Ann Zootech (1998) 47, 59–66

Original article

Milk yield adjustments for milking length and age-parity-lambing month interaction in Sarda dairy sheep

Antonello Carta[a*], Sebastiano Renato Sanna[a], Andrea Rosati[b], Salvatore Casu[a]

[a]Istituto Zootecnico e Caseario per la Sardegna, Reg Tottubella, 07040 Olmedo, Italy
[b]Associazione Italiana Allevatori, Via Tomassetti 9, 00161 Rome, Italy

(Received 20 January 1997; accepted 7 November 1997)

Abstract – Milk yield adjustments for milking length and age-parity-lambing month interaction were estimated to allow effective comparisons between yields and with the perspective of improving the reliability of the genetic evaluation of Sarda dairy ewes. The analysis included 671 404 records used for the genetic evaluation round of the year 1995. Predicted milk yields for levels of milking length were obtained by applying a model containing the maximum test day yield as covariate. This approach was used to account for different production capabilities and to avoid correction for factors other than duration. The predicted values were interpolated by third degree polynomial function to smooth differences between classes and multiplicative coefficients estimated by using base milking length (162 days). On adjusted milk yields a repeated animal model, including as fixed effects the flock-year-age-parity and year-age-parity-lambing month interactions, was applied. For each record the sum of fixed effect solutions was calculated. Averages of fixed effect sums were used to estimate multiplicative coefficients, the base being associated to a level defined by lactations of fourth age class, third-fourth parities and August–November lambing months. The new milk trait, defined as mature ewe equivalent (MEE), could be used by breeders to compare milk yields within flock-year and to make more accurate culling choices. The higher homogeneity of means and standard deviations within age-parity classes seems interesting for genetic evaluations based on MEE rather than milk yield adjusted for milking length only. (© Elsevier / Inra.)

dairy sheep / milking length / equivalent mature ewe

Résumé – Ajustements de la production laitière pour la durée de traite et l'interaction âge–parité–mois d'agnelage chez les brebis de race Sarde. Des ajustements de la production laitière des brebis de race Sarde ont été estimés pour la durée de traite et pour l'interaction âge–parité–mois d'agnelage afin de réaliser une comparaison efficace des lactations de toutes parités et en vue d'améliorer la précision des valeurs génétiques estimées. L'analyse porte sur 671 404

* Correspondence and reprints

lactations utilisées pour l'indexation en 1995. Pour tenir compte des différences de potentiel laitier des lactations et corriger uniquement la durée de traite, les productions brutes ont été analysées dans un premier temps à l'aide d'un modèle linéaire incluant en covariate le contrôle laitier maximal. Puis, les moyennes par classe de durée de traite estimées par le modèle ont été ajustées par une fonction polynomiale de troisième degré. Les coefficients d'ajustement par niveau de durée ont été calculés à l'aide du rapport entre la production estimée pour la durée de référence (162 j) et les moyennes estimées pour les autres classes de durée (322 niveaux). À partir des quantités ainsi ajustées une évaluation génétique modèle animale avec répétabilité a été réalisée en incluant comme effets fixés les interactions troupeau-année–âge–parité et année–âge–parité–mois d'agnelage. Pour chaque enregistrement la somme des solutions des effets fixés a été calculée, et les valeurs moyennes pour les différents niveaux des effets ont été utilisées pour l'estimation des coefficients multiplicatifs d'ajustement des quantités comparativement à la référence : une troisième ou quatrième lactation réalisée à l'âge de 4 ans suite à un agnelage intervenant entre août et novembre. La production laitière ainsi obtenue, appelée Équivalent brebis adulte, peut être utilisée par les éleveurs pour comparer les productions laitières de brebis de toutes parités, afin de gérer au mieux les réformes annuelles. La meilleure homogénéité des moyennes et des écarts types entre classes d'âge–parité présente un intérêt certain pour réaliser une évaluation génétique sur cette lactation Equivalent brebis adulte plutôt que sur la seule production laitière corrigée pour la durée de traite. (© Elsevier / Inra.)

ovins laitiers / durée de traite / équivalent brebis adulte

1. INTRODUCTION

To achieve a good reliability in phenotypic and genetic evaluation of dairy animals, production variability caused by systematic environmental effects must be removed. It has been realized usually by multiplicative corrections for factors as age, parity, season and their interactions. In dairy species estimating adjustment factors is interesting: i) to allow effective comparisons between production records being on different lactation categories; and ii) to improve reliability of estimated breeding values by higher homogeneity of means and standard deviations.

In dairy cattle adjustment factors are usually applied on milk yields standardized for lactation length at 305 d by excluding yields over standard length. Completed lactations less than 305 d are considered differently according to different countries. Some countries do not realize any extrapolation to 305 d, while other countries do it only if a minimum lactation length is reached [9]. In France milk yields are preadjusted for milking length by the multiplicative factor proposed by Poutous and Mocquot [15]. This approach aims to make lactations over 250 d independent from length thus avoiding an underestimation of cows showing a good fertility [3]. In this study the authors also showed that: i) a negative correlation between the bulls breeding values and the percentage of short lactations of their daughters exists; and ii) the inclusion and the preadjustment of the short lactations with the multiplicative factor avoids overestimation of bulls with low breeding values. This type of preadjustment for milking length has been applied also in French dairy sheep [4]. In Mediterranean dairy sheep breeds the length of completed lactations is an important systematic source of environmental variability of milk yields due to seasonal reproduction [6]. Particularly, in Sarda breed lambings occur once a year, mainly in November–December for ewes older than 18 months and in February–March for yearlings between 12 and 18 months of age. On the other hand, the milking is prolonged in summer according to pasture availability of farms, but in any case the dry-off is almost simultaneous for all ewes of the flock. Thus, milking length is strongly affected by factors other than production capability of lactation. Nevertheless, estimation of heritability for milking length was 0.14 and estimate of genetic correlation between milking length and milk yield was 0.59 [18], so that the including of milking length in the model could cause a correction reducing differences among estimated breeding values. The method of estimating multiplicative coefficients should separate the genetic component of milking length from the environmental component. Nowadays, preadjustment is realized by the multiplicative coefficient proposed by Poutous and Mocquot [15], and adapted to Sarda breed by Sanna et al. [17].

As regards the other sources of systematic environmental variability of milk yields, in dairy cattle multiplicative coefficients were calculated for age by month [11] and age by parity interactions [2]. Keown and Everett [11] concluded that multiplicative factors should be estimated periodically, whereas Ptak et al. [16] suggested to include an interaction of age and month with year of calving in the animal model for genetic evaluation rather than preadjusting production records. The use of inadequate correction factors could be an important source of bias in phenotypic and genetic ranking of animals and in estimating related trends [5]. Recently Khan and Shook [12] compared multiplicative, additive and combined age adjustments for the effect on heterogeneity of standard deviations within age class and on estimated genetic trend. The authors concluded that adjustment factors should be updated at short intervals and that multiplicative correction inflates genetic trend estimates.

In dairy sheep different strategies of preadjustment or inclusion in the animal model for genetic evaluation were used, according to different breeds and countries [1, 4, 7, 17, 19]. Particularly, in Sarda breed milk yields are not preadjusted for age, while in France a precorrection is applied to smooth differences of standard deviations within parity. The definition of preadjustments for Sarda breed should take into account the typical production system. It is based on pasture and related food availability is strongly affected by seasonal and annual climatic variations. The effect on milk yields will result from interaction between animal conditions (age, parity, lactation stage, etc.) and seasonal influences on food availability causing high variation in daily yields [6, 8].

Thus, the objectives of this study were: i) to find a method to estimate multiplicative preadjustment for milking length of completed lactation records; and ii) to find preadjustment factors to mature ewe equivalent (MEE) for the interaction age class-parity-lambing month.

The new milk trait is expected to allow more accurate culling choices within flock-year and to have positive consequences on genetic evaluations because of better homogeneity of standard deviations within age-parity classes.

2. MATERIALS AND METHODS

2.1. Adjustment for milking length

The analysis was carried out on 671 404 lactations performed between the 1st August 1982 and the 31th July 1995. Predicted values for the milking length levels were obtained by applying the linear model:

$$Y_{ijk} = MT_i + ML_j + e_{ijk} \qquad (1)$$

where Y_{ijk} is milk yield (MY) calculated according to International Committee for Animal Recording [10], MT_i the maximum test day yield as covariate and ML_j milking length in classes (322 levels). In order to smooth differences between classes a third-degree polynomial function was fitted to predicted yields for level of ML obtained from equation (1) weighting for the number of records in each class. The set of multiplicative factors was calculated by using a base length of 162 d.

2.2. Adjustment for age-parity-lambing month interaction

Milk yields corrected for length (CMY) were analyzed by applying a mixed model containing the flock-year-age class-parity (38 683 levels) and year-age class-parity-lambing month (290 levels) interactions as fixed effects. Years of production and birth began the 1st of August and ended the next 31th of July. Age classes (four levels) were obtained by difference between year of production and birth. The second age class was divided according to parity in two subclasses to distinguish first from second lactation. For each age by parity level 5 months were considered, from December to April for yearlings and from November to March for adult ewes, the lambings in other months being included in the external classes.

Random factors were additive genetic and permanent environmental. All known informative pedigrees, up to grandparents of ewes born in the year 1982, were included. Finally, 336 201 individuals, 289 066 of which with records, and 52 genetic groups were analyzed. Heritability and repeatability were assumed to be 0.28 and 0.45 respectively [18]. Solutions were obtained by iterative procedure [13] and calculation stopped after 200 iterations when the convergence criterion [14] reached a value near 10^{-9}. Solutions of fixed effects were associated to each record and summed. Average values of fixed effect sums (FMY) for the 25 classes of age-parity-lambing month interaction were used to estimate multiplicative factors, the base being associated to lactations performed by ewes in 4th age class, 3rd-4th parity and with lambing month between August and November. The reference was chosen according to a typical production system with lambing season of mature ewes concentrated in November (84% of reference class lambings).

3. RESULTS AND DISCUSSION

Averages and standard deviations of variables used in the analysis per age at lambing class, lambing month and parity order are shown in *table I*. Lambings are distributed differently according to age class and there is evidence for a significant relation between ML and lambing month. Averages of MY increase as ML becomes larger and in fact the estimate of raw correlation between MY and ML was 0.74 (*table II*). Interactions between ML, MY and MT are shown in *figure 1*. MY becomes larger as the ML values increase. Beyond a threshold of ML, there is evidence for MY being independent of MT, that after the threshold remains constant so that differences among MY are due mainly to ML. Before the threshold different levels of productions are due to ML but also to different levels of MT that become larger as ML values increase, meaning that short lactation MY levels were determined not only by external factors as farmer decisions or lambing period but also by lower production capabilities. Lactations with a low level of ML are mainly present when lambing is late in the season or when other abnormalities causing interruption of milking before summer season occur. To avoid flattening of milk productions in the whole range of ML a correction is needed considering the same level of MT. As shown by CMY trend (*figure 1*), multiplicative factors calculated by predicted values of equation (1) and subsequently smoothed (PMY), allow to remove only the variation caused by ML and to rank short lactations according to MT yield. *Figure 2* shows the comparison between the old and the new correction factors (OC and NC) and the related corrected yields (OCMY and CMY). Multiplicative factors and corrected yields were practically equivalent except for ML which was shorter than 50 d. This result seems to be interesting for including short lactations in animal models avoiding overestimation of sires with lower breeding values [3]. *Table I* reports means and standard deviations for milk yields and the multiplicative factor. MEE showed higher homogeneity of means and standard deviations within age-parity classes with respect to milk yield corrected for ML only (CMY). However, it must be stressed that the preadjustment for ML had already realized a better homoge-

Table I. Means and standard deviations per age-class, parity and lambing month for milk yield traits and adjustment coefficient.

Age class (1)	Parity	Month	N	ML (d) Mean	ML (d) S.D.	MY (L) Mean	MY (L) S.D.	CMY (L) Mean	CMY (L) S.D.	FMY (L) Mean	FMY (L) S.D.	MEE (L) Mean	MEE (L) S.D.	KMEE Mean
All	All	All	671404	154	49	190	78	196	57	196	43	200	56	1.027
1	1	All	191771	118	32	142	54	184	53	184	42	200	56	1.095
2	1	All	97278	159	48	184	70	185	53	187	41	198	56	1.071
2	2	All	124107	159	45	204	73	207	58	207	43	200	55	0.968
3	2–3	All	154801	174	46	218	79	203	58	204	42	200	56	0.985
4	3–4	All	103447	179	47	224	83	203	58	202	42	200	57	0.990
1	1	08–12	6640	172	42	195	69	184	53	185	42	199	57	1.082
		01	32369	142	29	177	54	198	51	197	40	201	52	1.014
		02	88140	121	24	148	47	190	51	190	41	200	54	1.052
		03	56472	100	24	116	41	172	50	172	40	200	58	1.061
		04–07	8150	76	25	78	35	139	51	140	41	199	74	1.432
2	1	08–11	28153	191	44	210	74	180	49	182	39	198	54	1.100
		12	27578	172	39	196	66	183	49	185	38	198	53	1.081
		01	18860	147	32	181	61	195	54	197	40	198	55	1.014
		02	14939	122	29	151	54	192	58	194	43	198	60	1.031
		03–07	7748	97	30	114	47	173	60	175	42	198	68	1.144
2	2	08–11	31731	191	43	228	78	195	52	196	41	199	53	1.020
		12	33863	174	36	219	70	203	54	204	41	200	53	0.981
		01	27517	150	29	207	65	220	59	219	42	201	54	0.914
		02	20925	126	28	176	58	219	62	218	44	201	57	0.919
		03–07	10071	98	28	132	52	198	64	197	44	202	65	1.016
3	2–3	08–11	77726	191	45	232	82	198	54	199	41	199	54	1.005
		12	44276	173	38	218	74	203	56	203	41	200	55	0.988
		01	17612	150	31	207	69	220	63	219	42	201	58	0.914
		02	10650	127	30	175	61	217	67	216	44	201	62	0.927
		03–07	4537	101	31	134	55	198	69	198	45	200	70	1.010
4	3–4	08–11	63837	191	47	235	85	201	55	200	41	201	55	1.000
		12	26187	173	39	220	76	205	57	203	41	201	56	0.984
		01	7254	150	33	205	70	218	63	215	41	203	59	0.931
		02	4182	127	33	172	65	214	70	212	46	201	66	0.943
		03–07	1987	101	33	129	57	190	72	190	46	200	76	1.055

(1) The age classes 1, 2, 3, 4 were defined by the difference between year of production and year of birth. They correspond approximately to month ages of: 6–17; 18–29; 30–42; 43–54 respectively. ML, milking length; MY, milk yield; CMY, milk yield preadjusted for milking length; FMY, sum of the fixed effect solutions; MEE, equivalent mature ewe; KMEE, correction coefficient for the age class-parity-lambing month interaction.

nization of standard deviations with respect to MY. The comparison between KMEE reported in *table I* and NC in *figure 2* shows that the preadjustment for ML was actually more important than the successive preadjustment to MEE.

Table II. Raw correlation coefficients (r) among milk yield traits.

Traits	r
ML × MY	0.74
ML × CMY	0.20
ML × MEE	0.14
ML × MT	0.14
MY × CMY	0.78
MY × MEE	0.72
MY × MT	0.68
CMY × MEE	0.97
CMY × MT	0.89
EME × MT	0.86

ML, milking length; MY, milk yield without preadjustments; CMY, milk yield preadjusted for milking length; MEE, equivalent mature ewe; MT, maximum test day yield.

The MEE average for first lactations at 2 years of age was 2 L lower than others. This result seems to be related to the lower average genetic merit of ewes that become cyclic later in the season and suggests the need of further research on the existence of a negative genetic correlation between milk yield and age at first lambing.

The raw correlation coefficients reported in *table II* show that MEE maintained a strong relationship with MY, despite the fact that the correlation coefficient with ML was substantially lower than between MY and ML.

4. CONCLUSIONS

The projection of the EME method applied in this study seems to be adequate to realize a correct phenotypic and genetic ranking of Sarda dairy ewes. Particularly, the multiplicative factors estimated for milking length realize projection of short lactations according to their milk capability. The projection factors used up to now are similar to those applied in this study for

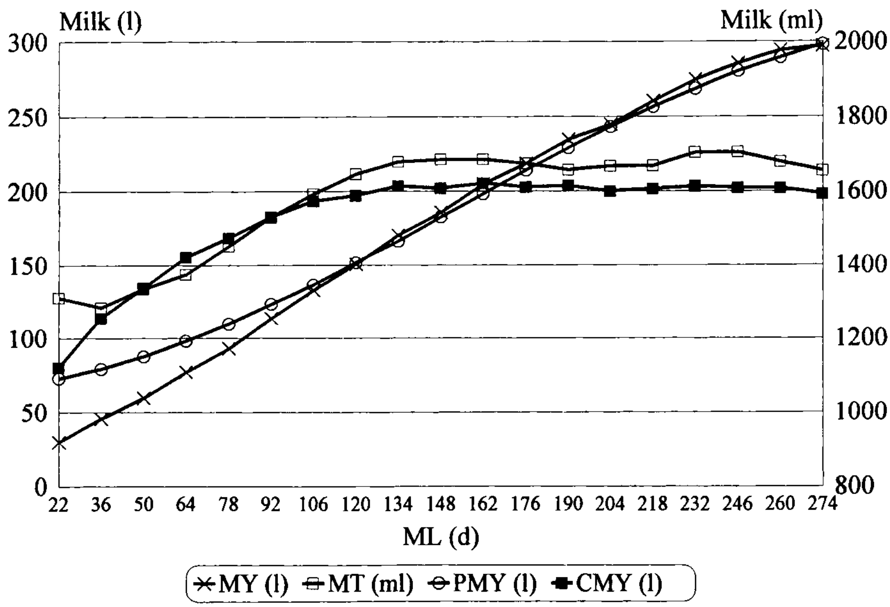

Figure 1. Trends of milk yields with milking length. MY, milk yield; MT, maximum test day yield; PMY, predicted milk yield; ; CMY, milk yield preadjusted for milking length.

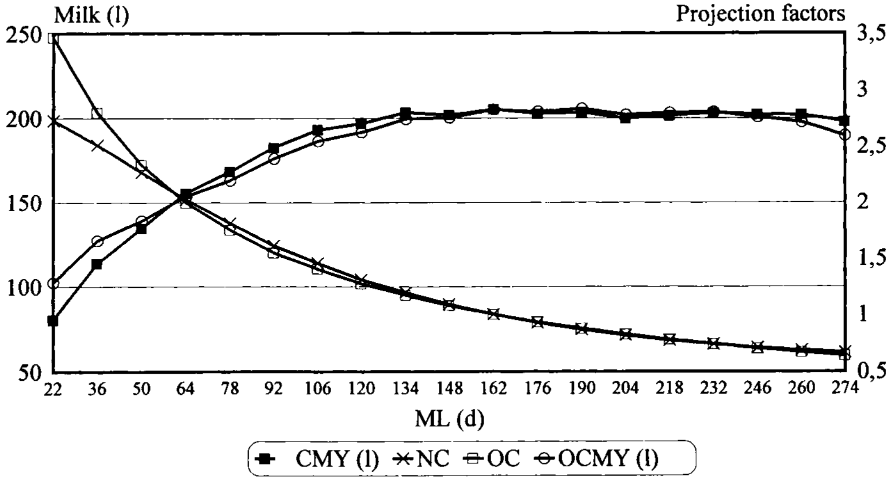

Figure 2. Comparison between milking length projection factors. CMY, milk yield preadjusted for milking length with NC; NC, correction coefficient estimated by equation 1; OC, old correction coefficient; OCMY, milk yield preadjusted for milking length with OC.

milking longer than 50 d. Nevertheless, the new correction method appeared more useful for short lactations in order to avoid overestimation of animals with low genetic merit. Type of estimation of projection coefficients utilized in this research considered only differences among MT and not production persistency. Persistency is indirectly considered because for same levels of MT less persistent lactations will be estimated to be less productive. Further research is needed to detect a more precise evaluation of persistency to be included in lactation projection.

Subsequent pre-adjustment for the age-parity-lambing month interaction will allow breeders to compare within-year lactations of different categories and to make more accurate culling choices. The lower MEE average for the 2-year-old first lactations is consistent with the objective of increasing lifetime production by reducing age at first lambing. The comparison between average values of MEE and MY for the reference age-parity-lambing month class (200 L vs. 235 L) showed that production capability of reference ewes is higher than that estimated by MEE due to lower ML level used as reference (162 d vs. 191 d).

The higher homogeneity of means and standard deviations seems to be interesting for genetic evaluation, particularly to avoid underestimation of young rams progeny tested on yearling lactations only.

Furthermore, pre-adjustment could allow the grouping in the same flock-year of lactations of ewes of different age-parity-lambing month and consequently the increasing of the number of compared rams within flock-year. This strategy could reduce bias in genetic evaluation generated by confusion between genetic and environmental effects mainly in flocks with a low rate of artificial insemination where only one or two rams per year were used for natural mating.

Likely, the projection coefficients to MEE should be estimated periodically to account for changes in management and an interaction age by month with year of lambing should be included in the animal model for genetic evaluation to account mainly for annual variations of pasture food availability.

REFERENCES

[1] Astruc J.M., Barillet F., Carta A., Gabina D., Manfredi E., Moioli B., Piacère A., Pilla A.M., Sanna S.R., Sigwald J.P., Ugarte E., Use of the animal model for genetic evaluation of dairy sheep and goats in several ICAR member countries, Proceedings 29th biennial Session of International Committee for Animal Recording (ICAR), Ottawa, Ontario, Canada, July 31-August 6, 1994, EAAP Publication No. 75, 1995, pp. 271–275.

[2] Bagnato A., Canavesi F., Rozzi P., Effect of parity in age adjustment factors in the Italian Holstein Friesian cattle breed, Proc. 5th World Congr. Genet. Appl. Livest. Prod. 17 (1994) 30–33.

[3] Barbat A., Bonaiti B., Boichard D., Comparaison de 2 méthodes de précorrection des lactations courtes pour l'évaluation des reproducteurs laitiers, Ann. Zootech. 44,(1995) 161–172.

[4] Barillet F., Boichard D., Barbat A., Astruc J.M., Bonaiti B., Use of an animal model for genetic evaluation of the Lacaune dairy sheep, Livest. Prod. Sci. 31 (1992) 287–299.

[5] Boichard D., Bonaïti A., Barbat A., Mattalia S., Three methods to validate the estimation of genetic trend for dairy cattle. J. Dairy Sci., 78 (1994) 431–437.

[6] Boyazoglu J., Aspects quantitatifs de la production laitière des brebis, Ann. Zootech. 12 (1963) 237–296.

[7] Caroli A., Moioli B.M., Pagnacco G., Aggiustamento per l'età al parto della produzione di latte nella razza ovina Delle Langhe, Zoot. Nutr. Anim. 19 (1993) 227–230.

[8] Carta A., Sanna S.R., Casu S., Estimating lactation curves and seasonal effects for milk, fat and protein in Sarda dairy sheep with a test day model, Livest. Prod. Sci. 44 (1995) 37–44.

[9] Interbull, Sire evaluation procedure for dairy production traits practised in various countries, Interbull Bull no. 5, Uppsala Sweden, 1992, p. 84.

[10] International Committee for Animal Recording, International regulations for milk recording in sheep, ICAR (Ed) 1993.

[11] Keown J.F., Everett R.W., Age month adjustment factors for milk, fat and protein yields in Holstein cattle, J. Dairy Sci. 68 (1985) 2664–2669.

[12] Khan M.S., Shook G.E., Effects of age on milk yield: time trends and method of adjustment, J. Dairy Sci. 79 (1996) 1057–1064.

[13] Misztal I., Gianola D., Indirect solution of mixed model equations, J. Dairy. Sci., 70 (1987) 716–723.

[14] Misztal I., Gianola D., Schaeffer L.R., Extrapolation and convergence criteria with Jacobi and Gauss-Seidel iteration in animal models, J. Dairy. Sci., 70 (1987) 2577.

[15] Poutous M., Mocquot J.C., Études sur la production laitière des Bovins. III. Relations entre critères de production, durée de lactation et intervalle entre le 1er et le 2^{e} vêlage, Ann. Génét Sél Anim 7 (1975) 181–189.

[16] Ptak E., Horst H.S., Schaeffer L.R., Interaction of age and month of calving with year of calving for production traits of Ontario Holsteins, J. Dairy Sci. 76 (1993) 3792–3798.

[17] Sanna S.R., Carta A., Casu S., Moioli B.M., Pagnacco G., Valutazione genetica della razza ovina Sarda. I. Effetti ambientali, Zoot. Nutr. Anim. 20 (1994) 217–222.

[18] Sanna S.R., Carta A., Casu S., Moioli B.M., Pilla, A.M., Valutazione genetica della razza ovina Sarda. II. Ereditabilità e correlazioni genetiche, Zoot. Nutr. Anim. 20 (1994) 247–251.

[19] Sanna S.R., Carta A., Casu S., Pilla A.M., Pagnacco G., Valutazione genetica della razza ovina Sarda. III.Indici e andamenti genetici ed ambientali, Zoot. Nutr. Anim. 20 (1994) 313–318.