ESTIMATION OF GENETIC PARAMETERS FOR MILK, FAT, PROTEIN AND MOZZARELLA CHEESE PRODUCTION IN THE ITALIAN RIVER BUFFALO POPULATION

A. Rosati[1,2] and L.D. Van Vleck[2,3]

[1]A.I.A. Italian Animal Breeders Association, Rome - Italy
[2]Animal Science Department, University of Nebraska, Lincoln 68583-0908
[3]Roman L. Hruska U.S. Meat Animal Research Center, ARS, USDA - Clay Center, NE 68933-0166

SUMMARY
The population of Italian river buffaloes is currently about 200,000. Mozzarella cheese is produced using buffalo milk. Lactations from 1980 up to now were considered in the analysis. After editing, 10,663 lactation records for milk, fat, protein and mozzarella cheese production of river buffalo cows were analysed using restricted maximum likelihood, by fitting a multiple trait repeated records animal model with a derivative-free algorithm. The number of cows with records was 3,873 with 6,842 animals in the relationship matrix. Three different fixed effects were included in the model: 575 levels of herd and year subclasses, 12 levels of calendar month of calving and 2 levels of number of times milked per day. A cubic covariate was used to adjust for months of age at parity. A quadratic covariate was used to adjust for days in the previous dry period. The averages of milk, fat, protein and mozzarella yields in kilograms and fat and protein percentages of milk yield were 2,286.8 ± 492.1, 196.9 ± 45.6, 104.7 ± 21.7, 589.1 ± 125.4, 8.59 ± .85, 4.55 ± .28 respectively. Heritability estimates were 0.14 for milk yield, 0.11 for fat yield, 0.14 for protein yield, 0.13 for mozzarella cheese yield, 0.17 for fat percentage and 0.10 for protein percentage. The proportions of total variance due to permanent environmental effects of the cows for yields of milk, fat and protein and percentages of fat and protein were 0.24, 0.16, 0.29, 0.23, 0.12 and 0.22, respectively.
Keywords: Buffalo, Genetic parameters, Selection

INTRODUCTION
Buffaloes in Italy are traditionally bred in the region around Naples. Some buffalo farms have been recently established in areas other than the traditional ones, e.g. in the Po valley. Almost all buffalo milk production is transformed to Mozzarella cheese, an expensive fresh cheese. Thus the milk price is about two and half times the price from milk of dairy cattle. Traditionally little attention has been given to calf rearing because of the high longevity of buffalo cows and because no importance is given to buffalo meat in the Italian market. Calves that are kept are artificially fostered or, more rarely, fostered by dairy cows. The annual herd replacement rate is 15-18%. Health problems are mainly from brucellosis. Sanitary conditions have improved in the last forty years. Systems with total mixed rations are mainly used as well as semi-stabled management (Zicarelli, 1994a). Significant effects of parity order and farms for milk yield were found by Arora *et al.* (1962) and Reddy and Tenaja (1984). Bhat and Batro (1978) reported the effects on milk yield of age and weight at calving and preceding

dry period. Heritability estimates for the Indian population of buffaloes for first lactation milk yield vary from 0.08 to 0.65. Buffalo milk is richer in both fat and protein percentages than milk of dairy and zebu cattle milk (Table 1). Italian animal breeders association (A.I.A.) maintains a selection scheme to increase milk yield. The selection program is based on a progeny testing. Recently some research to improve reproductive traits has been conducted in Italy (Zicarelli, 1994b).

MATERIALS AND METHODS

Description of data. The population examined comes from farms registered in the national herd book. Records of lactation yields from 1980 were available. All production records were projected to a conventional lactation length of 270 days. No records after the eighth parity were analysed. Because of the poor quality of recording in some areas and because of limited use of artificial insemination only 10,663 lactations were available after editing. Traits measured were milk, fat and protein yields in kilograms and fat and protein percentages. All observations were obtained for each animal with the A4 type of recording (ICAR, 1995). Estimation of amount of mozzarella cheese produced is computed as explained by Altiero *et al.* (1989) that gives specific weights to kilograms of milk and percentages of protein and fat. The number of calvings differ among calendar months. Calving rate increases from April to July, when it reaches the maximum, then the calving rate decreases to a minimum in November. The second maximum is in January. The bimodal shape can be explained by the fact that naturally buffalo cows tended to calve in Summer and in Autumn. Only recently some farmers have tried to have buffalo cows calve in winter to produce most of the lactation in Spring and Summer, when milk price is higher. Animals calving out of season seem to have poor reproduction due to low fertility, difficult heat detection and low quality of semen. Buffalo cows are usually milked twice a day. Only 11% of the analysed population was milked once a day. Age of cow also influences production.

Table 1. Summary of production for records in the analyses.

	Average	Standard Dev.	Minimum	Maximum	Number
Milk, kg	**2,286.8**	**492.1**	**702.2**	**5061.1**	**10,663**
Fat, kg	**196.9**	**45.6**	**65.5**	**495.2**	**10,313**
Fat, %	**8.59**	**.85**	**5.15**	**13.26**	**10,313**
Protein, kg	**104.7**	**21.7**	**35.0**	**213.3**	**9,441**
Protein, %	**4.55**	**.28**	**3.13**	**6.46**	**9,441**
Mozzarella, kg	**589.1**	**125.4**	**208.7**	**1,301.2**	**9,420**

Model

An animal model was used to analyse the data. Observations were kilograms of milk, fat and protein yield, percentage of fat and protein and estimated kilograms of mozzarella for 270 days of lactation. All traits were analysed using the same model. Herd and year combinations with 584 levels were considered as fixed effects together with month of calving with 12 levels, and number of milkings per day with 2 levels. A cubic covariate was used to adjust for age at calving in months and a quadratic covariate was used to adjust for the previous dry period in days. Animal genetic and permanent random environment effects were associated with cows. Thus the model was:

$$\mathbf{y} = \mathbf{X}\beta + \mathbf{Zu} + \mathbf{Wp} + \mathbf{e}$$

where, **y** is the vector of one of the following for each analysis: milk kg, fat kg, protein kg, fat and protein percentage or mozzarella kg, β is the vector of fixed effects of herd-year, number of milkings per day and month of calving, covariates for age at calving and for dry period, **u** is the vector of breeding values for direct genetic effects, **p** is the vector of permanent environmental effects of the cows, **X, Z** and **W** are the matrices that associate β, **u** and **p** with **y** and **e** is the vector of residual temporary environmental effects not explained by other parts of the model. Estimates of variance components were obtained using a multiple-trait derivative-free REML program (Boldman *et al.*, 1993). Heritability and genetic and environmental correlations among traits were estimated from the covariance components.

RESULTS AND DISCUSSION

Genetic parameters. Estimates of parameters for heritability and permanent environment effects for milk, fat and protein yields and mozzarella cheese yields and percentages of fat and protein are shown in Tables 2 and 3. All estimates of genetic parameters seem to be low. Buffaloes have not been intensively selected in the past, so great genetic variability among animals would be expected. Some possible causes of low estimates of genetic parameters can be addressed. There is traditionally considerable variability in management both among and inside herds. The model can only partially account for management variability. Though editing on data was done before the analysis to exclude cows without known sire and dam, some wrong genealogy may be present causing in assigning part of the genetic variability to environmental effects and reduces the estimate of heritability for direct genetic effects.

The low estimate of heritability for mozzarella production, as for all other traits, indicates that progress due to selection might be slow if traditional selection schemes are used to improve quantity and quality of milk to produce mozzarella cheese. Alternative selection schemes may need to be found.

Table 2. Estimates of heritability (on the diagonal) and genetic correlations among traits.

	Milk, kg	Fat, kg	Fat, %	Prot., kg	Protein, %	Mozz., kg
Milk yield, kg	**.14**	**.88**	**-.08**	**.95**	**-.12**	**.95**
Fat yield, kg		**.11**	**.41**	**.38**	**.44**	**.54**
Fat, %			**.17**	**-.04**	**.31**	**.62**
Prot. yield, kg				**.14**	**.65**	**.66**
Prot., %					**.10**	**.87**
Mozzarella, kg						**.13**

Table 3. Estimates of relative variance due to permanent environmental effect (diagonal) and correlations among traits for permanent (above diagonal) and temporary environmental effects (below diagonal).

	Milk, kg	Fat, kg	Fat, %	Prot., kg	Protein, %	Mozz., kg
Milk yield, kg	**.24**	**.94**	**-.55**	**.97**	**-.51**	**.54**
Fat yield, kg	**.85**	**.16**	**-.24**	**.13**	**-.02**	**.69**
Fat, %	**-.16**	**.36**	**.29**	**.61**	**.82**	**.04**
Prot., yield, kg	**.93**	**.51**	**.21**	**.23**	**-.15**	**.98**
Prot., %	**-.21**	**.01**	**.21**	**.31**	**.12**	**-.03**
Mozzarella	**.72**	**-.10**	**.51**	**.76**	**.45**	**.22**

Correlations among traits. Estimates of genetic correlations among traits are similar to those found in literature for dairy cattle (e.g. Barker *et al.*, 1966). The small negative genetic correlations of milk yield with protein and fat percentages indicate that milk yield can be increased through selection without large decreases in quality of milk. A selection goal for the buffalo population is producing milk to obtain mozzarella cheese. The breeding values for mozzarella production can be considered as a kind of selection index because all available information about the individual are used to maximise mozzarella yield, thus large estimates of genetic correlation between mozzarella production and milk yield were expected.

CONCLUSIONS

Weight of mozzarella cheese estimated from observations on other traits can be used as a selection criterion to improve overall economic return. Relatively small estimates of genetic variances were found for all traits analysed, including mozzarella cheese production, resulting in low heritability estimates. New strategies for selection may need to be found in order to improve buffalo for mozzarella production more rapidly than with traditional means.

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