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Morphological characteristics of udders as selection criteria for improvement of mammary gland health and productivity of sheep. 3. Simulated selection for improvement of mammary gland health and productivity

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ABSTRACT

A simulation of index selection was carried out for improvement of sheep mammary gland health and productivity, especially in terms of lamb rearing results. Selection indices were elaborated using the DZUPLAN program. These indices included different configurations of production record, somatic cell count in milk (as an indicator of mammary gland health) and selected morphological traits of udder and teats. The simulation of index selection was carried out based on these indices, together with an examination of the genetic effects of selection. Additionaly, the correlated response in daily gain of lambs was estimated from birth to weaning.

The results obtained clearly indicate that taking udder morphological traits into consideration in sheep breeding programmes can result not only in the improvement of ewe fertility and udder health but also in an increased growth rate of their progeny.

KEY WORDS: simulated index selection indices, productivity, health, sheep

INTRODUCTION

Many authors recommend using udder morphology traits as selection criteria for improving milk yield and reducing the occurrence of mastitis both in cows (Almlid, 1981; Hibbitt, 1983; Lie, 1985; Madsen et al., 1987) and in sheep (Papachristoforou and Mavrogenis, 1981; Labussière, 1988). However, the choice of morphological traits used as phenotypic markers varies due to differences in the assessment of the relationships between such traits and productivity. For example, Papachristoforou and Mavrogenis (1981) found a negative correlation between the depth of udders and milk yield in Chios sheep, while a similar

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relationship in a study by Labuissièrre et al. (1981) was found to be positive. This is why it seems reasonable to take into account breed-specific differences when analyzing the suitability of udder traits as selection criteria in sheep.

One of the difficulties in choosing selection criteria is the fact that certain morphological traits, their correlation with milk productivity and the occurrence of mastitis have opposite signs.

Improvement of milk yield may thus cause a rise in the incidence of mastitis (Madsen et al., 1987). Therefore, it becomes necessary to carry out a complex study of selection markers and their relationship with the productivity of ewes.

Certain authors (Grootenhuis, 1981; Emanuelson and Philipsson, 1984; Coffey, 1985) suggest a direct selection of cows and bulls (on the basis of analysis of their daughters) for a decreasing somatic cell count in milk. There is, however, the danger of an unwanted and unfavourable effect of this selection, i.e. undermining of the immunological response of the gland to infection (Kokkalis et al., 1986). It seems therefore that indirect selection based on udder and teat morphology may help avoid this danger and, simultaneously, enable the breeder to obtain the results desired.

CHOICE OF TRAITS - SELECTION CRITERIA

In the opinion of many authors udder circumference has a distinct, positive corrrelation with the milk yield of ewes (Papachristoforou and Mavrogenis, 1981; Labussière, 1988). The heritability of the longitudinal circumference the udders of Polish Lowland ewes exceeds 0.3 (see Part 1). Though the transverse circumference shows a slightly higher value ($h^2 = 0.4$), its repeatability is lower when compared with that of the longitudinal measurement (0.24 ± 0.06 vs 0.38 ± 0.05; Part 1). Also the correlation between the longitudinal circumference and the remaining udder traits estimated for Polish Lowland ewes ($r_g = 0.43$ to 0.90; $r_p = 0.52$ to 0.74, Part 1), especially the positive effect of this trait on lamb weight gain ($r_g = 0.54$; Part 2), suggest this will be a good selection marker.

Among the teat traits analyzed in cows, teat length has a significant effect on mammary gland health (Magid, 1983; Jensen et al., 1985; Madsen et al., 1987; Pander and Chopra, 1987). The longer the teats, the more frequent the occurrence of mastitis.

The genetic parameters of teat length estimated in Part 1 ($h^2 = 0.32 \pm 0.11$ and 0.45 ± 0.12; repeatability coefficient 0.52 ± 0.04 and 0.61 ± 0.04, for left and right teat, respectively) had the highest value among the studied teat traits. These results, together with observations made by the mentioned authors, indicate that this trait can constitute one more selection marker for the improvement of mammary gland health and productivity. Teat length should also facilitate the rearing of lambs what is especially important in Poland, where dairy sheep are

not common. According to breeders observations, teats which are too large may make suckling difficult and sometimes even impossible for the lamb, especially in the first period of its life. Thus teat length may be one of the reasons behind poor body weight gain or even lamb mortality.

The repeatability coefficients of selected morphological udder and teat traits range from 0.38 to 0.61 (Part 1), which indicates that these traits do not change very much with the ewe's increasing age and that their phenotypic expression is to a large degree controlled by genetic factors.

In order to verify these assumptions, simulated index selection based on the DZUPLAN program was carried out, using the selected traits as its criteria.

DESCRIPTION OF THE DZUPLAN PROGRAM

The DZUPLAN computer program for optimization of animal breeding schemes was developed at the Hohenheim University by two authors (Dr. K. Karras and Dr. E. Niebiel) and is used in several countries for constructing of selection indices and carrying simulation of selection.

This program was used to develop an optimum system of selection of Polish Lowland sheep of the Żelazna variety. The calculations were conducted at the Hohenheim University, Institut für Tierhaltung und Tierzüchtung, according to instructions by Komender (1989).

The assumptions of the breeding program were adjusted to accomodate those used at the Experimental Agricultural Farm in Żelazna. The herd for which selection simulation was conducted numbered 700 ewes and 24 rams. Both the ewes and rams were utilised for 4 years, the number of ewes per young ram being 25 and 30 for an older one. Herd replacement rate equalled 30% since in addition to the 25% of animals replaced annually (4 years of utilization), mortality, infertility and culling of sick animals had been taken into account. It was assumed that among of the young rams admitted to the breeding season 10% were not effective (e.g. reluctance to serve, infertility, etc.) and that 10% of all the ewes were not fertile. The fertility index of ewes was accepted as 1.5, what was justified by the variations previously observed in the number of weaned lambs. It was also assumed that the survival rate of ewes and rams equalled 0.95. Information for the estimation of the breeding value in both analyzed systems was obtained from half-sib groups, numbering 10 animals each.

The value of the correlation and heritability coefficients used in the program are presented in Table 1. These values are based on earlier results obtained by this author and on literature data (Turner and Young, 1969; Falconer, 1974; Owen, 1976; Atkins and McGuirk, 1979; Coop, 1982; Pirchner, 1983). In cases when no data existed, a zero correlation coefficient was accepted. Since, as already mentioned, increased fertility and wool yield were the main goal of

breeding the Polish Lowland sheep of the Żelazna variety, these two traits were assigned economic weights.

TABLE 1

Heritability (on diagonal) of traits – selection criteria and genetic (above diagonal) and phenotypic (below diagonal) correlations

Traits	1	2	3	4	5	6
1. Body weight at 12 month [kg]	0.30	0.10	0.10	0	0	0
2. Fleece weight at 12 month [kg]	0.20	0.30	0	0	0	0
3. Prolificacy (litter size)	0	0	0.15	−0.10	0.30	−0.30
4. Somatic cell count in 1 ml of milk [log]	0	0	0.10	0.10	0	0
5. Udde longit. cir. [cm]	0.10	0	0.10	0.10	0.30	0.40
6. Teat length [cm]	0	0	0.10	0.10	0.10	0.35

SELECTION SYSTEMS

A simulated index selection was carried out for two systems of selection, denoted OS and 02, using four selection indices (Table 2).

TABLE 2

Analysed systems of selection (OS and O2)

Selection criteria	Step of selection	Sources of information	Indices			
			I	II	III	IV
Body weight at 12 month	I	own performance M, MM, MO, HS	x	x	x	x
Fleece weight at 12 month	I	own performance, M, MM, MO, HS	x	x	x	x
Prolificacy	I	M, MM, MO	x	x	x	x
	II	own performance, HS	*	*	*	*
Udder morphological traits	I	M		x		x
	II	own performance, HS		*		*
Somatic celll count in 1 ml of milk	I	M			x	x
	II	own performance, HS			*	*

M – mother
MM mother's mother
MO – father's mother
HS half sibs
x / Traits – selection criteria in selection OS and I step of selection O2
* / Traits – selection criteria in II step of selection O2

These selection indices included different configurations of productive records (in the present study they were: body and fleece weights at 12 months of age, number of lambs per litter) and, as an additional criteria, selected

morphological traits of the udder (longitudinal circumference and average teat length) and somatic cell count in 1 ml of milk (indicator of mammary gland health – Methods Part 2) (Table 2).

The OS system (Old System) consisted of a one-stage selection of rams and ewes. This selection was carried out on one-year-old animals on the basis of their own productivity and that of their dams, sire's dam, dam's dam and half-sibs. The criteria of this type of selection varied depending on its objective (improvement of productivity record, morphology and health of udder, (Table 2).

System O2 also used one-stage selection of rams (at 12 months of age), as in system OS. The ewes, however, were subjected to selection twice: after reaching one year of age (the first stage of selection) and after completing their first lactation (second stage of selection). The first stage was similar to that of the OS, with one exception: the number of young ewes retained was double that which would be left on the basis of the accepted parameters of herd replacement. In the second stage of selection, the productivity of the animal and its half-siblings was used as an additional criterion in respect to fertility and the health and morphology of the udder (Table 2).

For both selection systems the genetic progress for the generation was evaluated using selection indices based on different traits.

RESULTS AND DISCUSSION

Table 3 illustrates the expected genetic progress per generation in one-stage (OS) and two-stage (O2) selection systems depending on the criteria used. As expected, compared with OS, system O2 resulted in a higher direct or indirect (correlated response to selection) breeding progress in respect to all the analyzed traits. Only the longitudinal circumference of the udder decreased as result of the two-stage selection for production increase (first index), which is an undiserable selection effect.

Although body weight at 12 months was a selection criterion, it was not one of the main goals of selection. Thus one must ensure this parameter does not decrease, but at the same time, its rapid increase was not required. Both selection systems fulfilled this assumption (Table 3).

The most important features of Polish Lowland sheep of the Żelazna variety, which should have been improved, were wool yield and fertility. In respect to the latter, response to selection was greatest when, in addition to productive records, the indices included somatic cell count in milk and selected morphological traits of udders and teats. This supports suggestions that the mammary gland health is one of the factors affecting rearing results of lambs. It should thus be taken into account in breeding practice. However, when using an index including both productivity and morphological traits a slightly smaller progress must be expected.

TABLE 3

Genetic gain in productive results, SCC and udder morphological traits of Polish Lowland sheep

Indices (traits included in)	Selection system	Body weight [kg]	Fleece weight [kg]	Number of reared lambs	Log. SCC	Udder longit. cir. [cm]	Teat length [cm]
I. A	OS	0.1929	0.1400	0.0139	−0.0013	0.0256	−0.0038
	O2	0.2020	0.1424	0.0208	−0.0020	−0.0392	−0.0058
II. A+B	OS	0.1736	0.1277	0.0196	−0.0011	0.0231	−0.0105
	O2	0.1796	0.1295	0.0279	−0.0017	0.0370	−0.0147
III. A+C	OS	0.1921	0.1393	0.0142	−0.0031	0.0258	−0.0038
	O2	0.2011	0.1417	0.0212	−0.0047	0.0395	−0.0058
	OS	0.1730	0.1274	0.0197	−0.0024	0.0252	−0.0103
IV. A+B+C	O2	0.1790	0.1292	0.0281	−0.0036	0.0397	−0.0144

The fleece weight will increase most rapidly when the selection conducted is based exclusively on productive traits, which results from the assumption made in this study that there is no correlation among production traits, fertility and additional characteristics. However, breeding progress achieved through selection in which were used both productivity and udder morphology traits seems to be equally satisfactory (Table 3).

It should not be expected that introducing additional traits into the index will lead to a significant increase in selection response. However, it should be taken into account that the basic aim of the present work was to improve the health of the mammary gland and its morphology.

Moreover, changes in the lambs' daily gains during rearing that are selection effect (correlated response to selection) (Table 4) argue in favour of this type of selection. The increase in the average daily gain will be almost double if the index

TABLE 4

Correlated selection response in the average daily gain [kg] of lamb during rearing period

Indices*	Selection system	
	OS	O2
A	0.0011	0.0017
A+B	0.0028	0.0039
A+C	0.0012	0.0018
A+B+C	0.0028	0.0040

*/

A – productive traits (body weight, fleece weight, prolificacy)

B – udder morphological traits (udder longitudinal circumference, teat length)

C – somatic cell count in logarithmic scale

includes both productivity and additional characteristics (index 3 and 4). This significant response to selection is most likely the result of a strong relationships (high values of correlation coefficients, Part 2) between the selected morphological traits of the dams' udders and the daily gain of their offspring.

At first glance, the average daily weight gain, presented in Table 4, does not appear to be very high. If, however, we multiply it by the number of days of rearing and the number of lambs in the herd, we will obtain not grams, but kilograms of additional liveweight. It can then be expected that taking the morphological traits of the dam's udder into account in the process of selection will not only help improve the health of the mammary gland, but will also increase ewe fertility and growth rate of their offspring. This will result in an increased profitability of sheep breeding.

CONCLUSIONS

1. The longitudinal circumference of the udder and teat length seem to be the best selection criteria among the analyzed morphological traits.
2. Simulated index selection, which included selected morphological traits in addition to productive traits, has shown that it is possible to obtain favourable changes in these traits as well as to improve the health of the mammary gland and lamb rearing results.

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STRESZCZENIE

Cechy morfologiczne wymion jako kryteria selekcji w celu poprawy zdrowotności gruczołu mlekowego i produkcyjności owiec. 3. Symulacja selekcji w kierunku poprawy zdrowotności i produkcyjności gruczołu mlekowego

Przeprowadzono symulację selekcji wskaźnikowej w kierunku poprawy zdrowotności gruczołu mlekowego owiec i efektów produkcyjnych, zwłaszcza wyników odchowu jagniąt. Wykorzystując program DZUPLAN skonstruowano indeksy selekcyjne obejmujące w różnych konfiguracjach cechy produkcyjne, zawartość komórek somatycznych w mleku (wskaźnik zdrowotności wymienia) i wybrane cechy budowy morfologicznej wymienia. Indeksy te były podstawą przeprowadzonej selekcji symulowanej. Oszacowano oczekiwany postęp genetyczny w zakresie cech będących kryteriami selekcji.

Oszacowano także skorelowaną reakcję na selekcję w zakresie dziennych przyrostów jagniąt w okresie od urodzenia do odsadzenia.

Uzyskane wyniki wyraźnie wskazują, iż przyjęcie cech budowy morfologicznej wymienia jako dodatkowych kryteriów selekcji nie tylko nie obniży efektów ekonomicznych hodowli, ale przyczyni się do poprawienia plenności owiec i zdrowotności ich wymion oraz lepszych przyrostów ich potomstwa.