cases of sterility, weakened constitution, and idiocy. Had he tested this sire on sows known to be fertile and found him fertile, he would have had better ground for his argument against in-breeding. The fact that this boar sired only one pig in the last litter, mentioned as sired by him, leads one to doubt the fertility of this animal rather than the sow, because she later proved fertile.

Nathusius found that in-breeding was injurious to hogs, although his experiment covered only three generations, and his conclusions cannot be strongly relied upon. One point of interest is again brought out in his experiment; that is, there seems to be a tendency toward low productiveness and sterility between in-bred animals, and yet they may both prove rather prolific when mated to unrelated individuals. It is hard to realize that germ cells could become so closely related that they would fail to unite. If such a condition does exist, the whole problem of in-breeding must be worked out by biologists. I have been unable to find a single piece of work along this line, and besides it would be a very difficult undertaking to try to establish why fertilization does not take place. From the abundant literature on the development of our present day breeds of domestic animals, we come to the conclusion that many, if not all, were

in-bred to a certain extent in their early development. Long continued in-breeding, covering many generations, was practiced by the early Shorthorn breeders. (Discussed later under another head)

Charles Darwin, who has contributed more literature on this subject than any other one person, was a strong believer in wide spreading pedigrees, but he did not fail to recognize the good of in-breeding. He acknowledged that this practice could be followed for many generations with cattle without showing ill effects, although he was positive of the good effects of an occasional cross. His plant experiments led him to believe that crosses were always beneficial. However, his in-bred plant "Hero" failed to be improved by crossing. The offspring was inferior to the self-fertilized descendants of Hero. This is one of the few instances where in-bred plants failed to ^{produce} superior offspring when crossed with unrelated plants of the same species.

East, Hayes, and Carrier found that crossing produced more grain and vigor in the F_1 corn plant, while Love found that oats (normally self-fertilized) was both favorable and unfavorable to crossing. Whether these experiments in the plant kingdom have any significance in this paper, I am unable to say, although I am of the opinion that they are of little or no value to the animal breeder. Every breeder of live stock is aware of the fact

that all crosses between unrelated animals are not successful. Examples of this nature come before our eyes every year when the new crops of calves, lambs, and colts are dropped. The case of the mulatto as mentioned by Guyer and Taylor is certainly a case of an undesirable cross. This cross is rather numerous in some sections of the South, and beyond a doubt they are the most undesirable citizens in that section today. They are classed as negroes, and considered the most treacherous and the least dependable of our negro race. A just criticism can be brought against the above as being an unsuccessful cross, because the whites that inter-cross with the negroes are no better, and in some cases not as good citizens as the negro; therefore, we should expect no improvement. We should expect them to be equal to the negro, on the average, but are they? From what I have seen of this class of people in the Southeastern States, I am inclined to look upon them as inferior to the pure negro.

Taking this class of literature as a whole, there is little evidence to show that in-breeding per se is the cause of the many evils charged against this method of breeding. The strangest point brought out against this method of breeding is the apparent failure, in some cases, of closely related individuals producing offspring when mated together; yet, when mated to unrelated animals they prove fertile. This seems to be especially true in some

of the experiments with swine.

(b) POPULAR LITERATURE

In-Breeding Dogs. (Huth, 18. p271) "Dr. Child instances a case in which a dog was put to his daughter, and in succession to her puppies, and also to one of the puppies of the latter; yet, they were all good dogs. Turnspits and pugs were probably derived from 'sports', and must necessarily have been much bred in-and-in." (Burges, 31) "Mr. Laverack, a most successful breeder, and the creator of the 'Blue Belton' race of setters is a most determined advocate of in-and-in breeding." His system is to select strong parents of the quality he wants, and then to stick to his own strain. He (Laverack) states that he tried crossing more than a dozen times, but the results were always unsatisfactory. He also states that the most valuable dog he ever possessed was the product of full-brother by full-sister mating. Burges says that until recent years all in-bred animals were looked upon with disfavor in America; but experience has modified these views, and many of our best horses, cattle, and dogs are inter-bred. Mr. Burges also states that he had owned and seen many dogs from brother by sister matings, and, with the exception of one animal, they were fully up to the standard of their parents.

Huth (18) (p271) quotes M. Anbe as giving an instance of a farmer in-breeding a pair of dogs (brother by sister) and the offspring proved very inferior; their bodies were smaller in

proportion to those of their parents, with their heads and tails relatively large, and their backs weak and bowed. Though they retained the hunting instincts of their parents, they had none of their endurance, and the whole family died out at the third generation.

(Darwin, 12,--pp 99 & 100) "Mr. Meynell's famous fox hounds were closely in-bred for several generations and no ill effects followed. He frequently bred from father and daughter, mother and son, and sometimes even from brothers and sisters. On the other hand, Sir John Sebright declares that by breeding in-and-in, he has actually seen the offspring of strong spaniels degenerate into weak and diminutive lap dogs; and the Rev. W. D. Fox reports a case in which some blood hounds on being bred in-and-in were affected with a bony enlargement of the tail; a malformation which was removed by a single cross."

Hayes (10) made a study of the champion dogs of the Scotch Terrier and Airdale Terrier breeds. In this study, he made a comparison between in-bred, line-bred, and out-bred dogs, and found the larger percentage (considering the number so bred) of champions came from those line-bred.

Walsh's (32) Statement of In-Breeding Dogs. "Like many other practices essentially good, in-breeding has been grossly abused. Owners of a good kennel have become bigoted to their own strain, and, from keeping to it exclusively, have at length reduced their dogs to a state of idiocy and delicacy of constitution which has rendered them quite useless. I have seen in the course of twenty years a most valuable breed of pointers, by a persistence in

avoiding any cross, become so full of excitability that they were perpetually at "a false point," and backing one another at the same time without game near them; and, what is worse, they could not be stirred from their position. This last was from a want of mental capacity, for it is by their reasoning powers that these dogs find out when they have made a mistake, and without a good knowledge both the pointers or setters are useless." Walsh says that Mr. A. Graham who has been a breeder of dogs for years, believes that "once in and once out" is the extent to which in-breeding can be carried in the greyhound, and probably the same will apply to other breeds.

In regard to the degree of relationship between individuals, Walsh has the following to say:--"Sometimes a sister may be put to a brother when there has been no previous relationship in their sire and dam; but though this has answered well two or three times, it is not to be generally recommended. A father may in preference be put to a daughter, because there is only half the same blood in them; but a better plan is to breed an uncle to a niece; a still better plan is to obtain a dog that has a considerable portion of the same blood as the bitch, but separated by one or two crosses; that is to say, to put two animals together whose grandfathers or great-grandfathers were brothers, but whose mothers and grandmothers were not related to each other. This relationship applies equally as well for the dam's side when the sires are unrelated. This method of breeding has given good results with the greyhound, and the most noted dogs of the breed thus produced. Some in-bred

bitches fail to breed, but I do not attribute this fault to in-breeding, because it is not limited to in-bred animals. Thus, I have shown that in practice, within certain bounds, in-and-in breeding is not only not prejudicial, but absolutely advantageous, in as much as it does not injure the nervous temperament and mental qualities of the produce; and the body does not suffer is a well known fact, easily capable of proof by examining the external forms of dogs so bred. Theoretically, also, it should answer, because we find in nature gregarious wild animals resorting to in-breeding in all cases. The stag adds his daughters to his harem as long as he has strength enough to beat off his younger rivals. In the same way, the bull and the stallion fight for supremacy, until at length they are beaten off, and a younger and more vigorous animal masters them and their female attendants. Yet, this appears to be nature's mode of insuring a superior stock, and preventing the degeneration which occurs among human beings, when a feeble pair take upon themselves the task of producing a family."

Darwin's Conclusions on In-Breeding Cattle, Sheep, Pigs, and Fowls. Darwin (12) (p97), after a careful study of Bakewell's in-breeding with Longhorns and Bate's in-breeding with Shorthorn cattle, comes to the following conclusions in regard to in-breeding cattle:--"By carefully selecting the best animals (as nature effectually does by the law of battle) close inter-breeding may be long carried on with cattle; yet, the good effects of a cross between almost any two breeds is at once shown by the greater size and vigor of the offspring; as Mr. Spooner writes

to me:--'Crossing distinct breeds certainly improves cattle for the butcher.' Such crossed animals are of course of no value to the breeder; but, they have been raised during many years in several parts of England to be slaughtered; and their merit is now so fully recognized, that at fat-cattle shows a separate class has been formed for their reception."

(p99) "By the aid of careful selection, the near interbreeding of sheep may be long continued without any manifest evil; yet it has often been the practice with farmers to cross distinct breeds to obtain animals for the butcher, which plainly shows that good of some kind is derived from this practice."

(12--p100) "With respect to pigs, there is more unanimity amongst breeders on the evil effects of close interbreeding than, perhaps, with any other large animal." He quotes the belief of Druce, Hobbs, Sidney, and cites the experiments of John Wright and Nathusius in connection with the above statement. Druce, Hobbs, and Sidney are all strongly against in-breeding. The results of John Wright's experiment and the experiment of Nathusius are mentioned in literature under the head Scientific.

(12--p95) "The evil effects of in-breeding can most readily be acquired in the case of animals, such as fowls, pigeons, etc., which propagate quickly. He also believed in-breeding to be more harmful when animals are kept in the same place and exposed to the same conditions. In other words, he thought a change of environment would ward off, to a certain extent, the bad

effects of in-breeding. "I have inquired of very many breeders of these birds, and I have hitherto not met with a single man who was not thoroughly convinced that an occasional cross with another strain of the same sub-variety was absolutely necessary."

Statements of Other Men in Regard to In-Breeding Sheep.

(Huth, 1 p253) "M. Boudin cites a flock at Petit-Bourg, France, which has diminished greatly, 'since it passed into other hands and in-breeding has been practiced.' Stephens' observations led him to the same conclusions; the progeny, he says, though improved in form, firmness of bone, etc., are nevertheless delicate of skin, and, therefore, liable to the attacks of insects, and to inflammation; but this evil is only the result of long continued in-breeding, and by no means, the immediate results. M. Aubé declares that in-breeding of sheep will produce a dark kind."

The above statements of these men are of little value, but they are interesting for discussion. Stephens acknowledges the superior form and firmness of bone of in-bred sheep. This part of his statement surely conflicts with many men who are opposed to in-breeding. Many claim that in-breeding is a cause of rickets,--this surely is the opposite of firm bones, and should we expect in-breeding per se to produce such opposite results unless the determiners for said characters are present. M. Aubé's black color is just as amusing. Who can imagine in-breeding producing a black coat for a sheep? It is true that this black color must have been brought to the surface in

a larger percentage of cases by in-breeding, but on the other hand it would have just as readily been brought to the surface by unrelated matings, had the heterozygous condition for color been present in both individuals.

(33) The Messrs. Brown believed in close breeding, because they infused no fresh blood into their excellent flock of Leicester sheep for a period of fifty years. (34) Mr. Barford acted upon the same principle in regard to the Festac Flock. He asserts that half a century of experience has taught him that when two nearly related animals are quite sound in constitution, in-and-in breeding does not induce degeneracy; but he does not believe in continued mating of nearest affinities.

Huth (18--p252) gives M. Beaudouin's account of a flock of three hundred Merinos bred in-and-in for a period of twenty-two years. The original stock was selected from a flock noted for their purity of blood, but were not robust, although they were not suffering from any particular disease. This system of breeding began in 1840, and by judicious selection eliminating about 15% yearly, the flock soon became remarkably strong and healthy. These sheep bred in-and-in for 22 years, far from degenerating, became finer and far more to be depended upon to reproduce their proper types than is ordinary in flocks which are crossed. According to Huth, "M. Beaudouin concluded that in-and-in breeding, combined with proper selection, has no evil effects on sheep."

Huth's Statement in Regard to Sheep (18--p257). "We must remember that ill directed breeding is as bad when there are

frequent crosses as when there are none; that it is selection which is the great improver, when properly directed, and that in-breeding is only advantageous because it fixes the characters we select. Indeed a cross may decrease size, a charge against in-breeding, just as in-breeding may do so under the same circumstances. The Romney Marsh, Teeswater, the sheep of Shetland, and the mongrels of the Merino and Scotch, or the Southdown and Scotch breeds are examples of crosses which were deleterious to the breeds. On the other hand, we know that all our improved breeds have been established by close breeding, and had it not been for this method of establishing a type, many of our breeds would have been lost."

Lehndorff's and Dimon's Statements in Regard to In-Breeding Horses ~~1944-63~~. Count Lehndorff (35) made a study of all noted thoroughbred stallions and mares of England, and found that the larger number of noted horses on the turf and those that had shown their ability to produce noted animals were offspring of moderately related parents. The offspring of such parents were more numerous among noted horses than those descended from closely in-bred parents or from parents totally unrelated. He considered moderate relationship as the mating of stallions and mares that are removed from their common ancestors at least four generations. He admits that breeders are prejudiced against in-bred stallions, and that his study probably did not give in-bred animals a proper rating.

Mr. Dimon (36) believes that nature's great law is to

transmit the general character of the parent to the offspring, and in proportion as the breed is firmly established and uniform in its characters; so will the produce be uniform in its characters. "This great rule of nature is applicable not only to horses, but it is universally true for all animals."

In regard to horse breeding, Mr. Dimon has the following to say:--"Avoid breeding to any hereditary unsoundness liable to be transmitted. An unsound horse is a perpetual source of annoyance to any owner and never a source of profit to the breeder. There is no greater trouble in breeding what you want in horses than in any other stock, providing you get the type established, and then, by judicious in-breeding, retain it.

And right here, I wish to remark that there is no part of the business that requires more careful study than this in-breeding. Ignorantly or carelessly conducted, it is the cause of sure failure; on the other hand, when judiciously practiced, the results will usually be satisfactory.

When a blood is kept pure to its own type, in its own family, possessed of the same blood instinct in both male and female, then like begets like, and not until then. As an illustration of this great truth, I refer my readers to the buffalo, the elk, and the deer of our country in their primitive states. I might also mention

the wild turkey, the wild goose, and birds and wild fowls of different classes, which have undoubtedly bred in-and-in from time immemorial, and whose offspring possess a uniform type and a degree of hardiness rarely attainable by any of our domestic animals or birds."

It should be noted here that Mr. Dimon does not define "judicious in-breeding", but at the same time, he makes himself very clear. He believes in in-breeding when the individuals mated are fairly well fixed in type, and are free from hereditary blemishes or unsoundness.

Other Opinions on In-Breeding Horses. Huth (18--p268) gives many instances of close breeding among our famous race horses. Yonatt (37--p121) also states that many of our best horses are closely bred, but that the most talented breeders have avoided in-breeding, because they are convinced that it does harm. Walsh (Stonehenge 38--pp139, 141, 142) says:--"Breeding 'in-and-in' is injurious to mankind, and has always been forbidden by the Divine law, as well as by most human law givers. On the other hand, it prevails in a state of nature with all gregarious animals, such as the horse, among whom the strongest male retains his daughters and granddaughters until deprived of his harem by younger and stronger males. Hence, in those of our domestic animals which are naturally gregarious, it is reasonable to conclude that breeding 'in-and-in' is not prejudicial, because it is

in conformity of their natural instincts, if not carried farther by art than nature teaches by her example." He states that "twice in and once out" is more nearly the practice of nature in the case of horses and this conforms closely to the practice of our most successful early breeders, and it is unwise for the breeder to sacrifice good points, with the view that in-breeding is not to be indulged in. "There are scarcely two thorbred horses in the Stud-book," says Mr. Walsh, "that can not be traced back to the same stock in one or more lines.

Darwin (39) states that statistics show nearly one-third of our race horses have proven barren, or have slipped their foals; a fact which he ascribes to their high nurture and close inter-breeding. Can we attribute the above to in-breeding? Is it not a fact that the present day horse breeders are well satisfied if two-thirds of mares bred produce colts? We have no grounds to attribute this condition to in-breeding and therefore it is logical to conclude that it is due to various environmental conditions. Mares are subjected to strenuous labor, hurried off to a stallion, and probably not returned at the proper time the next heat; all such conditions are not favorable for maximum fertility, and we do not expect the same percentage of offspring from mares as we do from cows. On the male side, we find many stallions subjected to close confinement and lack

of exercise which is far from natural conditions, and only tends to lower the productiveness of animals so handled.

(Huth 18--p268) "Mr. N. H. Smith, long a resident among the Arabs, quotes with approval the opinion of an experienced friend that colts bred in-and-in 'show more blood in their heads, are of better form, and are fit to start with fewer sweats than are others; but, when incestuous matings are continued for three or four crosses, then he apprehends (merely an opinion) that the animal degenerates.' 'I cannot take upon myself,' he adds, 'to say how often incestuous matings may be carried on before degeneracy takes place, as I am not aware of that being the case in any instance. Experiments are in favor of breeding son to daughter, and daughter to father.' He describes his favorite method of breeding as 'once in and once out'; but then he considers that putting a mare to the same stallion that sired her dam is out-breeding."

Other Statements about In-Breeding. Macdonald (13) (p413) gives Mr. Bowly's idea of in-breeding as follows: "In-and-in breeding will undoubtedly insure greater certainty as to the produce; still, when carried beyond one or two generations, it is objectionable. Thus, while with in-and-in breeding, you secure perfect form, you run the risk of weakening the constitution of the offspring. The term in-and-in breeding should only apply to brother and sister matings. When animals carrying

one-half the blood of the other are mated, we can expect good results, provided you have been cautious in your selections." Macdonald stated that Mr. Bowly was a strong advocate of cross-breeding; yet, he made the above statement in regard to in-breeding. Mr. Hale, who is a good authority, according to Macdonald (p417), states that if you select a good stock, you may breed in-and-in as much as you please.

In regard to in-breeding or crossing of deer, Macdonald (p595) has the following to say:--"There is a great difference of opinion among owners of parks; some have not used an outcross for a time beyond the memory of man; while others consider that unless fresh blood is occasionally introduced, the deer deteriorate both in size and health.

(13--p642) "The roe deer differs in many respects from red and fallow deer. They live in separate families, and do not form into herds; so the practice of natural selection is eliminated. The female usually brings forth two young (male and female), and these young never quit each other unless killed. Here the closest possible in-breeding is carried on for generations without any apparent bad results."

After a study of the subject of in-breeding, Kraemer (40) came to the conclusion that it was a valuable instrument, but fraught with danger. He believes its effects are of themselves evil, regardless of the constitution of

the animals involved, when long continued. Kraemer's ~~belief~~ belief seems to have been drawn chiefly from the works of Nathusius, Darwin, Von Oettingen, De Chapeaurange, and Rau. Kraemer states that all of these men who were familiar with this method of breeding have expressed themselves in favor of wide spreading pedigrees.

Youatt (15--pl88) makes the following statement:

"In-breeding may be pursued until the excellent form and quality of a breed is established. It was this source which sprung the cattle and sheep of Bakewell, and the superior Shorthorns of Colling; and to it must be traced the speedy degeneracy, the absolute disappearance of the new Leicester cattle, and, in the hands of many an agriculturist, the impairment of constitution and decreased value of the Leicester sheep and Shorthorn beasts."

C. L. Redfield (41) states that the evil effects of in-and-in breeding arise from the fact that in many animals there are certain dormant defects. When unrelated animals are mated there is little probability that the same dormant defects will exist in both, but, when both parents are from the same stock, the probabilities of the same defect existing in both are increased, and the mating of these two may cause the dormant defect to become a manifest one. All of our fancy breeds of animals are the product of in-and-in breeding. That selection is a full cure for any ill effects of in-and-in breeding is abundantly proved by the superiority of pure breeds over mongrel stock."

Consanguineous Marriages. Huth (18) (pp140-147) cites many isolated English communities and island populations where continued close intermarrying has not deteriorated the human population. Charles Darwin (12) (p104) states that his son George made a careful study of all marriages in England, and found that four per cent were between first cousins; with them, he compared the rates of similar marriages among the parents of lunatics and idiots in asylums, and found it to be between three and four per cent--not higher, therefore, than in the general population. Talbat (42) (p41) states that the New York State Medical Society appointed a committee to investigate the influence of consanguineous marriages upon the offspring in 1869, and their results show that if the family be free from degenerate taint, marriage among its members in no way diminishes the chances of healthy offspring. On the other hand, Talbot states that S. M. Bemiss of New Orleans, Louisiana, made a study of the condition of the offspring of 580 intermarriages of first cousins, gathered mostly by medical men from most every state in the union, and found their condition as follows: "2,778 children were born of these cousins, of whom 793 were defectives, 117 deaf and dumb, 63 blind, 231 idiotic, 44 epileptic, 24 insane, 53 deformed, 189 scrofulous, and 673 died early.

What Mr. Wreidt says about in-breeding in Europe(43).

Abstracts from lectures given by Mr. Wreidt while touring the United States during the winter of 1915-16. Mr. Wreidt was sent to the United States by the Norwegian Department of Agriculture to make a study of the position of breeding and genetics here.

Mr. Wreidt emphasized the fact that practically all famous strains of every breed has only a few foundation animals, and it has been through the selection of these animals and the concentration of their blood by in-breeding that has brought fame to these animals. He states that in-breeding is now acknowledged by European breeders to be the most efficient means of improvement at their disposal. European breeders are better acquainted with the 'blood lines' of their breeds than are the breeders of America, according to Wreidt, and he makes the following suggestion: "Make more thorough studies of the 'blood lines' that are producing the greatest number of good performers, and perpetuate, multiply, intensify these blood lines by moderate line breeding, or if necessary by the strongest forms of in-breeding. If this is combined with stringent selection of the best animals, the breeder cannot fail."

DISCUSSION OF POPULAR LITERATURE

Much of the literature under this head is merely the statement of various men and requires no discussion.

There seems to be a divided opinion in regard to in-breeding dogs. Child, Laverick, Meynell, Hays, and Walsh are inclined to advocate in-breeding within certain limits, while Aubé, Sebright, and Fox cite instances in which this practice has proven deleterious to various breeds of dogs. Darwin believes that cattle and sheep could be inbred for many generations when strict selection was followed, but that this practice proved evil in the case of hogs and fowls.

Brown and Barford practiced in-breeding successfully with sheep, and M. Beoudouin concluded that in-and-in breeding, combined with proper selection, has no evil effects on sheep, while Boudin and Aubé declare that bad results are almost sure to follow this practice. Huth cites instances of unsuccessful crosses, and mentions the fact that nearly all our improved breeds of sheep were established by close breeding, and would have probably been lost had it not been for this method of breeding.

Lehndorff, Dimon, Huth, Youatt, Smith, and Walsh all recognize that a limited amount of in-breeding has proven beneficial to horses, while Darwin believed the barrenness of race horses could be attributed to close breeding. This conclusion is not justifiable because the percentage (33%) of barren mares found by Darwin in his investigations was not larger than we see in all breeds of horses today.

The case of the roe deer as cited by Macdonald is a good example of the closest in-breeding for

generations without evil results. I cannot agree with Kraemer's statement that in-breeding per se is injurious, regardless of the constitution of animals selected when long continued. He furnishes no proof of this statement, and besides the most thorough, long continued experiments, where judicious selection has been followed, do not bear out this statement.

The cases cited of the bad effects of consanguineous marriages on the offspring are interesting, although I do not attach so very much value to these investigations. Of all the animals in existence, I would choose man as the last resort to determine whether in-breeding per se is injurious. We have no class of domestic animals as immoral and defective as the human race, and it is perfectly natural that incestuous matings do bring to the surface a preponderous number of defects. Biologists agree that inborn diseases, or those which are the results of a definite variation in the germ plasm, are inherited. Idiocy, insanity, and deafness are classed as germinal diseases, and naturally they must come to the surface if present in the parents, whether it is a mating between related or non-related persons. Mr. Redfield makes a clear statement in regard to in-breeding and it is the one generally accepted by authorities today. Mr. Wreidt's suggestion in regard to in-breeding domestic animals is a good one, and if we are to make any appreciable progress

in the improvement of our breeds, his suggestion must be carefully studied and put into practice.

III. STUDY OF OTHER CASES OF IN-BREEDING.

(a) SHORTHORN CATTLE INBRED

The Early Development of Shorthorn Cattle and the Methods of Breeding Adopted by the more Distinguished Improvers of the Breed. It is not my purpose to give a complete history of the early development of Shorthorn cattle, but it seems absolutely necessary to give a brief of the foundation animals used by such distinguished improvers as Charles and Robert Colling, Thomas Bates, Thomas Booth, and his sons, John and Richard, and Amos and Anthony Cruickshank. We have just reviewed the method of breeding employed by Robert Bakewell, the father of improved domestic animals, in the improvement of the Longhorn breed of cattle, and by glancing through the first few volumes of Coates' Herd Book, we are convinced that the most noted improvers of the Shorthorn breed adapted his (Bakewell) method of in-and-in breeding before they attained the uniformity of the most desirable characteristics they so earnestly sought. Then it is more the methods of breeding, rather than the foundation stock, that we are interested in at the present time.

Early Foundation Stock. The earliest foundation sires of importance (Coates' Herd Book) were William

Barker's Bull (51), James Brown's Red Bull (97), the Studley Bull (626), and Hubback (319). By a study of these animals through the early volumes of Coates' Herd Book, we find that there is little known about their ancestors. James Brown's Red Bull (97) was sired by Barker's Bull (51) and beyond this, their ancestors are not known. At this time, the dams were seldom mentioned and only a few of the most noted bulls were named. Hubback (319) was beyond a question of doubt the most valuable of these foundation sires and was used in the herds of Robert and Charles Colling with remarkable success. He was a yellow red with some white, calved in 1777. He was sired by Snowdoc's Bull (612), he by Waistell's Bull (558), he by Masterman's Bull (422), he by the Studley Bull (626). His dam was out of a cow bred by Mr. Stephenson of Keiliser. John Watson (44) states that the dam of Hubback became so fat when put on grass that she did not breed again, and her son had the same predisposition toward obesity, and was useful as a bull only a short time. Regardless of the length of time used, we find that his descendants are the most important animals found in early Shorthorn history.

In-Breeding Began by Charles Colling. Bakewell's method of close-breeding began in 1792, when C. Colling mated Bolingbroke (86) to Phoenix. Both Bolingbroke and Phoenix were sired by Faljambe (263), and the dam of

Phoenix, Lady Maynard, was also the grand-dam of Bolingbroke on his dam's side. The result of this close-breeding was the noted bull Favourite (252).

Mr. Sanders (45) ("Shorthorn Cattle", 1916,--p41) has the following to say about Favourite:--"Favourite was a light roan, dropped in 1793, and died in 1809. So nearly did he meet Mr. Colling's idea of what a Shorthorn bull should be that he now began a most extraordinary course of in-breeding. For years, the bull was used indiscriminately upon his own offspring, often to the third and in one or two instances to the fifth and sixth generations. His get were not only the most celebrated Shorthorns of their day, but his immediate descendants constitute a large percentage of the entire foundation stock upon which the herd-book record stands." A good example of the extreme concentration of Favourite's blood is seen in the pedigree of Comet (155). Comet was the most noted Shorthorn bull *of his day and the first* to sell for \$5,000. This bull Comet was sired by Favourite and out of Young Phoenix by Favourite. Young Phoenix's dam, Phoenix, was also Favourite's dam.

To illustrate that Favourite's in-breeding did not reduce the size of his offspring, I shall give the weights of the famous "Durham Ox" and the "White ^{Heifer} ~~Heifer~~ that Traveled" sired by Favourite. The Durham Ox at five years of age weighed 3,024 pounds, and was shown extensively throughout England. The "White Heifer that Traveled"

reached the weight of 2,300 pounds and was also extensively exhibited.

To verify the practice of in-breeding indulged in by Charles Colling, I submit the pedigrees (Coates' ~~Herd~~ Book) of the following animals which were recognized as superior individuals bred by him, and were leading animals in the early development of the improved Shorthorn: Favourite (252), Comet (155), North Star (458), and Albion (14) (used as foundation sire by Thomas Booth). Many others could be mentioned but these illustrate the method of breeding which proved so successful in Charles Colling's herd.

Robert Colling's Herd Closely Inbred. Robert Colling's foundation animals were composed of the best Teeswater cows he could obtain, and Hubback (319) proved his ^{first} valuable sire. Although Hubback was only used one season at Barmpton, we find that the first sires of importance bred by R. Colling were closely bred in Hubback's blood. The bulls Punch (531), Ben (70), and Twin Brother to Ben (660) are good examples of the earlier breeding at Barmpton. No doubt R. Colling had some good foundation animals by this time, but it is evident he thought Favourite (252), owned by his brother Charles, was a valuable animal, because we find that he sent many cows to be bred to Favourite and the most noted bulls bred in the herd were closely bred in the blood of Favourite. The bulls Mars~~he~~ (418), North Star (459), Phenomenon (491), Styford (629), and

Pedigree of *Lancaster* (360)

BRED BY

R. Ceebing

Canet (155)

[*North Star* (458)]

Harauit (252)

Flourit

Belgimbe (263)
Young Stenbury
Belgimbe (263)
Lady Maynard

Young Flourit

Flourit

Harauit (252)

Wheeling
(680)

Harauit

Widdair

Ben (70)

Canet (531)
Belgimbe (263)

Whitlock (319)

Harauit
(252)

Belgimbe (186)

Belgimbe (263)
Young Stenbury

Barter's Buel
Whitlock (158)
Lady Maynard

Flourit

Belgimbe (263)
Lady Maynard (and *Lucas*)

Mass Race

Harauit
(252)

Red Race

Canet (531)

Lancaster (360)

Pedigree of *Picat (496)*

BRED BY

R. Celling

Whetting
1680?

Canet (155)

Favourite
(1252)

Young Phoenix
Phoenix

Favourite (1252)

Wheeler

Favourite
(1252)

Ben (170)

Punch (1531)

Whitlock (1319)

Picat (496)

Favourite
(1252)

Belting Duke (180)

Favourite (1253)

Young Storking

Antoin's Blue
Young Blue One
Whitlock White (18)
Lady Maynard

Phoenix

Favourite (1253)

Lady Maynard

(lost name)

Red Rose

Punch (1531)

Broken Run (95)

Whitlock (1319)
(Whitlock (1319))

Broken Run (95)

Favourite (1253)

Whitlock

Pedigree of *Thurwarner* (636)

BRED BY

P. Cullis

Thurwarner
(252)

St. Paul (629)

St. Paul's dam

Thurwarner

St. Paul's dam

Belmont (86)

Thurwarner (265)
Young Sturtevant

Thurwarner

Lady Maynard

Belmont (531)

Belmont (95)

Belmont (319)

Belmont (95)

Thurwarner (265)

Belmont (319)

Belmont's dam

Belmont's dam (188)

Lady Maynard

Thurwarner (265)

(not known)

1

1

1

1

1

1

1

Pedigree of *Clarissa*

BRED BY

R. Bell

Caust (155)

Caust (155)

Bell (86)

Belmont (1263)

Caust

Belmont (1263)

Young Caust

Caust

Caust (1252)

Belmont (1263)

Wellington
(680)

Caust
(252)

Wellington

Bell (170)

Bell (153)

Belmont (1263)

Black (1319)

Clarissa

Caust (1252)

Bell (86)

Belmont (1263)

Bell (1302)

Caust

Young Belmont

Bell (188)

Caust

Belmont (1263)

Belmont (1263)

Belmont (1263)

Caust
(252)

Caust
(252)

Caust
(252)

Caust
(252)

Belmont (1263)

Colling's White Bull (151) were all sired by Favourite. Marske (418) was otherwise closely bred in the blood of Favourite. Other famous bulls bred by R. Colling which were overflowing in Favourite's blood were Lancaster (360), Pilot (496), and Sowerrow (636). Lancaster (360) was the highest priced individual sold at the Barmpton sale in 1818. The price was \$3,105. The bull calf Pilot (496), half brother to Lancaster, sold for \$1,350 to Thomas Booth of Killerby.

The cow, Clarisse, and the bull, Lancaster (360) were extremely close bred animals in the blood of Favourite, as their pedigrees show; yet when mated, they produced the famous bull Albany (13) and the cow Restless, also a good individual.

From the pedigrees of animals bred by Charles and Robert Colling, we find that they bred much in concert, following the same system of blood concentration, and in fact were almost identical in their practice. (Short-horn Cattle by Sanders (45)--pp50-55) "To sum up the results of their joint action, it may be said that they, in the midst of older and more experienced breeders, combatted the rooted prejudices of the day, and through the Bakewell system established a new school of breeding.

(p 55) Whether the Collings really earned the right to be called the first great improvers of the modern Shorthorn, or whether they gained their fame mainly by

reason of the novelty of their methods and their superior enterprise as advertisers, the fact remains that more pedigrees in the Shorthorn Hand-books of England and America trace to the Colling herds ~~more~~ than to any other dozen herds of the same period combined. Manifestly there was some good reason for the general adaptation of Colling blood. That the breeders of that day conceded leadership to the breeder of Faljaube, Favourite, and Comet is indicated by a testimonial tendered Charles Colling on his retirement from breeding in 1810. A valuable piece of plate bearing the names of more than fifty breeders was presented to this gentleman as a token of gratitude due for the benefit they derived from his judgment, and also as a testimony of their esteem for him as a man."

The Booths and In-Breeding. Thomas Booth, known as the "Elder Booth", began breeding Shorthorn cattle prior to 1790. His experiment was differently directed than those of Thomas Bates and others of the time. He believed that by using strongly bred Colling bulls upon large-framed, roomy cows, showing great constitution and aptitude to fatten, he could improve even upon the work of the Collings, although he recognized that the Colling brothers had struck upon the long-sought line of progression.

According to Sanders (45) (p 59), the first bulls used at Killerby were Twin Brother to Ben (660) and one

of his sons. These animals were closely bred in the blood of Hubback. Later we find that the bull Suwarrow (636), also of Barmpton breeding and full of the blood of Hubback and Favourite, was introduced. These bulls were crossed upon carefully selected cows for several years with fair success. At Charles Colling's sale in 1810, the bull calf Albion (14) was purchased, and it is said that he effected even greater improvement in the herd than either of the following bulls. Albion was also closely bred in the blood of Favourite. The next bull purchased was Pilot (496), also bred by R. Colling, and intensely bred in the blood of Favourite. The last bull purchased of similar breeding was Marshall Beresford (415), by Comet (155) and out of C. Colling's Daisy.

Up to this time (about 1815), close breeding had not been practiced to any extent in the herd at Killerby, but recognizing the superiority of these Colling bred bulls and their offspring, the Bakewell idea of breeding from close affinities was successfully adopted. Sir Henry (597), his son Lane Bull (359), and Young Albion (15) were among the earlier sires representing the first fruits of Mr. Booth's in-breeding. The closest in-breeding indulged in by the Booths was at Warlaby, but it does not compare to the in-and-in breeding practiced by Bates. Thomas Booth gave up his farm at Killerby in 1819 to his son John, and moved to Warlaby. He took a portion of *the*

herd to Warlaby, and left the remainder for John who continued breeding Shorthorns at Killerby. Richard had already begun breeding Shorthorn cattle at Studley prior to this time (1819), but in 1835 he moved to Warlaby and took charge of his father's estate. Richard and John were both students of their father's method and bred their herds in the same manner; in fact, they had practically the same blood in each herd.

Cattle shows became prominent in England about 1840, and for years Booth bred cattle were famous in the showing. The Booth cattle were not as prolific as they should have been, and Mr. Sanders (45--p 136) states that fitting for show, or over-feeding was no doubt the cause of their low productiveness.

The following animals bred by the Booths were noted for either show or breeding purposes, the majority being noted for both; yet they were close-bred animals:

Bracelet, Necklace, Julius Caesar (1143), Windsor (1403), Priam (2452), Isabella, Birthday, Buckingham (3239), Crown Prince (10087), Red Rose and her "queenly" quartet of daughters; Queen of the May, Queen Mab, Queen of the Vale, and Queen of the Ocean; Campflower, and Commander in Chief (21451).

The winnings of Booth Cattle in the leading shows was a great advertisement for the Killerby and Warlaby herds, and for many years the demand for Booth bred

Pedigree of Necklace & Bracket

BRED BY

Thomson Buck
Kilbride

Nease (1129)

Young Albin
(15)

Albin (114)
Kilbride

Count (155)
Beauty

Kilbride (1496)

Prunus (19)

Backella

Prunus
(2452)

Kilbride (1496)

Wellington
(1680)

Count (155)
Kilbride
Prunus (1552)

Stearns

Count (1552)

Trinity

Kilbride

Old Sandy
Kilbride (1312)

Young Albin
(15)

✓

Nease (752)

Kilbride (1496)

✓

Nease

Produce

Albin (114)

1897

Kilbride (1496)

✓

Kilbride

Nease (1552) Count (1552)

Kilbride

Prunus (1552) Count (1552)

Pedigree of *Julius Caesar* (1143)

BRED BY

J. Bock

Young Albion
(15)

Albion (14)

Albion

Albion (14)

Caesar (155)

Freemantle (1252)

Albion (186)

Young Freemantle

Freemantle (1352)

Freemantle (1418)

Freemantle (1352)

Beauty

Miss Blacklight (lost given)

June Tree (357)

Trinity (592)

Freemantle (636)

Old Beauty

Freemantle (636)

Beauty (232)

Freemantle (636)

Freemantle (636)

Beauty (232)

Freemantle (636)

5th Feb (639)

Freemantle

Mr. Smith's son of 1834

June (190)

June (531)

Est. 1834

(and given)

June (531)

Pedigree of Windsor (14013)

BRED BY

R. B. Smith
Windsor

High Leonard (17010)

Leonard (4210)

Lord Lieutenant
White Stambury

Rocketing Rose (12551)

^(u) Gaskell
Young Melikun 4422

^(u) Gaskell
Rider (1496)

Melikun (12281)
Young Cavitation

Præm Præm
(10087)

Rocketing Rose
(5259)

Clarity

^(u) Leonard (4210)

Rope

Paick

Rocketing Rose (14875)
Hawthorne

Melikun
(4525)

Myrrum Rose (2245)
Charles II (1879)
Dorcas (1450)

Rocketing Rose
(5259)

Branch

Præm (12452)
Zoe (1129)

Ray

Stambury
Regius (1767)
Hector

Præm Præm

Leonard (4210)

Lord Lieutenant

Præm 5th & Young Red Rose (14905)
Red Rose (13082)
Young Cavitation
Rider (1496)

bulls was so great that it was difficult to supply the customers.

Thomas Bates and the Duchesses. To illustrate Bates' method of breeding, I shall mention only the once famous Duchess family and the bulls used in this experiment of close breeding. According to Mr. Sanders (45--p730), Bates began breeding Shorthorn cattle about 1800, and continued until his death in 1849. From this time of his death, for a period of about a quarter of a century, cattle bearing the Bates blood were one of the great factors in the Shorthorn trade, not only of England but of the United States as well. During that period, so great was the demand for animals descended from his favorite Duchess family that a range of speculative values unheard of before or since was for a time established, the climax being reached at New York Mills, near Utica N. Y., in 1873, when the fabulous sum of \$40,600 was paid for 8th Duchess of Geneva by R. P. Davies of England.

One can grasp Mr. Bates' method of breeding by glancing over the pedigrees of members of the Duchess family, but to make his method more clear, and at the same time give the reader an idea of what Mr. Sanders (45) thought of Bates' breeding, I quote the following: (p 70) "Injudicious in-and-in breeding, the retention of all animals dropped within the charmed circle of the Kirklevington tribes, regardless of individual character, and

the evil influence of certain reckless speculators, long since undermined the work of Thomas Bates; but the main facts connected with his career and the world wide popularity attained after his death by stock derived from the Kirklevington herd must ever possess a fascination for the student of Shorthorn history. Moreover, they are not without a lesson to posterity."

The Duchess Foundation Stock. As previously stated Bates began breeding Shorthorns in 1800, although his first Duchess animal was not purchased until 1804. This was a cow named Duchess purchased from Charles Colling for 100 guineas (\$500). She was sired by Daisy Bull (186) and in calf to Favourite (252). In this cow, Bates claimed to have secured not only the best cow in all England, but the only one then living running direct from Favourite to Hubback. In 1805, Duchess produced a bull calf, Ketton Ist (708) by Favourite (252), which was retained for subsequent service. She dropped one heifer Baroness by St. John (572), but becoming a "shy" breeder was sold to Mr. Donkin of Sandhoe, and as she did not in his possession settle down to bulls of desired form and quality her other calves (all bulls) did not carry the blood Mr. Bates sought. She was always a deep, rich milker, making as high as 14 pounds of butter per week, and when fed off at 17 years of age she is said to have made an excellent carcass of beef.

Bates had made up his mind that this Duchess blood was

the most valuable strain in the entire breed, and resolved to persevere in his efforts at acquiring it. At the Ketton dispersion in 1810, he bought Young Duchess (Duchess I by Bates), a granddaughter of Duchess by Daisy Bull (186), sired by Comet (155), at 183 guineas (\$915). She was a poor specimen, but Bates relied upon her breeding, and under the name of Duchess 1st she proved the ancestress of the far famed Duchess family which ultimately became the highest priced and most widely sought tribe in Shorthorn history.

Bulls used on the Duchess. ^{fermales} The first bull used was the previously mentioned bull, Ketton 1st (709), and in spite of his close breeding, he was said to have been an animal of strong constitution and possessed the refinement and character so earnestly sought. It was said that Ketton I (709) never got a "middling calf". All were above the average. Ketton I (709) was used in the herd until 1815. Here it should be noted that both Ketton I and Duchess I were inbred animals, and closely related, both being full of the blood of Favourite (252).

From 1816 to 1820, the bulls Ketton 2d (710) and Ketton 3d (349) (son and grandson of Ketton I, 709) were used but not so successfully as Ketton I. The next bull used was Marske (418), and it is claimed that through him fresh blood was introduced, although his breeding was disappointing. I cannot see where there could have been much stronger blood brought into the herd through

Marske, because his pedigree shows that he was closely bred in the blood of Favourite on both sire's and dam's side. Not being satisfied with Marske (418), he (Mr. Bates) sent Duchess 3d to be bred to Duke (226), full brother to Duchess I by Comet (155), and the result was the noted sire The Earl (646). The Earl was used extensively in the herd at Ridley Hall where the herd was maintained until 1830, then being transferred to Kirklevington. The Earl (646) was succeeded by his son 2d Hubback (1423). This bull was said to have had all the quality of old Hubback, and was noted for the uniformity of his get. This bull was probably the best of early bulls used in the herd, and it should be noted that he was not out of a Duchess cow, but out of Red Rose I, a cow closely bred in Favourite blood. Along about the time The Earl and 2d Hubback were being used in the herd, we find that Cleveland (146), 2d Earl (1511), and 3d Earl (1514) were used to a limited extent.

The next bull of importance was Belvedere (1706). He was used extensively from about 1831 to 1837. During this time, the bulls Gambier (2046) and Norfolk (2377) were used in a limited way. Belvedere (1706) was spoken of as the bull of Princess blood, when in reality Princess was only a concentration of the blood of Favourite. The cow Princess occurs twice in the third ancestral generation of his pedigree, she being sired by Favourite and out of a

daughter of Favourite. Belvedere was closely bred in the blood of Favourite, and it is misleading to speak of him as of Princess blood. Besides having the concentration of Favourite's blood, he (Belvedere) was the product of full brother by sister mating. The bull Norfolk (2377) bred by Mr. Whitaker, was also closely bred in Favourite's blood, and his dam, Nonpareil, was the product of full brother by sister mating. Following Belvedere (1706) his son, Short Tail (2621), was used for several years, then Duke of Northumberland (1940), Cleveland Lad (1706), 2nd Cleveland Lad (3408), Holkar (4041), 4th Duke of Northumberland (3646), Lord Barrington (9308), and 2d Duke of Oxford. These last named bulls, beginning with Duke of Northumberland, were used over a period of ten years, from 1839 until Bates' death in 1849, and were all inbred animals.

Study of the Duchess^{family} and In-Breeding. This once famous family was closely inbred for generations (1808-1849), and the foundation stock was closely inbred to begin with; yet superior individuals were produced. I could give pages in regard to show yard fame, the craze to obtain descendants of this family at fabulous prices, etc., but it would be useless here. It is well known that this family has degenerated, and was very unproductive in the hands of its maker. Unproductiveness is no doubt the final cause of its disappearance, but what caused this

unproductiveness or sterility? There is no other family in Shorthorn history so well adapted to a study of in-breeding, and ~~yet~~ it is little better than valueless because records were kept rather spasmodically at the time of this experiment, and all missing links are lost. However, I shall make a study of the 58 Duchess cows old enough to breed at the time of Mr. Bates' death.

My first study will deal with the number of cows sterile; number producing one, two, and three calves; and also the total number of calves produced during the first and last half of the experiment. If continued in-breeding is harmful in itself and is a cause of sterility and low productiveness as claimed, we would expect an increased number of sterile and also an increased number producing only one or two calves in the latter half of this experiment.

Note: According to Mr. Sanders (45--pp 110, 111), the following table was obtained from Mr. Richard Gibson and is complete for all Duchess cows living long enough to breed at the time of Mr. Bates' death in 1849. Two cows, Duchess 13th and 57th, are said to have died young, but as neither had any offspring and one occurs within the first twenty-nine cows and the other in the latter twenty-nine, I shall consider them as sterile cows and not omit them.

Table I (45—p.111)

Name	Born	Sire	Dam	Calves Produced			
				Male	Female		
				Bulls named	Steers or un-named	Lived	Died
Duchess 1	1808	Comet		1		4	
Duchess 2	1812	Ketton	1	2		2	
Duchess 3	1815	"	1	4	1	4	
Duchess 4	1816	Ketton 2d	1	1		3	
Duchess 5	1817	"			1	1	
Duchess 6	1819	Ketton 3d	4		1	4	
Duchess 7	1820	Marske	3				
Duchess 8	1820	"	2	1	1	3	
Duchess 9	1821	"	2		1	2	
Duchess 10	182-	Cleveland	4				
Duchess 11	1822	Young Marske	5		1	2	
Duchess 12	1822	The Earl	4			1	
Duchess 13	1823	"	9				
Duchess 14	1823	"	6		1		
Duchess 15	1824	"	8				
Duchess 16	1824	"	3			1	
Duchess 17	1825	3rd Earl	11				
Duchess 18	1825	2d Hubback	6				
Duchess 19	1825	"	12			5	1
Duchess 20	1825	2d Earl	8			2	
Duchess 21	1825	"	3				
Duchess 22	1826	2d Hubback	9				
Duchess 23	1826	2d Earl	11				
Duchess 24	1826	2d Hubback	6				

Name	Born	Sire	Dam	Calves produced			
				Male	Female		
				Bulls named	Steers or un-named	Lived	Died
Duchess 25	1826	2d Hubback	8				
Duchess 26	1826	"	3	1	1	1	
Duchess 27	1827	"	16				
Duchess 28	1827	"	6				
Duchess 29	1829	"	20			1	
<hr/>							
Duchess 30	1830	2d Hubback	20		3	6	
Duchess 31	1830	"	26				
Duchess 32	1831	"	19	1		1	
Duchess 33	1832	Belvedere	19			1	
Duchess 34	1832	"	29	4	1	2	
Duchess 35	1833	Gambier	19				
Duchess 36	1834	Belvedere	19				
Duchess 37	1834	"	30	1	2	2	
Duchess 38	1835	Norfolk	33	1		2	
Duchess 39	1835	Belvedere	30				
Duchess 40	1835	"	19				
Duchess 41	1835	"	32	2		2	
Duchess 42	1837	"	30		1		
Duchess 43	1837	"	34	1	1		
Duchess 44	1838	Short Tail	37				
Duchess 45	1838	"	30				
Duchess 46	1838	"	34				
Duchess 47	1839	"	37				

Name	Born	Sire	Dam	Calves produced			
				Male		Female	
				Bulls named	Steers or un- named	Lived	Died
Duchess 48	1839	Short Tail	30				
Duchess 49	1839	"	30	1		1	
Duchess 50	1839	Duke of Northumberland	38	1		1	
Duchess 51	1840	Cleveland Lad	41	3		2	1
Duchess 52	1841	Holkar	38				
Duchess 53	1842	Duke of Northumberland	41				
Duchess 54	1844	2d Cleveland Lad	49	1		3	
Duchess 55	1844	4th Duke of Northumberland	38	1		1	
Duchess 56	1844	2d Duke of Northumberland	51	1		2	
Duchess 57	1845	2d Cleveland Lad	50				
Duchess 58	1846	Lord Barrington	54			1	
Total.....				29	16	63	2

From the above table we find, in considering the first half or the first twenty nine cows, that the following number were sterile, etc.

Number of cows sterile.....	13
" " " producing one calf....	4
" " " " 2 calves....	1
" " " " 3 calves....	3
Total number of calves produced.....	55

Results of last 29 cows:

Number of cows sterile.....	12	(one twin with a bull)
" " " producing one calf..	4	
" " " " 2 calves...	4	
" " " " 3 calves...	2	
Total number of calves produced...		55

Can we draw any conclusions from the above tabulations? I don't believe we can, although there is nothing to indicate that continued in-breeding brought about an increased number of sterile, or an increased number producing only one calf. The number of sterile individuals decreased by one in the last half of the experiment, and one of those individuals, Duchess 53d, was a twin with a bull.

Now we shall work out the "coefficient of in-breeding" and also the "coefficient of relationship" for each of these fifty-eight (58) Duchess cows. By taking an average of these coefficients for all sterile and all fertile cows, we probably can make a comparison that will throw some light upon the subject. This comparison will include the fifth ancestral generation.

The "coefficient of in-breeding" simply means that the individual under consideration has a certain percentage fewer ancestors in any given generation (here the fifth) than the maximum possible number. This is the expression used by Raymond Pearl (46) and in no way represents the

relationship between the sires' and dams' side of a pedigree. The reappearance of any animal in a pedigree is checked (2) and this means that all the ancestors of checked animals are counted in any generation, and the percentage of reduced ancestors worked out on the basis of the total possible number for the generation under consideration.

The "coefficient of relationship" expresses the percentage of total ancestors on one side (sire's) of a pedigree which are common to the other side (dam's). This means that whenever an individual occurs on both sides of a pedigree, he or she is checked (✓) on one side for each time they appear on the other side, and the percentage calculated from the number checked and the total number of ancestors for one side of a pedigree. This total number of ancestors is thirty-one (31) when the fifth ancestral generation is included. This "coefficient of relationship" differs somewhat from the coefficient suggested by Pearl (46). Pearl considers the primary reappearance of all animals that first appear on the sire's side and then reappear on the dam's side, and vice versa. Then from the number thus appearing, he works out the coefficient of relationship for sire's and dam's ancestors, based on the number of possible ancestors for sire or dam in any given generation. As an example to illustrate where I differ with his method,

Pedigree of

BRED BY

King Melia Rieter 14th

103901

King Melia Rieter

73104

Lanisso Marie
262996

Majorie Melia Ann's

San 63200

Letty Silver Hair
181544

King Melia Rieter
73104

Dula Rieteress
Maid
219360

Melia Ann's King
56581

56581

Melia Ann's Son 22041
Lottie Melia Ann 100775
Loy's State Regis (115441)
Melia Ann (5444)
Melia Ann's State Regis (22044)
Melia Ann 3rd (168070)

Majorie Melia Ann
157263

157263

Melia Ann's Son 22041
Loy's State Regis (115441)
Melia Ann (5444)
Mary Melia Ann 90583
Loy's State Regis 4th (206533)
Melia Ann 3rd (16807)

King of All Kings
58169

58169

St. Lambert's Rieter King King of St. Lambert 15725
54896
St. Lambert's Rieteress
106220
St. Lambert's Letty 114804
St. Lambert Bay (17408)
Letty Rieter (123425)

Erile's Silver Hair
148456

148456

Erile of St. Anne's 32539
Erile of St. Lambert (13657)
Moy Regis of St. Anne's 2nd (41009)
Silver Hair 4th 60449
Erile of St. Lambert (17053)
Silver Hair (14665)

Majorie Melia Ann's
San 63200

San 63200

Melia Ann's King 56581
Lottie Melia Ann 100775
Majorie Melia Ann 58169
Mary Melia Ann 90583

Letty Silver Hair
181544

181544

King of All Kings 58169
St. Lambert's Rieter King 54896
St. Lambert's Rieteress
106220
Erile's Silver Hair 148456
Erile of St. Anne's 32539
Silver Hair 4th 60449

King Rieter's Lass
63098

63098

St. Lambert's Rieter King King of St. Lambert 151735
54896
St. Lambert's Rieteress
106220
King's Rieteress Maid 142296
King of St. Lambert 151735
St. Lambert's Letty 114804

St. Lambert's Rule
55775

55775

St. Lambert's Bay St. Lambert's Bayman 55775
St. Lambert's Bayman 55775
St. Lambert's Bayman 55775

I give the pedigree of King Melia Rioter 14th, used by Pearl in his explanation of the "coefficient of relationship". Here we find that the sire of King Melia Rioter 14th is also his grandsire on his dam's side, and yet Pearl's coefficient of relationship is zero (0) for the second ancestral generation. I contend that this does not express the relationship between the sire's and dam's side of the pedigree, because Larissa Marie certainly contains one-half the blood of King Melia Rioter. I acknowledge that my coefficient of relationship does not fill the true meaning of the term, but at the same time it shows the percentage of common ancestors to each side of the pedigree, and is applicable to any pedigree.

Table II contains the coefficients of in-breeding and coefficients of relationship for all sterile females occurring in the first fifty-eight cows of the Duchess family. Table III contains the same coefficients for all fertile cows.

Table II

(Containing only Sterile Animals)

Name	:	I	:	R
		In-breeding Coefficient:		Relationship Coeff.
Duchess 7th		71.9		41.9
" 10th		75.0		70.9
" 13th		81.2		58.1
" 15th		81.2		58.1
" 17th		84.4		77.4
" 18th		65.6		45.1

Table II, Cont.

Name	In-breeding Coefficient	Relationship Coeff.
Duchess 21st	84.4	70.9
" 22nd	62.5	45.1
" 23rd	81.2	61.3
" 24th	65.6	45.1
" 25th	62.5	45.1
" 27th	68.7	61.3
" 28th	65.6	45.1
" 31st	68.7	80.6
" 35th	37.5	9.7
" 36th	65.6	16.1
" 39th	62.5	9.7
" 40th	65.6	16.1
" 44th	65.6	74.2
" 46th	65.6	74.2
" 47th	65.6	74.2
" 48th	56.2	25.8
" 52nd	59.4	54.8
" 53rd	65.6	58.1
" 57th	53.1	39.9
Average.....	67.2	53.5

Table III

(Containing only fertile individuals)

Name		I In-breeding Coefficient	R Relationship Coefficient
Duchess	1	71.9	58.1
"	2	71.9	58.1
"	3	71.9	58.1
"	4	62.5	32.2
"	5	62.5	32.2
"	6	75.0	87.1
"	8-	71.9	41.9
"	9	71.9	41.9
"	11	68.7	71.3
"	12	75.0-	67.7
"	14	81.2	41.9
"	16	84.4	80.6
"	19	71.0	61.3
"	20	75.0	51.6
"	26	68.7	45.1
"	29	71.9	54.8
"	30	71.9	64.4
"	33	65.6	16.1
"	34	62.5	9.7
"	37	62.5	9.7
"	38	50.0	35.5
"	41	62.5	6.4
"	42	62.5	9.7

Table III, Cont.

Name	In-breeding Coefficient	Relationship Coefficient
Duchess 43	65.6	48.4
" 45	56.2	25.8
" 50	59.4	32.2
" 49	56.2	25.8
" 51	53.1	51.6
" 54	50.0	48.4
" 55	65.6	48.4
" 56	62.5	45.1
" 58	62.5	45.1
Average.....	66.6	43.9

From these tables, it is shown that the average of the "coefficients of in-breeding" is almost identical for the sterile (67.2) and the fertile (66.6) groups, but there is a difference of about ten (10) per cent in the average of the "coefficients of relationship". At first glance we might come to the conclusion that this difference, which is ten per cent higher in case of the sterile group, has a real meaning, but by studying the individuals of each group, we can see no significance in this higher percentage, because we find more animals with extremely low coefficients of relationship in table III than in table II. This seems to be a strong indication that the coefficient of relationship has no bearing whatsoever on sterility.

What caused this large percentage of sterility in

the above family? It has been claimed by many that in-breeding was the cause of low-productiveness, and sterility in Bates' bred cattle. Mr. Sanders (45) (p 136) makes the positive statement that the low-productiveness of the Dutchess family was unquestionably due to incestuous breeding. Are we justified in making such a statement? Why did this incestuous breeding affect some animals and not others subjected to the same degree of in-breeding? There are cases of full sisters in this family where one proved to be fertile and the other sterile. Duchess 48th and 49th is an example of this condition. Another case of identical breeding where one proved sterile and the other two were fertile is shown in Duchess 7th (sterile), 8th and 9th (fertile). Another case of low and high productiveness crops out in the full sisters, Duchess 29th and Duchess 30th. Duchess 29th produced only one calf, while Duchess 30th produced nine.

How are we to explain these conditions? Does it not seem plausible, since most authorities agree that different degrees of fertility come about through the germinal make-up of an individual's parents (inheritance of fertility), that segregation has played the all important part in determining the animals carrying the characters for high-productiveness, low-productiveness, and sterility? This surely is a more logical explanation of what really existed, than to say that incestuous breeding was unquestionably the cause. Of course we are

absolutely ignorant of the multiplicity of factors involved in the determination of such a character as fertility, but if it is inherited we can expect segregation to take place and in-breeding is an excellent means of bringing hidden characters to the surface. The probability that low-productiveness and sterility were germinal in this family seem more than likely, since Hubback's dam was a shy breeder and never produced another calf after she dropped Hubback, and the first Duchess cow owned by Bates was disposed of because she was a shy breeder. This Duchess cow was really the foundation of the Duchess family, she being the dam of Ketton I (709) and the grand-dam of Duchess I. The very fact that sterility appeared in some of the Duchess cows which were not so closely inbred and others more closely inbred were fertile (Tables I., II, and III) proves to me that in-breeding per se was not the cause.

In-Breeding of the Duchess Blood Continued after Bates' Death. Mr. Butts (47) makes the following statement in regard to in-breeding Shorthorns in America:

"I bred Apricot's Gloster 2500 upon the second generation of heifers of his own get, thereby producing Treble Gloster 7331. I then bred him (T. Gloster) back to his dam, Spring Beauty, and the result was the very fine heifer, Souvenir. I then bred Treble Gloster to Souvenir, and the result was an extra fine heifer which is May Beauty; and I wish here to say that the above course of breeding

Pedigree of *May Beauty*

BRED BY

Geo. Butler

Mandarin, N.Y.

Irish & Galles

2331

Sauveur

Opus's Galles

2320

Spring Beauty

Irish & Galles

2331

Spring Beauty

Black of Galles

(11582)

Grand Black

(10284)

2nd Cleveland 2113008

Black 5574

2nd Black of 24th 1900

Black of 5674

3rd Black of York

(10166)

4th Black of 24th 1900

Black 5151

Opus's

1st Anna

4th Black of 24th 1900

1st Anna (5649)

Opus's Galles

2320

Opus's Galles

2320

Self

Sally Rutherford 1st 1100

May 7th

has been so entirely satisfactory in the past that I am now breeding Treble Gloster to all my females, regardless of relationship to them, in the fullest confidence in this course of breeding." The pedigree of May Beauty (American Shorthorn Herd Book) given here verifies this experiment, and we find that Apricot's Gloster 2500 was overflowing in Duchess blood through both his sire and dam.

The above breeding is an excellent example to verify my statement that in-breeding per se does not produce sterility. This is also proof that long continued in-breeding does not produce degeneracy of other characters. Here we have a case of in-breeding carried from Favourite (252) through many generations without evil results. To sum up this experiment, we can say that it represents the in-breeding experiment begun by Charles Colling in 1792,--continued for many years in his own herd; then taken up by Thomas Bates and continued throughout the breeding of the Duchess family, and finally being handed over to Mr. Butts of *Manlius*, N. Y., who continued the same practice for several years, or until 1874. These animals bred by Mr. Butts were subjected to more or less close breeding for a period of more than eighty years; yet, good individuals were produced.

Methods Pursued by the Messrs. Cruickshank. (Sanders 45) One of the greatest Shorthorn herds in the history of

the breed was built up through the efforts of the Cruickshank brothers (Amos and Anthony) at Sittytton, Aberdeen, Scotland. The foundation animals of this herd were purchased in 1837 and 1838, and the management of the herd was directed by Amos until his death in 1895. His brother Anthony, although engaged in banking at Aberdeen, was a partner in the business, and it is claimed that it was through his efforts that nothing but good animals were used in the foundation stock.

The ambition of the Booths was to establish a new type of cattle capable of turning raw material into flesh to a greater degree of satisfaction than had been done by their brother breeders. This ambition was realized by Amos before his death. His brother Anthony had died in 1879, or just about the time the Cruickshank cattle were becoming famous. Until about this date, the cattle of Bates blood were the craze. Amos Cruickshank did not recognize good animals by their pedigrees as did Thomas Bates, nor did he select an individual because of a beautiful head or nice straight outlines. His first requirement was a "good middle", as vitality and feeding quality can come only through animals so equipped. Although holding the above idea, he was not opposed to finish and style but rather tried to combine all.

In selecting his original cows, particular emphasis was placed upon constitution and aptitude to fatten. These

Pedigree of Billy (3151)

BRED BY

Capt. Buckley
Owned by
A. Cruickshank

Maresk
(2224)

Satellit
(1420)

Swiss (598)
Rue

Milord (435)
Wheeling to 679
Ruey
Chales (1127)

Maresk
(4495)

Lady Sarsk

Satellit
(1420)

No. 2

Cats (1119)

Guards (542)

Billy (3151)

Guards
(14076)

Swiss Satellit

Satellit
(1420)

(red picture)

Maresk

Mares (411)

Star

Guards (542)

Red Stars

Calumella
(904)

Swiss (496)

Wheeling to
Red Stars

Flora

Carey

Young Albion (505)
Fidlin

Albion (441) Guard (1007)

Pedigree of *Laurel's Camel*

(116637)

BRED BY

Mr. W. H. L. L. L.
M. H. L. L. L.
and H. A. Smith

White Hare

Frederick (5835)

Rebecca (1374)

Lucy (1341)

Charles

Young (1723)

Epithet (56)

Young (15)

Epithet

Major (3981)

Queen's Rose
(17389)

William 3rd
(4420)

John of William
(2281)

William (2281)

Redy

William (3192)

Barbara (3192)

Charles (1725)

—

Charles (1725)

White Hare
(3266)

Frank (17020)

Frederick (3488)

William (1420)

Super

Epithet

Frederick (3488)

Laurel's Camel (116637)

cows were selected from the leading herds throughout England, but realizing that he (Amos) could not get a herd of cows that suited his fancy in all respects, decided to bring about the desired improvement through good sires. His first sires were purchased of Capt. Barclay, England, and were full of Colling's breeding. The pedigree of Billy (3151) purchased from Capt. Barclay is an example of Barclay's breeding. Lancaster Comet (116637) purchased from Mr. Wilkinson is another example of close breeding among the early sires used. Other famous sires used in the early history of the herd were Fairfax Royal (6987), Hudson (9228), Matadore (11800), Lord Raglan (13244) Fourth (17866), and others. Duchess blood was introduced into the herd through the cows Strawberry by 2d Duke of Northumberland, and the heifer Premium in calf to Holker. The calf Matchless produced by Premium to the cover of Holker was said to have been one of the best cows in the herd at that time.

After selecting the best sires obtainable for a period of more than twenty years, the Cruickshank cattle had not developed that uniformity in essential characteristics which the brothers so earnestly desired; so, their policy of purchasing bulls was modified in 1860, and a system of in-and-in breeding began. This system began when the first get of the home bred bull Champion of England (17526) made their appearance. His get approached

Pedigree of *Rosa Parvula*
(35284)

BRED BY

A. Crutcher

Grand Duke of
Saxony
(176288)

Champion of
England (175726)

Lord Raglan (15244)

Queen (17958)

Queen of Saxony
(175726)

Queen of Saxony
(175726)

Queen of Saxony
(175726)

Royal Duke of
Saxony
(29864)

Miner

Champion of
England (175726)

Middle

Lord Raglan
(15244)

Middle

Queen (17958)

Queen's Rose
(175726)

Queen's Rose
(175726)

Queen's Rose
(175726)

(175726)

Champion of
England
(175726)

Queen's Rose
(175726)

Queen's Rose
(175726)

Queen's Rose
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Queen's Rose
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Queen's Rose
(175726)

Queen's Rose
(175726)

Queen's Rose
(175726)

closely the Sittyton idea of what a "North Scotland" Shorthorn should be, and for generations afterwards, the best of his sons, grandsons, and great-grandsons were used in the herd.

The most noted bulls used at Sittyton after the blood of Champion of England (17526) had been concentrated were Royal Duke of Gloster (29864), Roan Gauntlet (35284), and Cumberland (46144).

Royal Duke of Gloster (29864). Both his sire and dam were by Champion of England and out of cows by Lord Raglan (13244). He proved an excellent sire and was used extensively in the herd.

Roan Gauntlet (35284). Sired by Royal Duke of Gloster (29864) and out of Princess Royal by Champion of England. He represented the closest concentration of the blood of champion of England and yet was one of the greatest sires of his day. He was used for several years in the Sittyton herd.

Cumberland (46144). Sire Pride of Isles (35072), containing Champion of England as grandsire, and out of Custard, own sister to Roan Gauntlet; Cumberland was said to have been an animal of extreme blocky form, low to the ground, and heavily fleshed. He was a great sire and used at Sittyton eight years.

Regardless of what we may think of close breeding, the cattle of Cruickshank origin are the most popular of

Shorthorn history, and his final goal was not reached until he began close breeding. In regard to the Cruickshank cattle, I quote the following from "Shorthorn Cattle" by Sanders (45--p 601):--"There is not in Shorthorn history a record of greater success attained in the production of valuable cattle for practical farm and feedlot purposes than that which attended the breeding operations at Sittyton after the practice of using only home bred bulls was adopted. The herd began at once to take on a uniformity in essential points which it had not hitherto possessed, and the further the concentration of blood was carried, up to a certain point, the better the results. The fruit of Mr. Cruickshank's appeal to the practice of in-breeding was the establishment of a well-fixed type of short-legged, broad-ribbed, thick-fleshed cattle feeding to satisfactory weights at an early age; and the same concentration of blood that served to fix these desirable characteristics insured the prepotency of the stock for reproduction purposes."

I agree with Mr. Sander's statement with the exception of one point. He states that the further the concentration of blood was carried, "up to a certain point", the better the results. Where is this "certain point"? It seems to me that this is the most "uncertain point" in existence. I can find no indication of in-breeding being carried too far in the Sittyton herd, and

some of the most noted animals bred by Mr. Cruickshank were among those closely bred.

(6) HEREFORD CATTLE INBRED

Early Improvers and Their Breeding Methods. The most distinguished early improvers of Hereford cattle were Benjamin Thompkins, Sr., Benjamin Thompkins, Jr., John Price, John Hower, and Thomas Jeffries.

The Thompkins. (29 & 48) Little is known of the Thompkins' operations, but they are supposed to be the senior improvers of Hereford cattle. Richard Thompkins, the father of "Benjamin the Elder" is supposed to have bred Hereford cattle at New House, Kings Pyon, prior to 1723, and left some cattle to his son, Benjamin of Court House and Wellington Court, Canon Pyon, which were above the average. These cattle were bred with success for many years, but the real improvement was brought about by "Benjamin the Younger", who was born at Wellington Court in 1745, and began breeding Hereford Cattle in 1766. His breeding operations were carried on for about fifty years at Blackhall and Wellington Court, Kings Pyon. His method was to breed from close affinities, according to Sanders (48--p 52) and Plumb (29--p 202). Through this method of close breeding, his cattle became better covered over the back, produced less offal, matured

earlier, and was of a more uniform character than those possessed by his father.

John Price (29--p 203 and 48--p 58). John Price of Earl's Croome and Ryall, Worcestershire, became interested in Hereford Cattle in about 1804, and at the time of his death in 1841, he had developed a famous herd. Being a close disciple of "Thompkins the Younger", he secured his foundation stock from Wellington Court and bred from close affinities. The old Thompkins strain of Herefords were white and mottled of face and no effort was made by Price to establish uniformity of color.

John Hewer(48--pp64, 65) John Hewer occupied many farms in Shropshire and Herefordshire during his time, and was an eminent Hereford breeder. He began breeding Hereford Cattle in 1817, and continued until 1873. He is said to have established the uniform white face of the present day Hereford. His practice was in-and-in breeding. The foundation bulls were closely related to a bull called Silver (540). Chiefly sons and grandsons of this bull were used in the early development of his herd. Through Young Wellington (505), Old Favourite (442), and Waxy (403), the blood was strongly concentrated. One of the greatest of the Hewer bulls, Old Sovereign (404), was the progeny of an own brother and sister. It is claimed that he was acknowledged to be "the best bull ever bred in the county

Pedigree of *Celene* (576)

BRED BY

*Mr. Arthur
H. Hume,
Leicester*

*Savanna
(404)*

*Francis
(442)*

Cambria

*Young Wellington
(1505)*

*Wellington
(1507)*

*Stear (1540)
Leicester
Clay (403)
Sick (1540)
Stear (1540)
Leicester*

Cherry

*Wellington
(1507)*

*Clay (403)
Stear (1540)
Leicester*

*Young Wellington
(1505)*

Wellington (1507)

Cherry

(1507)

Leicester (410)

*Old Leicester
(410)*

*Celene (1535)
Young
Wellington (1507)*

*Clay (403)
Stear (1540)
Leicester (404)
Old Leicester (1540)
Leicester*

Red Run

Wellington (1507)

*Clay (403) (1507)
Stear (1540)
Leicester*

(not given)

Celene (576)

of Hereford and the sire and grandsire of more prize cattle at Smithfield and elsewhere than any other bull in the Kingdom". Notice his pedigree as the sire of Catmore (376) spoken of later. Lottery (410) and many other famous bulls bred by Hewer were closely inbred.

Thomas Jeffries. (29--p204 & 48--pp69 and 70) Thomas Jeffries of the Grove, Pembridge, and other estates, was a noted breeder of Hereford Cattle during the second quarter of the nineteenth century. His success was attributed to his method of close breeding and the use of close bred bulls hired of John Hewer. The previously mentioned bulls, Sovereign (404) and Lottery (410) were among the earlier bulls hired by Jeffries. The noted bull Catmore (376) sired by Sovereign and out of a daughter of Lottery represents in-breeding as practiced by Jeffries. Catmore (376) won first prize at the first Royal show at Oxford in 1839, and left some valuable offspring at the grave. He was said to have been a fine specimen of Hereford flesh and reached the enormous weight of 3950 pounds, probably estimated. His pedigree given here verifies his close breeding.

Later Improvers of Fame in England and America.

The two most conspicuous herds of the latter part of the nineteenth century were the herds of T. J. Carwardice, Stoctonbury, England, and Gudgeon and Simpson of Independence, Missouri, U. S. A. Many other breeders of importance could be mentioned, but it is conceded that

the descendants of these two herds contain more superior show and breeding animals than all other herds combined.

T. J. Cawardice. (48--pp422, 426 ~~P~~. A. H. Herd Book)

In the hands of this noble, broad-minded breeder, the foundation stock of the present day Hereford favorites were bred. Both Anxiety (5188)--2238 and Lord Wilton (4740) were used in his herd, and the descendants of these great bulls have made Herefords famous on both sides of the Atlantic.

Anxiety 2238 was imported to America in 1879, and although he lived only one year on this side of the ocean, he left a few valuable offspring in Mr. Culbertson's herd, Douglas County, Illinois. The most valuable offspring of Anxiety were sired before his importation in Mr. Cowardice's herd. His best get were the bulls, Anxiety 4th (5188) 2338 and Anxiety 3d 4466 and the cow Prettyface 5735. Although Anxiety 2238 was not an inbred animal, we find that his three best get were inbred. The three animals just mentioned were all the product of half-brother by half-sister matings. Both sire and dam of Anxiety 4th, Anxiety 3d, and Prettyface 5735 were sired by Longhorns (4711), and in the case of Anxiety 4th both of his grand-dams were by Decote (3060); so he was a closely inbred animal, and the most famous of all the get of old Anxiety.

Anxiety 4th 2338 was imported to America by Gudgeall

and Simpson, and by the judicious concentration of his blood, they built up the most famous herd of Hereford Cattle in America. Anxiety 3rd 4466 was also imported to this country, and gave valuable service in Tom Clark's herd of Illinois. He proved an excellent sire of daughters, and for several years, his daughters made their mark at the leading shows. Prettyface 5736 was imported in 1881, after winning fame both as a breeder and as a show cow in England. When imported she was in calf to Lord Wilton (4740) and to this cover she produced Lord Wilton 5799, which proved an excellent sire in the Culbertson herd. Lord Wilton (4740) was also an inbred animal. He was strong of the blood of Pilot (2156) and Sir David (349). While this Anxiety blood in the Culbertson herd became very famous, the herd never reached the fame attached to the Gudell and Simpson herd. The Anxiety and Lord Wilton blood was freely used in the Cawardice herd and by a certain amount of in-breeding, the herd became famous on both sides of the Atlantic.

Gudgell and Simpson (48--F. A. H. Herd Book). The foundation of the Gudgell and Simpson herd was laid in 1877. The foundation animals were purchased by Charles Gudgell from F. W. Stone, Guelph, Ontario, and were said to have been a choice selection. Mr. Simpson became a joint partner in 1880, and then they began to make importations. In their second importation in 1881, they

obtained four daughters of old Anxiety and one son, the famous Anxiety 4th. The bull North Pole 8946 was also imported at the same time, and used in the herd, but he did not equal Anxiety 4th as an individual or as a sire. Anxiety 4th, as previously stated, came from the famous Cawardice herd, and was an excellent individual with much better hind quarters than Herefords carried at that time. This character was transmitted to his offspring, and by judicious in-breeding, Anxiety 4th made the Gudgell and Simpson herd famous. Mr. Sanders (48) (p 481) states that Anxiety 4th was probably the greatest "all around" breeding bull ever imported.

For several years, Gudgell and Simpson followed the same lines of various American Hereford breeders, who were religiously abstaining from breeding to close affinities, and for several years, they bred the four heifers bought of Mr. Cawardice and sired by Old Anxiety 2238 to North Pole 8946. As an experiment, one of these heifers was bred to Anxiety 4th and produced a very fine calf. This calf proved so markedly superior to other calves of the same cow and those from other cows sired by Anxiety 2238 that the eyes of these breeders were opened to the possibilities of a changed system of breeding. They had already noticed that Anxiety 4th was a product of close breeding; so, they began concentrating the blood of this great bull by the use of his sons and grandsons in the herd. All fresh blood introduced after this time

was brought in through a few females. Several noted bulls were later tried in the herd, but failed to give good results and were discarded. The famous show bull Earl of Shadeland 47th 36644 and Mark Hanna 74230 were two of the well-known bulls tried in the herd that proved so unprofitable.

To show the concentration of the blood of Anxiety 4th in this famous herd, I submit the pedigrees of a few of the most famous animals bred by Gudgell and Simpson. The pedigrees of Beau Donald 58996, Dandy Rex 71689, Militant 71755, Mischievous 71750, Miss Caprice 109725, and Mischief Maker 97907 show that they were closely inbred; yet they were among the most famous animals of their day, and proved valuable breeders. The concentration of the blood of Anxiety 4th in these animals is analogous to the concentration of Champion of England's blood in the Cruickshank herd, and I fail to see that injury resulted in either case; but on the contrary, it seems to have been the main factor in producing uniformity and prepotency in each herd.

Many cases of close breeding can be cited in our famous Herefords of the present day. The young Hereford bull, Woodford 6th 505407, winner of the first prize in the junior yearling class at the International at Chicago, 1916, is an example of close in-breeding. He was sold at this show for \$15,100 to N. J. Camden of Versailles, Ky. He was bred by W. H. Curtis of Eminence,

Pedigree of *Beau Laurel*

BRED BY
58996

Trudgell & Sons
see, *the dependence*
see, 1720

Beau Laurel

51817

Van Carter

33734

Beck 24629

Beauty 4th

9904

Beauty 2231

Langhorne 2239

Willow 2240

Langhorne 2239

Left 9906

Si' Frank 2674

Refraction 2675

Deposition 2679

Langner 6934

William 2411

Tom 8th 4441

Edward 3045

Charles 7817

Mark Lee

8746

Ther 1275

4462

Creary 8947

Harwood

5473

Si' Humphry 2602

Alice 13628

Mutter Olive 2981

Beauty 2929 2973

Beulah Beauty

10095

Beauty 5th

10096

Beauty 2238

Langhorne 2239

Mercury 2241

Blackdo 2242

Wheat 2243

Regina 2244

Mercury 2241

Blackdo 2243

Wheat 2243

Young (1978)

Tag Law 9905

Langhorne 2239

Left 9906

Young Si' Frank

2669

Si' Frank 2674

Refraction 2675

Young Laurel 2676

Si' Frank 2674

Refraction 2675

Young Laurel 2676

Langner 675

6932

Langner 675

Beau Laurel 58996

Pedigree of *Michivious 71758*

BRED BY

Goodell & Simpson
Michigan
Mo.

53734

Goodell & Simpson
51834

Goodell & Simpson
51101

Goodell & Simpson
53752

Goodell & Simpson
11123

Goodell & Simpson
11081

Goodell & Simpson
19904

Goodell & Simpson
6932

Goodell & Simpson
8946

Goodell & Simpson
9861

Goodell & Simpson
19904

Goodell & Simpson
9246

Goodell & Simpson
19904

Goodell & Simpson
2238
2239
2240

Goodell & Simpson
9905
9906
9907

Goodell & Simpson
3644
2345
2346

Goodell & Simpson
6934
2678
6935

Goodell & Simpson
1275
4412
4411

Goodell & Simpson
8947
3045
7817

Goodell & Simpson
9210
4787
5724

Goodell & Simpson
9863
41
9864

Goodell & Simpson
4581
2246
2247

Goodell & Simpson
9247
8
9248

Goodell & Simpson
4661
2246
2248

Goodell & Simpson
2247
8
9248

Goodell & Simpson
9247
8
9248

Goodell & Simpson
9247
8
9248

Goodell & Simpson
9247
8
9248

Pedigree of *Herefords*
Sex: *Females*
BRED BY

Goodwell & Simpson
Andover, Mo.

See Breeding
51817

New Carle
33734

Calving 4th 9904
Wager 6th 6932

Calving 2338
See Cal 9905
Wager 2644
Wager 6934

Young Bull 3rd
11038

Calving 4th 9904
Young Bull 11034

(see above)

Calving 1403
Young Bull 10651

Michael
71755

New Carle
33734

(see above)

Calving 3rd
33731

Calving 4th 9904
Calving 4th 9858

(see above)

Young Bull 9210
Calving 3rd 9805

Michael
97907

New Carle
33734

(see above)

Young Bull
51834

Calving 3rd
31101

Calving 8946
Calving 4th 9861

Calving 4462
Calving 8947
Calving 9210
Calving 9863

Michael
71758

Young Bull
11123

Calving 4th 9904
Calving 9246

(see above)

Calving 4th
33752

Calving 4th 9904
Calving 4th 9904 (see above)

Calving 4581
Calving 9247

Kentucky, and previous to the above sale was owned by E. H. Taylor, Frankfort, Ky. I have seen this bull on two different occasions, and knowing him to be an inbred animal, I examined him with a view of detecting some fault in his make-up, but as his faults were so deeply buried beneath his beautiful outward appearance, I came to the conclusion that they did not exist.

Woodford 6th was sired by Woodford 500000 and out of Belle Perfection 19th 372547. Both Woodford and Belle Perfection 19th were sired by Perfection 93891 and out of closely related dams, Belle Donald 114th 267191 and Belle Donald 113th 267190.

Of course I have given a mere sketch of Hereford breeding, but it is evident that in-breeding has played its part both in the early development of the breed and in the establishing of desirable qualities today. Had it not been for the concentration of the Anxiety blood, the American Hereford would no doubt still lack the good hind quarters seen on good specimens of the breed today.

(c) Polled Durham Cattle Inbred. The Polled Durham breed of cattle has been established in America (U. S.) by close breeding between a few individuals possessing the polled character or scurs. Young Hamilton 114169 was the product of a half-brother by half-sister mating. His sire and dam both were sired by Acklam Sharon 2nd 49641. Young Hamilton was an excellent individual, and the grand champion of the breed at the Columbian Exposition.

Ottawa Duke 109292 and Ottawa King 109293 (full brothers) were out of a half-brother by half-sister mating, and their ancestors were otherwise closely related. The breed was built up from two cows, Nellie Gwyne and Mollie Gwyne (full sisters) and their close descendants.

(d) Experiments of Rhys. Arthur Rhys, the herdsman at the University of Missouri, has practiced close in-breeding of dogs and rabbits without observing any evil results. He closely inbred fox terriers for nine generations. For seven generations, the male (Designer) of the originally unrelated pair, was bred to his daughters. A son of this last litter was then mated to his dam, and from the resulting litter, a brother and sister were selected and inbred. Strict selection for strong individuals was practiced throughout the experiment, and Mr. Rhys states that he could see no evidence of loss in constitution, diminished size, or decrease in fertility as a result of in-breeding fox terriers. Although the later generation seemed to lack courage to some extent, he did not attribute this latter condition to in-breeding.

He inbred Belgian rabbits for several generations without observing any evil effects. In regard to in-breeding, Mr. Rhys states that, "I see no evil effects from my own experiments, and I have seen many other inbred animals that were superior individuals. If a man knows something about the ancestors of his animals and uses good judgment in his selections, I don't believe there

is harm done by in-breeding."

IV. IS FERTILITY INHERITED?

From the available literature on the subject of in-breeding and from my study of the breeding methods adopted by the early Shorthorn breeders (especially Bates' experiment), there seems to be some foundation for the argument that in-breeding per se has some effect upon the fertility of animals, or that there is some physiological condition brought about which interferes with the union of the sperm and ovum of closely related animals. If the latter condition exists, there is no available literature, as far as I know, which will clear up this point. There has been some work done on the inheritance of the fertility of domestic animals, and I shall review some of this work in order to determine whether or not we should charge low productiveness or sterility to in-breeding.

Review of Literature. The experiments of Pearl (49) at the Maine Agricultural Experiment Station led him to believe that the "hatching quality of eggs" (measured by per cent of fertile eggs hatched) is definitely inherited in the female line, and probably also in the male line.

A correlation table was formed which showed for every possible pair of full sisters which occurred in the pedigree records, the per cent of each sister's fertile eggs hatched. The coefficient of correlation indicating the degree of "fraternal" inheritance with

reference to this character was calculated with the following results:

Correlation between sisters in respect to per cent of fertile eggs hatched, $r = 0.188 \pm 0.060$.

This shows a sensible positive sister--sister correlation. This result is contradictory to the results obtained when the coefficient of correlation was worked out for the same character between mothers and daughters. After a careful study of the individual records, it was found that sensible coefficients of fraternal inheritance associated with low or insignificant parental coefficients occurred, whenever the phenomenon of prepotency occurs in the ancestral line. This merely means that the existence of such parental inheritance is masked by the existence of varying degrees of prepotency with reference to this character amongst the mothers; so the absence of a significant parental correlation does not mean that hatching quality is not inherited.

Twinning. Reitz and Roberts (50) of the Illinois Station found the following positive correlation coefficients in their biometric studies with respect to twinning in Shropshire sheep:

Between the sum of the numbers in litters in which the two parents are born and the size of litter in which the corresponding offspring are born, $r = 0.0880 \pm 0.0070$;
between sizes of litters in which dams are born and sizes

of litters in which their offspring are born, $r = 0.0869 \pm 0.0065$; between sizes of litters in which sires are born and sizes of litters in which their offspring are born, $r = 0.0527 \pm 0.0070$. They also found that twin parents give a larger percentage of twins among their offspring than do parents born as singles. Rommel and Phillips (51) studied the inheritance of the size of litters in the female line of Poland China sows, and found the positive correlation coefficient of $0.0601 \pm .0086$ between the size of litters in which dams and daughters were farrowed. They concluded that the size of litter is a character transmitted from mother to daughter.

Simpson (52) crossed a wild German Schwarzwald boar with a young Tamworth sow. The Schwarzwald normally averages 4 pigs to the litter, while the Tamworth averages about 11. The Tamworth sow was farrowed in a litter of 12 pigs, and to the cover of the wild boar, farrowed 9 pigs. In the F_1 generation, three females were bred, one to a litter mate and the other two to unnamed sires. These sows produced 4, 4 and 6 pigs, respectfully, in their first litters. When the sow which produced the litter of 6 pigs was bred to a pure Swarzwald boar, she farrowed 7 pigs, being apparently constant for that degree of fertility. One of the sows from the litter of 6 pigs farrowed 12 pigs when mated to pure Tamworth boar. Although the numbers were small, Mr. Simpson believed that

there was a clear segregation of fecundity factors, and that the boar was just as important as the female in regard to the inheritance of fecundity.

Pearson (53) and others found correlation coefficients ranging between 0.0418 and 0.213 in their study of fertility inheritance in the human race and the thoroughbred horse. They believed fertility to be markedly inherited in both man and the race horse. Danforth (54), in making a study of the births in St. Louis during the five years from February 1910 to February 1915, found that of the 75,030 births recorded, 828 were reported as twins or triplets. This indicates that multiple births were one to 90.6 single. In looking into 50 cases of twins (50 families where twins were born), he found that these 50 pairs of twins had 171 older brothers and sisters born singly and ten (10) pairs of twins. The frequency of twins among the brothers and sisters of twins then is one to 18. In the mothers fraternities there had been 318 single births and ten pairs of twins, or one pair of twins to 32 single births; in the fathers' side there had been 219 single births and eight pairs of twins, or one pair of twins to 37 single births. Danforth concluded that twinning runs in certain families. Pearl (55) discovered an arbitrary division point of thirty (30) eggs in the winter laying period of hens, for which inheritance apparently depends upon two factors; one

of which behaves as an ordinary Mendelian, and the other a sex-linked condition.

Discussion. The above literature verifies the opinions of many breeders of today; that fertility or fecundity is an inherent character. We know that there exists a real difference in fecundity between some of our breeds of swine, and even between different strains of the same breed. What causes this variability of fecundity if it is not germinal and therefore inherited? These biometric studies (where the data has been taken from herd books) are not accepted by all authorities as being of great genetic value due to the inaccuracy of the herd-book records. I am inclined to believe that the inaccuracies of the present day herd books are not so great, but that we can rely on this character of work to some extent. An animal never exceeds her hereditary possibilities in number of offspring, and there are numerous conditions (physical and environmental) which may cause an animal to fall short of that number. Wentworth (56) states that lack of proper nutrition, failure to have all ova released or fertilized, loss of ova, atrophy of fertilized ova or embryos, and disease may all operate against the complete realization of the hereditary make-up of swine. Many other environmental conditions such as the of farrowing time, number of litters per year, may also reduce the size of litters.

Considering all these conditions, it does not seem

plausible that we have enough of dishonest breeders to make our herd-book records valueless in a study of this kind. Considering the literature as a whole, there is strong evidence that fertility or fecundity is inherited, in some fashion, in the case of domestic animals and man.

V CONCLUSIONS

1. In-breeding has been the means of accelerating and fixing the uniform type of many of our domestic animals.

2. Had in-breeding not been indulged in by many of the most famous improvers of domestic animals, improvement would have been slow, and the valuable characters of a few exceptionally good individuals would have been lost to future generations.

3. The more nearly homozygous the hereditary material (germ plasm) of an animal becomes for certain or all characters, the more uniformly will these characters be transmitted to the offspring.

4. Although the majority of evidence is negative, there is little doubt, but that the closest forms of in-breeding can be practiced for many generations with our domestic animals, without evil results, provided the animals first selected are good individuals, and strict selection is followed in future matings.

5. Segregation of all hereditary characters, so far as we know, will take place in accordance with "Mendel's Law", and only strict selection will prevent the intensification of undesirable characters, if such characters be present in the original stock.

6. Good and bad results must come from in-breeding just as good and bad results follow cross-breeding, because few breeders are familiar enough with the good and bad qualities of their animals to make the proper selection of individuals to be subjected to the test of close breeding.

7. In-breeding should not be condemned because of bad results, no more than should cross-breeding (may be applied to the crossing of unrelated animals of the same breed, or to the crossing of different breeds).

8. Cross-breeding, between different breeds, produces good animals for the slaughter-house, although they are useless in the improvement of our breeds.

9. In-breeding per se is not the cause of any hereditary defect. Such defects would be just as readily brought to the surface by crossing, if such characters are present in the parental stock.

10. Selection seems to be the all important factor in controlling bad qualities of our domestic animals, and biometric studies and experimental work indicate that fertility may be controlled by the breeder.

11. Long continued inbreeding did not increase the

number of sterile individuals in Bates' experiment with the Duchess family, and as they were the most noted animals of the Shorthorn breed for many years, there is every reason to believe that their constitution and vigor were not impaired. The experiment of Dr. King (rats) also bears out the latter conclusion. Evidence shows that Bates began this experiment with animals rather unprolific, and we should not be surprised that sterility and low productiveness remained in the herd, because Bates selected his animals by pedigrees rather than by their merits.

12. There is some evidence in the case of hogs and cattle which leads one to believe that there is a possibility of in-breeding bringing about a physiological condition which interferes with the union of closely related sperms and ova. Some animals failed to produce offspring when mated to closely related individuals, but prove rather prolific where mated to unrelated animals. The experiments of Wright and Nathusius with swine and the first Duchess cow used by Bates are examples of such a condition existing, although cases of this nature are too few, and the fact that other animals more closely related have produced offspring when mated to closely related individuals, indicates that there is a very slight possibility of such a condition existing.

13. The extent to which in-breeding may be practiced

depends entirely upon the germinal constitution of animals involved and the ability of the breeder to make the proper selections.

VII UNDER WHAT CONDITIONS IN-BREED-
ING SHOULD BE PRACTICED

There are two conditions which to me are constantly calling for this method of breeding. One of these arises in the very best purebred herds of our domestic animals, and the other in grading or improving common stock.

In all breeds of purebred stock, there exists, from time to time, a few really superior breeding animals; and if we allow their good qualities to be mingled with inferior animals, they soon will be lost. How can these valuable qualities be preserved in order to improve the breed? There is only one answer to this question: "By in-breeding". If we are to make any progress in the improvement of our best breeds of today, this system of breeding is undoubtedly going to be the main instrument in bringing it about.

It was this system of blood concentration which brought fame to Gentry's Berkshires, Cruickshank's Shorthorns, and Gudgell and Simpson's Herefords. What is the practice of many of the best breeders of dairy cattle today? A good sire from a prepotent strain, or a tested sire is selected to head the herd, and then kept in service until his grand-daughters, also daughters, are old enough

to breed. This means that sire is bred to his daughters. Many of our college herds are being bred in this manner, and the results are very satisfactory. Of course it is necessary that sires so used should not only transmit milking qualities to their daughters, but type and constitution as well. To use an animal lacking these qualities would be stamping the same defects into the herd, and should be avoided.

Grading presents a condition where in-breeding can be practiced with impunity for one or two generations. If a good purebred sire is selected to build up a grade herd, he should be retained and bred to his daughters. This method not only brings about a more uniform type in a limited time, but it reduces the cost of improvement. Few breeders of grade stock can afford to buy a high-priced animal every other year, but in-breeding offers him an opportunity of purchasing a first class animal and retaining him a longer period for service. There is not a question of doubt but that this method of breeding will bring about greater improvement than to breed from mediocre animals.

The number of generations such a practice can be followed depends entirely upon the animals under consideration. If strict selection is followed, which is necessary in any form of breeding if the breeder is to be successful, in-breeding may be practiced for many generations. On the

other hand, every breeder is not capable of making the proper selections and should avoid this method of breeding. Remember that in-breeding is a means of concentration and not a means of elimination. Bad as well as good qualities are concentrated, and if the breeder constantly keeps this in mind, he will be more careful in his selections, and should have little fear of in-breeding.

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Pedigree of Duckham 7th

BRED BY

C. Selby.

Haumont (252)

Bellinghute (86)

Haumont (263)

Young Sturtevant

Barker's Buck
Naughton's
Walter's Buck (188)
Lady Maynard

Phaenix

Lady Maynard

Cornet (185)

Haumont (252)

Young Phaenix

Phaenix

Duckham 1st

12th Duckham

⊗

Haumont

(252)

11th Duckham

Young Buck (186)

Haumont (252)

Buck (1831)

18-58-11

Pedigree of *Bluebees 2nd & 3rd*

BRED BY

J. Bates

Harriet
(252)

Bessie Beck
(186)

Helene (263)

Robert's Bess

Young Frederick

William Bates (18)

Harriet
(252)

Harriet

Fredrick (263)

Fredrick

William I
(1709)

Bluebees
(186)

Young Bess
(186)

Harriet (252)

Bess (1531)

Harriet
(252)

William (319)

Harriet
(155)

Harriet (252)

Harriet (252)

William (319)

Young Harriet

Harriet (252)

Harriet

Bluebees I

Harriet
(252)

Bluebees
(252)

Bluebees
(252)

Bluebees 2nd and 3rd

I, J. J. J.
18-18-1

Pedigree of Blackburn 6th

BRED BY

J. Bates

Blackburn II
(1710)

Blackburn I
(1709)

Favourite (1252) Belgic Bull (186)
Young Favourite
Young Bull (186)

Grandson of Favourite Cardinal (115)

Mr. Brown's Red Bull

Blackburn III
(1349)

Blackburn I
(1709)

Blackburn 3rd

Blackburn I

Blackburn 6th

Blackburn II
(1714)

Blackburn I
(1709)

Blackburn 4th

Cowslip (1155)

Young Favourite

Favourite (1252)

I = 75
R = 521

Favourite

Blackburn I

Blackburn I

Pedigree of Duckens 7th, 8th, & 9th

BRED BY

J. Baker

Mother

(1418)

Favourite
(252)

Working Buck
(186)

Young 5th & 6th Buck

Barren Buck
Young 1st Buck
Young 2nd Buck (188)

Flourish

Young 1st Buck
Young 2nd Buck

Favourite (252)

Young 1st Buck
Young 2nd Buck

Black (319)

Heaven I (1709)

Favourite
(252)

Working Buck
(186)

Young 1st Buck
Young 2nd Buck

Barren Buck
Young 1st Buck
Young 2nd Buck (188)

Duckens III
for 7th

Duckens II
for 8th & 9th

Flourish (155)

Young 1st Buck
Young 2nd Buck

Barren Buck
Young 1st Buck
Young 2nd Buck (188)

Duckens I

Working Buck
(186)

Young 1st Buck
Young 2nd Buck

Barren Buck
Young 1st Buck
Young 2nd Buck (188)

Duckens 7th, 8th, & 9th

I = 71.9
R = 41.9

Pedigree of Blueberries 10th

BRED BY
J. B. B. B.

Cleveland
(146)

Kellan 3rd
(349)

Kellan III
(710)

Blueberries III

Kellan I (1209)

Blueberries I

Cornell (155)

Frazerite
(252)

Beltinghake (56)

Phaeus

Frazerite (253)

Phaeus

Young Phaeus

(14) Blueberries

Frazerite
(252)

Young Blue (186)

Kellan I (1209)

Frazerite
(252)

(6) Blueberries

Grand son of Frazerite

Caroline (115)

Cherry

Penck (551)

Kellan II
(710)

Blueberries 4th

Cornell (155)

Blueberries I

(14) Blueberries

Blueberries 10th

I-75,
R-709

Pedigree of Duchess 11th

BRED BY

J. B. B. Co.

Marek (418)

Harmonite
(252)

Belting Duke
(86)

Harmonite (265)
Young Strawberry
Harmonite (1865)
Reddy Maryland

Harmonite
(252)

Harmonite (252)

Young Marek
(419)

Belton 2nd
(710)

Duchess 8th

Duchess 1

Belton 1
(709)

Harmonite (202)

161 Duchess

Young Duke (186)

Grandson of Harmonite

Carlisle (115)

Cherry

Reverend (1531)

Duchess 5th

Conrad (155)

Harmonite (252)

Young Prince

Harmonite (252)

Duchess 1

I = 68.25

R = 61.3

1st Duchess (252)
2nd Duchess (252)
3rd Duchess (252)
4th Duchess (252)
5th Duchess (252)
6th Duchess (252)
7th Duchess (252)
8th Duchess (252)
9th Duchess (252)
10th Duchess (252)
11th Duchess (252)
12th Duchess (252)
13th Duchess (252)
14th Duchess (252)
15th Duchess (252)
16th Duchess (252)
17th Duchess (252)
18th Duchess (252)
19th Duchess (252)
20th Duchess (252)

Pedigree of Duckess 13th

BRED BY

J. Bell

The Earl
(646)

Ducke (226)

Caesel (155)

Harvinit (252) { Balding hute (186)
Young Phoenix { Phoenix
Harvinit (252) { Phoenix

(a) Duckess

(b) Duckess

Living Seal (186)

Bellum I (709)

Harvinit (252)

Duckess 3rd

Duckess I

Bellum I (709)

Bellum 2nd
(710)

Five of Harvinit

Carbide (115)
Phoenix
Mr. Brown's Red Buck (197)

Duckess 4th

Caesel (155)

Duckess I

I = 75
8-627

Pedigree of Duckens 14th

BRED BY

J. Bates

Heard (1646)

Ducke (1226)

Cowell (1555)

Favourite (1252) Bulldog (186)

Young Henry

Henry

Favourite (1352)

(a) Duckens

Favourite (252)

Henry Bull (186)

(b) Duckens

Kellam I (709)

Favourite (1252)

(c) Duckens

Duckens 3rd

Duckens I

Cowell (155)

(a) Duckens

Duckens 14th

Kellam 3rd (1349)

Kellam II (710)

Kellam I (709)

Spencer of Favourite

Duckens 3rd

Duckens 6th

Kellam II (710)

Duckens 4th

I = 8.2
R = 4.9

Duckens 3rd

Pedigree of *Bluebees* 15415th

BRED BY
J. Bates

The Tale
(646)

Blue (226)

Blue 3rd

Cow (155)

Heavens (1352) *Blue* (86)
Young Heavens *Heavens* (1352)
Heavens (1352)

Blue

Blue (1352) *Blue* (186)

Blue I

Heavens (1352) *Blue* (1352)

Blue I

Cow (155) *Blue* (1352)

Blue (418)

Heavens (252)

Blue (86) *Blue* (263)
Heavens (1352) *Blue* (1352)

Blue 9th for 13th

Heavens (252)

Blue (1352)

Blue 8th for 15th

Heavens I (109)

Heavens (1352) *Blue* (1352)

Blue 2nd

Blue I

I = 81.2
R = 58.1

Blue 13415th

Pedigree of *Bluehens 16th*

BRED BY

J. Bates

Blue (226)

Caenot (155)

12 Bluehens

Hee Lee (646)

Bluehens 3rd

Bluehens 16th

Bluehens 3rd

Blue I (709)

1st
Caenot (155)

1st
Caenot (155)

1st
Caenot (155)

12 Bluehens

12 Bluehens

1st
Caenot (155)

1st
Caenot (155)

1st
Caenot (155)

1st
Caenot (155)

1st
Caenot (155)

I = 54.4
P = 50.6

Pedigree of Bluebird 17th

BRED BY

J. Boer

1st Case (646)

Buck (226)

Count (155)

Young Plover
Count (252)

(12) Bluebird

Count (252)

(16) Bluebird

Count I (709)

Count (252)

Bluebird 3rd

Bluebird I

Count (155)

(12) Bluebird

Murks (418)

Count (252)

Count (86)

Count (252)

Bluebird 5th

Count I (709)

Bluebird II

Bluebird I

Murks (418)

Count (252)

Count (252)

Young Murks
(419)

Bluebird 4th

Count 2nd (710)

Count I (709)

Bluebird 11th

Count 2nd
(710)

Count I (709)

Count (252)

Count I

Count (155)

Bluebird 5th

Count I

Count (155)

Count (252)

December 17th

I = 84.4
R = 77.4

Pedigree of Blue Deer 18th, 24th & 28th

BRED BY

J. B. B. B.

He Deer (646)

Male (226)

Female (155) { Favorite (252)
Young Favorite
Favorite (252)
Blue Deer

Blue Deer 3rd

He Deer I (709) { Favorite (252)
Blue Deer
Female (155)
Blue Deer

2nd He Deer
(1423)

He Deer 1st
(705)

Female (177) { Female Sum of Favorite
He Deer
Favorite (252)

Red Deer I

Favorite 2nd

Favorite (252) { Belknap (56)
He Deer
Blue Deer (531)

24th
28th

"

He Deer 3rd
(349)

He Deer 2nd
(710)

He Deer I (709) { Sum of Favorite
Blue Deer 3rd
Blue Deer 2nd

Blue Deer 3rd

Blue Deer 3rd { Blue Deer
Blue Deer 2nd
Blue Deer 1st

Blue Deer 6th

He Deer 2nd
(710)

He Deer 2nd { Favorite (252)
Blue Deer
Blue Deer 1st

Blue Deer 4th

I = 65.6
R = 45.1

Blue Deer I

Blue Deer I { Favorite (252)
Blue Deer
Blue Deer 1st

Pedigree of Bluebees 19th

BRED BY

1 Bates

He Earl (646)

Blue (1226)

Caunt (1555)

Harmonite (1352)

1/4 Bluebees

Young Henry
Harmonite (1352)

1/2 Blue I (709)

1/4 Bluebees
Harmonite (1352)

Bluebees 3rd

Bluebees I

Caunt (1555)

2nd Bluebees
(1423)

Peckhampt (1205)

Cupid (1177)

1/4 Bluebees
1/2 Cupid's son of Harmonite
Harmonite (1352)

Red Race I

Amuseur Cur

Harmonite (1352)

1/2 Cupid's son of Harmonite
Harmonite (186)

Harmonite (1531)

Bluebees 19th

1/4 He Earl (646)

Bluebees 12th

Caunt (1555)

1/4 Harmonite (1352)

Young Henry

1/4 Harmonite (1352)
Harmonite

Bluebees I

I = 71.9
R = 61.3

Pedigree of Duckens 20th

BRED BY

J. Bates

2nd. Earl

(1211)

1st. Earl

(646)

Duckens III

Duckens (418)

Duckens 8th

Duck (1226)

Cowd (1355)

Harrold (1352)

(a) Duckens

Young Harrold

Harrold (1352)

Duckens 5th

Belton I (1709)

Duckens I

Belton I

(1709)

Harrold (1352)

Bolingbroke (186)

(b) Duckens I

Living Bull (186)

Duckens I

Cowd (1355)

(a) Duckens

Harrold (1352)

Bolingbroke (186)

Harrold (1352)

Harrold

Young Harrold

Harrold (1352)

Harrold (1352)

Black (1319)

Belton I (1709)

Harrold (1352)

(b) Duckens

Duckens 2nd

Duckens I

Duckens 20th

I = 75
R = 516

Pedigree of Duckers 21st

BRED BY

J. B. Baker

1st Duck 1846

Duck 1226

Cumel 1155

Harvard 1352

(a) Duck 1846

Young Phoenix

Duck 354

Belton I 1709

Harvard 1352

Duck 17

Cumel 1155

2nd Duck

(1511)

Belton I 1709

Harvard 1352

(b) Duck 1846

Phoenix

Duck 354

Duck 17

Cumel 1155

Duck 17

(a) Duck 1846

Duck 21st

Harvard 1352

Belton I 1709

Harvard 1352

Phoenix

Harvard 1352

Belton I

(1709)

(b) Duck 1846

Young Phoenix

Harvard 1352

Duck 354

Cumel 1155

Harvard 1352

Young Phoenix

Harvard 1352

Duck 17

(a) Duck 1846

Harvard 1352

I = 84.4
R = 74.9

Pedigree of Bluebird 23rd

BRED BY

Y. Root

1st Case (1646)

Waka (1226)

Count (1535) { Young Flamingo
Flamingo (1252)
Bluebird (1252)

Waka I (1709)

Flamingo (1252)

Bluebird 3rd

Bluebird I

Count (1535)

2nd Case (1511)

Waka I (1709)

Flamingo (1252)

Young Flamingo

Bluebird 3rd

Bluebird I

Count (1535)

Flamingo (1252)

Bluebird I

Count (1535)

Young Flamingo

Bluebird 23rd

Young Flamingo
(1419)

Waka (1415)

Count (1535)

Flamingo (1252)

Bluebird 4th

Bluebird I

Count (1535)

Bluebird 11th

Waka 2nd
(1710)

Count (1535)

Flamingo (1252)

Bluebird 5th

Bluebird I

Count (1535)

Flamingo (1252)

I = 81.2

R = 61.3

Pedigree of *Blueberries* 22nd and 25th

BRED BY

J. Baker

The Earl (1846)

Duke (1826)

Count (1555) { *Young Phoenix* }
(a) Blueberry { *Phaenocarpa* (1863) }
(b) Blueberry { *Phaenocarpa* (1863) }

Blueberry

3rd

Hellstar I (1709) { *Phaenocarpa* (1863) }
Blueberry I { *Count* (1555) }
(a) Blueberry { *Count* (1555) }

and Mulberry
(1423)

Phaenocarpa (1863)

Cupid (1777)

Red Sun of Phaenocarpa
Streak { *Phaenocarpa* (1863) }

Red Rue I

American One

Phaenocarpa (1863) { *Blueberry* (186) }
Phaenocarpa (1863) { *Blueberry* (186) }

Phaenocarpa (1863)

Blueberry (186) { *Phaenocarpa* (1863) }

Phoenix { *Young Streak* }
Phaenocarpa (1863) { *Blueberry* (1863) }

Murder (1418)

Phaenocarpa (1863) { *Blueberry* (186) }

Blueberry 9th for 22nd

Phaenocarpa (1863) { *Blueberry* (186) }

Blueberry 8th for 25th

Hellstar I (1709)

Phaenocarpa (1863) { *Blueberry* (186) }

Blueberry 2nd

Blueberry I

Count (1555) { *Blueberry* (186) }

Blueberries 22nd and 25th

I = 1825
R = 1851

Pedigree of *Duckers 26th*

BRED BY

J. B. Allen

The Earl (1646)

Ante (1226)

Cornet (1555)

Haarwilt (252)

(a) Duckers

Young Phoenix
Haarwilt (252)

Duckers 3rd

Lettau I (1709)

Haarwilt (252)

Duckers I

Cornet (1555)

Carpenter (1777)

Red. Sm. 5 Haarwilt
Blackie
Haarwilt (252)

Sharkawake
(705)

Red Race I

American Cuck

Haarwilt (252)

Bellinghams (186)

Phoenix

Cornet (531)

Haarwilt (252)

Bellinghams (186)

Halpinde (263)

Phoenix

Halpinde (263)

Lettau I (1709)

(b) Duckers

Young Race
(186)

Haarwilt (252)

Duckers
3rd

Cornet (1555)

Haarwilt (252)

Young Phoenix

Haarwilt (252)

Phoenix

Duckers I

(a) Duckers

Haarwilt (252)

(b) Duckers

Young Race (186)

Duckers 26th

I = 68, 75

R = 75, 1

Pedigree of Bluehens 29th and 30th

BRED BY

7 Bitter

The Earl (646)

Blue (226)

Count (1555)

Harmonite (252)

(a) Blue

Young Phoenix
Harmonite (252)

Blue III

Belton I (709)

Harmonite (252)

Blue I

Count (1555)

2nd Black
(1425)

Macarouph (1905)

Enfield (177)

Religio son of Phoenix
Harmonite (252)

Red Rose I

American Cur

Harmonite (252)

Rolling back (186)
Phoenix

Bluehens 29th and 30th

2nd Earl (1511)

White Earl (646)

White (226)

Blue III

Blue III

Marble (418)

Harmonite (252)

Harmonite (252)

Blue 8th

Helton I (709)

Blue 2nd

Blue I

$I = 71.9$
 $R = 54.5$

Pedigree of Bluebird 31st

BRED BY

J. Miller

2nd Woodcock
(1423)

The Rose (646)

Red Rose I

2nd Woodcock
(1423)

Bluebird 2674

White (226)

Bluebird 3rd

American Crow

Marborough (705)

Belton I (709)

Bluebird I

Cornet (155)

(12) Bluebirds

Bluebird I

Harmonite (352)

Euprid (177)

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Harmonite (252)

Young Harmonite

(16) Bluebirds

Harmonite (252)

(16) Bluebirds

Cornet (155)

(12) Bluebirds

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Harmonite (351)

Belling broods (56)

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Cornet (155)

(12) Bluebirds

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Bluebird 31st

I = 68.75

R = 50.5

Pedigree of Bluebird 32779

BRED BY

J. Ball

1st Earl (1646)

Bluebird (2226)

Cumt (1555)

Harmonite (2552)

(a) Bluebird

Young Phoenix
Harmonite (2552)

Bluebird 3279

Edith I (709)

Harmonite (2552)

Bluebird T

Cumt (1555)

2nd Bluebird
(1423)

Harmonite (708)

Cupid (177)

Edith's son of Harmonite

Red Rose I

Harmonite (2552)

American Crow

Harmonite (2552)

Edith's son of Harmonite
Phoenix
Cumt (1531)

Bluebird 32779

3rd Bluebird
(1423)

Bluebird 1974

1st Earl (1646)

Bluebird 1274

Bluebird I

Cumt (1555)

Edith's son of Harmonite

Is 71.7
184 = 24.4
64.4

Pedigree of *Bluebird 38th*

BRED BY

I. B. Davis

2nd Bucktail (1423)

1st Blue (1646)

Blue (1226)

Caual (1555)

Bluebird 3rd

1st Bluebird

Red Rose I

Markborough (1905)

Belton I (1709)

American Cur

Butcher I

Black

(12377)

Magnum

(2240)

North Star (457)

Magnum Cur

Magnum

Young Belle

Magnum (1123)

Young Belle

Isabel (2816)

Young Wagon

Frederick

Bluebird (1706)

Angelina

Frederick (1491)

Angelina 2nd

Young Wagon

Anna Bulger

Butcher 33rd

2nd Bucktail (1423)

Bluebird 19th

I = 50
18 = 35.5

Bluebird 12th

1st Blue (1646)

Bluebird 12th

Pedigree of *Buckner 33rd, 36th & 40th*

BRED BY

J. Baker

W. Baker (2816)

Young Wagon (2859)

W. Baker (1871)

W. Baker (1855)

Carpenter

Penman (491)

Penman (1852)

B. Baker (1706)

Young Wagon (2859)

Carpenter 2nd

Carpenter

W. Baker (1416)

Baker (226)

Baker (155)

W. Baker (1423)

Baker 3rd

Baker 1 (1709)

Red Rose 1

Baker (1705)

Baker (1177)

Buckner 19th

W. Baker (1416)

Buckner 12th

Baker 1

Baker (155)

Baker (1852)

*I = 15.6
R = 16.1*

Baker 1

Baker (155)

Baker (1852)

Pedigree of Duckens 41st

BRED BY

W. B. B.

W. B. B. (2816)

Young Wyeupend
(12857)

Wellington (180)

Caust (1855)

W. B. B. (1852)

W. B. B. (1852)

Angelina

Anna Ballyne

Caust (1852)

Bleedure
(1706)

Young Wyeupend
(12857)

Angelina 2nd

Angelina

The Cael (1646)

W. B. B. (226)

Caust (1555)

Duckens 3rd

W. B. B. (1709)

2nd Duckback
(1423)

Red Bee I

W. B. B. (1905)

Caust (177)

Duckens 32nd

American Caust

Caust (1252)

2nd Duckback
(1423)

Duckens 19th

Duckens 12th

The Cael (1646)

I₂ = 62.5

Duckens 41st

Pedigree of Blackhens 37, 37th, 39th and 42nd

BRED BY

J. Baker

Waters (12816)

Young Weyward (12859)

Wellington (1680) Cornel (1555)
Princes Widair
Princess Lawrence (1252)
Princess W.R. Selwyn (1252)
Princess Lawrence (1252)

Angeline

Anna Belyas

Thomson (1252)
Princess

Blackhens
1706

Young Weyward (12859)

Angeline 2nd

Angeline

The Tare (1646)

Wate (1226) Cornel (1555)
Blackhens 3rd W.R. Selwyn I (1709)
Blackhens 3rd Blackhens I

2nd Blackhens (11423)

Red Run I

Blackhens (1705) Expid (1777)
Princess Lawrence (1252)

Blackhens 2nd for 37th
" 30th for 37th, 39th & 42nd

2nd Tare (1511)

1st Tare (1646)
Blackhens 3rd

Blackhens 20th

Blackhens 8th

Thomson (1418) Lawrence (1252)

T = 62.5

62.5

Pedigree of *Bluebees 35th*

BRED BY

J. B. B. B.

Beetrum (1716)

Indurick (1060)

Orbit

duellon (11121)

Melton (11271)

Count (1555)

Red Waring

Mavin (398)

Widener (1498)

Dee Waring

Calypso (1338)

Burroughs (54)

George (12155)

Young Napier's

Burroughs (54)

George (12155)

Curran

Count (1555)

Young Napier's

Curran

Count (1555)

Young Napier's

Curran

Count (1555)

Young Napier's

Curran

Count (1555)

Young Napier's

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Count (1555)

Young Napier's

Curran

Count (1555)

Young Napier's

Bluebees 35th

Franklin

(2046)

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Wetzel

Bluebees

1914

Bluebees

Bluebees

Bluebees

Bluebees

Bluebees

Bluebees

Bluebees 12th

Bluebees I

Count (1555)

Young Napier's

Count (1555)

Young Napier's

I = 376

R = 87

Pedigree of *Bluebirds 43rd*

BRED BY

F. Baker

Walter (2816)

Angelina

Anna B. Baker

Harriet (1352)

(1706)

Young Wymond (2859)

Angelina 2nd

Angelina

Bluebirds 43rd

Bluebird (1706)

Bluebird 34th

Bluebird 29th

2nd Hubbard (1423)

1st Earl (1446)

Wm (1226)

Red Rose I

Hubbard (1705)

2nd Earl (1511)

American Earl (1646)

Bluebird 20th

Bluebird 3rd

I = 65.6

Bluebird 3rd

Pedigree of

Blueback 44th
" 46th
" 47th

BRED BY

J. B. Bates

Blueback

(1706)

Wooler
(1816)

Young Weyward
(1859)

Woolington (1880)
Reicher
Pruettman (1902)
Anna Blythe

Blueback 2nd

Young Weyward
(1859)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Pauline

(1821)

3rd Blueback (1823)

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Blueback 19th

3rd Blueback (1823)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 12th

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

(1706)

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 44th

46th
47th

Blueback 37th

" 34th for 46th

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

Blueback 3rd

Heide (1846)

Blueback 3rd
Pruettman (1902)
Anna Blythe

I = 65.6

R = 74.2

Pedigree of Bluebird 45th, 48th & 49th

BRED BY

Bellevue (1776)

1st Bluebird (2816)

Young Weyland (2859)

Weyland (1880)

Weyland (1880)

Bluebird 2nd

Young Weyland (2859)

Weyland (1880)

Short Tail
(2621)

2nd Blackback
(1423)

Bluebird 32nd

Bluebird 19th

2nd Blackback
(1423)

1st Bluebird (646)

"

Bluebird 45th

2nd Blackback
(1423)

1st Bluebird (646)

White (226)

Weyland (1880)

Bluebird 30th

2nd Blackback
(1423)

White (646)

Weyland (1880)

I = 56.2

R = 25.8

Pedigree of Duckens 53th

BRED BY
J. Baloo

State of
Northumberland
11940

Duckens 34th

Belvedere (1706)

Walsley (2816)

Young Walsley
(2859)
Angelina

Wellington (689)
Frederick
Thurman (99)
Anna Blake

Angelina 2nd

Young Walsley 2nd
(2859)
Angelina

Belvedere (1706)

Duckens 29th

2nd Duckback
(1423)

Duckens 20th { 1st Earl (1671)
Duckens 8th }

2nd Duckback
(1423)

1st Earl (1671) { State (226)
Duckens 3rd }

Harriet (2377)

Newman

Ed. Rose T. Harcourt (1705)
American Env.
Margaret (2240) { North Sts (459)
Young Sells
North Sts (459)
Young Sells

Duckens 38th

Belvedere (1706)

Duckens 33rd

Duckens 19th

2nd Duckback
(1423)

Duckens 20th { 1st Earl (1671)
Duckens 8th }

Duckens 50th

I = 59.4

0 = 52.2

Pedigree of Bluebees 51st

BRED BY

Start Fair
(19621)

Bluebees 32nd

Cleveland Park
(13407)

Matekum 1281

St Albans (1412)

Wynyard (1203)

Red Turquoise

Flowers (2512)

Matekum 1281

Young Weyward (12859)

Wellingham (630)

Frederick

(not found)

Bluebees 51st

Bluebees (1706)

Walsley (12816)

Young Weyward (12859)

Congelina

Heavenly (491)

Anna Blyne

Congelina 2nd

Young Weyward (12859)

Congelina

Bluebees 41st

2nd Walsley

1st Earl (646)

Wells (1226)

Bluebees III

Red Rose I

Washington (1705)

Bluebees 32nd

Bluebees 1914

2nd Walsley (1423)

Bluebees 1314

1st Earl (646)

1-531

Pedigree of Shuckee 52nd

BRED BY

W. Bates

Belvedere (1706)

Walter (2816)

Young Wyngard (2859)

Wellingham (632)
Winters
Thompson (4912)
Anna Belyus

Angelina 2nd

Young Wyngard (2859)
Angelina

Wells (226)
Shuckee 3rd
Yorkington (705)
American Cur

Walter

(4041)

2nd Whillock (1423)

The Cure (646)
Red Rose I

Wells (226)
Shuckee 3rd
Yorkington (705)
American Cur

2nd Whillock (1423)

2nd Whillock (1423)

2nd Whillock (319)

2nd Whillock (1423)

2nd Whillock (1423)

2nd Whillock (319)

Shuckee 52nd

Marquet (2377)

2nd Whillock (1423)

Marquet (2240)

North Star (459)
Young Steel
North Star (459)
Young Steel

Marquet

Marquet (2240)

North Star (459)
Young Steel
North Star (459)
Young Steel

Shuckee 38th

Belvedere (1706)

Belvedere (1706)

Belvedere (1706)

Shuckee 33rd

Shuckee 19th

2nd Whillock (1423)

Shuckee 19th
Red Rose (646)

I = 59.4

R = 54.8

Pedigree of Bluebird 53rd

BRED BY

1 Bates

Bluebird (1706)

Walden (2816)

Young Wagoner (2859)

Walden (680)

Carpenter

Walden (491)

Carpenter 2nd

Young Wagoner (2859)

Anna P. Wagoner

Wife of
Northumberland
(1940)

Bluebird (1706)

Bluebird (1706)

Bluebird 34th

Bluebird 29th

2nd Wagoner (1425)

Bluebird 8th

Bluebird 29th

Bluebird 20th

Bluebird 8th

Bluebird 53rd

Bluebird (1706)

Bluebird 41st

Bluebird 32nd

2nd Wagoner (1425)

Bluebird 32nd

Bluebird 32nd

Red Run 1

Bluebird 32nd

2nd Wagoner (1425)

Bluebird 32nd

I = 65.6

R = 58.1

Pedigree of Blackburn 54th

BRED BY

P. B. Bates

2nd Cleveland
(3408)

Stout Tail (2621)

Mathews ears

Belvedere (1706)

Waterloo (2816) Young Weyward (2859)
Angelina (2839)

Blackburn 32nd

2nd Mullock
(1423)

Blackburn 19th

2nd Mullock (1423)

Mathews (2281)

St. Albans
(1412)

Weyward (203)
Miss Gwynne
Harriet (257)

Mathews ears

Young Weyward (2869)

Wellington (680)
Pinebar
(not found)

Stout Tail
(2621)

Blackburn 42th

Blackburn 30th

2nd Mullock (1423)

Wile Earl (646)
Red Run I

Wente (226)
Blackburn III
Yorkshire (205)
Quercus ears

Blackburn 20th

2nd Earl (1511)

Wile Earl (646)

Blackburn 8th

Wente (418)

Slutkins 54th

I=50

R=48.4

Pedigree of Bluebees 55th

BRED BY

J. R. R. R.

Start 900 (2021)

Bluebees (1706)

Bluebees (12816) { Young Weyland (12859)
Angelina 2nd { Young Weyland (12859)
Bluebees 32nd { Bluebees (1423)
Bluebees 19th { Red Run I (1423)
Bluebees 12th { Bluebees (1423)

Bluebees 32nd

Bluebees 19th { Bluebees (1423)
Bluebees 12th { Bluebees (1423)

4th West of
Northumberland

(3649)

Bluebees (1706)

Bluebees (12816) { Young Weyland (12859)
Angelina 2nd { Bluebees (1423)
Bluebees 32nd { Bluebees (1423)

Bluebees 34th

Bluebees 29th

Bluebees 20th { Bluebees (1423)
Bluebees 8th { Bluebees (1423)

2nd Bluebees
(1423)

Bluebees 16th { Bluebees (1423)
Bluebees 32nd { Bluebees (1423)

Bluebees (2377)

Bluebees

Bluebees (2377) { Bluebees (1423)
Bluebees 32nd { Bluebees (1423)

Bluebees 38th

Bluebees (1706)

Bluebees (12816) { Bluebees (1423)
Bluebees 32nd { Bluebees (1423)

Bluebees 33rd

Bluebees 19th

Bluebees 12th { Bluebees (1423)
Bluebees 8th { Bluebees (1423)

Is = 656

Pedigree of Bluehens 56th

BRED BY

J. Boller

Bluehens (1706)

Watales (2816)

Young Watales

Welling Tare (1680)
Pringfours
Reunumun (1491)

Angelina 2nd

Young Watales

Reunumun (1491)
Reunumun (1491)
Reunumun (1491)

2nd Duke of Northumberland
(3646)

Bluehens (1706)

Watales (2816)

Young Watales
Angelina

Bluehens 29th

2nd Watales
(11423)

Red Rue I
Red Rue I
Bluehens 8th

Bluehens 56th

Cleveland 1st
(3407)

Star Fair (262)

Bluehens 32nd

Bluehens 19th
Bluehens 19th

Matehens end

Matehens (228)

Sh. Albano (1412)

Bluehens 5th

Bluehens (1706)

Watales (2816)

Young Watales
Angelina

Bluehens 41st

Bluehens 32nd

2nd Watales
(11423)

Red Rue I
Red Rue I
Bluehens 19th

I = 62.5
R = 45.1

Pedigree of Buckner 57th

BRED BY

I. Bates

Steed Pale (2621)

Buckner 32nd

2nd Cleveland St

(3408)

Mothburn (2281)

Maiden Ear

Young Weyward (2859)

Wellington (1680)

Caedice

(not found)

Bloodred (1706)

W. Atterley (2516) Young Weyward (2859)
Angelina 2nd Young Weyward (2859)
Angelina

Book of
Northumberland
(1940)

Buckner 34th

Bloodred (1706) W. Atterley (2816)
Buckner 29th Angelina 2nd
Buckner 20th

Musket (2372)

2nd Bullock (1425) Red Run I
Margaret (2240)

Buckner 38th

Buckner 33rd

Bloodred (1706) W. Atterley (2816)
Buckner 19th 2nd Bullock (1425)

Buckner 57th

I = 531
II = 39.9

Pedigree of Bluebird 58th

BRED BY

2nd Mate of North
Hutchinson (1846)

Red Northington
(9508)

Bluebird (1706)

Waterloo (12816) { Young Winged
English (2859)
English 2nd { Young Winged
English (2816)

Bluebird 54th

Bluebird (1706) { English 2nd
Bluebird 29th { English 2nd
Bluebird 20th

Cleveland Lad
(13407)

Short Tail (12621) { Bluebird (1706)
Milkman Cow { Bluebird 32nd
Milkman (12281)

Bluebird (1706) { Waterloo (12816)
English 2nd
Young of the season (1504)
Young Alice

Short Tail (12621)

Bluebird (1706) { Waterloo (12816)
Bluebird 32nd { English 2nd
Bluebird 19th

2nd Cleveland Lad
(3408)

Milkman Cow

Milkman (12281) { St. Albans (1412)
Young Winged
(12839)

Bluebird 54th

Short Tail (12621)

Bluebird (1706) { Waterloo (12816)
Bluebird 32nd { English 2nd
Bluebird 19th

Bluebird 49th

Bluebird 30th

Bluebird 20th { Bluebird 19th
Bluebird 20th { 2nd Blue (1511)
Red Rose I

I = 62.5
R = 45.1

Bluebird 58th

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