THE FREQUENCY, REPEATABILITY AND HERITABILITY OF DIGESTIVE UPSETS IN A GUERNSEY HERD

by

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INTRODUCTION

The production records of a cow are known to vary from one lactation to the next though in a broad sense the heredity of the animal does not change. Standard correction factors are commonly used to adjust for several of the environmental factors affecting production records. Although the correction factors when applied to production records tend to make records of the same cow more similar, the adjusted records often vary widely. Many other undetermined environmental factors must be involved in the low repeatability of production records. During the course of lactation, some of these environmental factors cause a temporary reduction in production which may not be completely overcome when the animal recovers. These environmental factors include infections, hardware, upsets of the digestive tract, abrupt changes in weather, and variable milking practices. The effects of some of these factors can be eliminated by good feeding and management. The effects of others can be lessened by good management, but they cannot be completely eliminated. Digestive upsets are known to affect production records adversely. These upsets may be caused by overfeeding, infections, sudden changes in feeds, toxic chemicals, hunger, and spoiled feed, according to the Merck Veterinary Manual (1955).

Herdsmen have observed apparent differences in the frequency of digestive troubles among daughters of different sires. If such differences exist, it would be advantageous to be able to select sires whose daughters are less susceptible to digestive upsets.

This study was undertaken to determine the frequency of digestive upsets, their severity, to what extent they are repeated in subsequent lactations, and whether or not the susceptibility to these upsets is heritable.

LITERATURE REVIEW

The repeatability and heritability of several characteristics in dairy cattle have been estimated. Most of these estimates have been on milk or butterfat production. The literature concerning repeatability and heritability is reviewed here to indicate the range of these estimates for different characteristics. Thus the repeatability and heritability of susceptibility to digestive upsets may be compared with some other characteristics of the dairy cow.

Repeatability

Repeatability is the correlation between observations made on the same characteristic on the same individual. It may be explained as the percentage of the difference between a cow's record and the herd or breed average that she may be expected to produce in subsequent lactations. For example, if a cow produces 20 pounds of butterfat more than the breed or herd average in one lactation and the repeatability is 0.40, then, in the next lactation she may be expected to produce eight pounds of butterfat more than the breed or herd average. As the number of records on a cow increases the accuracy of the prediction of the cow's productivity ability increases. Most of the estimates of repeatability that have been determined have been on an intra-herd basis rather than on an inter-herd basis. When the correlations are made on an inter-herd basis, herd to herd environmental effects are not removed, thus leading to a larger correlation. The values obtained from the early studies of repeatability were too high due to their calculation on an inter-herd basis. Many of these early values were of the order of 0.55 to 0.75 according to Madden (1954). These early studies were mainly of A.R. records from the various breed associations and therefore included records from selected cows.

Legates (1949) summarized the estimates of intra-herd repeatability for butterfat production and reported a range of 0.29 to 0.43 with most of the estimates being approximately 0.40.

Gifford (1939) reported that, within a breed, milk and butterfat production were both repeated to about the same degree. He also stated that there was a tendency for a larger fraction of the repeatability during the later months of lactation to be accounted for by the herd effects.

In comparing the reliability of different numbers of lactation records Berry (1945), working with Holsteins, found that the average repeatability of butterfat production for cows with six records was 0.29. For cows with seven records the average repeatability was 0.23. He found the average estimates of repeatability for the same data without considering herd effects to be 0.41 and 0.38, respectively. He found that there was a tendency for the later records of a cow to be more closely correlated than were the early ones.

Verna (1945) found the repeatability of milk production to be 0.52 for Holsteins in the Iowa State College herd. For the same data he found that repeatability of butterfat production and fat test was 0.43, and 0.66, respectively. There was practically no effect due to time trends; however, environment had remained fairly constant in this herd. This would account for the high estimates of repeatability obtained.

Legates (1949) determined the repeatability of butterfat production for Jerseys. The estimate he obtained was 0.412 before the removal of yearly differences, and 0.459 after these differences had been removed.

Johansson (1950) reviewed his previous work on the repeatability of milk yield, butterfat yield, butterfat percentage, persistency, dry period, and calving interval. His four studies with Swedish Red and White and Swedish Polled cattle showed a range from 0.38 to 0.42 for milk yield, 0.32 to 0.45 for butterfat yield, 0.58 to 0.70 for butterfat percentage, 0.13 to 0.32 for persistency, 0.18 to 0.28 for the length of dry period and 0.03 to 0.10 for the length of the calving interval. In all six categories, the study with the lowest average production showed the highest repeatability.

Laben and Herman (1950) found that there was an increase in repeatability as more corrections of the records were made. This is to be expected since the corrections should remove some of the environmental variation. They found repeatability of 305-day uncorrected Holstein records to be 0.29. When the records were corrected to a twice-a-day milking basis the estimate of repeatability increased to 0.34 and when further corrected to a 305-day, 2X, M.E. basis with the Holstein correction factors, repeatability was 0.40.

Mahadavan (1951) reported 0.464 as an average repeatability of milk yield for Scottish Ayrshires. He found the highest repeatability, 0.536, when only the first two records of cows with several records were considered. The lowest repeatability was 0.372 for cows that had only three records. According to his work the repeatability was somewhat lower for cows that only had two or three records than when the first two or three records were used from cows with more than two or three records.

Using Guernsey and Holstein records, Plum, et al. (1952) found the intra-herd repeatability to be 0.32. Only records from cows with at least two complete 305 day records were used in this study.

Carneiro (1953) obtained a repeatability estimate of 0.41 on grade Brazilian Simmenthaler cattle. The method he used only closely approximated the usual correlation of subsequent records with previous records.

Johansson (1953) investigated the difference in the repeatability of butterfat yield and butterfat percentage between high and low producing herds of Swedish Red and White cattle. The estimates of repeatability he found were 0.64 and 0.594 for butterfat percentage in the high and low herds respectively. For butterfat yield the repeatability was 0.223 for the high herds and 0.206 for the low herds. These differences in repeatability between high and low herds were not statistically significant.

Madden (1954) found that the highest repeatability of monthly milk production occurred in the second month while the lowest was for the ninth month. These estimates were 0.590 and 0.258, respectively. The repeatability of monthly fat yields showed a similar trend with a high of 0.516 for the first month and a low of 0.151 for the ninth month. He also obtained estimates of repeatability for cumulative milk and butterfat production. These estimates were 0.510 for milk production and 0.434 for butterfat production for a 305 day lactation. Although these estimates are higher than those reported by most workers they correspond to Verna's estimates obtained from the same herd.

In studying persistency of production, Corley (1956) obtained repeatability estimates of 0.35 to 0.45; for maximum period yield, 0.60 to 0.70; and for total milk and butterfat yield, 0.70 to 0.80. These high estimates of repeatability for total milk and butterfat yield are probably due to the uniformly good environment under which the cows were kept. These estimates were made from records of Holsteins, Jerseys and "crossbreds" from the U.S.D.A. research center at Beltsville, Md.

The repeatability estimates of several traits other than production have been investigated. These estimates may be used to give some idea of the size of the correlation that may be expected from environmentally influenced traits as compared with other traits where environment has little effect.

Hyatt, et al. (1949) found that the repeatability of type ratings was 0.55 for those ratings made after the first calving. When the type ratings of heifers were compared with those made after calving the repeatability was 0.30.

Dunbar and Henderson (1953) using non-return data from artificial breeding found the repeatability of fertility to be between 0.051 when all cows within a herd were used and 0.027 when only the half-sibs within the herd were used. Although these estimates vary widely, the difference is probably not significant.

The repeatability of milk production is intermediate to the repeatability of these other characteristics. Type ratings show a high repeatability while the repeatability of variations in fertility is low.

Heritability

The estimates of heritability are based on the likeness between relatives. Heritability is the fraction of the amount that the parents are above the breed or herd average that their offspring may be expected to be above the average. For example, if the parents average 100 pounds of butterfat above the breed or herd average and the heritability is 0.2, then the offspring may be expected to average 20 pounds of butterfat above this breed or herd average.

The heritability estimates of several characteristics have been reviewed to provide a yardstick with which the estimates obtained in this study may be compared.

Most estimates of heritability in dairy cattle have been made on milk and butterfat production. However, the heritability of several other characteristics has been estimated. No literature on the heritability of digestive upsets in cattle has been found.

Most of the estimates of heritability of intra-herd differences in milk and butterfat production have been about

0.2 to 0.3 as indicated by Shrode and Lush (1947). Legates (1949) summarized the heritability estimates of butterfat production and found them to vary from 0.12 to 0.30. The low estimate was obtained from eight-month lactation records. Two of the estimates he reviewed were obtained from ten-month lactation records, of which one was 0.17 and the other, 0.28. Most of the estimates were made on 365-day lactations and these ranged from 0.13 to 0.30.

According to Madden (1954) previous studies have resulted in estimates of heritability for butterfat production ranging from 0.07 to 0.521. The two extreme values resulted from the fact that in the former case selected records were used, while in the later, certain commonly removed environmental factors were not eliminated.

Lush and Straus (1942) using 2154 dam-daughter comparisons from Iowa D.H.I.A. records found that the heritability of butterfat production for single records was 0.174. When the calculations were made from records when the sire was used in only one herd, the estimate of heritability was 0.14. They found no significant difference in the heritability of butterfat production between breeds.

Tyler and Hyatt (1947) estimated the heritability of milk production, butterfat production and butterfat percentage for Ayrshires by the intra-sire regression of daughter on dam. The values they obtained were 0.31 for milk production, 0.28 for butterfat production and 0.55 for butterfat percentage.

Legates (1949) calculated the heritability of butterfat production from 12,405 Jersey cows with 23,330 H.I.R. records of 270 to 305 days in length. By doubling the intra-herd regression of daughter on dam he found the heritability to be 0.212. When the yearly differences were removed, the heritability estimate was 0.201.

Laben and Herman (1950) analyzed records from a selected Holstein-Friesian herd and found that the intra-sire regressions of daughter on dam on a single-record basis were 0.36 and 0.29 for milk and butterfat production, respectively. When the regressions were based on lifetime averages, the values were 0.33 to 0.29. They also found the heritability of butterfat percentages to be 0.54.

Beardsley, et al. (1950), studied the records of daughters and mates of 176 D.H.I.A. proved sires used in two or more herds. They found the heritability of butterfat yields to be 0.274. They also found that the heritability values decrease as the butterfat yield increased. In their work they stratified records according to the dam's production. This is believed to have resulted in the variable heritability estimates obtained.

Johansson (1950) summarized the heritability estimates that have been obtained from Swedish records. He found the intra-herd, intra-sire heritability estimates of butterfat production to range from 0.31 to 0.46. In his data, the heritability estimates of butterfat percentage were high, ranging from 0.50

to 0.78.

Mahadevan (1951) studied records of 12 Scottish Ayrshire herds and found that the estimate of heritability of milk yield, when only the first available records were used, was 0.304. When the average of all records was used, the estimate was lowered to 0.266.

Carneiro (1953) studied the records of grade Simmenthaler cattle in Brazil and found the heritability of 305-day milk production to be 0.23.

Madden (1954) calculated the heritability of milk and butterfat production for single months, and for eight-, nine- and ten-month cumulative lactation records on Holsteins in the Iowa State College herd. The values for single months ranged from -0.08 for the tenth month to 0.41 for the sixth month for milk production and from -0.15 for the tenth month to 0.32 for the second month for fat production. For the first 243 days production of first lactation records only, he found the heritability to be 0.63 and 0.47 for milk and butterfat production, respectively. When average records were used instead of first records, these values dropped to 0.45 for milk production and 0.35 for butterfat production. This lowering of the estimate of heritability when average records were used corresponds to the results of Mahadevan (1951) and Laben and Herman (1950). The estimates of heritability that Madden found agreed with previous estimates obtained from records made in the same herd.

Among Swedish Red and White cattle, Johansson (1953) found that the heritability of butterfat production and butterfat percentage was higher in herds with a high level of production than in herds producing at a low level. The estimates of the heritability of butterfat yield were 0.39 and 0.32 for the high and low herds, respectively, and 0.68 and 0.54 for butterfat percentage. These differences were not significant.

Corley (1956), using two methods of calculating persistency, obtained estimates of the heritability of the persistency of milk and butterfat production for Holsteins, Jerseys and Crossbreds. For the Holsteins, he obtained heritability estimates of 0.44 and 0.28 for the persistency of milk production and 0.16 and 0.18 for the persistency of butterfat production. The estimates he obtained for the Jerseys were somewhat lower, being 0.02 and 0.10 for milk production and 0.14 and 0.06 for butterfat production. The "crossbreds" resembled the Holsteins quite closely.

The heritability of characteristics other than milk production have been reported. These estimates provide a range with which to compare the estimates obtained on the susceptibility to digestive upsets in this study.

The heritability of fertility was reported by Dunbar and Henderson (1953). Their estimate was obtained from non-return data to first services in artificial breeding. They commented that the estimates of heritability of fertility may have been influenced by the fact that the data were taken only on cows with D.H.I.A. records. From the non-return data they estimated the heritability to be 0.004. When the heritability of fertility estimate was made from calving interval data it was zero.

Lush (1950) obtained a heritability estimate of 0.38 for the susceptibility to mastitis. This work was done on records from New Zealand and the susceptibility was measured in two grades. Cows that had had no mastitis attack until the age of eight years were considered to be resistant; otherwise, they were classified as susceptible. It seems that few cows would be able to escape a mastitis attack for eight years and that by using this long period the heritability would be expected to be high. Legates and Grinnels (1952) reported the heritability of resistance to mastitis to be 0.27. The data were taken from records of 11 herds with a total of 959 cows.

Heritability estimates of several physical characteristics of dairy cattle have been calculated by several workers. Tyler and Hyatt (1948) using data from the official Ayrshire type classification program studied the heritability of type classification. They obtained an estimate of heritability of less than 0.40 based on the paternal half-sib correlation; while heritability calculated from a daughter dam regression was 0.28. They state that the average heritability of type classification is 0.30.

Freeman and Dunbar (1954) estimated the heritability of the overall type rating and each classification breakdown for Ayrshires. The overall type rating had a heritability of 0.31 while heritability of the classification breakdowns ranged from 0.06 for udder attachments to 0.32 for breed character and rump and thighs. The estimates for udder attachments, and udder size and shape were low. However, the other heritability estimates were appreciably larger.

The heritability of the udder proportions has been investigated by Johansson and Korkman (1952). They found that the heritability of the proportionality of production from the front to rear halves of the udder was 0.763.

Briquet and Lush (1947) determined the heritability of differences in white spotting in Holsteins. The parent-offspring regression gave a heritability of 0.99. When the mid-parent offspring regression was used the estimate of heritability was 0.93. They concluded that the second was the more reliable estimate of the two.

EXPERIMENTAL PROCEDURE

The daily barn reports and daily milk weight records of the Franchester Farms Guernsey herd at Lyndhurst, Ohio, were available for this study. The daily barn reports used covered a ten-year period from January 1, 1931, to January 1, 1941, and milk weights were available for the years from 1933 through 1940, with the exception of 1936. During this period a program of continous A.R. testing was maintained. The herd environment was much better than average. Two farms were maintained but all the records are from the Lyndhurst farm where most of the cows kept were 2-year-olds. Thus there was a preponderence of first lactation records in the data studied. Short lactations resulted from cows being shipped to the other farm before the lactation was complete. Throughout the entire period the herd was under the same management with all veterinary services being performed by the same veterinarian.

The daily barn reports provided a record of all digestive upsets, injuries, diseases, veterinary treatment, breedings, calvings, and cattle transfers between the two farms. Also noted were the feeding changes and some other management practices. These remarks were noted as indicated in the excerpt from one daily barn book.

Excerpt from daily barn report

"June 27

Had Dr. Laughlin come down and look at Fran. Rosamond. Gave us some rumen stimulant to give every 6 hours.

June 28

Bred Fran. Credit to Fran. Sovereign. Discharging a considerable amount of white matter after breeding. Fran. Rosamond seems improved a little today. Gave the rumen stimulant twice today.

"June 29
Fran. Corrinna slowing up on feed a little. Acts as if she might have a touch of compaction. Gave her two doses of rumen stimulant.

June 30
Dr. Newton Laughlin drew blood sample on all the animals here today (39).
Fran. Slightly calved. Female by Gov. Grassy Grove. Clear Nose. Cleaned O.K.
Corinna better today.
Fran. Authoress has a large swelling on the left under side. Cause undetermined. Doesn't seem to be very serious although it is quite large."

The digestive upsets, calving dates, and cattle transfers were transferred to cards. A separate card was used for each cow in the herd. The digestive upsets were given a rating based on the severity and duration of the upset. Slight upsets, when the animal was still eating but showing some sign of digestive upset, were given a rating of 1. Severe upsets, when the cow had gone completely off-feed, were given a rating of 2. The ratings were made for each day and then the sum of these daily ratings was used as a final rating. The final ratings were then divided into three categories: a. slight, b. moderate, c. severe. The slight upsets were those with a cumulative rating of one or two. Moderate upsets were those with a cumulative rating of three to six and the severe upsets were those with ratings of six or higher.

The upsets were then recorded for each cow by lactations, calendar months, seasons, and calendar years. The seasons were divided as follows: Winter, (Dec., Jan., and Feb.,) Spring, (Mar., Apr., and May), Summer, (June, July, and Aug.), and Fall, (Sept., Oct., and Nov.) For the analysis the upsets per day per cow were calculated. This measure was used because of the variation in the number of days a cow was in the herd. The term "cow-year" was used to indicate 365 days of lactation per cow. The production for the 10 days previous to an upset and the first two 10-day periods following an upset was also recorded.

The frequency of the occurrence of digestive upsets during lactations of different lengths was analyzed to determine if there were any differences in the frequency of digestive upsets among different stages of lactation and among sire groups. The data were divided according to the length of lactation into five ninety-day groups as follows: 0-89, 90-179, 180-269, 270-359, and 360 or more.

The upsets per day were calculated for the longest lactation of each cow and then analyzed by an analysis of variance for unequal groups to determine group and sire differences. Only sires with four or more daughters were used in this analysis.

From the mean squares an estimate of heritability of digestive upsets was calculated. The statistical analyses were made by the standard statistical techniques as described by Anderson and Bancroft (1952).

The digestive upsets per day for each cow for each season of each year were calculated. These were then analyzed by an analysis of variance to determine whether or not there were any seasonal or yearly differences in the frequency of digestive upsets. The seasonal values for individual cows were then adjusted by subtracting the mean seasonal value for that particular season from the individual cow's record. These adjusted frequencies were then analyzed for sire differences by an analysis of variance for unequal groups. In this adjusted analysis all bulls with two or more daughters were included. An adjusted heritability was then calculated.

RESULTS

The records available for study included 253 cows sired by 46 bulls. Of these 253 cows 238 were sired by the 31 bulls with two or more daughters. Of these 31 sires only four had 20 or more daughters in the study.

The 253 cows had a total of 77,125 days in the herd, or an average of 304.8 days per cow. There was a total of 218 digestive upsets of which 149 were mild, 57 moderate, and 12 severe upsets. The average number of upsets per cow was 0.86. The average number of upsets per day per cow was 0.00282. There was approximately one upset per cow per 365 days of lactation.

Of the 253 cows in the study, 74 per cent had at least one digestive upset. Of the cows that were in the herd for 300 days or more, 64 per cent had at least one digestive upset. The cows having digestive upsets had an average of 1.17 upsets each.

The mild upsets accounted for 68 per cent of the total number of upsets; the moderate and severe upsets accounted for 26, and 6 per cent, respectively.

Environmental Factors Affecting the Frequency of Digestive Upsets

Several factors that might affect the frequency of digestive upsets were considered. Analyses were made to determine whether or not the data would have to be adjusted for the effects of these factors before sire differences could be analyzed. Such adjustments are necessary to obtain a more accurate estimate of the heritability of the susceptibility to digestive upsets. The digestive upsets for this herd during the period covered by this study are summarized in Table 1. The frequency of the total upsets and frequency of the various ratings are given in this table.

Table 1. The frequency of digestive upsets by years.

Year	No. of cows	Cow years	Total upsets per cow-year	Mild upsets per cow-year	Moderate upsets per cow-year	Severe upsets per cow-year
1931	35	17.5	0.857	0.571	0.286	----
1932	56	19.3	1.295	0.881	0.207	0.207
1933	44	18.5	0.703	0.486	0.162	0.054
1934	45	19.9	0.854	0.452	0.352	0.050
1935	56	21.5	0.698	0.419	0.279	----
1936	53	23.8	1.303	0.882	0.294	0.126
1937	55	22.7	1.498	1.013	0.396	0.088
1938	54	23.6	1.441	1.059	0.339	0.042
1939	45	21.4	0.888	0.561	0.327	----
1940	44	23.2	0.647	0.603	0.043	----

Effect of Seasons and Years. The frequencies of digestive upsets during the four seasons and several years were determined. These frequencies were then analyzed to determine whether or not there were significant seasonal and yearly differences in the frequency of digestive upsets.

The mean number of upsets per cow per day during various seasons varied widely. Upsets were most frequent in the spring and least frequent in the summer. The largest number of upsets per cow per season was 0.805 which occurred in the winter of 1932. The least number of upsets per cow per season occurred during the summer of 1935 when no upsets occurred as shown in Table 2.

The calendar year means ranged from a high of 1.815 upsets per cow in 1932 to a low of 0.635 in 1934. The years of 1936, 1937, and 1938 followed 1932 as the years with the highest frequency of upsets per cow as shown in Table 2.

An analysis of variance was made to determine whether there were any significant differences in these means. The analysis of the seasonal differences showed that these differences were significant at the 5 per cent level. This indicates that there is a difference in the frequency of digestive upsets among the four seasons of the year. Yearly differences were also significant at the 5 per cent level indicating a difference in the frequency of upsets for different years. No significant differences were found in the year-by-season interaction.

Table 2. Mean number of digestive upsets per cow by seasons and years.

Year	Winter	Spring	Summer	Fall	Yearly ave.
1931	0.171	0.215	0.080	0.252	0.719
1932	0.805	0.660	0.168	0.180	1.815
1933	0.165	0.077	0.077	0.238	0.840
1934	0.103	0.200	0.115	0.217	0.635
1935	0.349	0.245	0.000	0.167	0.763
1936	0.313	0.504	0.227	0.106	1.149
1937	0.628	0.512	0.334	0.236	1.712
1938	0.317	0.442	0.133	0.479	1.372
1939	0.035	0.254	0.268	0.304	0.858
1940	0.127	0.341	0.201	0.090	0.758
Ave.	0.301	0.345	0.160	0.227	1.062

This indicates that there are no differences in the frequency of digestive upsets among the same seasons in different years (Table 3)

Table 3. Analysis of variance of season and yearly differences.

Source of variation	Degrees of freedom	Mean square	F
Years	9	.0001392	1.96*
Seasons	3	.0002684	3.78*
Years X Seasons	27	.0000692	0.97 NS
Error	1091	.0000710	

* $P < .05$

The digestive upsets were most frequent during the spring, when the cows were being changed from barn to pasture feeding. This would indicate that changes in the type of feed may be one of the major causes of digestive upsets. The digestive upsets were more frequent during the winter and fall than during the summer. It would appear that climatic conditions as well as the sudden changes in the type of feed tend to make the cows more susceptible to digestive upsets.

Since the season-year interaction was not significant it appears that yearly differences are due to the increased frequency during one or two seasons during that year. This would also support the evidence that climatic conditions play a part in the frequency of digestive upsets.

Effect of Length of Lactation. Since many short lactations were included in the data it was necessary to determine whether or not differences in the frequency of upsets existed among the different lengths of lactation. These short lactations resulted from the cows being moved from one farm to the other. The lactations were divided into five groups according to their length. The grouping was as follows: 0-89 days, 90-179 days, 180-269 days, 270-359 days, and 360 days or more. The analysis of differences in the frequency of upsets among lactation lengths was performed to determine whether the upsets were more frequent in one stage of lactation than in another. At the same time, differences among daughters of different sires were also analyzed. Only sires with four or more daughters were used in this analysis. No significant differences were found to exist either among sire groups or among lactations of different lengths. (Table 4)

Table 4. Analysis of variance for lactational length and sire group differences.

Source of variation	Degrees of freedom	Mean square	F
Among lactation groups	4	.685717	1.65 NS
Among sire groups	16	.467541	1.12 NS
Error	184	.416736	

From this analysis it may be assumed that digestive upsets are no more frequent during the early stages of lactation than during advanced stages of lactation. It is possible that under the good management practiced in this herd fresh cows received better treatment than cows in later lactation. Thus the number of upsets for fresh cows may have been smaller than might be expected under average herd conditions.

Effect of Lactation Number. The lactational data were analyzed to determine whether there were any differences in the frequency of upsets among the various lactations of a cow. These data, consisting mainly of first lactations were classified as follows: 226 first, 59 second, and 50 third or higher lactations. In the first lactation group there were 154.9

cow-years and an average of 1.14 upsets per cow-year. In the second lactation group there were 32.9 cow-years and an average of 0.67 upsets per cow-year. When all lactations later than the second were grouped there was a total of 25.5 cow-years and an average of 0.86 upsets per cow year.

Table 5. The frequency of digestive upsets by lactations.

Lactation	No. of cows	Cow years	Total upsets per cow year	Mild upsets per cow year	Moderate upsets per cow year	Severe upsets per cow year
1	226	152.9	1.14	0.77	0.33	0.05
2	59	32.9	0.67	0.36	0.18	0.12
3	15	9.4	0.74	0.64	0.11	0.00
4	17	9.6	0.52	0.52	0.00	0.00
5 and over	18	6.5	1.54	1.38	0.00	0.15

When these data were subjected to analysis of variance, all lactations later than the second were combined into one group. No significant difference was found in the frequency of upsets in first and later lactations (Table 6).

Table 6. Analysis of variance of lactational differences in frequency of digestive upsets.

Source of variation	Degrees of freedom	Mean square	F
Among lactations	2	.0000999	2.57 NS
Error	332	.0000389	

Since nearly three-fourths of the total cow-years in the study were from the first lactation only a small amount of data was available on lactations subsequent to the first. Digestive upsets were more frequent during the first lactation. The F value in the analysis of lactational data was nearly significant ($.10 > P > .05$).

A correlation analysis was calculated on first and second lactations to determine the extent of the repeatability of digestive upsets. In these data only 42 cows had both first and second lactations. The repeatability found was 0.076. This very low repeatability suggests that the susceptibility to digestive upsets is not inherited but rather is largely an environmentally influenced trait.

Heritability of the Susceptibility to Digestive Upsets

The differences among progeny groups of different sires were first analyzed with differences in lactational length being considered as a source of variation. This analysis is shown in Table 4. Only data for sire progeny groups containing four or more daughters were used in this analysis. There were 17 sires with a total of 205 daughters, or an average of 12.06 daughters per sire. The analysis of variance (Table 4) indicated that there were no significant differences in the frequency of digestive upsets among sire groups.

Table 7. Average frequency of digestive upsets among progeny groups of bulls with two or more daughters.

Bull	No. of daughters	Cow years	Total upsets per cow year	Mild upsets per cow year	Moderate upsets per cow year	Severe upsets per cow year
Marblevale of Montfaucon	7	7.0	0.286	0.286	----	----
Franchester Cain	5	5.1	1.765	1.373	0.392	----
Franchester Standfast	2	1.5	2.667	2.000	0.667	----
Langwater Reflector	24	22.9	0.961	0.699	0.218	0.044
Franchester Sheik	10	10.3	1.359	1.068	0.291	----
Gayoso Golden Beau	20	15.5	0.968	0.581	0.258	0.129
Green Meadow Constant	45	42.3	0.875	0.496	0.307	0.071
Franchester Royal Sequel	7	4.2	0.714	0.238	0.476	----
Franchester Corsican	2	0.3	----	----	----	----
Franchester Corsair	8	2.8	1.429	0.714	0.357	0.357
Franchester Czar	3	2.9	1.034	1.034	----	----
Franchester Conjuror	3	1.4	1.429	0.714	0.714	----
Langwater Countryman	4	3.1	0.968	0.645	0.323	----
Franchester Royal Lodestar	3	1.6	0.625	----	----	0.625

Table 7 (Con't.)

Bull	No. of daughters	Cow years	Total upsets per cow year	Mild upsets per cow year	Moderate upsets per cow year	Severe upsets per cow year
Franchester Governor	2	1.6	1.250	1.250	----	----
Franchester Knight	4	4.5	0.889	0.222	0.667	----
Franchester Kismet	3	1.8	1.111	0.555	0.555	----
Green Meadow Renown	6	4.5	0.667	0.667	----	----
Franchester Shadrack	4	3.8	0.789	----	0.789	----
Langwater Shah	42	35.6	1.348	1.039	0.281	0.028
Franchester Sovereign	5	4.5	1.333	0.667	0.667	----
Franchester Viking	5	4.4	1.364	1.364	----	----
Governor of Grassy Grove	4	4.1	1.220	0.976	0.244	----
Franchester Constantine	2	1.1	0.909	----	----	0.909
Green Meadow Coronation King	2	1.2	----	----	----	----
Brookmead's Searchlight	5	4.9	1.837	1.633	0.204	----
Highland Ringmaster	2	2.4	0.417	0.417	----	----
Franchester Sentinel	2	1.2	0.833	----	0.833	----
Dairy Maid's Warrior of Shuttlewick	2	2.1	----	----	----	----

Table 7 (Concl.)

Bull	No. of daugh-ters	Cow years	Total upsets per cow year	Mild upsets per cow year	Moderate upsets per cow year	Severe upsets per cow year
Lieutenant Governor	3	2.3	0.435	----	0.435	----
Langwater Africander	2	2.2	----	----	----	----

The heritability of susceptibility to digestive upsets was calculated from the paternal half-sib correlation in this analysis. The heritability estimate obtained was 0.0376.

The records were then adjusted for seasonal and yearly differences by the subtraction of the respective seasonal means (Appendix Table I). This was the only adjustment necessary since differences in the frequency of digestive upsets among the other environmental factors were not significant. In this analysis, data on all sire progeny groups with two or more daughters were used. There were 31 sires with 238 daughters, or an average of 7.7 daughters per sire. When the adjusted records were analyzed for sire differences no significant differences were found (Table 8).

Table 8. Analysis of variance of sire progeny group differences in frequency of digestive upsets.

Source of variation	Degrees of freedom	Mean square	F
Among sires	30	.0000410	0.73 NS
Error	207	.0000561	

A second heritability estimate of the susceptibility to digestive upsets was then calculated from these adjusted data. This estimate was also calculated from a paternal half-sib correlation and found to be -0.156. This estimate may be considered to be zero.

From Table 7 it would appear that there were differences in the frequency of digestive upsets among sire groups. It will be noted, however, that the largest variations occur among sire groups containing few daughters or few total cow-years. The progeny of the four bulls with 20 or more daughters accounted for 55 per cent of the cows in the study. These four sire groups showed a small amount of variation; however, the progeny group of Langwater Shah had 0.41 more upsets per cow-year than had the other three when averaged together.

The heritability of susceptibility to digestive upsets was estimated from two analyses. The first estimate included only records from cows whose sires had four or more daughters. These records were unadjusted and the estimate obtained was 0.0376. After records from progeny of all bulls with two or more daughters had been adjusted for seasonal and yearly differences, a second estimate of heritability was calculated. This estimate was zero (-0.156). These very low heritability estimates and the low repeatability strongly suggest that the susceptibility to digestive upsets in this herd is not inherited.

Effect of the Severity of Digestive Upsets on milk Production

To determine the sensitivity of the upset ratings given, their effects on milk production were analyzed. The average daily production during the first 10 days (S_1) following the upset, and the average daily production during the 11th through the 20th day (S_2) were recorded. These averages were then divided by the average production for the ten days preceding the upset (P). Two persistency indexes, S_1/P and S_2/P, which might show the effect of the digestive upsets on production were thus obtained.

If two or more upsets occurred sufficiently close together that there was an overlapping of the 10-day production periods, these upsets were not included in this analysis.

Table 9. Mean persistency indexes for the three digestive upset rating classifications.

Type of upset	Number	S_1/P	S_2/P
Mild	68	0.934	0.966
Moderate	36	0.856	0.912
Severe	4	0.704	0.717

Some reduction in production as the lactation progresses is expected. The persistency indexes were used in this analysis to show the differences in the effect of the upsets rather than the reduction in production.

An analysis of variance was made to determine if there were real differences in the reduction of production in accord with the severity of the upset as indicated by the three upset ratings. The differences were highly significant for both S_1/P and S_2/P (Tables 10 and 11).

Table 10. Analysis of variance of S_1/P index differences among severity of upset rating groups.

Source of variation	Degrees of freedom	Mean squares	F
Among severity of upset groups	2	.148994	25.40**
Within severity of upset groups	105	.005866	

** $P < .01$

Table 11. Analysis of variance of S_2/P index differences among severity of upset rating groups.

Source of variation	Degrees of freedom	Mean squares	F
Among severity of upset groups	2	.137066	26.96**
Within severity of upset groups	105	.005084	

** $P < .01$

Variance component estimates from these two analyses indicate that 55.38 per cent and 49.47 per cent respectively, of the variation in production had been accounted for by the severity ratings. These results indicated that the ratings of the severity of a digestive upset were sensitive at least as indicated by the reduction in production.

SUMMARY AND CONCLUSIONS

Records from Franchester Farms Guernsey herd that included data on digestive upsets were analyzed. Approximately one digestive upset occurred for every cow-year. Mild upsets accounted for 68 per cent of the total upsets while the moderate and severe upsets accounted for 26 and 6 per cent, respectively. Of the cows that were in the herd 300 or more days, 64 per cent had at least one digestive upset. Cows that had digestive upsets averaged 1.17 upsets each.

Seasonal and yearly differences in the frequency of digestive upsets were found to exist. Upsets were most frequent during the spring and least frequent during the summer. The yearly mean number of digestive upsets ranged from a high of 1.815 per cow in 1932 to a low of 0.635 in 1934. The years of 1936, 1937, and 1938 followed the high years of 1932 as the years with the highest frequency of upsets per cow.

It appears that sudden changes in the type of feed and changing climatic conditions tend to make cows more susceptible to digestive upsets.

The differences in the frequency of digestive upsets among lactations of different lengths were analyzed. No significant difference was found to exist. Thus, it may be assumed that the stage of lactation had little effect on the frequency of digestive upsets in this herd.

The frequency of digestive upsets was higher during the first lactation than in later lactations; however, the difference was not significant. The lactations subsequent to the first amounted to only a small portion of the data and this might have been the reason that no significant differences were found.

A correlation analysis was calculated on first and second lactations. This gave a measure of the repeatability of digestive upsets. The estimate obtained was 0.076.

There were no significant differences in the frequency of upsets among 31 sire groups, although the upsets per cow-year varied from 0.000 to 2.667 among sire groups. These extreme values were obtained from sires with very few daughters.

Two estimates of heritability of susceptibility to digestive upsets were obtained. One estimate was obtained from an analysis in which only progeny groups of sires with four or more daughters were included. This estimate of heritability was 0.0376. After the data had been adjusted for seasonal and yearly effects, a second estimate of heritability was calculated. This estimate was zero (-0.156).

From these very low estimates of heritability and the low repeatability of digestive upsets it may be supposed that the susceptibility to digestive upsets is not inherited.

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APPENDIX

Table 1. Mean upsets per cow per day by seasons and years.

Year	Winter	Spring	Summer	Fall	Yearly
1931	.00190	.00234	.00087	.00277	.00197
1932	.00885	.00717	.00183	.00198	.00496
1933	.00183	.00084	.00084	.00262	.00230
1934	.00114	.00217	.00125	.00238	.00174
1935	.00388	.00266	.00000	.00183	.00209
1936	.00344	.00548	.00247	.00117	.00314
1937	.00698	.00556	.00363	.00259	.00469
1938	.00352	.00480	.00145	.00526	.00376
1939	.00039	.00276	.00291	.00335	.00235
1940	.00140	.00371	.00219	.00099	.00207
Average	.00333	.00375	.00174	.00249	.00291

THE FREQUENCY, REPEATABILITY AND HERITABILITY OF DIGESTIVE UPSETS IN A GUERNSEY HERD

by

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The production records of a cow are known to vary from one lactation to the next though in a broad sense the heredity of the animal does not change. Factors causing this variation include, among the many, infections, hardware, upsets of the digestive tract, abrupt changes in weather, and variable milking practices. The digestive upsets may be caused by overfeeding, infections, sudden changes in feeds, toxic chemicals, hunger, and spoiled feed.

This study was undertaken to determine the frequency of digestive upsets, their severity, the extent of their repeatability in subsequent lactations, and whether or not the susceptibility to these upsets is heritable.

The daily barn reports and daily milk weight records of the Franchester Farms Guernsey herd at Lyndhurst, Ohio, were available for this study. These reports covered a ten-year period from January 1, 1931, to January 1, 1941. However, milk weights were only available for the years from 1933 through 1940, with the exception of 1936. The management in this herd was relatively constant and somewhat better than average.

The records of 253 cows sired by 46 bulls were included in this study. Of these 253 cows, 238 were sired by the 31 bulls with two or more daughters. Of these 31 sires, only four had 20 or more daughters in the study.

The 253 cows had a total of 77,125 days in the herd which is, an average of 304.8 days per cow. There was a total of 218 digestive upsets, of which 149 were mild, 57 moderate, and 12 severe upsets. Seventy-four percent of the cows in the study had at least one digestive upset. Those cows having digestive upsets had an average of 1.17 upsets each.

Significant differences were found in the frequency of upsets in different seasons and years. The upsets occurred most frequently during the spring and least frequently during the summer. It would appear that climatic conditions and sudden changes in the type of feed tend to make the cows more susceptible to digestive upsets.

No significant differences were found in the frequency of digestive upsets in lactations of different lengths. From this it may be assumed that digestive upsets are no more frequent during the early stages of lactation than during advanced stages of lactation. It is possible that under the good management practiced in this herd fresh cows received better treatment than cows in later lactation. Thus the number of upsets for fresh cows may have been smaller than might be expected under average herd conditions.

No significant difference was found in the frequency of upsets in first lactations and later lactations. However, the digestive upsets were more frequent during the first lactation than during later lactations.

The repeatability of digestive upsets was calculated from the correlation between first and second lactation records. The estimate of repeatability obtained was 0.076.

The heritability of the susceptibility of digestive upsets was found to be zero for these data. The zero heritability and low repeatability indicate that the susceptibility to digestive upsets probably is not heritable.