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Evaluating the Relationship Between Mature Age Milk Yield and Several Traits Using CHAID Analysis in Brown Swiss Cows

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Abstract: Milk yield is important in breeding studies because it is one of the economically important traits. Therefore, determining the relationship between milk yield and some other traits could provide some important easiness in animal breeding studies. In this study, the aim was to evaluate the relationship between mature age milk yield and 9 independent variables (cow age, first mating age, lactation order, lactation period, dry period, first calving age, calving season, birth type and sex of calf) using CHAID analysis. Seven hundred and seventy Brown Swiss animals' records (from 1987-1997) taken from Mus State Production Farm (in Turkey) were utilized. CHAID analysis results showed that lactation period was primary, sex of calf and cow age were secondary and first mating age and dry period were the tertiary variables affecting mature age milk yield.

Key words: CHAID, chi-square (χ^2), node, mature age milk yield, cow, lactation

INTRODUCTION

The success in animal breeding studies regarding to increase economically important traits depends largely on applying appropriate breeding strategies. Considering the genotype and environmental factors affecting production traits together it is very well known fact that low genotype animals could be best productive only within its genetic capacity even they are maintained in a good environmental conditions and on the other hand, high genotype animals could not express their high productivity in inappropriate environmental conditions. Age (year), birth season and lactation order are discontinuous; dry period, first mating age and 1st calving age (day) are continuous environmental factors affecting milk production. Determining the effects of continuous and discontinuous environmental factors on milk production and predicting mature age milk yield are important aspects in animal breeding studies. Evaluating all environmental factors that assumed to be effective on economically important trait (s) together will facilitate determining the interactions of these factors as well and the effects of these factors will be examined more accurately. There are plenty of studies determining the effects of some continuous and discontinuous environmental factors on milk production (Orman and Ertugrul, 1999; Kaygisiz and Dogan, 1999; Bakir and Çetin, 2003), nevertheless, studies examining the interaction of these factors are scarce.

Although, parametric methods usually have been used in determining the effects of environmental factors, non parametric methods also could be used for this purpose. One of the nonparametric methods is CHAID (chi-square (χ^2) Automatic Interaction Detection or Detector) analysis. CHAID analysis is an exploratory method used to determine the relationship between a dependent variable and independent variables. CHAID analysis can detect interactions between independent variables. Its advantages are that the output is visual, easy interpretable and contains no equations. Thus, in this study CHAID analysis was used to determine significant factors for mature age milk yield.

MATERIALS AND METHODS

Milk yield data of 770 Brown Swiss cows held from 1987-1997 Mus State Production Farm in Turkey have been utilized. Dependent variable was considered to mature age milk yield and independent variables were considered to cow age, 1st mating age, lactation order, lactation period, dry period, 1st calving age, calving season, birth type and sex of calf. CHAID analysis was used as classification method.

Descriptive statistics for mature age milk yield was assumed as dependent variables and continuous variables related to dependent variables were presented as mean±SD. In addition, categorical variables were expressed as count and percent.

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CHAID is a technique that recursively partitions (or splits) a population into separate and distinct segments. These segments, called nodes, are split in such a way that the variation of the dependent variable (categorical or continuous) is minimized within the segments and maximized among the segments. After the initial splitting of the population into two or more nodes (defined by values of an independent or predictor variable), the splitting process is repeated on each of the nodes. Each node is treated like a new sub-population. It is then split into 2 or more nodes (defined by the values of another predictor variable) such that the variation of the dependent variable is minimized within the nodes and maximized among the nodes. The splitting process is repeated until stopping rules are met. The output of CHAID is a tree display, where the root is the population and the branches are the connecting segments such that the variation of the dependent variable is minimized within all the segments and maximized among all the segments (Hill *et al*., 1997; Hébert *et al*., 2006).

RESULTS AND DISCUSSION

Descriptive statistics for mature age milk yield and variables assumed to affect its are given in Table 1 and 2.

Table 3 shows variables found to be significant for mature age milk yield in CHAID analysis. Accordingly, average milk yield was 3228.45 kg and primary variable affecting this variable was lactation period. Lactation period was divided into 5 nodes. Mean mature age milk yield of cows having 221 days or shorter lactation period was estimated to be 1716.65 kg; whereas mean mature age milk yield of cows having 372 days or longer lactation period was estimated to be 3923.28 kg. Thus, it appears that as the lactation period length increases, mature age milk yield tends to increase.

Second subgroup, named as node 2 and comprised of 156 cows having 221-272 days lactation period and whose mature age milk yield mean was estimated to be 2765.59 kg, was divided into node 6 and 7 subgroups as sex variable. Mean mature age milk yield of node 6 subgroup having 76 cows, which had female calves was estimated to be 2598.08 kg; whereas mean mature age milk yield of node 7 subgroup having 80 cows, which had male calves was estimated to be 2924.73 kg. Thus, sex of calf in cows having 221-272 days lactation period was found to be significant variable for mature age milk yield. In other words, sex of the calf affects mature age milk yield only in cows having 221-272 days lactation period. On the other hand, node 4 subgroup comprised of 383 cows having 284-372 days lactation period was divided into 2 subgroups as cow age variable. Mature age milk yield mean of node 8 (comprised of 267 cows at 3-6 years age) and node 9 subgroups (comprised of 116 cows at 7-9 years age) were estimated to be 3401.76 and 4003.87 kg, respectively.

Table 1: Descriptive statistics for the variables

Groups	Ort	SE	Min.	Max.
Mature age milk yield (kg)	3228.45	35.690	746	7693
1st mating age (day)	545.67	4.062	490	901
Lactation period (day)	298.14	2.288	164	375
Dry period (day)	121.84	3.403	7	146
1rst calving age (day)	900.73	7.696	850	1172

Thus, age variable affects mature age milk yield only in 284-372 days lactation period cows. Node 8 and 9 were divided into 2 subgroups for variable age at 1st mating age and dry period, respectively. While mean mature age milk yield of 180 cows with <775 days 1st mating age was estimated to be 3505.01 kg, it was 3188.13 kg in cows with >775 days 1st mating age.

On the other hand, in 7 years and older age cows which had 85 days or shorter dry period length the mature age milk yield mean was estimated to be 3689.26 kg, whereas, mature age milk yield mean of 85 days or longer dry period length cows was estimated to be 4287.54 kg. Thus, lactation period (varied between 284-372 days) in 7 years and older age cows has significant effect on mature age milk yield. Node 1, comprised of 221 days lactation period cows, was the lowest mean mature age milk yield subgroup and node 13 was the highest mean mature age milk yield subgroup. R^2 of model was found to be 76%. Accordingly, it can be said that 76% of the variation in mature age milk yield could be explained by the variables present in the model. Therefore, it appears that R^2 of model is adequate. Dogan (2003) reported that in Holstein cows primary variable affecting 305 days milk yield was 55-74 days dry period and 10-16 months 1st mating age was the most related variable with this trait.

Results obtained for mature age milk yield could be summarized as follow:

- Primary variable affecting mature age milk yield was lactation period
- Sex of calf was the secondary variable in 221-272 days lactation period cows affecting mature age milk yield, whereas, cow age was the secondary variable in 284-372 days lactation period cows for this trait
- For mature age milk yield, cows were divided into 2 subgroups according to age variable. Mature age milk yield in 5 years and younger age cows was found to be significantly lower than that of 7 years or older age cows
- First mating age in 284-372 days lactation period and younger than 7 years age cows was found to be tertiary factor for mature age milk yield, whereas, dry period was tertiary factor for this trait in 7 or older age cows

Table 2: Frequency and percentage values for several categorical variables

Cow age	Frequency	(%)	Lac. order	Frequency	(%)	Calving season	Frequency	(%)
3	161	20.9	1	210	27.3	1	195	25.3
4	171	22.2	2	186	24.2	2	215	27.9
5	145	18.8	3	150	19.5	3	164	21.3
6	113	14.7	4	111	14.4	4	196	25.5
7	90	11.7	5	64	8.3	Total	770	100.0
8	52	6.8	6	39	5.1			
9	38	4.9	7	10	1.2			
Total	770	100.0		770	100.0	Birth T.		
Sex of calf						Single	750	97.4
Female	394	51.2				Twin	20	2.6
Male	376	48.8				Total	770	100.0
Total	770	100.0						

Table 3: Summary for mature age milk yield and significant variables

Node	Predicted mean	SD	N	(%)	Parent node	Variable	p-value	F	df_1	df_2	Split values
0	3228.45	990.349	770	100.0							
1	1716.65	593.684	78	10.1	0	LP	0.000	124.126	4	765	≤221
2	2765.59	747.540	156	20.3	0	LP	0.000	124.126	4	765	(221-272)
3	3242.74	766.616	77	10.0	0	LP	0.000	124.126	4	765	(272-284)
4	3584.12	790.618	383	49.7	0	LP	0.000	124.126	4	765	(284-372)
5	3923.28	895.757	76	9.9	0	LP	0.000	124.126	4	765	>372
6	2598.08	560.026	76	9.9	2	Sex	0.018	7.766	1	154	Female
7	2924.73	863.726	80	10.4	2	Sex	0.018	7.766	1	154	Male
8	3401.76	746.133	267	34.7	4	Age	0.000	53.327	1	381	3; 4; 5; 6
9	4003.87	730.550	116	15.1	4	Age	0.000	53.327	1	381	7; 8; 9
10	3505.01	713.685	180	23.4	8	FMA	0.009	10.976	1	265	≤775
11	3188.13	770.257	87	11.3	8	FMA	0.009	10.976	1	265	>775
12	3689.26	634.906	55	7.1	9	DP	0.000	23.131	1	114	≤85
13	4287.54	698.279	61	7.9	9	DP	0.000	23.131	1	114	>85
Estimated risk: 229429.613±36630.543					$R^2 = (1- (229429.613/990.349^2)) = 0.766 = 76.6\%$						

LP: Lactaion Period; FMA: First Mating Age; DP: Dry Period

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