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New tools to appraise udder morphology and milkability in dairy sheep

C. Marie-Etancelin*, Sara Casu, M.R. Aurel*, F. Barillet*, A. Carta**, S. Deiana**, M. Jacquin*, F. Pailler*, D. Porte* and S. Tolu****
*Station d'Amélioration Génétique des Animaux, INRA-SAGA,
BP 27, 31326 Castanet Tolosan, France
**Istituto Zootecnico e Caseario per la Sardegna (IZCS), Str. Sassari-Fertilia km 18.6,
07040 Olmedo, Italy

SUMMARY – The aim of this paper was to estimate relevance of new tools to appraise traits related to the milkability of dairy ewes, in particular udder morphology and the kinetics of milk emission. Data were collected in two experimental flocks: a backcross population Sarda × Lacaune and a purebreed Lacaune flock. The tools applied were: (i) two scoring tables developed in Italy and France respectively and digital picture analysis, for udder conformation; and (ii) an INRA automatic milk recording device for the kinetics of milk emission. High correlations between the two scoring tables (from 0.65 to 0.85) as well as high average correlations between classifiers using the same table (from 0.60 to 0.83) were estimated. Furthermore scored traits were repeatable both within (from 0.69 to 81) and between lactations (from 0.55 to 0.68). The udder picture analysis allowed the extraction of original and reliable measurements, confirmed by sufficient repeatabilities and showing good correlations with scores. Finally, data collected with electronic jars permitted the kinetics trait to be identified showing high repeatabilities such as maximum milk flow (0.52-0.74) and latency time (0.53-0.65), these traits outlining strong differences between the 2 experimental flocks.

Key words: Udder morphology, udder scoring, milkability, milk flow, dairy ewes.

RESUME – *"Nouveaux outils d'appréciation de la morphologie mammaire et de la facilité de traite de brebis laitières". L'objectif de ce papier est d'estimer la pertinence de nouveaux outils d'appréciation de la facilité de traite de brebis laitières relatifs à la morphologie mammaire et aux cinétiques d'émission du lait. Les mesures sont effectuées sur 2 troupeaux expérimentaux : brebis backcross Sarde × Lacaune en Sardaigne et brebis de 2 lignées Lacaune en France. Les méthodes utilisées sont : (i) 2 tables de pointages développées respectivement en Italie et en France et des analyses de photographies numériques pour la morphologie mammaire ; et (ii) un automate INRA de contrôle laitier pour la cinétique d'émission du lait. Des corrélations élevées entre les tables de pointages (de 0,65 à 0,85) ainsi que des valeurs moyennes élevées de corrélations entre pointeurs utilisant la même table (de 0,60 à 0,83) sont obtenues. De plus, les caractères pointés sont répétables à la fois intra-lactation (de 0,69 à 0,81) et entre lactation (de 0,55 à 0,68). L'analyse des photographies a permis l'extraction de mesures originales et fiables, confirmées par des répétabilités suffisantes et montrant de bonnes corrélations avec les pointages. Enfin, les données recueillies grâce à l'automate de contrôle laitier ont permis d'identifier des critères de cinétiques ayant des répétabilités élevées tels que le débit maximum (0,52-0,74) et le temps de latence (0,53-0,65), ces 2 caractères soulignant les grandes différences existant entre les 2 troupeaux expérimentaux.*

Mots-clés : *Morphologie mammaire, pointage, facilité de traite, cinétique d'émission du lait, brebis laitières.*

Introduction

Since the 60s great attention has been paid by scientists to dairy sheep milkability. More recently the diffusion of milking machine and the need to contain time and cost of labour encouraged breeders to look for animals able to eject rapidly their production during machine milking with few manual interventions. Previous studies (Marie-Etancelin *et al.*, 2001) pointed out that ewes with well shaped udders, mainly with vertical low implanted teats, and having high milk emission flows are the most adapted to show this aptitude. Thus, the possibility to improve the milkability of dairy sheep by selection needs first to study the udder conformation traits and kinetics of milk emission. Provided the difficulty of directly measuring the mammary gland for genetic evaluation purposes, different subjective appraisals of udder morphology have been proposed (de la Fuente *et al.*, 1996; Marie *et al.*, 1999; Casu *et al.*, 2000). These tables, based on linear scales, mainly focus on few elementary traits, and differ according to the country in which they have been conceived. Further researches are anyway needed both to determine whether other anatomical udder traits are involved in the milkability of a dairy ewe and to investigate which traits related to the kinetics of milk emission should be considered for selection. New perspectives have been opened, in that way, by progress of digital technology and of images analysis softwares, which permit the extraction of indirect measures of an object provided the presence in the digital picture of a metric indication. On the other hand, the development of automatic devices for milk flow recording allows monitoring the kinetics of milk emission during routine collective milking. The collaboration between IZCS and INRA-SAGA in the framework of an European research project regarding the detection of QTL on dairy ewes, has improved the possibility of applying these techniques, as well as udder scoring, on two populations bred in experimental farms. The objective of this paper is to illustrate measurements performed on these two populations and evaluate the efficiency of the new techniques proposed to measure udder morphology and milk flow parameters in dairy ewes.

Materials and methods

Populations

The studied populations were two flocks of dairy ewes reared in two experimental farms (Bonassai and La Fage) belonging respectively to IZCS (Italy) and to INRA (France). In Sardinia, the experimental population consisted of around 900 backcross (BC) Sarda × Lacaune ewes. They were procreated from 10 F1 Sarda × Lacaune males, issued from 10 Lacaune families, and mated in 1998 with around 3000 Sarda ewes (Barillet *et al.*, this volume, pp. 13). In France, the experimental population was a flock of 550 Lacaune ewes, composed of 2 genetic lines divergently selected for milk yield (High and Low lines) bred in the same conditions. This genetic design was built on the milk selection criteria of the Lacaune population: 6 generations ewes were procreated from 1989 to 2001, with a ten-year of selection gap between lines.

Udder morphology

Udder scoring appraisal method

This method consists of a subjective appraisal of some elementary traits of the udder on the basis of a linear scale. Appraisal tables developed in the two countries, both based on 9 point scales per traits, were similar with only slight differences (Marie-Etancelin *et al.*, 2001):

(i) Udder Depth (UD) – distance between the abdominal wall and the udder cleft, in the Italian scale, or the udder floor, in the French scale, taking as reference the height of the hocks in order to consider differences in animal size.

(ii) Teat Position (TP) – indication of either the average cistern height in the Italian scale, or the right teat angle respect to the vertical, in the French one.

(iii) Udder Cleft (UC) – degree of separation of the two halves, appraised as the angle of the cleft in the Italian scale and as combination of the angle and the height of the cleft in the French one, expression of the strength of the suspensory ligament.

(iv) Udder Attachment (UA) – ratio between the width and the depth of the udder.

In order to compare the Italian and French appraisal tables, two samples of 96 Sarda and Lacaune ewes were scored twice by the two teams of classifiers. Average classifier repeatabilities were calculated as the mean of the individual correlations between the first and second round of scoring. Correlations between teams were calculated as the mean correlations between pairs of classifiers from different countries. Afterwards, the Lacaune flock was always scored with the French table while the BC flock with the Italian one.

Thus, in 2000, individual scoring of 898 BC ewes in their first lactation were monthly performed, before the morning or evening milking, by a group of 4 classifiers working in alternate pairs. In 2001, during their second lactation, ewes were scored only three times, always before the evening milking, by the same team of classifiers, at the beginning, middle and end of lactation. On the whole, 16,237 records of 933 Sarda × Lacaune BC ewes were collected.

From 1997 to 2001, all the ewes of the Lacaune flock were scored twice a year, after at least 4 hours from the morning milking, by 4 trained classifiers. Focusing on ewes in first and second lactation, 10,605 records of 655 ewes were collected.

BC Sarda × Lacaune data were analysed with the following mixed model:

y = P*LG*D*M + C*D + I + I(D) + I(P) + e

where P*LG*D*M was the fixed effect of the interaction of parity (P) with class of lambing period (LG), date of scoring (D) and moment of scoring (M) (31 levels); C*D was the classifier date interaction effect (61 levels), and I, I(D) and I(P) were the individual (933 levels), individual-within-date (7694 levels) and individual-within-lactation (1796 levels) random effects.

A slight different model was used for the Lacaune data-set:

y = P*D + C*D + L+ N + I + D*I + P*I + e

where fixed effects were the interaction of parity and date of scoring (P*D with 24 levels), the interaction of classifiers and date of scoring (C*D with 76 levels), the line of ewes (L with 2 levels) and the number of lambs sucking (N) (2 levels). I (655 levels), D*I (2782 levels) and P*I (1138 levels) were random effects, respectively the individual-within line effect, interactions of date and individuals within line effect and of parity and individuals within line effect.

For both models, the value of V(I) + V[I(D)] + V[I(P)][1] represents the covariance between scores expressed on the same animal by different classifiers in the same date, and its ratio on the total variances (R1) gives an estimation of the relevance of the appraisal method. The ratio between V(I) + V[I(P)] and the total variance, estimates repeatability of the trait within lactation (R2) while the ratio between V(I) and the total variance represents the repeatability of the traits across lactations (R3).

Analysis of udder digital pictures

The implementation of digital picture analysis for the measurements of udder morphology has been possible thanks to several macros developed by INRA for the software Optimas 6.5, that allow the extraction and calculation of measurements from a digital picture. Three pictures of the udder were analysed: fore and lateral views of the whole udder and a particular view of the right teat. Measurements extracted from photos which have been analysed in this work are reported in Annex.

With the aim of testing feasibility and pertinence of the new technique of image analysis, the udder of 28 animals was photographed and, at the same time, directly measured with special calliper and protractor. Both types of measurements were repeated twice, within one-week lag. Correlations were calculated both for measurements extracted with the same technique (28 pairs of data for each technique) and for measurements made with the two different methods (56 pairs of homologous records).

Digital pictures of whole the backcross and Lacaune flocks were taken in 2000 and 2001 respectively. In both cases, photos were taken in the milking parlor with at least 3 people to take the picture, move the equipment (artificial lights, metric standard, black panels to show up the contrast and camera), keep the animal in good position. 874 primiparous ewes, in 3rd lactation month and 162 primiparous Lacaune ewes in 2nd lactation month were photographed.

The pictures of the BC experimental population were analysed by two different operators and correlations between the 2 measurements were calculated. Italian and French computer measurements were adjusted for time of picture taking and genetic line and time respectively and then correlated with the udder score received by the ewe in the closest scoring round.

[1] V = variance.

Milk emission kinetics

Both IZCS and INRA-SAGA experimental farms are equipped with an automatic milk recording device. This tool, developed by INRA (Ricard *et al.*, 1994), is able to store milk flow information such as Latency Time (LT, the time needed to collect 160 ml of milk in the jar after the teat cup attachment) and 12 intermediate measures, recorded at prefixed time lags, of the milk ejected from each ewe during the standard collective milking. Thus, eleven milk flows can be calculated and, from those, their average value (Average Milk Flow, AMF), their maximum (peak of milk emission, MMF), and the moment of its occurrence (time of peak, TMF), can be estimated.

In 2000, kinetics of milk emission in the Sarda × Lacaune BC population was monitored 3 times a month both at the morning and evening milking. Twice a month the lag between measures was set to 8 s (at the beginning of lactation) or 6 s (at the end of lactation), while in the third, intermediate week, it was fixed to 4 or 3 s respectively. 17,565 individual kinetics recorded on 893 primiparous animals were available for the analysis.

Milk flow kinetics of all the Lacaune divergent lines ewes were recorded from 1996 to 2001 at each morning and evening milking recording (every 3 weeks) with a lag between measures of 10 s: a total of 10,251 milk flow records from 978 primiparous ewes.

For LT, AMF, MMF, TMF, variance due to the individual random effect was estimated, on data set from the BC population, with a REML algorithm applied to the following model:

$$y = LG*D*M(La) + O + I + e$$

where La is the lag between measurements effect (4 levels), O is the milker charged of putting the clusters on the animal, and the other symbols are the same as above.

To estimate repeatability of kinetics traits, French data were analysed using the following model:

$$y = D + L + M + S + N + I(L)$$

where S is the stage of lactation fixed effect and the other symbols are the same as above.

Results and discussion

Udder scoring

In Table 1 the results of the comparison between the Italian and French teams of classifiers are reported. Classifier repeatabilities were high whatever the team or the trait (between 0.73 and 0.89). Correlations showed a great likeness between teams, meanly for UD and TP. On the contrary, the appraisal of the UC and UA (scored for the first time by the French team) seem differing in the 2 tables of scoring as indicated by lower correlation. Lower values of both repeatability and correlations between teams found for the sample of Sarda ewes could be due to the less favourable conditions in which Sarda ewes were scored compared to Lacaune ewes (more narrow parlour with a bar avoiding the immediate vision of the udder) and could indicate higher difficulty in scoring a more homogeneous group of animals sd in Sarda ewes samples. Finally it has to be stress that although the good agreement in the ranking of animals, the two teams always expressed different mean values for the scored traits, with low differences for TP and UD but too high for UC and UA. Thus, mean values of udder conformation traits recorded in the two experimental flocks Lacaune (Table 2) and BC Lacaune × Sarda (Table 3), are difficult to be compared, given the confounding between breed and classifier team effects.

In both Italian and French data set (Tables 2 and 3), average correlations among classifiers (R1) were high, thus confirming the relevance of the appraisal method when applied by trained classifiers. These values were similar to repeatabilities obtained by de la Fuente *et al.* (1996) on Churra (ranging from 0.57 to 0.73) and higher than those estimated by Legarra *et al.* (1999) (ranging from 0.31 to 0.60). Both repeatabilities within lactation (R2), ranging from 0.65 to 0.76 (except UA in Lacaune) and repeatabilities across lactations (R3), between 0.54 and 0.68, were high. Repeatabilities estimated by other authors for similar traits were comparable: Fernandez *et al.* (1997) estimated repeatabilities of udder traits ranging from 0.48 to 0.64 within lactation and Ugarte *et al.* (2001) found repeatabilities ranging from 0.57 to 0.70 within lactation and from 0.35 to 0.59 between lactations. UA appears to be the easiest trait to score by the Italian team, while worst results of the Lacaune data can be explained by a lower experience of French classifiers for this trait, and a specific udder morphology less variable in the french experimental flock, which increases the difficulty of locating the attachment. The higher repeatabilities for the 3 other traits in BC than in Lacaune data-set could be explained by a more numerous and closer scoring in Sardinia.

Table 1. Comparison between French (F) and Italian (I) appraisal method

Classifiers	Traits							
	TP		UC		UD		UA	
	F	I	F	I	F	I	F	I
Lacaune lines								
Mean	6.82	7.28	4.72	5.65	5.90	6.42	–	5.19
sd	1.36	1.45	1.46	1.47	1.06	1.15		1.76
(min-max)	(3-9)	(3-9)	(1-8)	(1-9)	(3-8)	(3-9)		(2-8)
Repeatability	0.87	0.89	0.82	0.79	0.87	0.88	–	0.86
Correlation	0.83		0.72		0.85		–	
Sarda ewes								
Mean	7.49	7.79	5.05	6.25	5.46	6.29	5.06	4.05
sd	0.97	1.01	1.26	1.06	0.93	0.94	1.32	1.38
(min-max)	(5-9)	(4-9)	(2-8)	(3-8)	(3-8)	(3-8)	(1-8)	(1-7)
Repeatability	0.84	0.85	0.75	0.76	0.83	0.73	0.75	0.78
Correlation	0.75		0.65		0.72		0.66	

Table 2. Descriptive statistics and repeatabilities of udder scores of BC Sarda × Lacaune†

	Mean	Min-max	sd	1rst-2nd mean	V(I)	V[I(D)]	V[(I(P)]	V(e)	R1	R2	R3
TP	7.71	3-9	1.00	7.51-8.04	0.598	0.058	0.073	0.173	0.81	0.73	0.66
UC	6.67	1-9	1.06	6.61-6.80	0.724	0.078	0.079	0.275	0.76	0.69	0.62
UD	6.38	2-9	1.02	6.63-6.00	0.565	0.034	0.101	0.173	0.80	0.76	0.64
UA	4.94	1-9	1.73	4.94-3.80	1.394	0.142	0.174	0.333	0.83	0.76	0.68

†Scored only since 2000.

Table 3. Descriptive statistics and repeatabilities of udder scores of Lacaune lines

	Mean	Min-max	sd	1rst-2nd mean	V(I)	V[I(D)]	V[I(P)]	V(e)	R1	R2	R3
TP	6.48	2-9	1.23	6.32-6.77	0.790	0.596	0.071	0.342	0.73	0.68	0.62
UC	4.89	1-9	1.47	4.92-4.84	1.227	0.156	0.138	0.476	0.76	0.68	0.61
UD	6.92	3-9	0.90	7.15-6.52	0.289	0.019	0.057	0.163	0.69	0.65	0.54
UA	6.11	2-9	0.98	6.19-6.05	0.410	0.023	0.034	0.284	0.62	0.59	0.54

Images analysis

As far as the comparison between *in vivo* and on pictures measurements are concerned (Table 4), although the means did not substantially differ for most of the traits considered, correlations between the two methods were high for the cistern height (0.84) and the distance between teats (0.88) – which are identified by a clear anatomical reference –, intermediate (ranging from 0.61 to 0.69) for the distance between the point under the tail and the cleft (P) and lateral udder measurements and weak for teat angle and teat size (from 0.53 to 0.57). Repeatabilities of measurements extracted by image analysis were, in general, lower than those of direct measurements, especially for P (0.56 vs 0.82) and the T (0.51 vs 0.73). Nevertheless, on this small sample of data, picture measurements seem to be the best approach for α_1 and the repeatabilities of other traits measured on the pictures, ranging between 0.65 and 0.86, suggest a sufficient precision of the new technique in the measuring of udder conformation.

Table 4. Means, standard deviation, repeatabilities and correlations for *in vivo* and pictures measures

Trait[†]	*In vivo*			Pictures			Correlation
	Mean	sd	Repeatability	Mean	sd	Repeatability	
Fore udder view							
W (cm)	11.66	1.74	0.85	12.19	1.69	0.74	0.69
P (cm)	22.42	1.65	0.82	21.57	2.08	0.56	0.68
TD (cm)	18.34	1.68	0.94	17.66	1.75	0.86	0.84
c (cm)	5.34	0.98	0.85	5.74	1.46	0.70	0.88
α_1 (°)	65.23	6.69	–	65.99	9.79	0.84	0.53
Lateral udder view							
d (cm)	2.54	1.11	0.73	4.05	1.62	0.51	0.61
LD (cm)	13.00	1.48	0.88	14.53	2.11	0.84	0.64
Teat view							
B (cm)	1.99	0.28	0.61	2.47	0.37	0.65	0.57
L (cm)	2.30	0.26	0.76	2.31	0.46	0.65	0.57

[†]See Annex for abbreviation explanation.

The relevance of computer measurements was, in general, also confirmed by the high correlations between measurements made by two operators on the pictures of BC primiparous ewes (Table 5). Nevertheless, for s and S, the WT and the α_2, correlation values were low. According to our experience, better results could be obtained by improving the quality of the picture and, in particular, the lightening of the lowest part of the udder. Moreover, for the analysis of French photos in 2001, improved macros were written for the Optimas software enabling the correction of some picture defaults. Higher variability was detected in the BC flock then the Lacaune one. Differences in the 2 experimental populations were high for H, W/H ratio, c, s (between 30 and 60% of discrepancy). Higher cistern and longer H in the BC ewes sample confirmed the udder morphology well-known differences between Sarda and Lacaune breed. Moreover, teat angle appears more horizontal and teat size length was slightly smaller in BC ewes (difference equal to 9%). At last, in the lateral view, the BC udder seemed deeper with less frontal teats.

In order to strengthen the relevance of udder scoring, correlations between udder traits scored with the Italian and French tables and some measurements extracted on pictures of the two populations (calculated after correction for the main sources of variation) are reported in Table 6.

On both data-sets good correspondences were found for TP. TP showed high correlation with both c and α_l, which are the traits TP represents in the Italian and French scoring tables, respectively. Correlations between UC and s and S were quite low, especially for the BC data set, probably because of the imprecision of this measurement in the Italian pictures. This result outlined the complexity of UC appraisal which is composed by 2 traits: angle between half-udders and height of the cleft. While in the BC data set UA had higher correlation with the ratio between W and H rather than with the absolute value of the udder attachment width, UA was more correlated with H in the French data set. This fact reflects the better training of the Italian classifiers to appraise UA taking into account the two dimensions of the udder. At last, UD showed high correlation with H in both experimental populations and, in lower degree, with the udder attach ratio.

Table 5. Descriptive statistics of udder picture measures of BC Sarda × Lacaune and Lacaune line

Traits†	BC Sarda × Lacaune				Correlation††	Lacaune lines			
	Mean	Min	Max	sd		Mean	Min	Max	sd
Fore udder view									
W	12.3	6.0	18.7	1.8	0.75	10.5	7.3	13.6	1.2
H	14.5	8.6	27.6	2.6	0.88	9.0	4.4	15.2	1.9
Ratio W/H	0.88	0.38	1.70	0.23	0.88	1.23	0.55	2.77	0.35
c	4.4	–2.0	9.4	1.4	0.91	2.4	0.6	5.8	1.0
β	6.5	2.9	11.8	1.04	0.82	5.6	0.0	26.0	5.0
S	1.6	0.0	12.2	1.7	0.38	1.4	0.0	5.5	1.1
s	1.3	0.1	9.9	0.73	0.44	0.8	0.0	2.1	0.4
α_2	67.9	15.9	327.9	17.0	0.57	48.5	11.3	90.0	14.9
α_1	63.4	20.2	127.9	14.0	0.98	49.8	19.9	99.1	15.7
Lateral udder view									
d	4.1	0.7	10.4	1.4	0.95	3.6	1.0	5.9	1.0
D	7.4	3.5	11.4	1.2	0.96	5.0	2.7	8.3	1.1
LD	11.5	6.1	16.4	1.5	0.92	8.6	5.1	12.1	1.4
d/LD (%)	35.4	8.9	69.1	9.7	0.97	41.6	16.4	61.1	9.5
Teat view									
B	2.3	1.6	3.7	0.2	0.80	2.4	1.7	3.6	0.3
WT	1.4	0.9	3.1	0.2	0.64	1.3	1.0	4.6	0.3
L	2.1	1.2	4.3	0.4	0.96	2.3	1.6	3.5	0.4
TS (surface)	2.8	1.2	8.9	0.8	0.90	3.0	1.8	5.6	0.7

†See Annex for abbreviation explanation.
††Correlations between 2 operators measurements.

Table 6. Phenotypic correlation between udder scoring and picture measurements

Scoring	Picture analysis†	Flocks		Picture analysis†	Flocks		Picture analysis†	Flocks	
		Lacaune	BC		Lacaune	BC		Lacaune	BC
TP	α_1	0.77	0.72	C	0.78	0.73	α_2	0.64	0.52
UC	S	0.30	0.22	S	0.70	0.50			
UA	W	0.13	0.56	H	–0.57	–0.70	(W/H)	0.50	0.77
UD	H	–0.60	–0.72	(W/H)	0.49	0.63			

†See Annex for abbreviation explanation.

To conclude, TP and UC more variable in French data-set were the appraisal traits better correlated with picture measurements, while UA and UD, more variable in Italian data set, presented the higher correlations with digital analysis.

Kinetics of milk emission

Descriptive statistics of milk yield and traits related to milk emission, recorded on the primiparous ewes of the two experimental flocks, are reported on Tables 7 and 8. Beyond differences in the milking system (with confusion between breed and milking environment effects), the best values of milk emission parameters found in the BC experimental flock reflect the better milking aptitude of the Sarda breed in terms of total milking time and milk flow (Flamant, 1974; Partearroyo and Flamant, 1978; Labussière, 1983). Despite slight differences in milk yield (4%), in fact, the BC ewes were more rapid in ejecting the first 160 ml of milk (12 s vs 25 s) and in reaching the maximum milk flow (13 s vs 28 s). Furthermore, maximum milk flow and average milk flow were higher in the crossed population than in the purebred one, although this superiority could have been overestimated by the shorter lag between intermediate measurements (3 to 8 s vs 10 s) used for the BC flock. On the whole, repeatabilities of milk flow traits were moderate to high, especially for the BC flock probably due to more frequent recording. The low repeatability of time of peak occurrence of the French data can be explained by the lag between measurements in Lacaune flock too high to allow a precise estimation of this parameters. Anyway, French results were in accordance with repeatabilities within lactation estimated for Lacaune lines on all the flock (Marie *et al.*, 1999).

Table 7. Descriptive statistics and repeatabilities of milk flow of BC Sarda × Lacaune

Traits	Mean	Min-max	CV (%)	V(I)	V(e)	Repeatability
Milk at milking control (ml)	781	160-1840	29	21,810	11,658	0.65
Latency time (s)	12	2-59	42	18.23	6.27	0.74
Maximum milk flow (ml/s)	24.1	6.25-110	39	51.3	28.05	0.65
Time of peak occurrence (s)	13	1-95	72	24.31	58.23	0.29
Mean milk flow (ml/s)	8.23	0.15-30.3	49	4.1139	4.1605	0.50

Table 8. Descriptive statistics and repeatabilities of milk flow of Lacaune lines

Traits	Mean	Min-max	CV (%)	V[I(L]	V(e)	Repeatability
Milk at milking control (ml)	815	100-2880	50	37,848	27,573	0.58
Latency time (s)	25	1-186	59	0.0162	0.0142	0.53
Maximum milk flow (ml/s)	13.5	1.0-44.0	43	12.2288	11.1239	0.52
Time of peak occurrence (s)	28	10-110	76	0.0073	0.0737	0.09
Mean milk flow (ml/s)	5.50	0.10-22.3	61	2.6984	2.7006	0.50

At last, phenotypic correlations between milk flow kinetics and udder scoring (results not shown) were all very low (lower than 0.2) or not significant in the 2 populations. These results were in accordance with those found by Marie *et al.* (1999) and Carta *et al.* (2000).

Conclusion

Results confirm the reliability of the tables of scoring for the evaluation of udder morphology and the possibility of their application on large scale in a perspective of genetic improvement of milking aptitude in dairy ewes. Nevertheless, adaptations between udder appraisal traits and breed are needed: UA seem to be not adapted to Lacaune udder shape, and caution should be paid in comparing animals scored with different tables. On the other hand, picture analysis technique provides a great amount of measurements and has the advantage of a greater feasibility compared to direct measure of the udder. Once the picture taking and analysis techniques settled, this tool would benefit of a higher objectivity compared to the scoring. At least for the moment, anyway, this approach, requiring special condition of application, is possible only in experimental farms. Data recorded with the automatic recording device provided new objective information on the kinetics of milk emission characterizing the animal milking ease. These traits, and in particular latency time and maximum milk flow which show high repeatabilities, could be considered as selection criteria whether an industrial development of the automatic recording device enabled on farm-recording.

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Annex

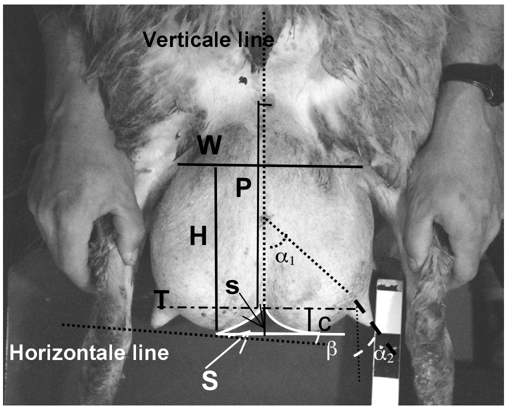

Fig. 1. Fore view of the udder.

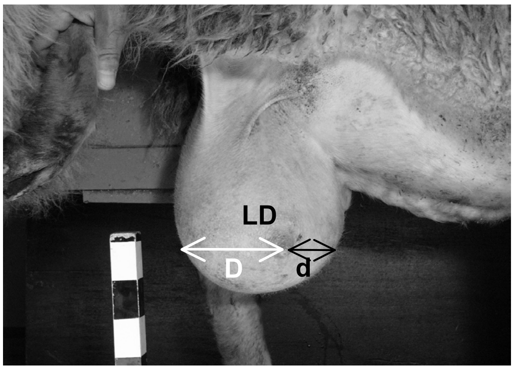

Fig. 2. Lateral view of the udder.

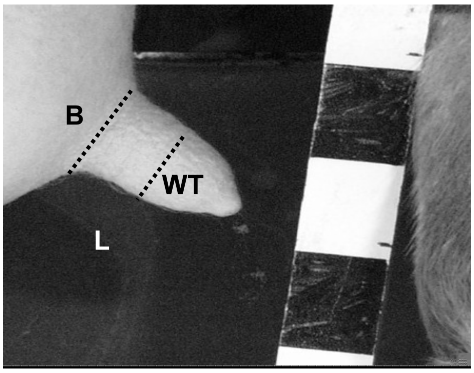

Fig. 3. View of the teat.

W: Attachment width
H: Attachment height
c: Right cistern height
S: Cleft surface
s: Cleft height
T: Teat distance
α_1: Angle of the teat
α_2: Direction of the teat
β: Udder balance
P: Point under the tail-cleft distance
D: Teat-udder front distance
d: Teat-udder back distance
B: Width of the teat base
LD: Lateral deep D + d
L: Teat length
wT: Width middle teat