Milk Yield and Quality to Estimate Genetic Parameters in Buffalo Cows

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Abstract: The objective of this study was to estimate genetic parameters for daily milk yield, fat and protein milk contents and their relationship with "mozzarella" cheese production using the classic instruments of the quantitative genetics. A total of 5130 daily milk yields records, belonging to 6 herds in South Italy were analyzed. The traits studied were: accumulated 270-day milk yield, milk fat and protein percentages, milk yield/day and mozzarella production. Descriptive statistics of the variables studied have been obtained with the procedure MEANS and FREQ, while the variation sources have been investigated using GLM procedure. With the objective to characterize the effects of greater impact on the production of milk (kg/days), fat and protein content (%) and "mozzarella" production (kg/days), has been used analysis of variance (ANOVA).

On average, buffalo cow's milk production during lactation was 9.21±2.79 kg/d with 8.73% of fat and 4.98% of protein. Heritability estimates were low. The genetic correlation estimates between milk yield and % of fat and % of protein were low.

These results showed that the genes affecting milk yield have an antagonistic effect on % of fat and % of protein traits. Its suggests that selection to increase milk yield, would in the long term probably cause a reduction in milk constituents.

Keywords: Buffalo cows, milk yield, milk quality, genetic parameters, “mozzarella” cheese.

IMPLICATIONS

The Italian Mediterranean Buffalo is one of the most important livestock resources in developing countries for milk and meat production.

There are few studies that reporting genetic parameter estimates for mozzarella production and their relationships with milk yield and milk components.

The methodology for genetic evaluation of buffalo for milk yield was approached by Jain and Sadana [1], however, selection schemes should not be aimed only to increases milk yield and quality but should consider functional traits in order to obtain higher productivity all over the lifetime of the buffalo cows.

INTRODUCTION

The Italian Mediterranean Buffalo cow is mainly reared for milk production. Almost all buffalo milk production is transformed to “mozzarella” cheese, expansive fresh milk. Thus the buffalo milk price is about three times that of milk of dairy cattle. A characteristic of Italian Mediterranean Buffalo is high percentage of fat and protein in the milk, although average milk yield per lactation is quite low if compared to dairy cattle. Milk yield was also reported to increase from first to sixth parity [2].

Milk production in buffaloes (Bubalus bubalis) is an economically important trait, accounting for over 50% of drinking milk in certain developing countries, such as India, Nepal, Pakistan and Egypt. During the process of “mozzarella” cheese making, fat and protein, casein in particular, are the major milk solid incorporated into the final product, these milk components being routinely used in many countries as criteria to determine the milk price.

The estimates of genetic parameters are helpful in determining the method of selection to predict direct and correlated response to selection, choosing a breeding system to be adopted for future improvement as well as in the estimation of genetic response.

Several studies have reported genetic parameter estimates for buffalo milk yield [3-7] and milk components such as protein and fat percentages [5, 8]. However, to date, there are few studies reporting genetic parameter estimates for mozzarella production and their relationships with milk yield and milk components. The buffalo species has been object of genetic characterizations by means of various multidisciplinary approaches, however, in the scientific literature, there is little information on the characters to greater economic impact of the genetic parameters (milk, fat, and protein and mozzarella cheese).

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ISSN: 1927-5196 / E-ISSN: 1927-520X/12

The objective of this work was to estimate genetic parameters for milk yield, and fat and protein percentages and their relationship with "mozzarella" cheese with the classic instruments of the quantitative genetics.

MATERIALS AND METHODS

A total of 5130 daily milk yields records from 2880 buffaloes cows (*Bubalus bubalis*), belonging to 6 herds in South Italy were analyzed. The traits studied were: accumulated 270-day milk yield (MY), milk fat (% F) and protein (% P) percentages, milk yield day (TD) and mozzarella production (MP).

No records after the eight parity were considered.

Total milk yield was defined as the amount of milk (kg) produced throughout the lactation period (270 days). The % F and % P values were obtained averaging the monthly test-day records per lactation [8]. As proposed by Altiero *et al*. [9], MP was based on MY, %F and %P, using the formula adopted in genetic evaluation programs in Italy:

$$MP\ (kg) = MY * \{[(3.5*\%P) + (1.23*\%F) - 0.88] / 100\}$$

The formula shows that increased production of mozzarella cheese can be obtained mainly by increasing milk yield and protein percent. Fat percentage has less influence on “mozzarella” cheese production than protein percentage.

Average lactation length for this population was 130.60 days with a standard deviation of 85.5 days.

Table **1** show number of observations (n) and means, standard deviation (SD) and standard error (SE) values of milk yield (kg) production in single control (TD1 to TD7).

Number of observations (n) and means, standard deviation (SD), standard error (SE) of % of fat (F), % of protein (P) and kg of mozzarella cheese (kg), per TD, ware reported in Table **2**.

The statistical analysis was obtained using the SPSS 12.0 Package software [10]. Descriptive statistics of the variable studied have been obtained with the procedure MEANS and FREQ, while the variation sources have been investigated using procedure GLM (General Linear Model). With the objective to characterize the effects of greater impact on the production of milk (kg/days), fat and protein content (%/days) and "mozzarella" production (kg/days), has been used analysis of variance (ANOVA) using the following model:

$$Y_{ijkl} = \mu + HTD_i + AGE_j + DIM_k + e_{ijkl}$$

Where:

Y_{ijkl} = milk (kg/day), fat(%), protein (%), “mozzarella” cheese (kg/day)

μ = general average of the considered variables;

HTD_i = fixed effect of i^{mo} the breeding-day of control (i=1,…., 7);

AGE_j = fixed effect of j^{mo} parity (k=1,…., 13);

DIM_k = fixed effect of k^{mo} state of lactation (k=1,…., 9);

e_{ijkl} = error

The factor of (co)variance of milk, fat, proteins and kg of “mozzarella” have been estimated using an animal model multivariate in which they have been considers the same effects described in the previous model and two new accidental effects: the

Table 1: Number of Observations (n) and Means, Standard Deviation (SD), Standard Error (SE) and Minimum and Maximum Values of TD in kg (TD1 to TD7)

Variable	n	Means (kg)	SD (kg)	SE (kg)	Min (kg)	Max (kg)
TD1	645	3.74	0.77	0.03	2.00	5.00
TD2	1122	6.53	0.91	0.03	5.00	8.20
TD3	1626	9.34	0.83	0.02	7.20	10.90
TD4	1131	12.23	0.88	0.03	11.0	14.80
TD5	411	15.04	0.93	0.05	11.60	16.80
TD6	153	18.02	0.83	0.07	17.00	19.80
TD7	42	22.08	1.15	0.20	20.10	23.80

Table 2: Number of Observations (n) and Means, Standard Deviation (SD), Standard Error (SE) and Minimum and Maximum Values of % of Fat (F), % of Protein (P) and kg of Mozzarella Cheese (kg) (MP), per TD

Variable		n	Means (kg)	SD (kg)	SE (kg)	Min (kg)	Max (kg)
F	TD1	645	8.67	1.44	0.06	5.27	12.68
	TD2	1113	8.57	1.42	0.04	5.22	12.85
	TD3	1623	8.66	1.54	0.04	5.05	13.49
	TD4	1125	8.73	1.49	0.04	5.09	14.95
	TD5	411	8.64	1.35	0.07	5.09	11.31
	TD6	153	8.65	1.35	0.11	5.39	11.79
	TD7	42	9.07	1.76	0.27	5.04	11.56
P	TD1	642	4.95	0.44	0.02	3.74	6.29
	TD2	1122	4.94	0.43	0.01	3.90	6.32
	TD3	1626	4.99	0.47	0.01	3.70	6.99
	TD4	1128	4.97	0.47	0.01	3.86	6.28
	TD5	411	4.99	0.65	0.03	3.23	6.41
	TD6	153	5.00	0.51	0.04	3.84	5.88
	TD7	42	5.04	0.52	0.08	4.03	5.73
MP	TD1	642	1.01	0.23	0.01	0.45	1.57
	TD2	1113	1.76	0.31	0.01	1.15	2.79
	TD3	1623	2.54	0.33	0.01	1.59	3.65
	TD4	1122	3.32	0.38	0.01	2.39	4.61
	TD5	411	4.09	0.50	0.02	1.88	5.76
	TD6	153	4.91	0.52	0.04	3.77	6.31
	TD7	42	6.16	0.71	0.10	5.24	7.54

environmental and the animal (genetic effect additive). The have been obtained using procedure REML.

Hereditability and genetic and environmental correlations among traits were estimated from the components of variance and covariance.

RESULTS AND DISCUSSION

The number of records and the milk yield in each days of lactation are shows in Figure **1**.

The corresponding mean and standard deviation for DMY during lactation were 9.21±2.79 kg. The DMY was maximum (12.82±3.15 kg) at 8th week of lactation and then decreased until the end of lactation (5.21±1.52 kg). The numbers of records was smaller at either extreme of the lactation curves (558 to 486). The standard deviation of DMY ranged from 3.59 (wk 4) to 1.52 (wk 36).

The means observed for MY270 (1271±529.99) were similar than the ones obtained by Tonhati *et al.* [8], which were 1259 kg and lower than the ones obtained by Malhado *et al.* [11], being 1650 kg and 1863 kg, respectively.

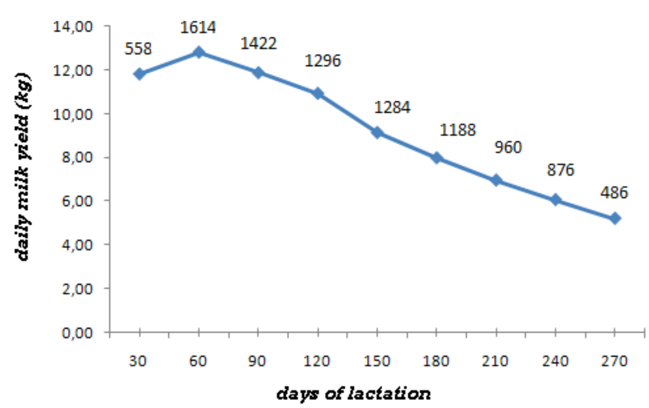

Figure 1: Milk yield and numbers of records in each days of lactation.

Rosati and Van Vleck [5], analyzing Mediterranean breed in Italy, observed for MY305 a mean value of 2286 kg.

Table 3: ANOVA for Milk Production (Kg/day), Protein Content (%), Fat Content (%) and "Mozzarella" Cheese Production (Kg)

	Milk		Protein		Fat		"Mozzarella"	
R^2	0.940		0.257		0.276		0.617	
Effects								
	F	P	F	P	F	P	F	P
Breeding	1469.00	***	0.180	n.s.	5.516	***	947.371	***
Parity	85.44	***	7.902	***	4.080	***	68.136	***
Days of lactation	1197.88	***	5.703	***	6.287	***	17.141	***

*** P<0.001.

The coefficient of determination (R^2), that is the proportion of variability of a character explained from a model, has turned out to be equal to 94% for the milk, 26% for proteins, 28% for fat and of 62% for the production of "mozzarella" (Table **3**). From these results is obvious that it is difficult to characterize the multiple environmental effects that, in our case, influences the protein and fat contents. All the included sources of variation in the model were significant (P<0.001) except for the protein content in function of the breeding. From the examination of the table it appears that for the milk and "mozzarella" production the breeding turns out the effect more important continuation from the lactation days, for the production of milk and from the parity for the production of mozzarella. The parity was the more important effect for the protein content.

The study of the component of variance (Table **4**) is the first step for the genetic evaluation of the animals and concurs to determine how much the phenotypic variable is influenced from the genetic and environmental aspects. These results pointed out that a great part of total phenotypic variation is due to the additive genetic action of the genes. Therefore, considerable genetic gain is expected if selection is applied for any trait.

Table 4: Component of Additive Genetic Variance (σ^2_a,), Permanent Environmental (σ^2_c) and Residual (σ^2_e)

	σ^2_a,	σ^2_c	σ^2_e
Milk	4.023	0.034	0.800
Fat	0.799	0.081	0.850
Protein	0.102	0.005	0.095
"Mozzarella"	0.840	0.055	0.218

For all traits, the permanent environmental estimates as a proportion of phenotypic variance were moderate. With the exception of %P, all σ^2_c estimates were similar to those reported by Rosati and Van Vleck [5].

With the ratio between (co)variances we obtained the genetic parameters (heritability and correlations) and repeatability (Table **5**). The repeatability is a useful parameter in the case of repeated measurements of the phenotype of an animal and, indirectly, helps measure the impact of environmental factors on the variability of a temporary character. It is clear that the lowest value of repeatability (59%) was calculated for the fat content (Table **5**). This trend may be justified in the fact that the degree of similarity between repeated measures on the same animal is not particularly high, or that the environmental variability due to temporary factors is predominant.

Table 5: Estimated Values of Repeatability for Productive Character

	r
Milk (Kg/d)	0.761
Fat (%)	0.590
Protein (%)	0.650
"Mozzarella" (Kg)	0.815

The MY, %F and %P heritability (Table **6**) estimates were close to those obtained by Rosati and Van Vleck [5] and Tonhati *et al*. [8]. These results shows that the heritability estimates for MY and MP were similar and the genetic correlation estimates was high. However, applying milk constituents (%F and %P) as selection criteria to improve mozzarella production, the genetic gain obtained for this trait was low. Although these traits have a large additive genetic influence, the genetic correlation estimates between MP and %F and %P were low and, thus, the correlated response obtained for MP was also low. However, lower MY

Table 6: Estimates of Heritability (in Diagonal), Genetic Correlations (Over Diagonal) and Phenotypic Correlation (under Diagonal) between Productive Characters

	Milk (kg/d)	Fat (%)	Protein (%)	"Mozzarella"
Milk Yield (kg/d)	0.008	0.021	0.020	0.968
Fat (%)	0.030	0.101	0.050	0.190
Protein (%)	0.053	0.053	0.049	0.188
"Mozzarella"	0.968	0.197	0.197	0.010

heritability estimates obtained in the present study may depend of differences in genetic variability of bread, in methodology applied to estimate the (co)variance components, and also in the production system (managements and environmental).

These results showed that the genes with the affect on milk yield have an antagonistic effect on % of fat and % of protein traits. Its suggest that selection to increase milk yield, would in the long term probably cause a reduction in milk constituents.

De Paula *et al.* [12] reported the same trend for the genetic correlation between yield and milk components.

The genetic correlation estimates between MY and MP were high, and close to those reported by Rosati and Van Vleck [5].

In agreement with by Rosati and Van Vleck [5] high genetic correlation estimate between MY and MP was obtained since MY in the main component of the formula applied to calculate MP. However, the genetic correlation between MP and %F and %P were positive and moderate.

CONCLUSION

Relatively small estimates of genetic variance were found for all traits analyzed, these results might be due to inaccurate identifications of true paternity. The development of genetic indices and mating plans should be associated with the enhancement of the intrinsic characteristics of race, such as longevity, fertility, hardiness and adaptability to different environmental conditions. However, the results obtained in the present study suggest that selection to increase milk yield would be effective to improve the "mozzarella" production.

ACKNOWLEDGEMENTS

Research supported by "Conoscenze Integrate per la Sostenibilità e l'Innovazione del made in Italy Agroalimentare" (CISIA - VaRiGeAV) – MIUR, Project "Caratterizzazione e valorizzazione delle risorse genetiche animali e vegetali della Campania e della Sardegna finalizzate allo sviluppo della filiera bufalina mediante approcci multidisciplinari ed innovativi"

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Received on 01-01-2012 Accepted on 08-02-2012 Published on 15-03-2012

DOI: http//dx.doi.org/10.6000/1927-520X.2012.01.01.17