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Breeding systems and selection strategies for sheep improvement in Cyprus

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SUMMARY - The aim of any breeding programme is to genetically improve one or more traits of economic importance in a population. The choice of any breeding and selection system depends on the degree of inheritance of the trait(s), the selection pressure (selection differential) and the generation interval. The necessary prerequisites to ensure genetic progress are the implementation of a performance recording scheme and of sound evaluation procedures and the organization of a programme for the dissemination (diffusion) of improved genetic material in the population. Animal breeding in Cyprus aims at improving genetically milk and meat production through selection and/or crossbreeding, the production of improved types suitable for environmental conditions they are called to perform in and the evaluation of the important environmental effects affecting animal productivity. The performance of purebreds and crossbreds under a semi-intensive production system, the procedures followed for the evaluation of superior individuals and the selection systems are discussed. Future work on breed evaluation and selection procedures and the formation of a synthetic breed involving two sheep breeds are also presented.

Key words: Selection, breeding, sheep.

Introduction

The diversity of objectives, the different management systems and breeds, the level of farmer's organization and the degree of involvement of government institutions in development, implementation and maintenance of recording schemes, are some of the reasons for the different programs towards the genetic improvement of sheep and goats.

The aim of any breeding programme is to genetically improve one or more traits of economic importance. The choice of the appropriate breeding programme depends on the degree of inheritance, the selection pressure and the generation interval. Hence the first step in developing an improvement programme is to define the breeding goals and device techniques appropriate for their measurement. The necessary tools for developing any improvement programme are:

1. Performance recording
2. Genetic evaluation procedures
3. Organization of a system for the diffusion of genetic material

In general, we recognize three major production objectives, milk, meat and wool in the case of sheep, or hair in the case of goats. The main targets of genetic improvement in Cyprus have been milk and meat.

Selection objectives and selection criteria

Selection is the deliberate differential reproduction of some individuals from others. It is either natural or artificial. In the world of animal production and improvement we are only concerned with artificial selection.

The main selection objectives in milk breeds are yield and quality of milk. Milk yield can be defined (in our breeding goals) as total production, part-lactation production following weaning or peak yield. It is important that we define the selection trait, because we shall have to measure it with accuracy and precision.

In addition, in meat breeds defining the selection criteria may also be cumbersome. Should we measure live weight, growth rate or carcass weight. How about measuring carcass composition. How important is mothering ability, litter size, quantity of milk suckled, fertility of ewe (goat), etc. Should we combine some of these traits into a total score (index) or should we select each trait independently. Do we have the means (tools) to measure these traits and sound evaluation procedures to objectively evaluate individual animals.

There is a lot of selection criteria to choose from if we want to improve milk, meat or both. However, some traits may be antagonistic to each other. Therefore, reliable estimates of the genetic parameters (heritability, genetic variances and covariances) and the generation interval are essential.

Our choice should always be to identify such selection criteria that are easy to measure and that describe the selection objective directly. In some cases it may be costly to do that. We then can resort to indirect selection criteria that are highly associated genetically with the primary selection criterion.

Selection of superior breeding stock

Selection of superior breeding stock is the process by which individuals are chosen, on the basis of their phenotypic merit, to be used as parents off the next generation. A number of systems of selection are available, such as:

1. Mass selection
2. Pedigree selection
3. Progeny test
4. Selection based on collaterals
5. Selection for specific or general combining ability

The methods of selection available to the animal breeder, regardless of the selection system employed are:

1. Linebreeding
2. Inbreeding
3. Outcrossing
4. Grading up
5. Crossbreeding
6. Formation of new breed

Selection tools

Performance recording

The first and most important selection tool is performance records. The magnitude and intensity of recording depends largely on the degree of organization, technical support of government or private institutions and it is often costly. We generally recognize two types of recording schemes. On-station and on-farm performance recording systems. The minimum requirements for either system are:

1. Individual identification of all animals
2. Mating and lambing dates
3. Type of birth and/or litter size
4. Monthly controls of milk yield (am. and pm.)
5. Fat content of milk
6. Liveweight records of lambs at regular intervals (birth, before and after weaning)
7. Liveweight records of ewes at mating and lambing

This basic recording structure can be adapted to the specific situation of different areas.

Estimation of breeding values

Genetic evaluation procedures should combine, in an optimum way, the performance of the individual and of his relatives (sire, dam, collaterals). Non-genetic effects such as season of freshening, age (or lactation number) at parturition and lactation length should be considered.

If the trait under selection pressure can be measured on the individual (live weight), mass selection is the best selection procedure. When milk yield is under selection, the use of relatives (dam sibs or progeny) becomes an integral part of the procedure, since it can be only be measured in one sex. When we aim for the simultaneous improvement of more than one traits, we must employ one of the following tools:

1. Independent culling levels
2. Tandem selection.
3. Selection based on total score (index)

A recently developed evaluation procedure combines information on the individual with that of his relatives using Best Linear Unbiased Predictors (BLUP) under an "Animal Model".

The selection index method is being used for over a decade in Cyprus. The basic requirements for its development are:

1. Estimates of genetic parameters (Tables 1 to 4)
2. Adjustment factors (additive or multiplicative) for growth traits (Tables 5 and 6)
3. Adjustment factors (additive or multiplicative) for milk production (Tables 7 and 8)

Table 1. Estimates of heritability, genetic and phenotypic variances and economic weights used in computing selection indexes for Chios sheep

Character	Parameter			
	h^2	σ^2_A	σ^2_P	Economic weights
Weaning weight	0.46	2.9486	6.4084	1.00
105-day weight	0.68	9.3804	13.7466	1.00
90-day milk yield	0.31	1436.8981	4635.1487	0.15
Total milk yield	0.34	1700.0592	5024.3544	0.15

Table 2. Estimates of genetic and phenotypic covariances and correlations among traits used in computing selection indexes for Chios sheep

Relationship/character	90-day milk yield		Total milk yield	
	Genetic	Phenotypic	Genetic	Phenotypic
Covariances				
weaning weight	-0.56	-7.49	-0.34	-11.58
105-days weight	2.80	-2.71	3.37	-8.22
Correlations				
weaning weight	-0.07	-0.06	-0.02	-0.06
105-days weight	0.19	-0.02	0.11	-0.03

Breeding programmes

The decision as to which programme should be employed for the genetic improvement of any population depends on a number of factors. The general idea is to utilize available resources and employ a breeding programme at minimum cost. A necessary prerequisite for the choice of the best suitable breeding programme is the knowledge of the kind of gene action (additive or nonadditive) with the grater influence on the traits we wish to improve

Table 3. Estimates of heritability, genetic and phenotypic variance and economic weights used in computing selection indexes for Damascus goats

Character	Parameter			
	h^2	σ^2_A	σ^2_P	Economic
Weaning weight	0.77	5.9000	7.6325	1.00
105-day weight	0.78	12.6594	16.2300	1.00
90-day milk yield	0.45	1596.4244	3514.5411	0.10
Total milk yield	0.28	3271.4308	11898.0813	0.10

Table 4. Estimates of genetic and phenotypic covariances and correlations among traits used in computing selection indexes for Damascus goats

Relationship/character	90-day milk yield		Total milk yield	
	Genetic	Phenotypic	Genetic	Phenotypic
Covariances				
weaning weight	1.31	-9.37	2.99	-14.92
105-days weight	15.94	8.98	36.98	14.31
Correlations				
weaning weight	0.05	-0.06	0.09	-0.05
105-day weight	0.26	0.03	0.43	0.03

Up grading of native populations using an 'improver' breed, systematic crossbreeding schemes aiming at the utilization of general and specific combining ability and breed substitution are some of the available methods that can be used to improve the productivity of the local breeds of sheep and goats.

Table 5. Effects of crossbreeding and estimates of heterosis in Chios x Awassi lambs

Breed or cross	Trait[1]				
	BWT	WWT	WT105	ADG1	ADG2
Chios (Ch)	4.0	13.5	27.5	0.215	0.230
Awassi (A)	4.9	16.8	30.7	0.257	0.238
Ch x A	5.1	17.1	30.1	0.260	0.220
A x Ch	4.2	16.2	31.9	0.250	0.274
Heterosis (%)	4.5	10.9	6.5	8.1	5.6

[1]BWT = birth weight; WWT = weaning weight; WT105 = 105 - day weight; ADG1 = preweaning gain; ADG2 = postweaning gain

Table 6. Reproductive traits of Chios x Awassi ewes

Breed or cross	Trait[1]				
	LSB	LSBL	LWTB	LSWN	LWTWN
Chios (Ch)	1.73	1.61	6.6	1.50	20.3
Awassi (A)	1.12	1.10	5.4	1.07	17.0
Ch x A	1.42	1.39	6.7	1.34	21.2
A x Ch	1.25	1.24	6.1	1.20	19.6
Heterosis (%)	neg.	neg.	6,67	neg.	9.38

[1]LSB = total lambs born; LSBL = lambs born live; LWTB = litter weight at birth; LSWN = total lambs weaned; LWTWN = litter weight at weaning

Several methods are available for the selection of superior breeding stock, such as mass selection, pedigree selection, progeny test and selection based on collateral relatives.

Whatever the proposed programme, it should be kept in mind that an efficient improvement programme must generate genetic progress and ensure the diffusion of improved genetic material to the entire population (recorded and nonrecorded flocks).

Table 7. Milk production of Chios x Awassi ewes

Breed or cross	Trait[1]					
	MLK90	DAYS	TOTMLK	FAT	FATKG	FCM
Chios (Ch)	130	161	174	6.4	11.1	179
Awassi (A)	113	173	173	7.3	12.7	194
Ch x A	131	133	167	6.5	11.0	175
A x Ch	119	118	150	6.5	9.8	157
Heterosis (%)	2.88	neg.	neg.	neg.	neg.	neg.

[1]MLK90 = 90-day milk yield; DAYS = lactation lenght; TOTMLK = total milk yield; FAT = fat content; FATKG = fat yield; FCM = fat corrected milk yield

Table 8. Lamb traits of Chios x East Friesian crosses

Breed or cross	Trait[1]				
	BWT	WWT	WT15	ADG1	ADG2
Chios (Ch)	4.0	13.5	27.5	0.215	0.230
EF x Ch (F_1)	4.7	16.7	31.0	0.247	0.250
EF x Ch (F_2)	4.2	14.8	31.3	0.246	0.266
(EF x Ch) x Ch	4.4	14.2	30.8	0.231	0.267
Ch x (EF x Ch)	4.4	14.6	31.4	0.240	0.269

[1]BWT = birth weight; WWT = weaning weight; WT105 = 105 - day weight; ADG1 = preweaning gain; ADG2 = postweaning gain

Animal improvement in Cyprus

The first serious attempts to improve livestock production were initiated with the importation of 'improvers' (Chios, Awassi and East Friesian breeds of sheep and Saanen and Damascus breeds of goats). Animal breeding work aimed at:

1. Improving through selection traits of economic importance, such as milk and meat
2. Producing, through crossbreeding, types which would combine the favourable attributes of parental breeds
3. Estimating the necessary genetic parameters for important economic traits and determine the appropriate methods for their improvement

4. Evaluate environmental effects affecting production and develop appropriate adjustment factors

Comparisons among breeds and estimation of heterotic effects for several breed crosses were carried out over a number of years for traits of economic importance. Reproductive traits were monitored systematically for ewes and lambs to establish breed differences in fertility, sexual maturity, seasonality of breeding and prolificacy. Crossbreds were evaluated under three different production systems. Selection procedures within purebreds, based initially on single trait selection, utilize the index method for the simultaneous improvement of both milk and meat production in Chios sheep and Damascus goats. Milk production is evaluated on the basis of the Dam's 90-day production following weaning and lamb live weight on the individual at 105 or 140 days of age for lambs and kids. respectively. These early criteria for live weight were decided upon following studies showing that, unlike weaning weight, they were free of maternal effects and were genetically independent of mature weight (Mavrogenis, 1985).

Table 9. Reproductive traits of Chios x Awassi ewes

Breed or cross	Trait[1]				
	LSB	LSBL	LWTB	LSWN	LWTWN
Chios (Ch)	1.73	1.61	6.6	1.50	20.3
EF x Ch (F_1)	1.91	1.83	8.5	1.70	25.6
EF x Ch (F_2)	1.69	1.60	7.2	1.48	21.6
(EF x Ch) x Ch	1.83	1.80	7.9	1.63	24.3
Ch x (EF x Ch)	1.58	1.54	6.9	1.49	23.4

[1]LSB = total lambs born; LSBL = lambs born live; LWTB = litter weight at birth; LSWN = total lambs weaned; LWTWN = litter weight at weaning

The selection scheme for both sheep and goats is organized in three levels (tiers). Closed nucleus units are maintained for Chios sheep and Damascus goats (700 sheep and 800 goats) at three government stations. About 4 to 5 thousand sheep and goats in private flocks are also under recording with some assistance from the government (extension). About 7% of males and 33% of females are selected as breeding replacements every year in the nucleus flocks. No migration into these closed flocks is allowed. About 10% of the males from the nucleus flocks are distributed to the multiplication units (private recorded flocks) and some 200 males to the commercial herds each year. There is free exchange of genetic material between recorded and nonrecorded flocks. IA is practised on a very limited scale. To enable the identification of both parents, hand-mating is practised in the nucleus flocks. No assortative mating is followed but random mating. The necessary precautions are maintained against relational interbreeding (mating among related individuals are avoided).

Table 10. Milk production of Chios x East Friesian ewes

Breed or cross	Trait[1]					
	MILK90	DAYS	TOTMLK	FAT	FATKG	FCM
Chios (Ch)	130	161	174	6.4	11.1	179
EF x Ch (F_1)	155	161	215	5.9	12.6	212
EF x Ch (F_2)	126	143	164	6.1	10.0	165
(EF x Ch) x Ch	131	144	169	6.1	10.2	170
Ch x (EF x Ch)	123	140	165	6.1	9.9	166

[1]MLK90 = 90-day milk yield; DAYS = lactation lenght; TOTMLK = total milk yield; FAT = fat content; FATKG = fat yield; FCM = fat corrected milk yield

Results of crossbreeding studies

Crossbreeding studies were at some point in time restricted to the most promising breed groups, i.e. between Chios and Awassi and Chios and E. Friesian. The crossbreeding programmes with Awassi aimed at improving the ability of Chios and its advanced crosses with the Cyprus fat-tailed sheep to withstand adverse management and environmental conditions. The programme involving the E. Friesian breed aimed at further improving the milking capacity and udder conformation traits as well as the growth potential of Chios breed and its crosses.

Estimates of Heterosis showed that in some cases crossbreeding was not the best method of improvement and that much more work was needed to understand the mode of inheritance and the effects of crossbreeding (Tables 5 to 10). For example, estimated heterosis in Chios x Awassi reciprocal crosses was 4.5% for birth weight and 10.9% for weaning weight, whereas estimates for litter size were negative and for litter weight were positive. The studies involving E. Friesian indicated that maternal effects could be important and further studies aiming at breed formation were initiated.

Results of selection studies

The estimation of heritabilities for and genetic associations among important economic traits indicated that genetic progress by selection would be effective. Evaluation procedures were improved using correction factors for the most important environmental effects and by the incorporation of grand-dam proofs in evaluating milk production. Based on those estimates selection on the basis of the index should be effective and genetic change for milk was estimated at about 6.7 kg per year and 1.8 kg per year for live weight.

Present and future work

Four projects are currently being implemented, all aiming at the genetic improvement of sheep and goats. A selection study involving the Chios sheep was initiated three years ago to measure response to selection for total score (index) and a crossbreeding study involving E. Friesian and Chios. A similar selection study to sheep is being implemented for Damascus goats, while a local goat breed is being evaluated under two different production systems.

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