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in

Priolo A. (ed.), Biondi L. (ed.), Ben Salem H. (ed.), Morand-Fehr P. (ed.).
Advanced nutrition and feeding strategies to improve sheep and goat

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 74

2007
pages 441-447

Use in selection of the measurements of feed intake and feeding behaviour parameters in sheep

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SUMMARY – Selection of meat sheep concerns currently two groups of traits, on the one hand the reproductive performances and on the other hand the meat traits such as growth and body composition. One way to improve lamb production may be to increase the efficiency of feed transformation by lambs. To avoid behaviour disorders it was necessary to be able to measure individual feed intake of group-reared lambs. In order to do that, the first step of the study was to develop an automatic feeder adapted for young rams. Then, each year, several groups of ram lambs included in individual performance tests had their feed intake measured. The genetic parameters were estimated and heritability coefficients were 0.43 for feed intake, 0.30 for residual daily feed intake estimated by regression of feed intake on growth, weight and body composition. Genetic correlation coefficients of selected traits (growth, weight, fat and conformation) were high with feed intake (0.83, 0.85, 0.31, 0.32) but very low with residual daily feed intake. Consumption of ewe lambs was measured in feedlots and seems to be positively linked with residual feed intake of ram lambs. Some parameters concerning the feeding behaviour have been described and the opportunity of the use of these feeding traits in meat sheep selection is discussed.

Keywords: Sheep, feed intake, feeding behaviour, feed efficiency, selection.

RESUME *– "Utilisation en sélection de mesures de consommation alimentaire et de comportement alimentaire en ovin allaitant". La sélection des ovins allaitants concerne généralement deux groupes de caractères, d'une part les caractères liés à la reproduction et aux qualités maternelles des brebis et d'autre part les caractères de croissance et de composition corporelle. Un moyen d'améliorer l'efficacité de la production d'agneaux de boucherie peut être d'accroître l'efficacité de la transformation des aliments ingérés par les agneaux. Pour éviter des problèmes de comportement il a été nécessaire de pouvoir mesurer la consommation alimentaire. Individuelle d'agneaux élevés en lot. Pour ce faire la première partie du travail a consisté à mettre au point un distributeur automatique de concentrés adapté aux agneaux. Puis chaque année plusieurs bandes de jeunes béliers faisant partie du contrôle individuel ont vu leur consommation mesurée. Les paramètres génétiques ont été estimés. Les coefficients d'héritabilité de la consommation, de la consommation résiduelle estimée par la régression de la consommation sur la croissance, le poids vif et la composition corporelle étaient respectivement de 0,43 et de 0,30. Les coefficients de corrélation génétique des caractères sélectionnés (croissance, poids, gras dorsal et conformation) étaient élevés avec la consommation totale (0,83, 0,85, 0,31, 0,32) et très faibles avec la consommation résiduelle. La consommation des agnelles a été mesurée en lots et semble être reliée positivement avec la consommation résiduelle des jeunes béliers. Des paramètres de comportement alimentaire ont été décrits. L'opportunité d'utiliser en sélection ces caractères liés à l'alimentation est discutée.*

Mots-clés : *Ovin, consommation alimentaire, efficacité alimentaire, sélection.*

Introduction

Meat sheep selection programs currently deals with two groups of traits, on the one hand reproductive performances and on the other hand meat traits such as growth and body composition. One way to improve lamb production may be to increase the efficiency of feed transformation by lambs. To evaluate the relationship between meat traits and feeding traits, it is necessary to estimate individual feed intake of group-reared lambs. To avoid behaviour problems, an automatic feeder was developed to be adapted for ram lambs. Measurements of feed intake of ram lambs included in individual performance tests were performed.

The genetic parameters have been estimated for feed intake, feed intake adjusted for weight, residual daily feed intake estimated by regression of feed intake on growth, weight and body composition. The traits currently selected (growth, adjusted weight, body composition and conformation) were also considered.

Relationship with the feed intake of ewe lambs is approached in a second experiment. Feeding behaviour parameters have been studied. The opportunity of the use of these feeding traits in meat sheep selection will be discussed.

Material and methods

The experiment took place at the experimental INRA farm of La Sapinière near Bourges, Cher, France. Here, 981 ram lambs of the breed INRA401 (Ricordeau *et al.*, 1992) were involved from 1997 to 1999 in French Individual Performance Test for Rams. The Test involves 2 weeks of devotion to adaptation and standardization for the young rams which are aged about 80 days when they are gathered from birth-flocks, and then 8 weeks of actual control from about 100 to 160 days of age (Perret *et al.*, 1994). The animals are fed *ad libitum* in order to exhibit their genetic potential. Weight is recorded at the beginning, mid and end of the control. Echotomography for backfat thickness and muscle depth (*longissimus dorsi*) is performed halfway through and at the end of the control. Conformation scoring and body defaults are checked at the end of the control. Rams are selected according to a synthetic index which combines indexes for growth, adjusted weight, body composition and conformation, every breed society defines its own weighting for the combination.

Among the ram lambs controlled as previously described, 752 of them had their feed intake recorded. The pellet was composed of wheat, barley, soya and colza cake, beet pulp and molasses. The individual intake of these group reared sheep was recorded with mono-place feeders for young rams, while they could get some unrecorded amount of hay. This automatic feeder is derived from the one developed for pig performance testing (Labroue *et al.*, 1999). Each time an animal visits the feeder the following data is recorded: its number encoded in an electronic tag, the exact time of its entrance and its exit, the difference of the weight of feed in the trough between these two with one gram precision.

A preliminary experiment showed in 1996 that the growth of 80 rams fed with this apparatus was equivalent to that of rams fed with collective feeders 371±52 g *vs* 358±54 g (François *et al.*, 1997). Twenty rams were penned in together for both an electronic feeder or a collective feeder.

The data was recorded by the feeders, then stored on the hard disk of the computer which drives the system and finally removed to a data base. The estimation of the genetic parameters was performed with VCE Software (Neumaier and Groeneveld, 1998) under an animal model.

Feeding traits results

Means and standard deviations are shown in Table 1. The daily feed intake was on average 1794 g during the 8 weeks of the test with a standard deviation of 242 g. When adjusted for the weight at the start of the test, the standard deviation decreases to 189 g. The residual daily feed intake was estimated as the residual of the multiple linear regression model applied on daily feed intake in relation with growth, weight and body composition. It was computed within each simultaneous tested rams group. Its mean was zero on average by definition and 117 g on standard deviation.

Feeding traits genetic parameters estimates

The genetic parameters have been estimated with a multiple trait model. The heritability coefficients of the gross variables (Table 2) are 0.43 for the daily feed intake, 0.43 for the ADG, 0.46 for backfat thickness, 0.36 for muscle depth. They are rather high for ADG and backfat and rather low for muscle depth compared to those estimated with younger lambs in the same breed by Moreno *et al.* (2001) and Bibé *et al.* (2002). The genetic correlations of the DFI are very high with ADG (0.83) and with live-weight (0.85), consistent with backfat (0.31) and muscle depth (0.32). These strong correlations were then bypassed in the analysis by the adjustment of feed intake with weight, growth and body composition.

Table 1. Statistics for both feeding traits and selected traits (from François *et al.*, 2002)

Variable	Description of the variable	N	Mean	Standard deviation
DFI	Daily feed intake over the 8 week period	752	1794 g	242 g
AFI	Adjusted DFI for weight at start of test	752	1794 g	189 g
RFI	Residual daily feed intake adjusted for weight at mid test, ADG, backfat and muscle depth	739	0	117 g
FE	Feed efficiency = ADG / DFI adjusted for weight at start	734	19.3 %	2.0 %
ADG	Average daily gain over the 8 week period	981	339 g	52 g
Backfat[†]	[backfat at mid + backfat at end] / 2	969	81[††]	10.0[††]
Backfat50[†]	Backfat adjusted at 50 kg from backfat at mid and backfat at end	967	79[††]	10.5[††]
Muscle[†]	[Muscle at mid+ muscle at end] / 2	969	255[††]	18.5[††]
Muscle50[†]	Muscle adjusted at 50 kg from muscle at mid and muscle at end	967	255[††]	19.9[††]
Wmid	Weight at mid test	981	47.2 kg	5.4 kg

[†]Backfat and Muscle measured by echotomography at mid and at end of the test. Backfat = thickness of the backfat plus the skin.
[††]in 1/10mm (uncorrected for the velocity of ultrasounds).

Table 2a. Estimates of genetic parameters[†] (from François *et al.*, 2002). Gross traits

Traits	DFI	ADG	Backfat	Muscle	Wmid
DFI	0.43	0.83	0.31	0.32	0.85
ADG		0.43	0.17	0.31	0.74
Backfat			0.46	0.26	0.18
Muscle				0.36	0.33
Wmid					0.36

[†]Heritabilities on the diagonal; genetic correlations above the diagonal.

Table 2b. Estimates of genetic parameters[†] (from François *et al.*, 2002). Adjusted traits

Traits	RFI	AFI	ADG	Backfat50	Muscle50	FE[††]
RFI	0.30	0.59	0	-0.05	0	-0.63
AFI		0.36	0.80	-0.16	-0.09	0.19
ADG			0.43	-0.33	-0.13	0.74
Backfat50				0.37	0.15	-0.42
Muscle50					0.23	-0.12
FE[††]						0.36

[†]Heritabilities on the diagonal, genetic correlations above the diagonal.
[††]FE=feed efficiency= ADG/DFI=1/FCR for feed conversion ratio.

Concerning adjusted variables of feed intake, we firstly observe that residual daily feed intake is quite independent of ADG, Backfat50 and Muscle50, the genetic correlations (Rg) are close to zero. This means that RFI and weight, ADG, body composition are linearly related. Consistent values for heritability coefficients were found for RFI (0.30±0.06), AFI (0.36) and FE (0.36).

Feed efficiency defined as the ratio of average daily gain on daily feed intake and inverse of the feed conversion ratio is strongly linked to average daily gain (Rg = 0.74), despite the high genetic correlation between growth and weight-adjusted feed intake (Rg = 0.80). Improvement of muscular development is neutral, reducing backfat is favourable: the genetic correlations are respectively -0.12 and -0.42 with FE.

RFI is linked to the adjusted daily feed intake (Rg = 0.59) and with feed efficiency (Rg = -0.63). RFI expresses the wasted feed by inefficient lambs in comparison to efficient ones both having the same phenotypic level for growth and body composition.

Relationship with female reproducers feed intake

In order to evaluate the relationship between the feed intake of ram lambs fed a pellet diet and the feed intake of related female reproducers fed a mixed hay plus pellet diet, two groups of ewe lambs were selected following a residual daily feed intake index computed with the residual daily feed intake of their sires and grand-sires. All animals were INRA401 breed.

The experiment took place at the same experimental farm in 2002. One group with the 80 most favourable index ewe lambs and one group with the 80 least favourable index ewe lambs were selected among 400 candidates. The gap between the RFI index mean of the two divergent lots was 64 g.

The experiment began in April when the females were 4 months old and ended in September when they were 9 months old. These females were fed and penned in 4 groups of 40 ewe lambs. The diet was *ad libitum* hay added with 300 grams of pellet. Wasted hay was weighed and removed as there was no waste of pellet.

Results (Table 3) show that there were minor differences in term of live-weight and growth (one fifth of one standard deviation for ADG). So the two lots can be compared on the lonely aspect of the feed intake. The residual daily feed intake favourable group had a 27 g less hay intake than the unfavourable group. Because of elimination of ill animals, the pellet diet was no more equal to 300 grams per day and per ewe lamb, but was 304 grams for the favourable and 317 grams for the unfavourable. Finally the gap between the two groups was 40 grams per day divided in 27 grams for hay and 13 grams for pellet.

Table 3. Comparison of the feed intake of two RFI index divergent groups of ewe lambs

	Favourable index group	Unfavourable index group	Gap between groups: Favourable minus unfavourable
Number of ewe lambs at the end	79	75	-
Weight at the start (kg)	37.5 ± 0.5	36.2 ± 0.6	1.3
Weight at the end (kg)	47.7 ± 0.6	47.2 ± 0.6	0.5
ADG (g)	63 ± 18	66 ± 16	-3
Hay intake (tons)	14.755	14.408	0.347
Average hay intake/day/ewe (kg)	1.153	1.180	-0.027
Average pellet intake/day/ewe (kg)	0.304	0.317	-0.013

Relying this observed 40 grams intake gap to the mean daily feed intake which was about 1470 grams (1170 grams of hay and 300 grams of pellet), the ratio was 2.7%. As the ratio of the RFI based predicted gap (64 grams) on the mean of the daily feed intake of a young ram (1794 grams) was 3.6%, this means that the residual feed intake of pellet-fed ram lambs is positively related with the feed intake of hay-fed young female reproducers.

Feeding behaviour

Regarding feeding behaviour, observations of the ram lambs experiment are presented in Table 4 and compared with a US-MARC experiment on composite ram lambs (Leymaster *et al.*, 2002) with another kind of automatic feeder.

Table 4. Ram lambs feeding behaviour parameters in two different experiments

	This experiment		Other experiment (Leymaster *et al.*, 2002)	
	Mean	Repeatability coefficient	Mean	Heritability coefficient
Number of meals per 24h	8.6	0.51	16.6	0.33
Feeding time per 24 h	29 mn	0.50	1.96 h	0.24
Per meal quantity	210 g	0.15	124 g	0.33
Per meal time	3.37 mn	0.20	8.54 mn	0.29

Following the difference between the two feeder systems, in our experiment the meals were about twice shorter, twice less frequent and lambs ate twice more at each meal than in the US-MARC experiment. Meal parameters were few repeatable as in the same time daily parameters show a consistent repeatability. Heritability coefficients estimated by Leymaster *et al.* are consistent both for meal and day parameters.

Around day and night we observe (Table 5) that a maximum of meals occurs (21.3%) from 8 a.m. to noon. We observe less meals in the afternoon and in the evening, less and less in the late evening and the early morning and the least in the middle of the night.

Table 5. Distribution of the meals all around 24 hours

Hours	0h-4h	4h-8h	8h-12h	12h-16h	16h-20h	20h-24h
% meals	14.0%	15.9%	21.3%	16.6%	16.3%	15.9%

Discussion

First feed intake genetic parameters in ram lambs were estimated by Cameron (1988) on individually penned sheep. They were very high (0.70) may be due to the feeding protocol.

Concerning group reared sheep feed intake, Cummins *et al.* (1997) measured the individual intake of 17 yearling rams over a 2 month period and found about 2.7 kg/day for a live-weight of 79 kg.

Leymaster *et al.* (2002) estimated heritability coefficient for daily feed intake of 0.25, while that of ADG was 0.27 in the same experiment. Genetic correlation between DFI and ADG was estimated 0.80.

Our estimate of the heritability coefficient for daily feed intake is 0.43, while that of ADG was also 0.43. Even our estimates are higher, this seems concordant heritability of daily feed intake being at the same level than heritability of average daily gain, the two being highly genetically correlated (0.82 in our experiment).

Calculating the residual feed intake, we found it heritable (0.30) and suggest that selection on this criterion could be promoted. We found a positive link between this measurement and the feed intake of ewe lambs suggesting that such a selection could gain both on fattening lambs and on reproducers.

FE is indirectly improved in the current French Sheep Individual Performance Test by the way of the favourable relationship with growth and lean. RFI direct selection could be relevant if the cost of these electronic tools (Bibé *et al.*, 1997) is recovered by the genetic progress expectable with a genetic standard deviation 65 g.

With beef cattle Arthur *et al.* (1999) found a higher heritability of RFI (0.43) but low genetic correlations with growth traits. The link between FE and growth is also found with beef cattle and pig (0.51 and 0.52, Bishop, and Cameron and Curran, cited by Cameron, 1998). In a one-generation divergent selection experiment, Arthur *et al.* (1999), found a very little genetic correlation between RFI and ADG (0.02) but a consistent one between RFI and live-weight at 365 days (- 0.25).

Regarding the feeding behaviour, its description should be taken in account since Jenkins and Leymaster (1987) noticed that as number of lambs within a pen increased, feed consumption per visit increased linearly.

Conclusion

This study show first a quite good feeding behaviour of group-reared sheep with an individual feeder, less than 10% of lambs need a human assistance during the first 2 weeks. Then the growth was found to be similar in collective and electronic feeder. The results in term of feed intake and residual daily feed intake remained stable for the 4 years of the experiment. The genetic parameter estimates of RFI (consistent heritability, favourable genetic correlations with growth) allow the proposal of the selection for this trait.

Positive link with consumption of ewe lambs need to be confirmed. Consequences of selection on residual feed intake in sheep on ingestion and nutrition is really a question. Collaborative studies should be carried out by nutritionists and geneticists on this topic.

Acknowledgements

This work was supported by both a grant from the French Ministry of Agriculture and Fisheries and a grant from the French Region Centre.

References

Arthur, P.F., Archer, J.A., Herd, R.M. and Richardson, E.C. (1999). Genetic improvement of feed efficiency of beef cattle. *Proc Europ. Ass. Anim.Prod*., G 6.7: 62.

Bibé, B., Barillet, F. and Poivey, J.P. (1997). Apports de l'automatisation dans les programmes d'amélioration génétique des petits ruminants. *Options Méditerranéennes, Série A*, 33: 35-41.

Bibé, B., Brunel, J.C., Bourdillon, Y., Loradoux, D., Gordy, M.H., Weisbecker, J.L. and Bouix, J. (2002). Genetic parameters of growth and carcass quality of lambs at the French progeny-test station Berrytest. *Proc. 7th World Cong. Genet. Appl. Livest. Prod*., Montpellier (France), 19-23 August 2002, pp. 335-338.

Cameron, N.D. (1988). Genetic relationships between growth and food intake in performance tested ram lambs: An investigation of variance component estimation procedures. *J. Anim. Breed. Genet*., 105: 431-440.

Cameron, N.D. (1998). Across species comparisons in selection for efficiency. *Proc. 6 th World Cong. Genet. Appl. Livest. Prod*., Armidale (Australia), 11-16 January 1988, Vol. 25, pp. 73-80.

Cummins, L., Knee, B. and Clark, A. (1997). Using automated feeders to collect preliminary feed conversion efficiency data in rams. *Proc. 12th Australian Assoc. Advanc. Anim. Br. Gen*., 12: 242-245.

François, D., Bibé, B., Bouix, J., Brunel, J.C., Weisbecker, J.L. and Ricard, E. (2002). Estimation of genetic parameters of feeding traits in meat sheep. *Proc. 7th World Congress on Genetics Applied to Livestock Production*, Montpellier (France), 19-23 August 2002, pp. 233-236.

François, D., Marie, C., Bibé, B., Barillet F., Weisbecker, J.L., Guillouet, P., Brunel, J.C., Aurel, M.R., Ricard, E., Bouix, J., Jacquin, M., Perret, G. and Poivey, J.P. (1997). Mesure de l'ingestion chez des jeunes béliers en croissance et chez des brebis laitières en lactation : perspectives d'utilisation en sélection ovine. *Renc. Rech. Ruminants*, 4: 219-222.

Jenkins, T.G. and Leymaster, K.A. (1987). Feeding behaviour characteristics of intact male lambs as affected by number of lambs in a pen with restricted access to the feed stall. *J. Anim. Sci*., 65: 422-430.

Labroue, F., Maignel, L., Sellier, P. and Noblet, J. (1999). Consommation résiduelle chez le porc en croissance alimenté à volonté. *Journ. Rech. Porcine en Fr.,* 31: 167-174.

Leymaster, K.A., Cammack, K.M., Nielsen, M.K. and Jenkins, T.G. (2002). Estimates of genetic parameters for daily gain, feed intake, and behaviour traits in ram lambs of a composite population. *Proc. 7th World Congress on Genetics Applied to Livestock Production*, Montpellier (France), 19-23 August 2002, pp. 229-232.

Moreno, C., Bouix, J., Brunel, J.C., Weisbecker, J.L., François, D., Lantier, F. and Elsen, J.M. (2001). Genetic parameter estimates for carcass traits in the INRA401 composite sheep strain. *Livest. Prod. Sci*, 69: 227-232.

Neumaier, A. and Groeneveld, E. (1998). Restricted maximum likelihood estimation of covariances in sparse linear models. *Genet. Sel. Evol*., 30: 3-26.

Perret, G., Bouix, J., Poivey, J.P., Bonnet, J.N. and Bibé, B. (1994). Contribution du contrôle individuel des jeunes béliers pour l'amélioration des aptitudes bouchères. *Renc. Rech. Ruminants,* 1: 187-192.

Ricordeau, G., Tchamitchian, L., Brunel, J.C., N'guyen, T.C. and François, D. (1992). Eléments de génétique quantitative et application aux populations animales, INRA Prod. Anim. (hors série), pp. 255-262.