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Type Appraisal: I. Effects of Age and Stage-of-Lactation on Type Ratings

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Abstract

Dairy cattle type appraisal data were examined to determine whether body and udder conformation and management ratings were affected by age and period of lactation at appraisal. Data were collected from 1961 to 1968 from 188 herds having over 23,000 Holstein type appraisals. The body and udder traits were scored by scheduled appraisers, and the management traits were coded by each dairyman. Some of the 35 original traits were composed of more than one descriptive characteristic and, as a result, 49 renamed traits were derived from these.

A model was selected that considered years and herds as well as cow effects to reduce bias in the estimates of age \times stage-of-lactation differences that would result from culling cows on type score. Age differences were large for about one-third of the traits, especially for mastitis, body weight, and depth of udder. In general, differences from stage-of-lactation were not as large as from age; nevertheless, trends were evident for several traits. Interactions between age and stage-of-lactation were relatively small.

Introduction

Two environmental factors which have influenced type classification scores are age and time of appraisal during the lactation. Hyatt and Tyler (4) studied type classification on 63 Ayrshires and reported scores were lower in mid-lactation than in early and late lactation. They also noted older cows scored higher than younger ones. Benson, Tyler, and Hyatt (1) later reported differences in rating due to age, season, and year of classification were nonsignificant but found substantial differences in type score due to stage-of-lactation. Wilcox et al. (7, 8) reported both age and stage-of-lactation influences in Holstein type classification

data. These workers reported that type traits with the exception of dairy character were classified higher in early and late lactation than in mid-lactation. Hansen, Barr, and Wieckert (2) using 8,551 Holstein type classifications found significant differences from age and stage-of-lactation for final score and all eight categories. White, Legates, and Koonce (6) reported age at appraisal and stage-of-lactation each significantly affected 12 of 22 type appraisal traits.

Classifiers and appraisers have considered stage-of-lactation in rating cows, but remaining differences in type scores due to various stages-of-lactation are evidence they have not been completely successful. A portion of these age differences in type scores probably has been deliberate to prevent overscoring young animals. These differences also represent changes in body form and indicate some selection for higher type scores. The failure to require standardized policy in considering environmental effects, particularly age, has added confusion to type classification.

The purposes of this study were to examine the ratings given to management, body, and udder traits in type appraisal and to determine the effects of age and stage-of-lactation on these ratings.

Data and Methods

A method of type appraisal of dairy cattle was designed by the Animal Science Extension Division at Cornell University in 1953. Objectives in designing the method were to furnish more descriptive measures of conformation than were then available through existing type classification to determine the importance of certain characteristics in a breeding program.

Type appraisals in this study were collected between 1961 and 1968 in a "special herd" project. Herds were selected at random from those meeting the following requirements:

1. Were enrolled on Dairy Herd Improvement testing,
2. Had used artificial insemination (AI) extensively,
3. Had 35 or more Holsteins, and
4. Had plans to continue in dairying.

The 188 herds selected represented 42 counties in New York and 3 counties in Ver-

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mont. Eighty-nine herds were appraised in odd-numbered years from 1961 to 1968, and 99 herds were appraised in even-numbered years.

To complete a single appraisal, nine management traits were checked by the dairyman and 26 body and udder traits were coded by the appraiser. The appraisers were personnel of the Animal Science Extension Division and Eastern AI Cooperative, Inc. More than 30 appraisers rated type traits.

A list of the 35 original type traits and 49 renamed traits that were derived from these is in Appendix I. Most of the traits were binomial or multinomial, and although the recorded observations take on discrete values, the traits likely possess an underlying continuous distribution. Numeric values were assigned to the renamed traits, and all analyses were based on these values. Four type traits were added after the 1961 appraisals. These were persistency of edema, height of thurls, heel depth, and upstandingness. A total of 22,703 to 23,388 appraisals for the various traits were coded.

Each appraisal was placed to one of six age groups according to the following months of age at appraisal: 1. Under 36; 2. 36 to 47; 3. 48 to 59; 4. 60 to 77; 5. 78 to 95; and 6. 96 and over. Likewise each appraisal was coded into one of six stage-of-lactation groups based on the bimonthly interval from date of calving. Records of cows appraised 11 or more months after calving were coded into stage "six".

Generalized least squares analyses (3) estimated joint effects of age and stage-of-lactation upon the 49 renamed type traits. Because of the complete confounding of sets of herds with years it was necessary to consider these as two data sets. Data set one included odd-numbered years and data set two included even-numbered years. The following model was used to describe the observations:

$$X_{ijk1mnp} = \mu + AS_{ij} + D_k + Y_{k1} + H_{km} + C_{kmn} + E_{k1mnp}$$

where: μ is an effect common to each appraisal;

AS_{ij} is an effect common to appraisals of all cows coded in the i^{th} age and the j^{th} stage-of-lactation;

D_k is an effect common to appraisals in data set k ;

Y_{k1} is an effect common to the 1^{th} year of data set k ;

H_{km} is an effect common to the m^{th} herd in data set k ;

C_{kmn} is a random effect associated with

the n^{th} cow in the m^{th} herd in data set k , distributed with mean zero and

variance σ_C^2 ; and

E_{k1mnp} is a random error associated with the p^{th} observation on the n^{th} cow in the m^{th} herd in the 1^{th} year of data set k , distributed with mean

zero and variance σ_E^2 .

Cow effects were assumed uncorrelated, error effects were assumed uncorrelated, and covariances between cow and error effects were

assumed zero. The ratio of σ_E^2 to σ_C^2 for each

trait was estimated from an intra-herd repeatability analysis based on pooled regression for all lactations (5), was then assumed known, and was used in estimating age x stage-of-lactation differences by generalized least squares. Cow effects were included in the model to eliminate bias in age x stage-of-lactation constants that would result from culling cows on type score. Constants were derived by making the solution for the age x

$$\text{stage-of-lactation groups } \begin{cases} \sum_{i=1}^6 \sum_{j=1}^6 AS_{ij} = 0 \\ \sum_{j=1}^6 AS_{ij} = 0 \end{cases}$$

sum to zero. The number of observations in the age x stage-of-lactation groups ranged from 38 to 1,270.

Testing for statistical significance of age effects, stage-of-lactation effects, and age x stage-of-lactation interaction effects would have been impractical because of insufficient knowledge of distributions; thus, summary analyses were used to provide information about the size of these effects. These summary analyses were based entirely on the estimated age x stage-of-lactation constants (AS_{ij}) for the 49 type traits and were unweighted for number of observations in each constant. To make these summary analyses comparable between type traits the constants were divided by their range of numeric values (in Appendix I). For example, excitability had numeric values from one to three so the age x stage-of-lactation constants for that trait were divided by two. The constants for body weight were divided by 18 (180 kg); thus, this trait is not directly comparable to the others. The following summary analysis was made on the 36 range-standardized age x stage-of-lactation constants for each of the type traits:

Source of variation	Degrees of freedom
Total (corrected for mean)	35
Age	5
Age, linear	1
Age, linear plus quadratic	2
Stage-of-lactation	5
Stage, linear	1
Stage, linear plus quadratic	2
Remainder	25
Age, linear plus quadratic x stage, linear plus quadratic	4
Residual	21

Because of the biological basis of these measurements, linear and quadratic responses were assumed to account for most real variation in the age and stage-of-lactation effects. For this reason sums of squares of main effects were partitioned as linear components and linear-plus-quadratic components, and these were expressed as a percentage of the sums of squares of main effects. The remainder sum of squares which includes any age x stage-of-lactation interaction effects was partitioned into two parts, one with 4 degrees of freedom (df) containing interaction of the linear-plus-quadratic components and the second with 21 df containing any other interaction effects. The 4 df contrast was assumed to contain most of any sums of squares due to interaction effects. If this last assumption were true, the method would give an indication of the relative importance of interaction between age and stage-of-lactation since the residual sum of squares (21 df) would be the result primarily of errors in estimating the age x stage-of-lactation constants.

Results and Discussion

The average scores for the 49 type appraisal traits and standard deviations within herd, within lactation for each are in Appendix I.

The 36 age x stage-of-lactation constants for each type trait are not given although the remainder of the discussion is based on an analysis of these constants. Average age con-

stants $(\sum AS_{ij}/6$ where sigma represents $j=1$

summation over j) are in Table 1 as the unweighted means of the six age x stage-of-lactation constants in each age group. The constants suggest that dairymen had trouble with mastitis traits-3, 4², ketosis-5, milk fever-6, breeding trouble-7, milking speed-9, milk leak-

10, and edema-11, 12 for cows in the older age groups. Fifty percent more of the older cows had mastitis than younger ones. Ratings for the other management traits changed only slightly with age.

Taped body weight-13 and the ratings for depth of body-22 increased substantially with age. Cows under 3 years of age were taped at 140 kg less than cows 5 years older. Numeric values for those traits measuring strength of shoulders-17, legs-19,20, and pasterns-21 decreased while height of thurls-26 and levelness of rump-23 increased in score with increasing age.

Differences in udder scores show that older cows were coded as longer in rear udder-29, weaker in fore and rear attachment-39, 40, and deeper in udder-36 with more slope to the udder floor-37 than younger cows. Increasing age was associated with lower ratings in udder quality-35, more udder halving-41 and quartering-42, and teats-43 to 46 that were somewhat more likely to point sideways or forward. It is not known to what extent consideration was given to age in rating these traits.

Constants for stage-of-lactation are in Table 2 as the unweighted means of the six age x stage-of-lactation constants in each stage-of-lactation group. In general, stage-of-lactation differences in the type ratings were not as large as age differences. Cows appraised in the first stage were scored .5 lower in udder quality-35 than cows in the sixth stage.

Each type trait for age and stage-of-lactation effects can be adjusted ignoring interactions by subtracting each of the appropriate constants for these two variables. The usefulness of the corrections ignoring interaction effects was examined. The summary analyses based on the age x stage-of-lactation constants are in Table 3. Because of standardizing the range in coding for the traits, an indication of the relative magnitude of the main effects was available to compare traits. Age differences were large for body weight-13, mastitis-3, and depth of udder-36. The linear effect of age accounted for 93 to 100% of the age sum of squares for these three traits, and the addition of the quadratic effect accounted for practically all of the remaining variation. The linear-plus-quadratic component accounted for 99 to 100% of the sums of squares for other traits having substantial age trends. There were only 13 traits for which the linear-plus-quadratic effects accounted for less than 96% of the age sums of squares; all were from the 19 traits having the smallest age sums of squares (less than .018) which suggests that the influences

² Hyphenated number following each trait is the trait number in Tables 1,2,and 3.

TABLE 1. Average constants for age at appraisal.

No.	Trait	Age group					
		1	2	3	4	5	6
Management traits							
1	Excitability	-.04	.01	.02	.02	.02	-.02
2	Feeding speed	-.02	.01	.00	.01	.03	-.02
3	Mastitis	-.25	-.17	-.05	.06	.15	.27
4	Mastitis from injury	-.10	-.07	-.03	.02	.07	.13
5	Ketosis	-.10	-.08	-.03	.03	.08	.11
6	Milk fever	-.08	-.07	-.06	-.01	.07	.17
7	Breeding problems	-.11	-.06	-.02	.02	.06	.12
8	Cystic ovaries	-.07	-.04	-.01	.00	.05	.07
9	Milking speed	.18	.12	.03	-.01	-.10	-.19
10	Milk leak	-.05	-.03	-.01	.00	.02	.04
11	Intensity of edema	-.13	-.07	-.02	.03	.07	.11
12	Persistency of edema	-.12	-.06	-.03	.03	.07	.10
Body traits							
13	Body weight (kg/10)	-9.	-4.	0.	3.	4.	5.
14	Sharpness	-.05	.00	.00	.00	.01	.04
15	Typical head	-.06	-.02	.01	.02	.03	.02
16	Strength of head	.00	-.01	.01	.01	.01	.01
17	Tightness of shoulder	.18	.08	.01	-.03	-.09	-.15
18	Arching of back	-.02	-.01	.01	.02	.00	-.03
19	Straightness of hock	.10	.05	.01	-.01	-.05	-.08
20	Straight legs (rear view)	.13	.10	.03	-.05	-.07	-.12
21	Strength of pasterns	.10	.07	-.01	-.02	-.05	-.10
22	Depth of body	-.25	-.14	-.04	.09	.17	.20
23	Levelness of rump	-.10	-.02	.03	.03	.03	.02
24	Smoothness of pelvic arch	-.02	-.03	.01	.03	.03	-.02
25	Height of tail setting	-.08	-.01	.00	.02	.03	.03
26	Height of thurls	-.27	-.13	.03	.12	.15	.10
27	Heel depth	-.01	-.01	-.01	.00	-.02	.02
28	Upstandingness	.00	.02	.02	.02	.00	-.05
Udder traits							
29	Rear udder length	-.14	-.04	.01	.05	.06	.06
30	Rear udder bulginess	-.02	.00	.00	.01	.00	.01
31	Rear udder fullness	-.03	-.01	.00	.02	.02	.02
32	Fore udder length	.01	.04	.06	.04	-.02	-.10
33	Fore udder bulginess	.00	-.01	.00	.00	.00	.00
34	Fore udder fullness	-.03	-.02	-.01	.01	.02	.04
35	Udder quality	.23	.14	.06	-.05	-.13	-.24
36	Depth of udder	-.57	-.38	-.16	.12	.37	.61
37	Forward slope to udder	-.33	-.18	-.03	.10	.19	.27
38	Height of rear udder	-.10	.00	.03	.05	.03	-.03
39	Strength R. udder attach.	.34	.30	.15	-.02	-.24	-.52
40	Strength F. udder attach.	.27	.24	.13	-.01	-.18	-.44
41	Udder halving	-.05	-.04	.00	.01	.01	.08
42	Udder quartering	-.11	-.07	-.03	.01	.08	.14
43	Rear teats forward	-.01	.00	.00	.01	.01	.01
44	Rear teats sideways	-.03	-.02	.00	.01	.03	.03
45	Fore teats forward	-.02	-.01	.00	.00	.01	.01
46	Fore teats sideways	-.06	-.03	-.02	.01	.03	.05
47	Rear teat spacing	-.04	-.03	-.02	.01	.04	.05
48	Fore teat spacing	-.05	-.02	-.01	-.01	.04	.05
49	Rear to fore teat spacing	-.01	.00	.00	.01	.01	.00

of age were small compared to sampling variation for these estimates.

The largest differences in stages-of-lactation were for the traits: udder quality-35, sharp-

ness-14, rear udder length-29, breeding problems-7, height of rear udder-38, fore udder bulginess-33, straight legs, rear view-20, body weight-13, fore udder length-32, and depth of

TABLE 2. Average constants for stage-of-lactation at appraisal.

		Stage-of-lactation group					
No.	Trait	1	2	3	4	5	6
Management traits							
1	Excitability	-.02	.01	.02	.02	.01	-.05
2	Feeding speed	-.08	-.02	.02	.01	.04	.03
3	Mastitis	-.00	.03	.01	-.00	-.01	-.03
4	Mastitis from injury	.00	.01	.00	.00	-.01	-.01
5	Ketosis	.04	.02	-.02	-.03	-.01	-.01
6	Milk fever	.02	.01	-.01	-.00	-.01	-.01
7	Breeding problems	-.06	-.05	-.04	.01	.04	.09
8	Cystic ovaries	-.02	-.01	-.01	.01	.00	.02
9	Milking speed	.00	-.03	-.00	-.02	.03	.03
10	Milk leak	.03	.03	.00	-.02	-.02	-.02
11	Intensity of edema	.12	.05	-.03	-.06	-.07	-.01
12	Persistence of edema	.14	.06	-.04	-.07	-.07	-.02
Body traits							
13	Body weight (kg/10)	-0.	-1.	-0.	-0.	0.	2.
14	Sharpness	.11	.16	.06	-.04	-.10	-.18
15	Typical head	-.02	.02	.01	.01	.00	-.02
16	Strength of head	-.00	-.01	-.01	-.00	.00	.02
17	Tightness of shoulder	-.04	-.03	.04	.02	.01	-.00
18	Arching of back	-.04	.04	.05	.03	-.03	-.06
19	Straightness of hock	.04	.02	.03	.01	-.06	-.04
20	Straight legs (rear view)	.17	.05	.01	-.01	-.11	-.11
21	Strength of pasterns	.04	.03	.03	.00	-.06	-.04
22	Depth of body	-.01	-.05	-.04	-.02	.03	.09
23	Levelness of rump	.01	-.02	-.03	-.02	.02	.05
24	Smoothness of pelvic arch	-.02	-.02	-.00	.00	.00	.04
25	Height of tail setting	.02	-.03	-.03	-.02	.01	.05
26	Height of thurls	-.05	-.10	-.03	.01	.05	.12
27	Heel depth	-.00	.00	.01	-.00	-.03	.01
28	Upstandingness	-.01	.01	.03	.01	-.05	.01
Udder traits							
29	Rear udder length	.23	.05	-.05	-.09	-.09	-.05
30	Rear udder bulginess	.01	.02	.01	.00	-.01	-.03
31	Rear udder funnelness	-.03	.00	.02	.03	-.00	-.02
32	Fore udder length	.18	.01	-.04	-.08	-.08	-.00
33	Fore udder bulginess	.09	.05	.01	-.02	-.05	-.07
34	Fore udder funnelness	-.01	-.00	.01	.02	.00	-.01
35	Udder quality	-.24	-.14	-.04	.05	.16	.22
36	Depth of udder	.22	.09	-.04	-.08	-.12	-.08
37	Forward slope to udder	-.01	.02	.03	.05	.01	-.10
38	Height of rear udder	.21	.07	-.04	-.09	-.11	-.03
39	Strength R. udder attach.	.11	-.04	-.06	-.04	-.06	.09
40	Strength F. udder attach.	-.08	-.10	-.04	.00	.06	.16
41	Udder halving	-.03	.04	.04	-.01	-.00	-.03
42	Udder quartering	-.02	.01	-.00	.01	.02	-.02
43	Rear teats forward	.01	.01	.00	-.00	-.01	-.01
44	Rear teats sideways	.02	.00	.00	-.00	-.01	-.02
45	Fore teats forward	.02	.01	-.00	-.01	-.01	-.00
46	Fore teats sideways	.03	.01	-.00	-.00	-.02	-.02
47	Rear teat spacing	.09	.02	-.03	-.03	-.04	-.01
48	Fore teat spacing	.07	.02	-.02	-.01	-.03	-.03
49	Rear to fore teat spacing	.02	.01	-.00	-.01	-.01	-.01

udder-36; the linear-plus-quadratic components accounting for 94 to 100% of the stage-of-lactation variation in these traits.

Linear-plus-quadratic effects explained al-

most the entire trend in both age and stage-of-lactation effects; and, therefore, it seems likely that these same effects would have been important in explaining any interaction. If no

TABLE 3. Relative importance of age and stage-of-lactation on type ratings.

No.	Trait	Range-standardized sum of squares				Percent of sum of squares ^a				
		Total	Age	Stage	A×S	Age		Stage		A×S
						L	L+Q	L	L+Q	
Management traits										
1	Excitability	.02	.00	.01	.01	4	90	9	97	62
2	Feeding speed	.02	.00	.01	.00	8	53	76	93	30
3	Mastitis	1.19	1.17	.01	.01	100	100	55	79	32
4	Mastitis-injury	.23	.22	.00	.00	99	100	56	72	34
5	Ketosis	.26	.22	.02	.01	99	99	54	93	73
6	Milk fever	.30	.29	.00	.01	86	100	85	93	56
7	Breed. problems	.34	.22	.11	.02	100	100	92	98	57
8	Cystic ovaries	.10	.09	.01	.01	98	98	83	85	39
9	Milking speed	.15	.14	.00	.01	99	99	35	65	23
10	Milk leak	.05	.03	.01	.01	99	99	88	91	45
11	Intensity of edema	.11	.06	.04	.01	99	100	60	98	56
12	Persist. of edema	.11	.05	.05	.01	99	99	64	99	49
Body traits										
13	Body weight	2.72	2.61	.08	.02	93	100	70	100	47
14	Sharpness	.14	.01	.13	.00	80	82	91	94	42
15	Typical head	.05	.04	.01	.01	79	100	4	81	7
16	Strength of head	.00	.00	.00	.00	57	66	60	98	7
17	Tightness-shoulder	.12	.11	.01	.01	98	99	27	78	8
18	Arching of back	.01	.00	.01	.00	0	84	16	85	40
19	Straightness-hock	.02	.01	.01	.00	99	99	75	76	29
20	Stra. legs (rear v.)	.16	.07	.08	.01	98	98	92	95	33
21	Strength-pasterns	.07	.04	.02	.01	97	97	83	84	38
22	Depth of body	.26	.24	.02	.00	97	99	57	99	35
23	Levelness-rump	.04	.02	.01	.01	60	96	31	96	60
24	Smooth pelv. arch	.04	.02	.01	.02	11	57	87	93	45
25	Height-tail setting	.02	.01	.01	.00	82	94	14	96	21
26	Height of thurls	.26	.21	.05	.01	81	99	86	94	59
27	Heel depth	.01	.00	.00	.00	32	43	1	1	31
28	Upstandingness	.02	.01	.01	.01	42	97	4	13	9
Udder traits										
29	R. udder length	.17	.05	.11	.01	83	100	64	99	54
30	R. udder bulginess	.01	.00	.01	.00	70	90	79	96	14
31	R. udder funnelness	.04	.01	.01	.01	86	97	0	93	59
32	F. udder length	.12	.03	.07	.02	46	99	47	98	47
33	F. udder bulginess	.11	.00	.10	.01	3	23	98	100	36
34	F. udder funnelness	.02	.02	.00	.00	99	100	6	88	56
35	Udder quality	.48	.23	.23	.02	100	100	100	100	81
36	Depth of udder	.74	.68	.06	.01	100	100	78	99	58
37	F. sloping udder	.11	.10	.01	.00	98	100	18	89	12
38	Height R. udder	.14	.02	.10	.01	20	99	64	99	47
39	Str. R. udder att.	.40	.38	.02	.01	95	100	1	87	35
40	Str. F. udder att.	.29	.25	.03	.00	94	100	90	99	47
41	Udder halving	.02	.01	.00	.00	89	92	9	63	52
42	Udder quartering	.04	.03	.00	.01	98	100	0	60	50
43	R. teats forward	.01	.00	.00	.00	92	98	95	95	14
44	R. teats sideways	.03	.02	.01	.00	95	96	91	92	20
45	F. teats forward	.01	.00	.00	.00	90	98	71	92	23
46	F. teats sideways	.07	.05	.01	.00	98	99	90	97	19
47	Rear teat spacing	.03	.01	.02	.00	96	96	52	99	16
48	Fore teat spacing	.02	.01	.01	.00	94	95	82	96	42
49	Rear-fore teat sp.	.01	.00	.00	.00	60	70	90	97	7

^a L is the linear portion of the range-standardized sum of squares, L+Q is the linear-plus-quadratic portion of the range-standardized sum of squares.

interaction existed for a trait, then the linear-plus-quadratic portion of the age x stage-of-lactation sum of squares would be an estimate of the underlying error variance. The small size of the age x stage-of-lactation sums of squares for all traits suggest that the interaction effects were relatively unimportant. Thus age x stage-of-lactation interaction could be ignored if corrections are made for these two environmental effects.

Conclusions

The effects that age and stage-of-lactation have upon management, body, and udder traits were examined within/cow. Age differences appear to be quite large for about one-third of the type appraisal traits. Changes with age were especially apparent in mastitis, body weight, and depth of udder. In general, stage-

of-lactation differences were not as large as those of age differences. Trends nevertheless were evident for most of the variables. Scores for udder quality were low in the first two months of lactation. Although interactions between age and stage-of-lactation ratings were apparent for a number of variables, the sizes of these effects were relatively small.

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Appendix 1. Listing of original and renamed appraisal traits.

Original traits, categories and frequencies	Renamed traits/categories	Numeric value	Mean	Standard deviation
1. Temperament	1. Excitability		2.19	.42
a. Quiet .77	Dull, c	1		
b. Nervous .21	Quiet, a	2		
c. Dull, stolid .02	Nervous, b	3		
2. Feeding habits	2. Feeding speed		2.49	.52
a. Aggressive feeder .52	Slow, c	1		
b. Average .44	Average, b	2		
c. Slow .03	Fast, a	3		
3. Incidence of mastitis	3. Mastitis		1.30	.41
a. No mastitis .70	None, a	1		
b. Mastitis first lactation .05	Mastitis, b, c, d	2		
c. Mastitis, injury .10				
d. Mastitis, other causes .15	4. Mastitis from injury		1.10	.28
	None reported for			
	mastitis, a, b, d	1		
	Mastitis from injury, c	2		
4. Ketosis — milk fever	5. Ketosis		1.12	.28
a. Neither .84	None, a, c	1		
b. Ketosis .09	Ketosis, b, d	2		
c. Milk fever .04				
d. Both .03	6. Milk fever		1.07	.22
	None, a, b	1		
	Milk fever, c, d	2		
5. Breeding trouble	7. Breeding problems		1.16	.35
a. None .84	None, a	1		
b. Cystic ovaries .08	Breeding problems, b, c	2		
c. Other (4 or more services) .08				
	8. Cystic ovaries		1.08	.26
	Not reported, a, c	1		
	Cystic ovaries, b	2		
6. Milking speed	9. Milking speed		2.33	.62
a. Fast .44	Slow, c	1		
b. Average .46	Average, b	2		
c. Slow .11	Fast, a	3		
7. Milk leak	10. Milk leak		1.07	.25
a. Nonleaker .93	Nonleaker, a	1		
b. Leaks milk, no injury .07	Leaks milk, b	2		

Original traits, categories and frequencies	Renamed traits/categories	Numeric value	Mean	Standard deviation
8. Udder edema, caked after calving	11. Intensity of edema		1.53	.51
a. None to slight .52	None to slight, a	1		
b. Moderate .43	Moderate, b	2		
c. Severe .05	Severe, c	3		
9. Persistence of udder edema	12. Persistency of edema		1.46	.53
a. One week .60	One week, a	1		
b. Two weeks .34	Two weeks, b	2		
c. More than 2 weeks .06	More than two weeks, c	3		
10. Taped weight lb.	13. Body weight, 10's kg.		58.15	5.65
11. Dairy character	14. Sharpness		2.60	.52
a. Sharp, angular .62	Thick, c	1		
b. Moderate .35	Moderate, b	2		
c. Coarse or thick .03	Sharp, a	3		
12. Head	15. Typical head		1.84	.36
a. Typical for breed .84	Not typical, b, c, d	1		
b. Plain .12	Typical for breed, a	2		
c. Coarse or beefy .02				
d. Weak .01				
	16. Strength of head		2.01	.19
	Weak, d	1		
	Intermediate, a, b	2		
	Coarse, c	3		
13. Shoulder	17. Tightness of shoulder		2.62	.54
a. Not winged, tight .66	Severely winged, c	1		
b. Slightly winged, loose .30	Slightly winged, b	2		
c. Severely winged .04	Tight, a	3		
14. Back (hip to shoulder)	18. Arching of back		2.89	.56
a. Straight .67	Severely swayed, g	1		
b. High chine .10	Low back, c, d, f	2		
c. Low loin .12	Straight, a	3		
d. Low chine .03	High back, b, e	4		
e. Roached .01				
f. Slightly sway back .07				
g. Severely swayed .00				
15. Hind legs, side view	19. Straightness of hock		2.32	.63
a. Nearly straight .40	Sickled, c	1		
b. Intermediate .50	Intermediate, b	2		
c. Sickled .10	Nearly straight, a	3		
d. Hind legs too straight .01	Too straight, d	4		
16. Hind legs, rear view	20. Straight legs, rear view		2.38	.57
a. Toe-out, none to slight .44	Severe toe-out, c	1		
b. Moderate toe-out .51	Moderate toe-out, b	2		
c. Severe toe-out .06	None to slight toe-out, a	3		
17. Pasterns	21. Strength of pasterns		2.39	.61
a. Strong .47	Weak, c	1		
b. Intermediate .44	Intermediate, b	2		
c. Weak .09	Strong, a	3		
18. Depth of body	22. Depth of body		2.59	.50
a. Deep for age .61	Shallow, c	1		
b. Intermediate for age .36	Intermediate, b	2		
c. Shallow for age .03	Deep, a	3		
19. Rump levelness and tail setting	23. Levelness of rump		2.77	.49
a. Nearly level, smooth pelvic arch .14	Sloping, g	1		
b. Nearly level, notched pelvic arch .17	Slight slope, e, f	2		
	Nearly level, a, b, c, d	3		

Original traits, categories and frequencies	Renamed traits/categories	Numeric value	Mean	Standard deviation
c. Nearly level, high pelvic arch .39	24. Smoothness of pelvic arch		1.25	.43
d. Nearly level, high tail head .10	Not smooth, b, c, d, f, g	1		
e. Slightly sloping, relatively smooth pelvic arch .12	Smooth, a, e	2		
f. Plain with low tail setting .04	25. Height of tail setting		2.03	.41
g. Sloping .04	Low, f, g	1		
	Intermediate, a, b, c, e	2		
	High, d	3		
20. Rump rear view	26. Height of thurls		2.28	.60
a. High thurls, square .38	Low, c	1		
b. Intermediate thurls .51	Intermediate, b	2		
c. Low thurls .11	High, a	3		
21. Heel depth	27. Heel depth		2.16	.57
a. Deep .27	Shallow, c	1		
b. Intermediate .62	Intermediate, b	2		
c. Shallow .10	Deep, a	3		
22. Upstandingness, consider breed and age	28. Upstandingness		2.40	.62
a. Tall .49	Low set, c	1		
b. Medium .43	Medium, b	2		
c. Low set .08	Tall, a	3		
23. Udder shape, rear	29. Rear udder length		2.04	.62
a. Long .23	Short, c, e	1		
b. Intermediate length .53	Intermediate, b, d	2		
c. Short .12	Long, a	3		
d. Bulgy .06	30. Rear udder bulginess		1.06	.24
e. Funnel .06	Not bulgy, a, b, c, e	1		
	Bulgy, d	2		
	31. Rear udder funnelness		1.06	.24
	Not funnel, a, b, c, d	1		
	Funnel-shaped, e	2		
24. Udder shape, fore	32. Fore udder length		2.03	.58
a. Long .20	Short, c, e	1		
b. Intermediate length .51	Intermediate, b, d	2		
c. Short .14	Long, a	3		
d. Bulgy .12	33. Fore udder bulginess		1.12	.32
e. Funnel .03	Not bulgy, a, b, c, e	1		
	Bulgy, d	2		
	34. Fore udder funnelness		1.03	.17
	Not funnel, a, b, c, d	1		
	Funnel-shaped, e	2		
25. Udder texture	35. Udder quality		2.46	.58
a. Collapsed after milking .53	Meaty, c	1		
b. Intermediate .40	Intermediate, b	2		
c. Meaty .07	Collapsed after milking, a	3		
26. Depth of udder	36. Depth of udder		2.52	.55
a. Deep .42	Shallow, c	1		
b. Intermediate .47	Intermediate, b	2		
c. Shallow .04	Deep, a	3		
d. Too deep .07	Too deep, d	4		
27. Levelness of udder floor	37. Forward slope to udder		2.45	.76
a. Nearly level .63	Rear higher than fore, e	1		
b. Slight tilt .24	Nearly level, a	2		
c. Fore higher than rear .06	Slight forward tilt, b	3		

Original traits, categories and frequencies	Renamed traits categories	Numeric value	Mean	Standard deviation
d. Pronounced tilt .04	Fore higher than rear, c	4		
e. Rear higher than fore .02	Pronounced tilt, d	5		
28. Height of rear udder attachment	38. Height of rear udder		2.19	.57
a. High .29	Low, c	1		
b. Intermediate .61	Intermediate, b	2		
c. Low .10	High, a	3		
29. Strength of udder attachment, rear	39. Strength of rear udder attachment		3.32	.67
a. High .47	Broken away, d	1		
b. Intermediate .38	Loose, c	2		
c. Loose .13	Intermediate, b	3		
d. Broken away .02	Strong, a	4		
30. Strength of udder attachment, fore	40. Strength of fore udder attachment		3.47	.65
a. Strong .59	Broken away, d	1		
b. Intermediate .31	Loose, c	2		
c. Loose .09	Intermediate, b	3		
d. Broken away .01	Strong, a	4		
31. Udder halving, rear view	41. Udder halving		2.58	.61
a. Cleft 1-2 FW* .43	Floor nearly flat, d	1		
b. Cleft 2-3 FW .48	Cleft 1-2 FW, a	2		
c. More than 3 FW .06	Cleft 2-3 FW, b	3		
d. Floor nearly flat .02	Cleft more than 3 FW, c	4		
32. Udder quartering, side view	42. Udder quartering		1.31	.51
a. Floor nearly flat .72	Floor nearly flat, a	1		
b. Cleft 1-2 FW .25	Cleft 1-2 FW, b	2		
c. Cleft 2-3 FW .02	Cleft 2-3 FW, c	3		
d. Cleft over 3 FW .00	Cleft more than 3 FW, d	4		
33. Teat position, rear	43. Rear teats forward		1.05	.22
a. Plumb .89	Not forward, a, c	1		
b. Pointing forward .05	Pointing forward, b	2		
c. Pointing sideways .06	44. Rear teats sideways		1.06	.23
	Not sideways, a, b	1		
	Pointing sideways, c	2		
34. Teat position, fore	45. Fore teats forward		1.06	.23
a. Plumb .82	Not forward, a, c	1		
b. Pointing forward .06	Pointing forward, b	2		
c. Pointing sideways .12	46. Fore teats sideways		1.12	.31
	Not sideways, a, b	1		
	Sideways, c	2		
35. Placement	47. Rear teat spacing		1.88	.39
a. Well-spaced .69	Too close, b, d	1		
b. Rear too close .14	Well-spaced, a, c, e	2		
c. Side view close .03	Too wide, f	3		
d. All bunched .01	48. Fore teat spacing		2.11	.34
e. Front too wide .09	Too close, d	1		
f. Front and rear too wide .03	Well-spaced, a, b, c	2		
	Too wide, e, f	3		
	49. Rear to fore teat spacing		1.96	.20
	Too close, c, d	1		
	Well-spaced, a, b, e, f	2		

* Finger width.

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