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fect of Inbreeding on Body Size, Anatomy, and Producing Capacity of Grade Holstein Cows[1]

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CONTENTS

INTRODUCTION

The study on which this report is based was undertaken in an attempt to measure the differences, in animal form and internal anatomy, between outbred dairy cows and cows representing various intensities of inbreeding, and if possible to determine the significance of such differences from the standpoint of functional ability.

REVIEW OF LITERATURE

Numerous attempts have been made by other investigators to measure the specific effects of inbreeding in various species of animals. Much of the available information pertaining to the effects of inbreeding on the size and structure of the animals has been obtained through studies of laboratory animals. A long-time, well controlled study of

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[2] T. E. Woodward, formerly senior dairy husbandman, who retired July 31, 1944, calculated all of the coefficients of inbreeding used in this study. R. R. Graves, who retired March 30, 1946, was head of the Division of Dairy Cattle Breeding, Feeding, and Management while most of the experimental work was in progress.

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tall and narrow—signifying that the impulse to make skeletal growth is stronger than the impulse to increase in weight.

Many breeders of cattle and other livestock have practiced inbreeding to a limited extent and have drawn various conclusions with regard to its desirability. In most cases, interpretation of the results with cattle has been based on small numbers of animals and short periods of time. This probably is because few breeders have had the facilities for carrying on intensive inbreeding practices over the length of time required to obtain results involving numerous successive generations.

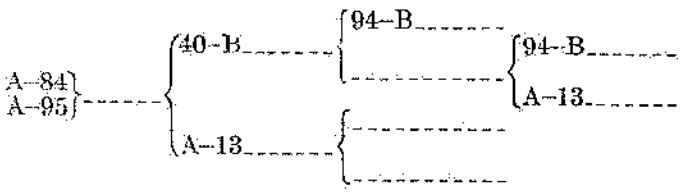
A few reports giving the results of organized inbreeding experiments with cattle have appeared. Woodward and Graves (*9*) found that birth weight was lowered and that rate of growth and mature size appeared to be reduced by inbreeding. Dickerson (*2*) reported that birth weight was lowered by inbreeding, but that the difference in size decreased with age. Bartlett, Reece, and Lepard (*1*) concluded that neither birth weight nor rate of growth was depressed by inbreeding in a family of Holsteins and that type was unaffected. The results of a more complete analysis by Woodward and Graves (*10*) confirm in general those previously reported by the same authors. They indicate that intensive inbreeding lowered breeding efficiency; lowered the birth weight of calves and tended to reduce their vigor; and resulted in smaller mature cows, though the effect was not as marked, relatively, at maturity as at birth. The results showed marked reductions in both milk and butterfat production in the fifth and sixth generations of highly inbred cows, although in the earlier generations level of production had been well maintained.

EXPERIMENTAL PROCEDURE AND DATA USED

The Beltsville inbreeding experiment on which the reports of Woodward and Graves (*9*, *10*) were based was begun in 1913 and continued until 1943. During the last 20 years of this period it was carried on concurrently with a study of the interrelationships between body form, internal anatomy, and producing ability in dairy cattle. In the latter study, which is still under way at Beltsville, cows that have demonstrated their producing capacity and are to be removed from the herd are first measured in detail in order to record body conformation in terms of body dimensions and proportions. Then they are slaughtered and all of their internal organs, endocrine glands, and body parts are weighed or measured. The same plan is carried out at a number of State experiment stations that are cooperating in the study. A summary (*6*) of the breed averages for body weight and dimensions, and for the size of the internal organs and body parts—based on the first 593 cows studied that had records of production—affords a basis for comparing the body form and anatomy of cows representing different breeds and families, and of cows kept under various environmental conditions.

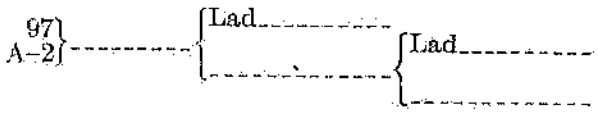
As the cows in the inbreeding experiment—both inbred and outbred—were removed from the herd, they were handled according to the above-described plan by which ante-mortem and post-mortem data were obtained. Some of the cows went out of the herd during

EXAMPLE A



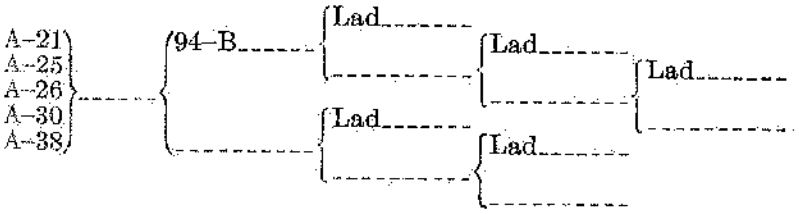
Example A is the pedigree of 2 cows (A–84 and A–95) with 12.5 ent as the coefficient of inbreeding, the lowest among the 49 inbred . The inbreeding was through cow A–13. Although the sire was an inbred son of 94–B, this did not affect the inbreeding cients of the daughters of A–13 because there was no relationship een 94–B and A–13.

EXAMPLE B



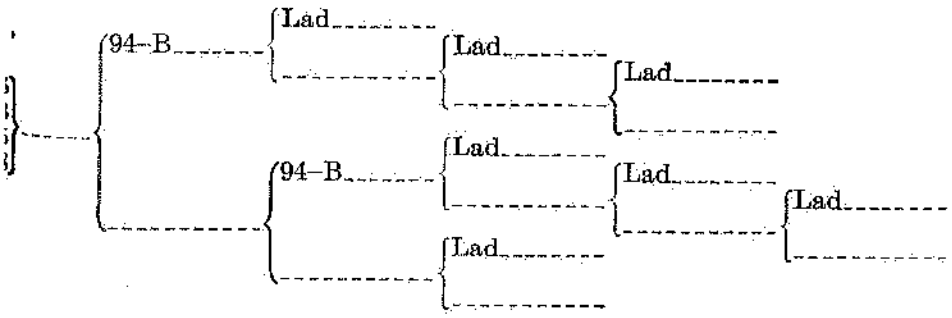
Example B is a simple illustration of a sire-to-daughter mating h gives an inbreeding coefficient of 25.0 percent.

EXAMPLE C



Example C is a simplified pedigree of five cows with an inbreeding cient of 32.8 percent. The dams of all five cows had inbreeding cients of 25.0 percent.

EXAMPLE D



Example D is a simplified pedigree of four cows that had inbreeding cients of 45.3 percent.

nple E shows the pedigree of the cow A–148 that had an inbreed- fficient of 64.6 percent. This was the highest in the group, and reeding coefficient of 58.1 percent for her dam was next to the for the cows included in this study. Coefficients for other ancestors of A–148 were 50.4 percent for cow A–106, 37.9 per- r cow A–80, 32.8 percent for cow A–26, and 25.0 percent for -3.

Age and Number of Cows in the Inbred Groups

ty-four of the 71 cows in this study were under 5 years of age ge 3 years 10 months) and 37 were over 5 years (average 8 years hs) at the time of slaughter. In the outbred group there were ler 5 years (average 3 years 8 months) and 12 over 5 years ge 9 years 4 months). In the group with the lowest inbreeding ents (below 30), there were 6 cows under 5 years (average 4 and 9 cows over 5 years (average 8 years 9 months). The e inbred group (coefficients between 30 and 49) contained 14 cows 5 years (average 3 years 11 months) and 13 cows over 5 years ge 8 years). The highly inbred group (coefficients between 50) contained 4 cows under 5 years (average 3 years 6 months) cows over 5 years of age (average 6 years 3 months). The uni- ty of distribution in number of cows with respect to age in the ups indicates that age differences were not a serious disturbing in interpreting the effects of inbreeding in this study.

Weights and Measurements Used in Analysis

rty-one different weights or measurements for each animal were n this analysis. They include 3 body measurements taken just to slaughter; live weights taken at 3 different periods of life; 5 weights and measurements of organs and body parts obtained slaughter.

hough 35 external body measurements were obtained prior to hter, in order to minimize detail only 3 (height at withers, width ps, and length from withers to pinbone) were selected to repre- the 3 body dimensions, height, width, and length. The live hts used were taken at 18 months of age, at approximately 3 ths after first calving, and again when the animal was measured r to slaughter. Udder capacity was determined by filling the etory system with fluid and measuring the quantity held.

ecords of milk and butterfat production also were used. Since t of the production records were made during the first lactation and mmenced at ages ranging from 2 to 2½ years, those that were made ther ages were adjusted to the basis of the average age of first ing, which was 2 years 2 months and 10 days. The various items e divided into six groups as follows: (1) Those representing body ght or mass, (2) those which indicate skeletal size, (3) the internal ans, (4) the endocrine glands, (5) the udder, and (6) milk and terfat production records. Average values were used as a basis for parison.

as body mass. Weight of brain and weight of empty stomachs were reduced about 10 percent. Weight of lungs was definitely greater in the inbred cows and length of intestines was only slightly affected.

The endocrine glands, on an average, were reduced in size. Greatest reductions were in weights of parathyroids, pituitary, and pancreas; no significant change occurred in weights of pineal or adrenals; and the heaviest thyroids were found in the most intensely inbred group.

Weight of udder was greatly reduced in the more intensely inbred cows, but changes in udder capacity were not consistent. However, the relation of capacity to weight (porosity) of udder increased with inbreeding. Milk production was substantially lowered (7.8 percent) in the highly inbred cows, and butterfat production showed an even greater decrease (17.4 percent).

It is of interest that the pituitary body, which supposedly is closely tied up with the physiology of growth and lactation, declined in weight to 80.2 percent in the most highly inbred group; that milk and butterfat production declined to 92.2 and 82.6 percent, respectively; and that the items representing body mass declined to 87.3 percent of the values represented by the outbred group. Weight of udder decreased to an even greater extent (to nearly 60 percent), but this may have been compensated for to some extent in the matter of producing ability, by a greater degree of porosity in the mammary tissue which is indicated by the high relation of capacity to weight of udder in the more highly inbred groups. The different effects of inbreeding on size of various endocrine glands (pituitary, thyroid, and adrenals) suggest the possibility that a lack of endocrine balance might have existed.

It would seem logical to assume that, if the outbred cows had had a higher percentage of Holstein instead of Jersey and Guernsey ancestry, some of these effects of inbreeding would have been more pronounced.

As inbreeding increased and the size of the cows became smaller the organs and body parts, on an average, came to represent a larger proportion of the total animal structure. They did not decline as much as did empty body weight. To just what extent this tendency can be attributed to inbreeding cannot be determined accurately as it occurs to some degree in most cases when cows are grouped on the basis of live weight. Most notable exceptions were weights of parathyroids, pancreas, and the weight and capacity of the udder. These glands were reduced in size relatively more than empty body weight.

The outbred grade Holstein cows included in this study were only slightly smaller in weight and skeletal size than 75 registered Holstein cows slaughtered at Beltsville in studies of conformation and anatomy in relation to producing capacity, but their internal organs and especially their endocrine glands differed to a greater extent. Percentages showing the relation of outbred grade cows to registered cows average 94.0 for body weight or mass, 96.8 for skeletal size, 92.2 for internal organs, and 87.8 for endocrine glands. Size was smaller in the outbred grade cows than in the registered cows for every item compared.

Correlation coefficients showed that producing ability was more adversely affected by intensive inbreeding than measures of body or skeletal size and internal organs or gland size, although most of the

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